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| **Joint Video Experts Team (JVET)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11**  16th Meeting: Geneva, CH, 1–11 Oct. 2019 | Document: JVET-P\_Notes\_dB |

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| *Title:* | **Meeting Report of the 16th Meeting of the Joint Video Experts Team (JVET), Geneva, CH, 1–11 Oct. 2019** | | |
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| *Purpose:* | Report | | |
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| *Source:* | Chairs of JVET | | |

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# Summary

The Joint Video Experts Team (JVET) of ITU-T WP3/16 and ISO/IEC JTC 1/ SC 29/ WG 11 held its sixteenth meeting during 1–11 October 2019 at the ITU premises in Geneva, CH. The JVET meeting was held under the chairmanship of Dr Gary Sullivan (Microsoft/USA) and Dr Jens-Rainer Ohm (RWTH Aachen/Germany). For rapid access to particular topics in this report, a subject categorization is found (with hyperlinks) in section 2.13 of this document. It is further noted that the unabbreviated name of JVET was formerly known as “Joint Video *Exploration* Team”, but the parent bodies modified it when entering the phase of formal development of a new standard. The name Versatile Video Coding (VVC) was chosen in April 2018 as the informal nickname for the new standard.

The JVET meeting began at approximately 1400 hours on Tuesday 1 October 2019. Meeting sessions were held on all days (including weekend days) until the meeting was closed at approximately XXXX hours on Friday 11 October 2019. On the first two days of the meeting, only aspects related to high level syntax were on the agenda. Approximately XXX people attended the JVET meeting, and approximately XXX input documents, 8 CE summary reports, and 18 AHG reports were discussed. The meeting took place in a collocated fashion with a meeting of SG16 – one of the two parent bodies of the JVET. The subject matter of the JVET meeting activities consisted of developing video coding technology with a compression capability that significantly exceeds that of the current HEVC standard, or otherwise gives better support regarding the requirements of future application domains of video coding. As a primary goal, the JVET meeting reviewed the work that was performed in the interim period since the fourteenth JVET meeting in producing a fifth draft of the VVC standard and the fifth version of the associated VVC test model (VTM). Further important goals were reviewing the results of 8 Core Experiments (CE), reviewing other technical input on novel aspects of video coding technology, producing the next versions of the VVC draft text and VTM, and plan next steps for further investigation of candidate technology towards the formal standard development.

The JVET produced XX output documents from the meeting (update):

* JVET-O2001 Versatile Video Coding specification text (Draft 6), also issued as ISO/IEC CD 23090-3 Versatile Video Coding
* JVET-O2002 Algorithm description for Versatile Video Coding and Test Model 6 (VTM 6)
* JVET-O2007 Supplemental enhancement information messages for coded video bitstreams
* JVET-O2011, JVET common test conditions and software reference configurations for HDR/WCG video
* JVET-O2021 through JVET-O2028, Description of Core Experiments 1 through 8

For the organization and planning of its future work, the JVET established XX “ad hoc groups” (AHGs) to progress the work on particular subject areas. At this meeting, X Core Experiments (CE) were defined. The next four JVET meetings were planned for 8–17 January 2020 under WG 11 auspices in Brussels, BE, during 15–24 April 2020 under WG 11 auspices in Alpbach, AT, during 23 June – 01 July 2020 under ITU-T SG16 auspices in Geneva, CH, and during 7–16 October 2020 under WG 11 auspices in Rennes, FR.

The document distribution site <http://phenix.it-sudparis.eu/jvet/> was used for distribution of all documents.

The reflector to be used for discussions by the JVET and all its AHGs is the JVET reflector:  
[jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de) hosted at RWTH Aachen University. For subscription to this list, see  
<https://lists.rwth-aachen.de/postorius/lists/jvet.lists.rwth-aachen.de/>.

# Administrative topics

## Organization

The ITU-T/ISO/IEC Joint Video Experts Team (JVET) is a group of video coding experts from the ITU-T Study Group 16 Visual Coding Experts Group (VCEG) and the ISO/IEC JTC 1/SC 29/WG 11 Moving Picture Experts Group (MPEG). The parent bodies of the JVET are ITU-T WP3/16 and ISO/IEC JTC 1/SC 29/WG 11.

The Joint Video Experts Team (JVET) of ITU-T WP3/16 and ISO/IEC JTC 1/ SC 29/ WG 11 held its sixteenth meeting during 1–11 October 2019 at the ITU premises in Geneva, CH. The JVET meeting was held under the chairmanship of Dr Gary Sullivan (Microsoft/USA) and Dr Jens-Rainer Ohm (RWTH Aachen/Germany).

It is further noted that the unabbreviated name of JVET was formerly known as “Joint Video *Exploration* Team”, but the parent bodies modified it when entering the phase of formal development of a new standard. The name Versatile Video Coding (VVC) was chosen in April 2018 as the informal nickname for the new standard.

## Meeting logistics

Information regarding logistics arrangements for the meeting had been provided via the email reflector [jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de) and at <http://wftp3.itu.int/av-arch/jvet-site/2019_10_P_Geneva/>.

## Primary goals

As a primary goal, the JVET meeting reviewed the work that was performed in the interim period since the fifteenth JVET meeting in producing a sixth draft of the VVC standard and the sixth version of the associated VVC test model (VTM). Further important goals were reviewing the results of 8 Core Experiments (CE), reviewing other technical input on novel aspects of video coding technology, producing the next versions of draft text and VTM, and planning next steps for further investigation of candidate technology towards the formal standard development.

## Documents and document handling considerations

### General

The documents of the JVET meeting are listed in Annex A of this report. The documents can be found at <http://phenix.it-sudparis.eu/jvet/>.

Registration timestamps, initial upload timestamps, and final upload timestamps are listed in Annex A of this report.

The document registration and upload times and dates listed in Annex A and in headings for documents in this report are in Paris/Geneva time. Dates mentioned for purposes of describing events at the meeting (other than as contribution registration and upload times) follow the local time at the meeting facility.

Highlighting of recorded decisions in this report is practised as follows:

* Decisions made by the group that might affect the normative content of a future standard are identified in this report by prefixing the description of the decision with the string “Decision:”.
* Decisions that affect the VTM software but have no normative effect are marked by the string “Decision (SW):”.
* Decisions that fix a “bug” in the VTM description (an error, oversight, or messiness) or in the software are marked by the string “Decision (BF):”.
* Decisions that are merely editorial without effect on the technical content of the draft standard are marked by the string "Decision (Ed.):". Such editorial decisions are merely suggestions to the editor, who has the discretion to determine the final action taken if their judgment differs.

This meeting report is based primarily on notes taken by the JVET chairs. The preliminary notes were also circulated publicly by ftp and http during the meeting on a daily basis. It should be understood by the reader that 1) some notes may appear in abbreviated form, 2) summaries of the content of contributions are often based on abstracts provided by contributing proponents without an intent to imply endorsement of the views expressed therein, and 3) the depth of discussion of the content of the various contributions in this report is not uniform. Generally, the report is written to include as much information about the contributions and discussions as is feasible (in the interest of aiding study), although this approach may not result in the most polished output report.

### Late and incomplete document considerations

The formal deadline for registering and uploading non-administrative contributions had been announced as Tuesday, 24 September 2019. Any documents uploaded after 1159 hours Paris/Geneva time on Wednesday 25 September were considered “officially late”, giving a grace period of 12 hours to accommodate those living in different time zones of the world. The deadline does not apply to AHG reports, and other such reports which can only be produced after the availability of other input documents.

As agreed by the fifteenth meeting as permanent rule, contributions related to CE proposals (including draft text) were to be uploaded 1 week ahead of the above mentioned deadline, such that more thourough study was possible, and in particular the CE summary reports could be provided in time by the regular deadline. Consequently, CE proposal documents which were uploaded after 1159 hours Paris/Geneva time on Wednesday 18 September were considered “officially late”.

It was suggested to have CE description documents include a description of how the results are planned to be reported – e.g., the form of the tables to be used for the results data. Complexity analysis characterizations were suggested to be a particular issue where this applies.

All contribution documents with registration numbers higher than JVET-P0618 were registered after the “officially late” deadline (and therefore were also uploaded late). Likewise, CE proposal documents with registration numbers higher than JVET-P0081 were registered late. However, some documents in the “late” range might include break-out activity reports that were generated during the meeting, and are therefore better considered as report documents rather than as late contributions. Also, all cross-check reports were uploaded late.

In many cases, contributions were also revised after the initial version was uploaded. The contribution document archive website retains publicly accessible prior versions in such cases. The timing of late document availability for contributions is generally noted in the section discussing each contribution in this report.

One suggestion to assist with the issue of late submissions was to require the submitters of late contributions and late revisions to describe the characteristics of the late or revised (or missing) material at the beginning of discussion of the contribution. This was agreed to be a helpful approach to be followed at the meeting.

The following technical design proposal contributions were registered and/or uploaded late:qq

* JVET-P0XXX (a proposal on …), uploaded XX-XX.
* …

It may be observed that some of the above-listed contributions were submissions made in response to issues that arose in discussions during the meeting or from the study of other contributions, and thus could not have been submitted by the ordinary deadline. For example, some of them were proposing combinations or simplifications of other proposals.

The following other document not proposing normative technical content, but with some need for consideration, were registered and/or uploaded late:

* JVET-P0XXX (a document on …), uploaded XX-XX.
* …

All cross-verification reports at this meeting (except for JVET-P0594) were registered late and all were uploaded late. In the interest of brevity, these are not specifically identified here. Initial upload times for each document are recorded in Annex A of this report.

The following (X) contribution registrations were later cancelled, withdrawn, never provided, were cross-checks of a withdrawn contribution, or were registered in error: JVET-P0XXX (withdrawn), JVET-P0XXX (missing by the end of meeting), … .

The following crosschecks had not been uploaded yet by the end of the meeting, but were provided later (check if they become available – otherwise withdraw them):

…

“Placeholder” contribution documents that were basically empty of content, or lacking any results showing benefit for the proposed technology, and obviously uploaded with an intent to provide a more complete submission as a revision, had been agreed to be considered unacceptable and to be rejected in the document management system until a more complete version was available (which would then typically be counted as a late contribution). At the current meeting, this situation applied to the initial uploads of documents JVET-P0487, JVET-P0596, JVET-P0620, and … .

Contributions that had significant problems with uploaded versions included the following:

* JVET-P0XXX (…)
* …

As a general policy, missing documents were not to be presented, and late documents (and substantial revisions) could only be presented when there was a consensus to consider them and there was sufficient time available for their review. Again, an exception is applied for AHG reports, CE summaries, and other such reports which can only be produced after the availability of other input documents. There were no objections raised by the group regarding presentation of late contributions, although there was some expression of annoyance and remarks on the difficulty of dealing with late contributions and late revisions.

It was remarked that documents that are substantially revised after the initial upload can also be a problem, as this becomes confusing, interferes with study, and puts an extra burden on synchronization of the discussion. This can especially be a problem in cases where the initial upload is clearly incomplete, and in cases where it is difficult to figure out what parts were changed in a revision. For document contributions, revision marking is very helpful to indicate what has been changed. Also, the “comments” field on the web site can be used to indicate what is different in a revision although participants tend to seldom notice what is recorded there.

A few contributions may have had some problems relating to IPR declarations in the initial uploaded versions (missing declarations, declarations saying they were from the wrong companies, etc.). These issues were corrected by later uploaded versions in a reasonably timely fashion in all cases (to the extent of the awareness of the responsible coordinators).

Some other errors were noticed in other initial document uploads (wrong document numbers or meeting dates or meeting locations in headers, etc.) which were generally sorted out in a reasonably timely fashion. The document web site contains an archive of each upload.

### Outputs of the preceding meeting

All output documents of the previous meeting, particularly the meeting report JVET-O2000, the Versatile Video Coding specification text (Draft 6) JVET-O2001, the Algorithm description for Versatile Video Coding and Test Model 6 (VTM 6) JVET-O2002, the Methodology and reporting template for coding tool testing JVET-O2005, the Supplemental enhancement information messages for coded video bitstreams JVET-O2007, the JVET common test conditions and software reference configurations for HDR/WCG video JVET-N2011, and the Description of Core Experiments 1 through 8 (JVET-O2021 through JVET-O2028), had been completed and were approved. The software implementation of VTM (versions 6.0 and 6.1) was also approved.

The group was initially asked to review the meeting report of the previous meeting for finalization. The meeting report was later approved without modification.

The available output documents of the previous meeting and the software had been made available in a reasonably timely fashion.

## Attendance

The list of participants in the JVET meeting can be found in Annex B of this report.

The meeting was open to those qualified to participate either in ITU-T WP3/16 or ISO/IEC JTC 1/‌SC 29/‌WG 11 (including experts who had been personally invited as permitted by ITU-T or ISO/IEC policies).

Participants had been reminded of the need to be properly qualified to attend. Those seeking further information regarding qualifications to attend future meetings may contact the responsible coordinators.

## Agenda

The agenda for the meeting was as follows:

* Opening remarks and review of meeting logistics and communication practices
* IPR policy reminder and declarations
* Contribution document allocation
* Review of results of the previous meeting
* Reports of *ad hoc* group (AHG) activities
* Reports of core experiments planned at the previous meeting
* Consideration of contributions and communications on project guidance
* Consideration of additional video coding technology contributions
* Consideration of information contributions
* Coordination activities
* Approval of output documents and associated editing periods
* Future planning: Determination of next steps, discussion of working methods, communication practices, establishment of coordinated experiments, establishment of AHGs, meeting planning, other planning issues
* Other business as appropriate for consideration

On the first two days of the meeting (October 1 and 2), only aspects related to high level syntax (including AHG8, AHG12, AHG14, and AHG17 reports) were on the agenda. In the morning of October 3, the meeting was continued with general status review and administrative matters, and then proceeded with reports of ad *hoc* group activities, reports of core experiments, and other matters.

## IPR policy reminder

Participants were reminded of the IPR policy established by the parent organizations of the JVET and were referred to the parent body websites for further information. The IPR policy was summarized for the participants.

The ITU-T/ITU-R/ISO/IEC common patent policy shall apply. Participants were particularly reminded that contributions proposing normative technical content shall contain a non-binding informal notice of whether the submitter may have patent rights that would be necessary for implementation of the resulting standard. The notice shall indicate the category of anticipated licensing terms according to the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form.

This obligation is supplemental to, and does not replace, any existing obligations of parties to submit formal IPR declarations to ITU-T/ITU-R/ISO/IEC.

Participants were also reminded of the need to formally report patent rights to the top-level parent bodies (using the common reporting form found on the database listed below) and to make verbal and/or document IPR reports within the JVET necessary in the event that they are aware of unreported patents that are essential to implementation of a standard or of a draft standard under development.

Some relevant links for organizational and IPR policy information are provided below:

* <http://www.itu.int/ITU-T/ipr/index.html> (common patent policy for ITU-T, ITU-R, ISO, and IEC, and guidelines and forms for formal reporting to the parent bodies)
* <http://ftp3.itu.int/av-arch/jvet-site> (JVET contribution templates)
* <http://www.itu.int/ITU-T/dbase/patent/index.html> (ITU-T IPR database)
* <http://www.itscj.ipsj.or.jp/sc29/29w7proc.htm> (JTC 1/‌SC 29 Procedures)

It is noted that the ITU TSB director’s AHG on IPR had issued a clarification of the IPR reporting process for ITU-T standards, as follows, per SG 16 TD 327 (GEN/16):

“TSB has reported to the TSB Director’s IPR Ad Hoc Group that they are receiving Patent Statement and Licensing Declaration forms regarding technology submitted in Contributions that may not yet be incorporated in a draft new or revised Recommendation. The IPR Ad Hoc Group observes that, while disclosure of patent information is strongly encouraged as early as possible, the premature submission of Patent Statement and Licensing Declaration forms is not an appropriate tool for such purpose.

In cases where a contributor wishes to disclose patents related to technology in Contributions, this can be done in the Contributions themselves, or informed verbally or otherwise in written form to the technical group (e.g. a Rapporteur’s group), disclosure which should then be duly noted in the meeting report for future reference and record keeping.

It should be noted that the TSB may not be able to meaningfully classify Patent Statement and Licensing Declaration forms for technology in Contributions, since sometimes there are no means to identify the exact work item to which the disclosure applies, or there is no way to ascertain whether the proposal in a Contribution would be adopted into a draft Recommendation.

Therefore, patent holders should submit the Patent Statement and Licensing Declaration form at the time the patent holder believes that the patent is essential to the implementation of a draft or approved Recommendation.”

The responsible coordinators invited participants to make any necessary verbal reports of previously-unreported IPR in technology that might be considered as prospective candidate for inclusion in future standards, and opened the floor for such reports: No such verbal reports were made.

## Software copyright disclaimer header reminder

It was noted that the VTM software implementation package uses the same software copyright license header as the HEVC reference software, where the latter had been agreed at the 5th meeting of the JCT-VC and approved by both parent bodies at their collocated meetings at that time. This license header language is based on the BSD license with a preceding sentence declaring that other contributor or third party rights, including patent rights, are not granted by the license, as recorded in [N 10791](http://phenix.it-sudparis.eu/mpeg/doc_end_user/current_document.php?id=27881&id_meeting=16) of the 89th meeting of ISO/IEC JTC 1/‌SC 29/‌WG 11. Both ITU and ISO/IEC will be identified in the <OWNER> and <ORGANIZATION> tags in the header. This software is used in the process of designing the VTM software, and for evaluating proposals for technology to be potentially included in the design. This software or parts thereof might be published by ITU-T and ISO/IEC as an example implementation of a future video coding standard and for use as the basis of products to promote adoption of such technology.

Different copyright statements shall not be committed to the committee software repository (in the absence of subsequent review and approval of any such actions). As noted previously, it must be further understood that any initially-adopted such copyright header statement language could further change in response to new information and guidance on the subject in the future.

These considerations apply to the 360Lib video conversion software and HDRTools as well.

## Communication practices

The documents for the meeting can be found at <http://phenix.it-sudparis.eu/jvet/>.

It was reminded to send a notice to the chairs in cases of changes to document titles, authors etc.

JVET email lists are managed through the site <https://lists.rwth-aachen.de/postorius/lists/jvet.lists.rwth-aachen.de/>, and to send email to the reflector, the email address is [jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de). Only members of the reflector can send email to the list. However, membership of the reflector is not limited to qualified JVET participants.

It was emphasized that reflector subscriptions and email sent to the reflector must use real names when subscribing and sending messages and subscribers must respond to inquiries regarding the nature of their interest in the work. The current number of subscribers was 1221.

For distribution of test sequences, a password-protected ftp site had been set up at RWTH Aachen University, with a mirror site at FhG-HHI. Accredited members of JVET may contact the responsible JVET coordinators to obtain the password information (but the site is not open for use by others).

## Terminology

Some terminology used in this report is explained below:

(check for completeness with JVET-N0013, and draft text)

* **ACT**: Adaptive colour transform.
* **AFF**: Affine.
* **AI**: All-intra.
* **AIF**: Adaptive interpolation filtering.
* **ALF**: Adaptive loop filter.
* **AMP**: Asymmetric motion partitioning – a motion prediction partitioning for which the sub-regions of a region are not equal in size (in HEVC, being N/2x2N and 3N/2x2N or 2NxN/2 and 2Nx3N/2 with 2N equal to 16 or 32 for the luma component).
* **AMVP**: Adaptive motion vector prediction.
* **AMT or MTS**: Adaptive multi-core transform, or multiple transform selection.
* **AMVR**: (Locally) adaptive motion vector resolution.
* **APS**: Adaptation parameter set.
* **ARC**: Adaptive resolution conversion (synonymous with DRC, and a form of RPR).
* **ARSS**: Adaptive reference sample smoothing.
* **ATMVP** or “subblock-based temporal merging candidates”: Alternative temporal motion vector prediction.
* **AU**: Access unit.
* **AUD**: Access unit delimiter.
* **AVC**: Advanced video coding – the video coding standard formally published as ITU-T Recommendation H.264 and ISO/IEC 14496-10.
* **BA**: Block adaptive.
* **BC**: See CPR or IBC.
* **BCW**: Biprediction with CU based weighting
* **BD**: Bjøntegaard-delta – a method for measuring percentage bit rate savings at equal PSNR or decibels of PSNR benefit at equal bit rate (e.g., as described in document VCEG-M33 of April 2001).
* **BDOF**: Bi-directional optical flow (formerly known as **BIO**).
* **BDPCM**: Block-wise DPCM.
* **BL**: Base layer.
* **BMS**: Benchmark set (no longer used), a former preliminary compilation of coding tools on top of VTM, which provide somewhat better compression performance, but are not deemed mature for standardzation.
* **BoG**: Break-out group.
* **BR**: Bit rate.
* **BV**: Block vector (used for intra BC prediction).
* **CABAC**: Context-adaptive binary arithmetic coding.
* **CBF**: Coded block flag(s).
* **CC**: May refer to context-coded, common (test) conditions, or cross-component.
* **CCLM**: Cross-component linear model.
* **CCP**: Cross-component prediction.
* **CE**: Core Experiment – a coordinated experiment conducted toward assessment of coding technology.
* **CG**: Coefficient group.
* **CGS**: Colour gamut scalability (historically, coarse-grained scalability).
* **CIIP**: Combined inter/intra prediction.
* **CL-RAS**: Cross-layer random-access skip.
* **CPMV**: Control-point motion vector.
* **CPMVP**: Control-point motion vector prediction (used in affine motion model).
* **CPR**: Current-picture referencing, also known as IBC – a technique by which sample values are predicted from other samples in the same picture by means of a displacement vector called a block vector, in a manner conceptually similar to motion-compensated prediction.
* **CST**: Chroma separate tree.
* **CTC**: Common test conditions.
* **CVS**: Coded video sequence.
* **DCT**: Discrete cosine transform (sometimes used loosely to refer to other transforms with conceptually similar characteristics).
* **DCTIF**: DCT-derived interpolation filter.
* **DF**: Deblocking filter.
* **DMVR**: Decoder-side motion vector refinement.
* **DPS**: Decoding parameter sets.
* **DRC**: Dynamic resolution conversion (synonymous with ARC, and a form of RPR).
* **DT**: Decoding time.
* **ECS**: Entropy coding synchronization (typically synonymous with WPP).
* **EMT**: Explicit multiple-core transform.
* **EOTF**: Electro-optical transfer function – a function that converts a representation value to a quantity of output light (e.g., light emitted by a display.
* **EPB**: Emulation prevention byte (as in the emulation\_prevention\_byte syntax element).
* **ECV**: Extended Colour Volume (up to WCG).
* **EL**: Enhancement layer.
* **ET**: Encoding time.
* **FRUC**: Frame rate up conversion (pattern matched motion vector derivation).
* **GRA**: Gradual random access
* **HDR**: High dynamic range.
* **HEVC**: High Efficiency Video Coding – the video coding standard developed and extended by the JCT-VC, formalized by ITU-T as Rec. ITU-T H.265 and by ISO/IEC as ISO/IEC 23008-2.
* **HLS**: High-level syntax.
* **HM**: HEVC Test Model – a video coding design containing selected coding tools that constitutes our draft standard design – now also used especially in reference to the (non-normative) encoder algorithms (see WD and TM).
* **HMVP**: History based motion vector prediction.
* **HRD**: Hypothetical reference decoder.
* **HyGT**: Hyper-cube Givens transform (a type of NSST).
* **IBC** (also **Intra BC**): Intra block copy, also known as CPR – a technique by which sample values are predicted from other samples in the same picture by means of a displacement vector called a block vector, in a manner conceptually similar to motion-compensated prediction.
* **IBDI**: Internal bit-depth increase – a technique by which lower bit-depth (8 bits per sample) source video is encoded using higher bit-depth signal processing, ordinarily including higher bit-depth reference picture storage (ordinarily 12 bits per sample).
* **IBF**: Intra boundary filtering.
* **ILP**: Inter-layer prediction (in scalable coding).
* **IPCM**: Intra pulse-code modulation (similar in spirit to IPCM in AVC and HEVC).
* **ISP**: Intra subblock partitioning
* **JCCR**: Joint coding of chroma residuals
* **JEM**: Joint exploration model – the software codebase for future video coding exploration.
* **JM**: Joint model – the primary software codebase that has been developed for the AVC standard.
* **JSVM**: Joint scalable video model – another software codebase that has been developed for the AVC standard, which includes support for scalable video coding extensions.
* **KLT**: Karhunen-Loève transform.
* **LB** or **LDB**: Low-delay B – the variant of the LD conditions that uses B pictures.
* **LD**: Low delay – one of two sets of coding conditions designed to enable interactive real-time communication, with less emphasis on ease of random access (contrast with RA). Typically refers to LB, although also applies to LP.
* **LFNST**: Low-frequency non-separable transform
* **LIC**: Local illumination compensation.
* **LM**: Linear model.
* **LMCS**: Luma mapping with chroma scaling (formerly sometimes called “in-loop reshaping”)
* **LP** or **LDP**: Low-delay P – the variant of the LD conditions that uses P frames.
* **LUT**: Look-up table.
* **LTRP**: Long-term reference pictures.
* **MC**: Motion compensation.
* **MCP**: Motion compensated prediction.
* **MDNSST**: Mode dependent non-separable secondary transform.
* **MIP**: Matrix-based intra prediction
* **MMLM**: Multi-model (cross component) linear mode.
* **MMVD**: Merge with MVD.
* **MPEG**: Moving picture experts group (WG 11, the parent body working group in ISO/IEC JTC 1/‌SC 29, one of the two parent bodies of the JVET).
* **MPM**: Most probable mode (in intra prediction).
* **MRL**: Multiple reference line intra prediction.
* **MV**: Motion vector.
* **MVD**: Motion vector difference.
* **NAL**: Network abstraction layer (as in AVC and HEVC).
* **NSQT**: Non-square quadtree.
* **NSST**: Non-separable secondary transform.
* **NUH**: NAL unit header.
* **NUT**: NAL unit type (as in AVC and HEVC).
* **OBMC**: Overlapped block motion compensation (e.g., as in H.263 Annex F).
* **OETF**: Opto-electronic transfer function – a function that converts to input light (e.g., light input to a camera) to a representation value.
* **OLS**: Output layer set.
* **OOTF**: Optical-to-optical transfer function – a function that converts input light (e.g. l,ight input to a camera) to output light (e.g., light emitted by a display).
* **operation point**: A temporal subset of an OLS.
* **PDPC**: Position dependent (intra) prediction combination.
* **PERP**: Padded equirectangular projection (a 360° projection format).
* **PHEC**: Padded hybrid equiangular cubemap (a 360° projection format).
* **PMMVD**: Pattern-matched motion vector derivation.
* **POC**: Picture order count.
* **PoR**: Plan of record.
* **PROF**: Prediction refinement with optical flow
* **PPS**: Picture parameter set (as in AVC and HEVC).
* **PTL**: Profile/tier/level combination.
* **QM**: Quantization matrix (as in AVC and HEVC).
* **QP**: Quantization parameter (as in AVC and HEVC, sometimes confused with quantization step size).
* **QT**: Quadtree.
* **BT**: Binary tree.
* **TT**: Ternary tree.
* **RA**: Random access – a set of coding conditions designed to enable relatively-frequent random access points in the coded video data, with less emphasis on minimization of delay (contrast with LD).
* **RADL**: Random-access decodable leading.
* **RASL**: Random-access skipped leading.
* **R-D**: Rate-distortion.
* **RDO**: Rate-distortion optimization.
* **RDOQ**: Rate-distortion optimized quantization.
* **RDPCM**: Residual DPCM
* **ROT**: Rotation operation for low-frequency transform coefficients.
* **RPLM**: Reference picture list modification.
* **RPR**: Reference picture resampling (e.g., as in H.263 Annex P), a special case of which is also known as ARC or DRC.
* **RPS**: Reference picture set.
* **RQT**: Residual quadtree.
* **RRU**: Reduced-resolution update (e.g. as in H.263 Annex Q).
* **RVM**: Rate variation measure.
* **SAO**: Sample-adaptive offset.
* **SBT**: Subblock transform.
* **SbTMVP**: Subblock based temporal motion vector prediction.
* **SCIPU**: Smallest chroma intra prediction unit.
* **SD**: Slice data; alternatively, standard-definition.
* **SDT**: Signal-dependent transform.
* **SEI**: Supplemental enhancement information (as in AVC and HEVC).
* **SH**: Slice header.
* **SHM**: Scalable HM.
* **SHVC**: Scalable high efficiency video coding.
* **SIF**: Switchable (motion) interpolation filter.
* **SIMD**: Single instruction, multiple data.
* **SMVD**: Symmetric MVD.
* **SPS**: Sequence parameter set (as in AVC and HEVC).
* **STMVP**: Spatial-temporal motion vector prediction.
* **TBA/TBD/TBP**: To be announced/determined/presented.
* **TGM**: Text and graphics with motion – a category of content that primarily contains rendered text and graphics with motion, mixed with a relatively small amount of camera-captured content.
* **TPM**: Triangular partitioning mode
* **UCBDS**: Unrestricted center-biased diamond search.
* **UWP**: Unequal weight prediction.
* **VCEG**: Visual coding experts group (ITU-T Q.6/16, the relevant rapporteur group in ITU-T WP3/16, which is one of the two parent bodies of the JVET).
* **VPS**: Video parameter set – a parameter set that describes the overall characteristics of a coded video sequence – conceptually sitting above the SPS in the syntax hierarchy.
* **VTM**: VVC Test Model.
* **VVC**: Versatile Video Coding, the standardization project developed by JVET.
* **WAIP**: Wide-angle intra prediction
* **WCG**: Wide colour gamut.
* **WG**: Working group, a group of technical experts (usually used to refer to WG 11, a.k.a. MPEG).
* **WPP**: Wavefront parallel processing (usually synonymous with ECS).
* Block and unit names in HEVC:
  + **CTB**: Coding tree block (luma or chroma) – unless the format is monochrome, there are three CTBs per CTU.
  + **CTU**: Coding tree unit (containing both luma and chroma, synonymous with LCU), with a size of 16x16, 32x32, or 64x64 for the luma component.
  + **CB**: Coding block (luma or chroma), a luma or chroma block in a CU.
  + **CU**: Coding unit (containing both luma and chroma), the level at which the prediction mode, such as intra versus inter, is determined in HEVC, with a size of 2Nx2N for 2N equal to 8, 16, 32, or 64 for luma.
  + **PB**: Prediction block (luma or chroma), a luma or chroma block of a PU, the level at which the prediction information is conveyed or the level at which the prediction process is performed in HEVC.
  + **PU**: Prediction unit (containing both luma and chroma), the level of the prediction control syntax within a CU, with eight shape possibilities in HEVC:
    - **2Nx2N**: Having the full width and height of the CU.
    - **2NxN (or Nx2N)**: Having two areas that each have the full width and half the height of the CU (or having two areas that each have half the width and the full height of the CU).
    - **NxN**: Having four areas that each have half the width and half the height of the CU, with N equal to 4, 8, 16, or 32 for intra-predicted luma and N equal to 8, 16, or 32 for inter-predicted luma – a case only used when 2N×2N is the minimum CU size.
    - **N/2x2N** paired with **3N/2x2N** or **2NxN/2** paired with **2Nx3N/2**: Having two areas that are different in size – cases referred to as AMP, with 2N equal to 16 or 32 for the luma component.
  + **TB**: Transform block (luma or chroma), a luma or chroma block of a TU, with a size of 4x4, 8x8, 16x16, or 32x32.
  + **TU**: Transform unit (containing both luma and chroma), the level of the residual transform (or transform skip or palette coding) segmentation within a CU (which, when using inter prediction in HEVC, may sometimes span across multiple PU regions).
* Block and unit names in VVC:
  + **CTB**: Coding tree block (luma or chroma) – there are three CTBs per CTU in a P or B slice or in an I slice that uses a single tree, and one CTB per luma CTU and two CTBs per chroma CTU in an I slice that uses separate trees.
  + **CTU**: Coding tree unit (synonymous with LCU, containing both luma and chroma in a P or B slice or in an I slice that uses a single tree, containing only luma or only chroma in an I slice that uses separate trees), with a size of 16x16, 32x32, 64x64, or 128x128 for the luma component.
  + **CB**: Coding block, a luma or chroma block in a CU.
  + **CU**: Coding unit (containing both luma and chroma in P/B slice, containing only luma or chroma in I slice), a leaf node of a QTBT. It’s the level at which the prediction process and residual transform are performed in JEM. A CU can be square or rectangle shape.
  + **PB**: Prediction block, a luma or chroma block of a PU.
  + **PU**: Prediction unit, has the same size as a CU in the VVC context.
  + **TB**: Transform block, a luma or chroma block of a TU.
  + **TU**: Transform unit, has the same size as a CU in the VVC context.

## Opening remarks

Remarks during the opening session of the meeting 1430 Tuesday 1 October (chaired by GJS) were as follows.

* The first two days are dedicated to high-level syntax
* Workshop on "The Future of Media" planned for October 8
* 0900 start time generally
* Balloting and approval timeline: "H.VVC" and ISO/IEC 23090-3
  + CD in July 2019 – Results: m49979
  + DIS as output of this meeting, with ballot period between the January and April meetings.
    - Post-meeting editing
  + FDIS and Consent in July
* The meeting logistics, agenda, working practices, policies, and document allocation were reviewed.
  + The meeting host is the ITU
  + Having text available is crucial (and not just arriving at the end of the meeting).
  + There were no objections voiced in the opening plenary to the consideration of late contributions.
* The results of the previous meeting were reviewed.
* On placeholders – there were a number of cases where there was some description of a concept but no test results (see section 2.4.2).
* The primary goals of the meeting were to review the results of CEs, identify promising technology directions, and adopt proposed technology into the VVC draft text and VTM.
* Due to the high number of input contributions, parallelization and breakout work were planned to be used at the meeting.
* Planning of viewing & equipment setup is needed
* Principles of standards development were discussed.

## Scheduling of discussions

Scheduling: Generally meeting time was scheduled during 0900–2100+ hours, with coffee and lunch breaks as convenient. Ongoing scheduling refinements were announced on the group email reflector as needed. Some particular scheduling notes are shown below, although not necessarily 100% accurate or complete:

* Tue. 1 Oct., 1st day
  + 1430–1530 Opening plenary remarks, review of practices, agenda, IPR reminder
  + 1530-1600 Reports of AHGs 8, 12, 17
  + 1630 High-level functional discussion:
    - Scalability
      * 1630 OLSs – section 6.20.1.1
      * 1750 RAPs – section 6.20.1.2
      * 1830 PTL / conformance – section 6.20.1.3
      * 1910 ROI scalability – section 6.20.1.4
      * 1950 VPS and single-layer decoders – section 6.20.1.5
      * 2005 External independent layers – section 6.20.1.6
      * 2015 Layered coding and subpictures – section 6.20.1.7
      * 2120 Diagonal inter-layer referencing – section 6.20.1.8
    - Subpictures
      * 2140-2215 JVET-P0693 summarizes some categories of the HLS proposals on subpictures – section 6.19.1.1
* Wed. 2 Oct., 2nd day
  + High-level syntax
    - 0900 Cross-RAP referencing / external decoder refresh section 6.18.3 [closed]
    - Subpictures
      * 1100-1645 JVET-P0693 some categories of the HLS proposals on subpictures – section 6.19.1.1
    - Slices, tiles, bricks
      * 1720-2000 JVET-P0686 HLS proposals on slices, tiles and bricks
    - 2030-2330 JVET-P0687 HLS proposals on access unit delimiter, picture header, and slice header parameters signalling
* Thu. 3 Oct., 3rd day
  + 0900-1030 Plenary status review, AHGs 1-3 and JCTVC-P0113 input from editors
  + 1100-1345 Track A: Review (JRO)
    - 1100 AHGs 4, 5, 6, 7, 9, 10, 11, 13, 14, 15, 16, 18
  + 1100 Track B (GJS)
    - 1100 HLS JVET-P0687 HLS proposals on access unit delimiter, picture header, and slice header parameters signalling
    - 1430 CE1 RPR
    - 1620 CE2 GDR
    - 1715 CE4 Inter prediction
  + 1430-2140 HLS BoG Room A
  + 1445-2000 Track A:
    - Planning of viewing related to CEs (CE4, CE5)
    - Review CE3, CE6, CE7
* Fri. 4 Oct., 4th day
  + 0900-1300 JCT-VC (outside of JVET)
  + 0900-1115, 1400-2000 BoG on CE3 related (G.v.d. Auwera)
  + 1430-2130 BoG on CE4 related (affine motion compensation and merge mode modifications)
  + 1130-2230 Track A (JRO)
    - 1130-1300 CE8
    - 1400-2230 CE6 related
  + 1430-1900 Track B (GJS) RPR filters – section 6.1
  + 0900-2135 BoG on HLS
* Sat. 5 Oct., 5th day
  + 0900-1315 Track A (JRO) in Popov
    - CE6 related
    - CE7 related
  + 0900- Track B (GJS)
    - Misc coding tools – section 6.14
  + 1445-2000 Track A (JRO) in Popov
    - CE7 related
    - CE8 related
  + 1430- Track B (GJS)
    - RPR filters (P0409 & P0592) – section 6.1
    - Partitioning – section 6.11
  + 1100 BoG on CE3 related intra prediction and mode coding (G.v.d. Auwera) in C2
  + 0900-2130 BoG on HLS in A
  + 1000-1230, 1400-2200 BoG on CE4 related in H2
    - 1000-1230 Decoder-side motion vector derivation
    - 1400-2200 Decoder-side motion vector derivation and switchable interpolation filter
* Sun. 6 Oct., 6th day
  + 0900-1400 Track A (JRO)
    - CE8 related screen content coding tools (non-palette contribs)
    - Lossless and near lossless coding
  + 0900 BoG on CE4 related in C1
  + 1400 Track B Partitioning – section 6.11
  + 1530 Plenary
  + 1810-2100 BoG on palette (X. Xu)
  + (We also have G2 of Varembe)
* Mon. 6 Oct., 6th day
  + 1400-2300 Track A (JRO)
    - Review CE3 related and CE8 related BoGs
    - CE5 results (and report of subjective viewing)
    - Quantization control (6.9)
* Tue. 7 Oct., 7th day
  + 0900-1300 and 1400-22?? CE5 related BoG (A. Norkin, C.-Y. Chen)
  + 1400-1800 Track A (JRO): Quantization control (6.9)
* Wed. 7 Oct., 7th day
  + Track B
    - 1130 Partitioning – section 6.11
    - 1215-1400, 1500-1730 CE4-related BoG review (P0986)
    - 1750-1900 FAU complexity analysis
    - 1900-2330 HLS BoG review
    - CE4 visual results
  + 1100-1400 and 1500-2030 CE5 related BoG (A. Norkin, C.-Y. ChenP0986)
  + 1130-1415 Track A (JRO): Quantization control (6.9)
  + 1515-2145 Track A (JRO):
    - Entropy coding (6.10)
    - Chroma sampling and chroma formats (6.12)
    - Neural networks (6.15)
    - Lossless and near lossless (6.13)
  + Track B
    - 1130 Partitioning – section 6.11
    - 1215-1400, 1500-1730 CE4-related BoG review (P0986)
    - 1750-1900 FAU complexity analysis
    - 1900-2330 HLS BoG review
* Thursday 10 Oct, 9th day
  + Track A
    - 0900-1230 CE5 related BoG (A. Norkin, C.-Y. ChenP0986)
    - 0900-1300 Track A (JRO): General review, remaining docs
    - 1400-1815 Track A (JRO): CE5 related BoG review
    - 1830-2000 CE5 related BoG (A. Norkin, C.-Y. ChenP0986)
  + Track B
    - 1115-1400 CE4 visual results
    - 1420-1815 HLS remainders
    - 1845- 360° applications
    - Until 2020 General review and further planning

CE4-related BoG (P0986)

* Oct. 4, 1430 to 2130, on the category of affine motion compensation and merge mode modifications.
* Oct. 5, 1000 to 1230, on the category of decoder side motion vector derivation.
* Oct. 5, 1400 to 2200, on the remaining contributions in the category of decoder side motion vector derivation and on the category of switchable interpolation filter.
* Oct. 6, 0900 to 1300, on the category of weighted prediction and others.

## Contribution topic overview

The approximate subject categories and quantity of contributions per category for the meeting were summarized as follows (note that the noted document counts do not include crosschecks, and may not be completely accurate):

* AHG reports (18) (section 3) (Plenary)
* Project development (X) (section 4) (Plenary)
  + Text and software development (1)
  + Test conditions (1)
  + Performance assessment (3)
  + Coding studies on specific use cases (0)
  + Test Material (0)
  + Conformance (6)
  + Implementation (3)
* Core Experiments (xx) (section 5) with subtopics
  + CE1: Reference picture resampling filters (4) (section 5.1) (Track B)
  + CE2: Gradual decoding refresh (3) (section 5.2) (Track B)
  + CE3: Intra prediction and mode coding (4) (section 5.3) (Track A)
  + CE4: Inter prediction (8) (section 5.4) (Track B)
  + CE5: Loop filtering (8) (section 5.5) (Track A)
  + CE6: Transforms and transform signalling (6) (section 5.6) (Track A)
  + CE7: Quantization and coefficient coding (9) (section 5.7) (Track A)
  + CE8: Screen content coding tools (6) (section 5.8) (Track A)
* Non-CE technology proposals (xx) (section 6) with subtopics
  + CE1 related – Reference picture resampling filters (9) (section 6.1) (Track B)
  + CE2 related – Gradual decoding refresh (0) (section 6.2) (Track B)
  + CE3 related – Intra prediction and mode coding (48) (section 6.3) (Track A)
  + CE4 related – Inter prediction (107) (section 6.4) (Track B)
  + CE5 related – Loop filtering (72) (section 6.5) (Track A)
  + CE6 related – Transforms and transform signalling (40) (section 6.6) (Track A)
  + CE7 related – Quantization and coefficient coding (24) (section 6.7) (Track A)
  + CE8 related – Screen content coding tools (36) (section 6.8) (Track A)
  + Quantization control (23) (section 6.9) (Track A)
  + Entropy coding (4) (section 6.10) (Track A)
  + Partitioning (14) (section 6.11) (Track B)
  + Chroma sampling and chroma formats (1) (section 6.12) (Track A)
  + Lossless and near lossless coding (24) (section 6.13) (Track A)
  + Miscellaneous coding tools (7) (section 6.14) (Track B)
  + Neural networks (1) (section 6.15) (Track A)
  + 360 degree video (2) (section 6.16) (Track B)
  + High level tool control (0) (section 6.17) (Track B)
  + AHG17: General high-level syntax (47) (section 6.18) (Track B)
  + AHG12: High-level parallelism and coded picture regions (46) (section 6.19) (Track B)
  + AHG8: Layered coding and resolution adaptation (36) (section 6.20) (Track B)
* Complexity analysis and reduction (2) (section 7) (Track B)
* Encoder optimization (1) (section 8) (Track X)
* Metrics and evaluation criteria (1) (section 9) (Track X)
* Withdrawn (13) (section 10) (Track none)
* Joint meetings, plenary discussions, BoG reports, Summary of actions (section 11)
* Project planning (section 12)
* Establishment of AHGs (section 13)
* Output documents (section 14)
* Future meeting plans and concluding remarks (section 15)

The document counts above do not include cross-checks and CE summary reports.

Track A (294) was generally chaired by JRO, and Track B (281) by GJS.

# AHG reports (18)

These reports were discussed Thursday 3 Oct. 0900–XXXX (chaired by GJS and JRO), except otherwise noted.

[JVET-P0001](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8564) JVET AHG report: Project management (AHG1) [J.-R. Ohm, G. J. Sullivan]

Discussed Thursday 0910 (GJS & JRO)

This document reports on the work of the JVET ad hoc group on Project Management, including an overall status report on the VVC standardization project and the progress made during the interim period since the preceding meeting.

The work of the JVET overall had proceeded well in the interim period with a huge number of input documents submitted to the current meeting. Intense discussion had been carried out on the group email reflector, and all output documents from the preceding meeting had been produced.

Output documents from the preceding meeting had been made available at the "Phenix" site (<http://phenix.it-sudparis.eu/jvet/>) or the ITU-based JVET site ([http://wftp3.itu.int/av-arch/jvet-site/2019\_07\_ O\_Gothenburg/](http://wftp3.itu.int/av-arch/jvet-site/2019_07_%20O_Gothenburg/)), particularly including the following:

* The meeting report (JVET-O2000) [Posted 2019-09-30]
* Versatile Video Coding (Draft 6) (JVET-O2001) [Posted 2019-07-13, last update 2019-07-31]
* Algorithm description for Versatile Video Coding and Test Model 6 (VTM 6) (JVET-O2002) [Posted 2019-08-15, last update 2019-09-10]
* Methodology and reporting template for coding tool testing (JVET-O2005) [Posted 2019-08-05]
* Supplemental enhancement information messages for coded video bitstreams (Draft 1) (JVET-O2007) [Posted 2019-07-31]
* JVET common test conditions and software reference configurations for HDR/WCG video (JVET-N2011) [Posted 2019-09-27]
* Description of CE 1..8 (JVET-O2021..28) [all first posted 2019-07-11/12/13, further updates during the CE definition period of 3 weeks after the meeting]. The following CE description documents had later updates (more than 4 weeks after the meeting):
  + - JVET-O2021 [last updated 2019-09-11]
    - JVET-O2023 [last updated 2019-09-03]
    - JVET-O2024 [last updated 2019-09-19]
    - JVET-O2025 [last updated 2019-08-30]
    - JVET-O2026 [last updated 2019-09-13]
    - JVET-O2027 [last updated 2019-08-22]
    - JVET-O2028 [last updated 2019-09-16]

The eighteen *ad hoc* groups had made progress, and reports from those activities had been submitted.

Software integration of VTM was finalized approximately according to the plan.

Various problem reports relating to asserted bugs in the software, draft specification text, and reference encoder description had been submitted to an informal "bug tracking" system. That system is not intended as a replacement of our ordinary contribution submission process. However, the bug tracking system was considered to have been helpful to the software coordinators and text editors. The bug tracker reports had been automatically forwarded to the group email reflector, where the issues were discussed – and this is reported to have been helpful.

Roughly 750 input contributions to the current meeting (not counting the AHG and CE summary reports) had been registered for consideration at the meeting. Though topics of Core Experiments and related documents for the development of low-level coding tools reflect the bulk of these documents, around 140 documents were submitted on aspects of high-level syntax.

A preliminary basis for the document subject allocation and meeting notes for the 16th meeting had been made publicly available on the ITU-hosted ftp site.

[JVET-P0002](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8565) JVET AHG report: Draft text and test model algorithm description editing (AHG2) [B. Bross, J. Chen, J. Boyce, S. Kim, S. Liu, Y.-K. Wang, Y. Ye]

Discussed Thursday 0920 (GJS & JRO)

This document reports the work of the JVET ad hoc group on draft text and test model algorithm description editing (AHG2) between the 15th meeting in Gothenburg, SE, (3–12 July 2019) and the 16th meeting in Geneva, CH, (1–11 October 2019).

At the 15th JVET meeting, it was decided to include additional coding features for intra picture-prediction, inter-picture prediction, transform, CABAC engine and in-loop filter in the sixth draft of Versatile Video Coding (VVC D6) and the VVC Test Model 6 (VTM6) encoding.

The normative decoding process for Versatile Video Coding is specified in the VVC draft 6 text specification document. The VVC Test Model 6 (VTM 6) Algorithm and Encoder Description document provides an algorithm description as well as an encoder-side description of the VVC Test Model 6, which serves as a tutorial for the algorithm and encoding model implemented in the VTM6.x software.

An issue tracker (<https://jvet.hhi.fraunhofer.de/trac/vvc>) was used to facilitate the reporting of errata with the VVC documents.

Fourteen versions of JVET-O2001 were published by the Editing AHG between the 15th meeting in Gothenburg, SE (3–12 July 2019) and the 16th meeting in Geneva, CH (1–11 October 2019).

The input document JVET-P0113 has been prepared to provide integrations of a number of bug fixes reported in the bug tracking system as well as some other editorial changes made by the authors, based on the latest JVET output draft VVC text in JVET-O2001-vE.

Two versions of JVET-O2002 were published by the Editing AHG between the 15th meeting in Gothenburg, SE, (3–12 July 2019) and the 16th meeting in Geneva, CH, (1–11 October 2019).

The AHG recommends to:

* Approve the edited JVET-O2001 and JVET-O2002 documents as JVET outputs,
* Continue to edit the VVC draft and Test Model documents to ensure that all agreed elements of VVC are fully described,
* Compare the VVC documents with the VVC software and resolve any discrepancies that may exist, in collaboration with the software AHG,
* Encourage the use of the issue tracker to report issues with the text of both the VVC specification draft and the algorithm and encoder description,
* Continue to improve the editorial consistency of VVC WD and Test Model documents,
* Ensure that, when considering the addition of new feature to VVC, properly drafted text for addition to the VVC Test Model and/or the VVC Working Draft is made available in a timely manner.
* Use the the editorial input and fixes for VVC draft 6 in JVET-P0113 as the basis for integration of adoptions of the 16th JVET meeting.

[JVET-P0003](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8566) JVET AHG report: Test model software development (AHG3) [F. Bossen, X. Li, K. Sühring]

Discussed Thursday 0945 (GJS & JRO)

This report summarizes the activities of the AhG3 on Test model software development that has taken place between the 15th and 16th JVET meetings.

*VTM software development*

Development was continued on the GitLab server, which allows participants to register accounts and use a distributed development workflow based on git.

The server is located at:

https://vcgit.hhi.fraunhofer.de

The registration and development workflow is documented at:

https://vcgit.hhi.fraunhofer.de/jvet/VVCSoftware\_VTM/wikis/VVC-Software-Development-Workflow

The VTM software can be found at

https://vcgit.hhi.fraunhofer.de/jvet/VVCSoftware\_VTM/

*CTC Performance*

The following table shows **VTM 6.1** performance over **HM 16.20**:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra** |  |  |
|  |  |  | **Over HM-16.20** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -28.12% | -33.44% | -33.64% | 1627% | 174% |
| Class A2 | -27.86% | -20.72% | -13.06% | 2625% | 183% |
| Class B | -21.10% | -19.86% | -27.27% | 2927% | 190% |
| Class C | -21.81% | -19.77% | -23.98% | 4098% | 204% |
| Class E | -25.16% | -21.29% | -25.60% | 2393% | 176% |
| **Overall** | -24.23% | -22.48% | -24.96% | 2716% | 187% |
| Class D | -17.70% | -14.41% | -15.71% | 4741% | 198% |
| Class F | -38.92% | -39.43% | -41.80% | 4338% | 186% |
|  |  |  |  |  |  |
|  |  |  | **Random Access** |  |  |
|  |  |  | **Over HM-16.20** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -37.32% | -38.56% | -44.50% | 843% | 162% |
| Class A2 | -41.64% | -38.65% | -32.64% | 932% | 174% |
| Class B | -33.98% | -41.65% | -43.13% | 902% | 160% |
| Class C | -28.65% | -32.77% | -34.87% | 1144% | 174% |
| Class E |  |  |  |  |  |
| **Overall** | -34.76% | -38.06% | -39.10% | 954% | 167% |
| Class D | -26.40% | -29.45% | -30.18% | 1231% | 178% |
| Class F | -40.66% | -45.33% | -46.77% | 640% | 142% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay B** |  |  |
|  |  |  | **Over HM-16.20** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -26.95% | -30.69% | -31.68% | 861% | 150% |
| Class C | -22.91% | -23.65% | -25.50% | 1005% | 153% |
| Class E | -25.56% | -31.33% | -33.57% | 435% | 121% |
| **Overall** | -25.25% | -28.50% | -30.09% | 764% | 143% |
| Class D | -21.34% | -19.29% | -21.28% | 1024% | 169% |
| Class F | -37.72% | -41.80% | -43.27% | 526% | 116% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay P** |  |  |
|  |  |  | **Over HM-16.20** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -31.87% | -34.39% | -35.33% | 809% | 149% |
| Class C | -25.45% | -25.00% | -26.93% | 964% | 160% |
| Class E | -29.82% | -36.00% | -37.95% | 425% | 123% |
| **Overall** | -29.22% | -31.66% | -33.18% | 730% | 145% |
| Class D | -23.47% | -21.35% | -22.26% | 987% | 171% |
| Class F | -37.62% | -41.91% | -43.00% | 575% | 122% |

The following table shows **VTM 6.0** performance compared to **VTM 5.2**:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra** |  |  |
|  |  |  | **Over VTM-5.2** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -1.91% | 9.60% | 4.82% | 73% | 99% |
| Class A2 | -3.68% | 7.65% | 7.61% | 75% | 100% |
| Class B | -0.81% | 6.57% | 7.39% | 77% | 101% |
| Class C | -0.69% | 2.95% | 4.11% | 82% | 102% |
| Class E | -0.74% | 3.55% | 5.32% | 84% | 98% |
| **Overall** | -1.43% | 5.95% | 5.92% | 78% | 100% |
| Class D | -0.69% | 4.75% | 6.19% | 82% | 106% |
| Class F | -1.38% | 0.54% | 0.84% | 91% | 102% |
|  |  |  |  |  |  |
|  |  |  | **Random Access** |  |  |
|  |  |  | **Over VTM-5.2** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -3.37% | -0.93% | -5.52% | 95% | 102% |
| Class A2 | -3.85% | -4.75% | -4.40% | 97% | 103% |
| Class B | -1.77% | -8.48% | -7.39% | 92% | 102% |
| Class C | -0.99% | -8.26% | -6.28% | 92% | 101% |
| Class E |  |  |  |  |  |
| **Overall** | -2.30% | -6.16% | -6.12% | 93% | 102% |
| Class D | -0.73% | -7.13% | -4.31% | 85% | 99% |
| Class F | -1.25% | -7.69% | -6.67% | 88% | 101% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay B** |  |  |
|  |  |  | **Over VTM-5.2** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -1.27% | -13.27% | -12.74% | 107% | 107% |
| Class C | -0.55% | -7.38% | -6.24% | 105% | 113% |
| Class E | -0.12% | -11.51% | -9.23% | 99% | 116% |
| **Overall** | -0.74% | -10.87% | -9.69% | 105% | 111% |
| Class D | -0.08% | -7.48% | -6.89% | 100% | 107% |
| Class F | -2.10% | -9.06% | -8.59% | 98% | 109% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay P** |  |  |
|  |  |  | **Over VTM-5.2** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -2.01% | -14.22% | -14.41% | 109% | 107% |
| Class C | -1.12% | -8.10% | -7.08% | 108% | 112% |
| Class E | -1.20% | -12.64% | -10.95% | 107% | 116% |
| **Overall** | -1.51% | -11.78% | -11.10% | 108% | 111% |
| Class D | -0.65% | -8.45% | -7.17% | 100% | 106% |
| Class F | -2.09% | -9.57% | -9.29% | 102% | 110% |

The following table shows **VTM 6.1** performance compared to **VTM 6.0**:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra** |  |  |
|  |  |  | **Over VTM-6.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.01% | 0.01% | 0.01% | 99% | 93% |
| Class A2 | 0.00% | 0.00% | 0.00% | 100% | 93% |
| Class B | 0.01% | 0.01% | 0.01% | 103% | 96% |
| Class C | 0.03% | 0.03% | 0.03% | 100% | 97% |
| Class E | 0.03% | 0.03% | 0.03% | 101% | 96% |
| **Overall** | 0.02% | 0.02% | 0.02% | 101% | 95% |
| Class D | 0.05% | 0.03% | 0.03% | 100% | 91% |
| Class F | 0.03% | 0.02% | 0.02% | 100% | 96% |
|  |  |  |  |  |  |
|  |  |  | **Random Access** |  |  |
|  |  |  | **Over VTM-6.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.00% | -0.03% | 0.01% | 98% | 87% |
| Class A2 | 0.00% | -0.04% | 0.04% | 98% | 90% |
| Class B | 0.00% | 0.00% | 0.00% | 99% | 88% |
| Class C | 0.00% | -0.01% | 0.05% | 99% | 88% |
| Class E |  |  |  |  |  |
| **Overall** | 0.00% | -0.01% | 0.02% | 99% | 88% |
| Class D | 0.00% | 0.03% | 0.08% | 100% | 83% |
| Class F | 0.02% | 0.01% | 0.01% | 102% | 89% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay B** |  |  |
|  |  |  | **Over VTM-6.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | 0.00% | -0.09% | -0.13% | 99% | 85% |
| Class C | 0.00% | 0.06% | -0.06% | 99% | 81% |
| Class E | 0.02% | 0.23% | 0.06% | 100% | 83% |
| **Overall** | 0.01% | 0.04% | -0.06% | 99% | 83% |
| Class D | -0.02% | 0.29% | -0.09% | 100% | 83% |
| Class F | 0.03% | 0.02% | -0.03% | 99% | 81% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay P** |  |  |
|  |  |  | **Over VTM-6.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | 0.00% | -0.04% | 0.07% | 98% | 84% |
| Class C | 0.00% | 0.14% | 0.00% | 99% | 81% |
| Class E | 0.13% | 0.01% | 0.26% | 100% | 82% |
| **Overall** | 0.03% | 0.03% | 0.10% | 99% | 82% |
| Class D | 0.06% | -0.57% | -0.30% | 100% | 83% |
| Class F | -0.03% | -0.11% | 0.25% | 101% | 82% |

Full.results are attached to this AHG report as Excel files.

Issues encountered during the software implementation process

Several issues were encountered during software development:

* Vacation time caused delays because people responsible for submitting software patches were not available.
  + The implementation of “JVET-O0050: avoid small intra prediction with a local dual-tree technique” was much larger than expected (~1000 lines of code changed) and the merge request was provided close to the VTM-6.0 deadline. It is generally a problem when large patches are provided late, because this gives software coordinators little time to review and test them and may thus cause delays in the release process.
  + It was discovered that “JVET-O0119: Base palette mode for 4:4:4” causes a significant increase in memory usage, even if not enabled (as in CTC). Coding tools should only have minimal impact on memory and coding time, when disabled. This needs to be fixed.
  + It is generally concerning that for many HLS implementations work seemed to start only close to the deadline or after the deadline. HLS implementations can start in parallel to the low-level implementations, because there are few conflicts to be expected.
  + Some software patches were submitted completely untested.
  + The quality of submitted SIMD code is generally not very high. A lot of SIMD code has been rewritten.
  + Configuration files were incorrect in VTM 6.0 release candidate 1 (incorrect naming of DBPCM parameter). This resulted in BDPCM not being enabled in the set (based on rc1) that was used to retrain initial CABAC states.
  + There was some confusion about how to configure QP settings in CTC for HDR PQ sequences following the adoption of JVET-O0650 (chroma QP mapping). In particular, the confusion arose from the fact that chroma offsets signaled in the PPS are now applied after QP mapping instead of before. This has a significant effect for PQ sequences, where custom chroma offsets are computed. The luma/chroma balance for PQ content may thus be significantly different in VTM 6 than in VTM 5. This should be addressed at the 16th meeting.
  + JVET-O0282 (low QP bug fix) was integrated under the macro of JVET-O0199 (base palette for 444), which led to confusion. Such practice should be avoided in the future.
  + An issue was identified regarding text and software integration of JVET-N0278, and the expectations of proponents, what would have been integrated. Draft 5 version 1 integrated the exact text of JVET-N0278, which defines an input filter for the decoder, that removes all layers, except for the target layer (LIdTarget). Software was provided implementing this filter into VTM. Later, in Draft 5 version 4 “fixes for JVET-N0278” were integrated that refer to layers in multiple locations of the specification, including definitions, reference picture list construction, and constraints on different NAL unit types. These changes are likely language from layered HEVC, but not required in the case, where a decoder would see only one specific value of nuh\_layer\_id. Proponents modified these editorially added constraints later on in the Gothenburg meeting. They expected the original constraints to be implemented in software. Also, for the implementation of scalable coding, proponents expected that the software would already contain some infrastructure for multi-layer coding, which does not exist.

At the beginning of the 16th meeting, the following implementations were still pending:

* + JVET-O0357 Maximum TU size for chroma format 4:2:2 and 4:4:4 [L. Li, J. Nam, J. Lim, S. Kim (LGE)]. O0389 was noted to be related [W. Cai, J. Zhu, J. Yao, K. Kazui (Fujitsu)]. The current text says that for chroma, the max TU size is:
    - For 4:4:4, max is 64x64
    - For 4:2:2, max is 32x64
    - For 4:2:0, max is 32x32

Proponents of O0357 and O0389 were asked to check these aspects for text and software. This was later discussed as a non-CE6 topic. It was confirmed that the current software operates as described above, and it was clarified that O0389 which had proposed 64x64 transform block for chroma was not adopted.

* + JVET-O0235: Constraints on nal\_unit\_type, TemporalId, etc. (Ericsson working on this)
  + JVET-O1143. Subpictures
  + JVET-O1159: Scalability

For the following implementations, issues remain:

* + JVET-O0147/JVET-O0226: A constraint was changed in the contributions to enable the use of more efficient field coding GOPs. An example field coding config file should be provided to guide users.
  + JVET-O0145/JVET-O0215: The number of entry points is derived instead of being signalled. For this the number of bricks needs to be known in the slice header. The software needs to be restructured to allow derivation of the slice/tile/brick related variables within the slice header parsing process. An initial version of the code has been merged, but disabled.
  + JVET-O0042: The syntax was included with JVET-O0041, but no configuration options exist for frame repetitions. Also, the decoder does not repeat frames.

*Software manual*

Few merge requests included the required contributions to the software manual. Updates were only provided after being requested by the software coordinators.

Many parameters still have their outdated HEVC documentation and need to be updated. Other parameters for VVC tools are completely missing.

To make the software manual a valuable document, those missing parts need to be added.

*CE software*

For each CE a group was created in GitLab and CE coordinators were given owner rights to the group. This way they could clone VTM as required, create branches for different tests and assign user access to the group themselves.

The CE development workflow is described at:

<https://vcgit.hhi.fraunhofer.de/jvet/VVCSoftware_VTM/wikis/Core-experiment-development-workflow>

CE read access is available using shared accounts: One account exists for MPEG members, which uses the usual MPEG account data (as announced on the appropriate email lists). A second account exists for VCEG members. The account information for VCEG members is available in the TIES system:

<https://www.itu.int/ifa/t/2017/sg16/exchange/wp3/q06/vceg_account.txt>

*Bug tracking*

The bug tracker for VTM and specification text is located at:

<https://jvet.hhi.fraunhofer.de/trac/vvc>

The bug tracker uses the same accounts as the HM software bug tracker. Users may need to log in again due to the different sub-domain. For spam fighting reasons account registration is only possible at the HM software bug tracker at

<https://hevc.hhi.fraunhofer.de/trac/hevc>

Please file all issues related to the VVC reference software into the bug tracker. Try to provide all the details, which are necessary to reproduce the issue. Patches for solving issues and improving the software are always appreciated.

The AHG recommended to:

* Continue to develop the VTM reference software
* Improve documentation, especially the software manual
* Resolve any normative issues resulting from the large number of integrations in the most recent development cycle
* Encourage people to test VTM software more extensively outside of common test conditions.
* Encourage people to report all (potential) bugs that they are finding.
* Encourage people to submit bitstreams/test cases that trigger bugs in VTM.
* Encourage people to submit non-normative changes that reduce encoder run time without significantly sacrificing compression performance
* Make sure that contributions considered for adoption in the future are subject to adequate text and software review by the JVET at large
* Identify which recent additions contribute to the increase of encoder run time for low delay configurations, in particular for low QP values

In the discussion, it was noted that Broadcom and Allegro had been particularly helpful in the interim period with checking and bug-fixing both software and text. This was greatly appreciated.

It was commented that integration of HLS aspects in software has sometimes been difficult. One issue has been the need for clarity on who is responsible for software for some of these aspects. Making sure we have a clear identification of one person responsible was a suggestion for how to improve this.

[JVET-P0004](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8567) JVET AHG report: Test material and visual assessment (AHG4) [T. Suzuki, M. Wien, V. Baroncini, R. Chernyak, A. Norkin, J. Ye]

The mandates of this AHG were:

• Maintain the video sequence test material database for development of the VVC standard.

• Identify and recommend appropriate test materials for use in the development of the VVC standard.

• Identify missing types of video material, solicit contributions, collect, and make available a variety of video sequence test material.

• Evaluate new test sequences, particularly including the material recently submitted by the Blender Foundation / Blender Animation Studio and Twitch.

• Propose a new structure for the test sequence repository.

• Prepare availability of viewing equipment and facilities arrangements for the next meeting, and prepare testing upon consultation with CE coordinators.

• Coordinate with AHG11 on test material for screen content coding

2 Test sequences

The test sequences used for CfP/CTC are available on ftp://jvet@ftp.ient.rwth-aachen.de in directory “/jvet-cfp” (accredited members of JVET may contact the JVET chairs for login information).

Due to copyright restrictions, the JVET database of test sequences is only available to accredited members of JVET (i.e. members of ISO/IEC MPEG and ITU-T VCEG).

3 New structure at test sequence repository

There was discussion in the last 2-3 meetings that the current directory structure of test sequence ftp site is not good for the current activities. The ftp directory structure was changed as follows.

- ctc/ Contains the active test set of the common testing conditions

- ahg/ Contains subdirectories with sequences under consideration.

- ce/ Contains subdirectories for data exchange for specific CE

- jvet-cfe/ The sequences used for CfE

- jvet-cfp/ The sequences used for CfP

- old/ Contains the JEM bitstreams directory, used before the CfP

- upload Stays as before

In the CTC directory, following subdirectories have been created:

ctc/360/

ctc/hdr/

ctc/scc/

ctc/sdr/

The directories are populated with the CTC test sets in each of the categories.

4 Related contributions

The no related contributions were submitted.

5 Recommendations

The AHG recommends:

• To continue to collect new test sequences available for JVET with licensing statement

It is mentioned that CE5 uses some sequences that cannot be made available from the ftp site (SVT sequences by EBU). In such cases, the CE description should contain information how to get such sequences.

[JVET-P0005](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8568) JVET AHG report: Memory bandwidth consumption of coding tools (AHG5) [R. Hashimoto, T. Ikai, X. Li, D. Luo, H. Yang, M. Zhou]

Mandates of this AHG

• Develop improved software tools for measuring both average and worst case of memory bandwidth, and provide information for usage of these tools.

• Study cache configurations for measuring decoder memory bandwidth consumption.

• Identify coding tools in CEs and VTM with significant memory bandwidth impact.

• Study the impact of memory bandwidth on specific application cases.

There is no related email discussion during this meeting cycle.

There is no related contribution in this meeting.

It was recommended to discontinue this AHG in this meeting if there is no strong opinion.

It was agreed to close the AHG, and include mandate of maintaining the SW into AHG13 and/orAHG16.

[JVET-P0006](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8543) JVET AHG Report: 360° video coding tools, software and test conditions (AHG6) [Y. He, J. Boyce, K. Choi, J.-L. Lin, Y. Ye]

The mandates of this AHG are as follows:

• Study the effect on compression and subjective quality of different projections formats, resolutions, and packing layouts.

• Discuss refinements of common test conditions, test sequences, and evaluation criteria.

• Solicit additional test sequences, and evaluate suitability of test sequences on head-mounted displays and normal 2D displays.

• Study coding tools dedicated to 360° video, their impact on compression, and implications to the core codec design.

• Study the effect of viewport resolution, field of view, and viewport speed/direction on visual comfort.

• Study complexity of GPU rendering of projection formats

• Study syntax for signalling of projection formats, cubeface layouts, spherical rotations

• Generate CTC (PHEC) anchors and PERP results for VTM according to JVET-L1012, and finalize the reporting template for the common test conditions.

Brief summary for the activities:

The 360Lib-9.2-dev software package included following changes:

Integrating FishEye project format in 360Lib software:

(1) Received one version of the FishEye projection format implementation from proponents (LGE), but the implementation was not completed yet.

Fixed the bug #536 in VTM-6.1:

(2) The bug #536 is caused by the change of mv clipping in VTM-6.1, and it affected the wrap-around in 360-degree video coding.

2 Software repository and versions

The 360Lib software is developed using a Subversion repository located at:

https://jvet.hhi.fraunhofer.de/svn/svn\_360Lib/

The released version of 360Lib-9.2-dev can be found at:

https://jvet.hhi.fraunhofer.de/svn/svn\_360Lib/branches/360Lib-9.2-dev/

360Lib-9.2-dev testing results can be found at:

ftp.ient.rwth-aachen.de/testresults/360Lib-9.1

360Lib bug tracker

https://hevc.hhi.fraunhofer.de/trac/jem/newticket?component=360Lib

3 360Lib-9.2-dev results

Table 1 is for the projection formats comparison using VTM-6.1 according to 360o video CTC (JVET-M1012). It compares padded hybrid equi-angular cubemap (PHEC) coding and padded equi-rectangular projection (PERP) coding using VTM-6.1.

Table 2 is for PERP coding comparison between VTM-6.1 and HM-16.16. Table 3 is to compare VTM-6.1 with PHEC coding and HM-16.16 with CMP coding.

Table 1. VTM-6.1 PHEC vs PERP (VTM-6.1 PERP as anchor)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **PHEC over PERP (VTM-6.1)** | | | | | |
|  | **End-to-end WS-PSNR** | | | **End-to-end S-PSNR-NN** | | |
|  | Y | U | V | Y | U | V |
| Class S1 | -11.59% | -6.36% | -6.69% | -11.52% | -6.27% | -6.63% |
| Class S2 | -5.27% | -1.72% | -1.69% | -5.26% | -1.62% | -1.62% |
| **Overall** | -9.06% | -4.51% | -4.69% | -9.02% | -4.41% | -4.63% |

Table 2. VTM-6.1 PERP vs HM-16.16 PERP (HM-16.16 PERP as anchor)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **VTM-6.1 PERP - Over HM-16.16 PERP** | | | | | |
|  | **End-to-end WS-PSNR** | | | **End-to-end S-PSNR-NN** | | |
|  | Y | U | V | Y | U | V |
| Class S1 | -24.95% | -40.43% | -43.03% | -24.92% | -40.45% | -43.00% |
| Class S2 | -34.72% | -39.52% | -42.32% | -34.71% | -39.55% | -42.37% |
| **Overall** | -28.86% | -40.07% | -42.75% | -28.83% | -40.09% | -42.75% |

Table 3. VTM-6.1 PHEC vs HM-16.16 CMP (HM-16.16 CMP as anchor)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **VTM-6.1 PHEC - Over HM-16.16 CMP** | | | | | |
|  | **End-to-end WS-PSNR** | | | **End-to-end S-PSNR-NN** | | |
|  | Y | U | V | Y | U | V |
| Class S1 | -29.32% | -41.70% | -43.88% | -29.20% | -41.68% | -43.85% |
| Class S2 | -37.40% | -42.15% | -44.69% | -37.39% | -42.15% | -44.73% |
| **Overall** | -32.55% | -41.88% | -44.20% | -32.48% | -41.87% | -44.20% |

4 Contributions

There are 4 input documents related to syntax for signalling of cubeface layouts, which are listed below.

JVET-P0315 Modified 360Lib for more flexible cube face arrangements [J. Sauer, M. Bläser (RWTH Aachen University)]

JVET-P0316 AHG6/AHG12/AHG17: Coding of 360° video in non-compact cube layout using uncoded areas [J. Sauer, M. Bläser (RWTH Aachen University)]

JVET-P0462 AHG6/AHG17: 360-degree video related SEI messages [ R. Skupin, Y. Sanchez, K. Suehring, T. Schierl (HHI)]

JVET-P0597 AHG6/AHG17: Generalized cubemap projection syntax for 360-degree videos [Y.-H. Lee, J.-L. Lin, Y.-J. Chen, C.-C. Ju (MediaTek), J. Boyce, M. Dmitrichenko (Intel)]

5 RecommendationsAHG recommends:

• To continue software development of the 360Lib software package (e.g. integrate FishEye projection format).

• To generate CTC VTM anchors according to 360 video CTC, and provide the reporting template for the common test conditions.

• Review input contributions

Target new version of 360lib

It is suggested to study the compression performance of subpictures in VTM (Minhua Zhou will help with recommending configuration). At least to be studied with ERP, potentially cubemap.

[JVET-P0007](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8569) JVET AHG report: Coding of HDR/WCG material (AHG7) [A. Segall, E. François, W. Husak, S. Iwamura, D. Rusanovskyy]

1 MandatesAHG was established with the following mandates:

• Study and evaluate available HDR/WCG test content.

• Study objective metrics for quality assessment of HDR/WCG material, including investigation of the correlation between subjective and objective results.

• Compare the performance of the VTM and HM for HDR/WCG content.

• Prepare for expert viewing of HDR content at the next JVET meeting if feasible.

• Investigate the implications of chroma sampling location.

• Coordinate implementation of HDR anchor aspects in the test model software with AHG3.

• Study additional aspects of coding HDR/WCG content.

2 Activities

The AHG used the main JVET reflector, jvet@lists.rwth-aachen.de, with an [AHG7] indication on message headers. The primary activity of the AhG was related to the mandates of (i) comparing the performance of the VTM for HDR/WCG content; (ii) preparing for expert viewing of HDR content at the 16th JVET meeting; (iii) investigating the implications of chroma sampling locations, and (iv) coordinating implementation of HDR anchor aspects in the test model software. This work is described in the following subsection.

2.1 Performance Comparison

The AhG performed experiments comparing the performance of the VTM 6.0 on HDR content. The first part of this work included determining the performance of VTM 6.0 relative to the VTM 5.0 and HM 16.18. A summary of the performance is provided below, and more detailed information may be found in the included XLS data.

It was observed that the bit-allocation between luma and chroma in the HDR configuration changed between the two releases of the VTM – especially for Class H1. This is likely due to the change in the chroma table mapping function adopted into VTM 6, as well as the merge of request 857 (discussed later).

2.1.1 VTM 6.0 versus VTM 5.0

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | | | | |
|  | **Over VTM-5.0** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | -9.90% | 1.15% | 1.19% | -13.94% | -28.44% | 1.14% | -13.57% | -26.92% | 86% | 125% |
| Class H2 |  |  |  |  |  | -0.40% | 1.30% | 0.05% | 80% | 92% |
| **Overall** | -9.90% | 1.15% | 1.19% | -13.94% | -28.44% | 0.58% | -8.17% | -17.11% | 84% | 112% |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access** | | | | | | | | | |
|  | **Over VTM-5.0** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | -8.65% | 1.17% | 1.11% | -18.02% | -32.70% | 1.03% | -18.39% | -32.42% | 106% | 100% |
| Class H2 |  |  |  |  |  | -1.69% | -2.59% | -2.17% | 98% | 78% |
| **Overall** | -8.65% | 1.17% | 1.11% | -18.02% | -32.70% | 0.04% | -12.64% | -21.42% | 103% | 91% |

2.1.2 VTM 6.0 versus HM 16.18

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | | | | |
|  | **Over HM-16.18** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | -46.38% | -23.60% | -23.40% | -58.05% | -49.74% | -21.83% | -53.54% | -43.10% | - | - |
| Class H2 |  |  |  |  |  | -21.15% | -37.56% | -39.83% | - | - |
| **Overall** | -46.38% | -23.60% | -23.40% | -58.05% | -49.74% | -21.58% | -47.73% | -41.91% | - | - |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access** | | | | | | | | | |
|  | **Over HM-16.18** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | -43.94% | -28.23% | -28.04% | -59.64% | -68.05% | -26.01% | -55.82% | -61.81% | - | - |
| Class H2 |  |  |  |  |  | -28.23% | -45.86% | -49.57% | - | - |
| **Overall** | -43.94% | -28.23% | -28.04% | -59.64% | -68.05% | -26.82% | -52.20% | -57.36% | - | - |

2.2 Tool-On / Tool-Off Comparisons

In addition to evaluating the performance of VTM 6.0, the AhG also studied the performance of individual coding tools in the context of HDR content. This was accomplished by conducting a Tool-On/Tool-Off test according to the methodology established in AhG13. The only exception was for the LMCS tool. Currently, the HDR CTC defines the tool to be off when coding Class H1 content. So, to account for this configuration, the AhG performed a Tool-On test (instead of a Tool-Off test) for the tool instead.

are summarized in the tables below. Additionally, more detailed results are provided in the included XLS data.

The AhG would like to thank the following companies for contributing to the Tool-On tests: Alibaba, Dolby, InterDigital, LG, MediaTek, NHK, and Sharp.

2.2.1 Class H1 (PQ)

Simulation Results for AI (Class H1)

**Simulation Results for AI (Class H1)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  | **AI** |  |  |  |  |
| **Acronym** | **DE100** | **PSNR-L** | **BDR-wY** | **BDR-wU** | **BDR-wV** | **Tester EncTime** | **Tester DecTime** | **XChecker EncTime** | **XChecker DecTime** |
| **CST** | **19.02%** | **0.77%** | **0.71%** | **22.69%** | **50.33%** | **155%** | **100%** | **151%** | **101%** |
| **DQ** | **-1.52%** | **1.58%** | **1.68%** | **-4.79%** | **-8.80%** | **100%** | **101%** | **98%** | **105%** |
| **CCLM** | **26.79%** | **2.94%** | **2.74%** | **96.24%** | **199.89%** | **101%** | **100%** | **101%** | **100%** |
| **MTS** | **0.86%** | **1.11%** | **1.23%** | **0.68%** | **0.59%** | **86%** | **100%** | **86%** | **101%** |
| **ALF** | **3.73%** | **2.75%** | **2.24%** | **6.88%** | **7.26%** | **99%** | **86%** | **94%** | **90%** |
| **MRLP** | **0.27%** | **0.39%** | **0.36%** | **0.40%** | **0.11%** | **99%** | **101%** | **98%** | **101%** |
| **IBC on** | **-0.28%** | **-0.34%** | **-0.34%** | **0.09%** | **-0.01%** | **138%** | **103%** | **148%** | **101%** |
| **ISP** | **0.29%** | **0.55%** | **0.61%** | **0.05%** | **-0.29%** | **90%** | **97%** | **87%** | **100%** |
| **LMCS on\*** | **2.36%** | **-1.46%** | **-1.01%** | **6.36%** | **14.44%** | **104%** | **101%** | **100%** | **101%** |
| **RDPCM on** | **0.09%** | **0.00%** | **-0.04%** | **0.26%** | **0.10%** | **105%** | **100%** | **106%** | **101%** |
| **MIP** | **0.51%** | **0.59%** | **0.50%** | **0.63%** | **-0.10%** | **86%** | **99%** | **91%** | **101%** |
| **LFNST** | **-0.58%** | **0.86%** | **0.75%** | **-1.04%** | **-0.83%** | **103%** | **100%** | **101%** | **102%** |
| **JCCR** | **-0.05%** | **0.66%** | **0.66%** | **4.05%** | **-3.31%** | **95%** | **99%** | **97%** | **102%** |
| **SAO** | **0.64%** | **0.07%** | **0.18%** | **0.67%** | **2.29%** | **101%** | **98%** | **100%** | **99%** |

\* Note: Unlike in AhG13, LMCS is evaluated with a Tool-On test here

**Simulation Results for RA (Class H1)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Acronym** | **DE100** | **PSNR-L** | **BDR-wY** | **BDR-wU** | **BDR-wV** | **Tester EncTime** | **Tester DecTime** | **XChecker EncTime** | **XChecker DecTime** |
| **CST** | **13.05%** | **0.37%** | **0.32%** | **15.55%** | **25.44%** | **103%** | **102%** | **104%** | **100%** |
| **DQ** | **-0.73%** | **1.66%** | **1.57%** | **-3.50%** | **-6.64%** | **101%** | **100%** | **100%** | **101%** |
| **CCLM** | **18.66%** | **1.41%** | **1.31%** | **91.24%** | **190.73%** | **99%** | **101%** | **101%** | **100%** |
| **MTS** | **1.00%** | **0.88%** | **0.96%** | **1.45%** | **1.38%** | **94%** | **98%** | **96%** | **100%** |
| **ALF** | **3.96%** | **2.23%** | **2.00%** | **6.11%** | **11.62%** | **94%** | **85%** | **91%** | **89%** |
| **AFF** | **0.80%** | **0.97%** | **0.98%** | **0.70%** | **0.30%** | **80%** | **97%** | **80%** | **99%** |
| **SbTMVP** | **0.74%** | **0.45%** | **0.45%** | **0.50%** | **0.52%** | **100%** | **103%** | **101%** | **102%** |
| **AMVR** | **1.11%** | **0.70%** | **0.73%** | **2.39%** | **4.72%** | **80%** | **89%** | **83%** | **101%** |
| **TPM** | **0.31%** | **0.17%** | **0.20%** | **1.10%** | **1.16%** | **98%** | **100%** | **99%** | **100%** |
| **BDOF** | **0.75%** | **0.92%** | **0.97%** | **0.24%** | **-0.03%** | **97%** | **97%** | **97%** | **98%** |
| **PROF** | **0.07%** | **0.10%** | **0.11%** | **0.13%** | **-0.11%** | **99%** | **100%** | **100%** | **99%** |
| **CIIP** | **-0.15%** | **0.10%** | **0.13%** | **-0.25%** | **-0.49%** | **97%** | **99%** | **97%** | **100%** |
| **MMVD** | **0.49%** | **0.29%** | **0.27%** | **0.71%** | **0.96%** | **89%** | **102%** | **89%** | **100%** |
| **BCW** | **0.61%** | **0.24%** | **0.22%** | **0.69%** | **1.00%** | **92%** | **102%** | **91%** | **102%** |
| **MRLP** | **0.21%** | **0.20%** | **0.18%** | **0.02%** | **0.35%** | **99%** | **101%** | **99%** | **100%** |
| **IBC on** | **0.10%** | **-0.05%** | **0.06%** | **0.72%** | **0.78%** | **105%** | **103%** | **105%** | **100%** |
| **ISP** | **0.26%** | **0.36%** | **0.35%** | **0.14%** | **0.82%** | **98%** | **100%** | **98%** | **100%** |
| **DMVR** | **1.13%** | **0.99%** | **0.84%** | **1.37%** | **1.66%** | **100%** | **96%** | **101%** | **97%** |
| **SBT** | **0.08%** | **0.13%** | **0.33%** | **0.28%** | **0.47%** | **97%** | **101%** | **98%** | **100%** |
| **LMCS on\*** | **0.20%** | **-1.12%** | **-0.92%** | **2.62%** | **11.66%** | **103%** | **102%** | **100%** | **102%** |
| **SMVD** | **0.21%** | **0.14%** | **0.16%** | **0.30%** | **0.58%** | **95%** | **101%** | **91%** | **100%** |
| **RDPCM on** | **0.16%** | **-0.01%** | **-0.01%** | **0.13%** | **0.79%** | **101%** | **102%** | **100%** | **100%** |
| **MIP** | **0.42%** | **0.42%** | **0.33%** | **0.68%** | **0.60%** | **93%** | **97%** | **98%** | **100%** |
| **LFNST** | **0.17%** | **0.49%** | **0.41%** | **0.66%** | **1.47%** | **94%** | **100%** | **97%** | **100%** |
| **JCCR** | **-0.61%** | **0.49%** | **0.52%** | **2.88%** | **-3.91%** | **97%** | **99%** | **100%** | **101%** |
| **SAO** | **0.72%** | **-0.03%** | **0.01%** | **0.79%** | **2.21%** | **99%** | **101%** | **100%** | **99%** |
| **SIF** | **0.25%** | **0.13%** | **0.10%** | **0.43%** | **1.04%** | **97%** | **100%** | **97%** | **100%** |



Figure 1. wPSNR-Y vs encoding runtime ratio of VTM with VTM tool tests (Class H1)



Figure 2. wPSNR-Y vs decoding runtime ratio of VTM with VTM tool tests (Class H1)



Figure 3. wPSNR-Y vs weighted runtime ratio (a = 6) of VTM with VTM tool tests (Class H1)

2.2.2 Class H2 (HLG)

**Simulation Results for AI (Class H2)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Acronym** | **BDR-Y** | **BDR-U** | **BDR-V** | **Tester EncTime** | **Tester DecTime** | **XChecker EncTime** | **XChecker DecTime** |
| **CST** | **0.60%** | **13.59%** | **21.01%** | **171%** | **104%** | **162%** | **101%** |
| **DQ** | **1.86%** | **-1.29%** | **-1.52%** | **99%** | **103%** | **99%** | **105%** |
| **CCLM** | **1.72%** | **40.73%** | **20.54%** | **102%** | **100%** | **101%** | **99%** |
| **MTS** | **1.85%** | **2.59%** | **1.90%** | **86%** | **97%** | **84%** | **98%** |
| **ALF** | **2.83%** | **2.16%** | **3.20%** | **97%** | **84%** | **94%** | **86%** |
| **MRLP** | **0.06%** | **-0.12%** | **0.08%** | **99%** | **101%** | **97%** | **101%** |
| **IBC on** | **-0.11%** | **-0.06%** | **0.03%** | **163%** | **101%** | **148%** | **100%** |
| **ISP** | **0.32%** | **-0.59%** | **-0.15%** | **87%** | **99%** | **86%** | **100%** |
| **LMCS** | **0.05%** | **-0.83%** | **-0.59%** | **93%** | **96%** | **97%** | **93%** |
| **RDPCM on** | **0.00%** | **-0.05%** | **0.03%** | **108%** | **101%** | **108%** | **100%** |
| **MIP** | **0.62%** | **0.85%** | **0.55%** | **92%** | **101%** | **92%** | **101%** |
| **LFNST** | **0.49%** | **-0.61%** | **-0.94%** | **106%** | **101%** | **103%** | **100%** |
| **JCCR** | **0.27%** | **0.38%** | **5.19%** | **99%** | **100%** | **97%** | **100%** |
| **SAO** | **0.05%** | **0.25%** | **0.59%** | **100%** | **96%** | **98%** | **97%** |

**Simulation Results for RA (Class H2)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Abbreviation** | **BDR-Y** | **BDR-U** | **BDR-V** | **Tester EncTime** | **Tester DecTime** | **XChecker EncTime** | **XChecker DecTime** |
| **CST** | **0.26%** | **8.07%** | **15.98%** | **103%** | **100%** | **102%** | **100%** |
| **DQ** | **1.81%** | **-0.41%** | **-0.86%** | **103%** | **102%** | **103%** | **102%** |
| **CCLM** | **0.76%** | **47.97%** | **25.56%** | **101%** | **100%** | **100%** | **101%** |
| **MTS** | **1.19%** | **1.43%** | **0.81%** | **95%** | **100%** | **95%** | **100%** |
| **ALF** | **3.53%** | **3.41%** | **3.04%** | **97%** | **84%** | **94%** | **89%** |
| **AFF** | **0.70%** | **0.45%** | **0.56%** | **80%** | **98%** | **81%** | **98%** |
| **SbTMVP** | **0.40%** | **0.28%** | **0.27%** | **102%** | **103%** | **100%** | **102%** |
| **AMVR** | **0.72%** | **1.12%** | **1.59%** | **82%** | **100%** | **81%** | **101%** |
| **TPM** | **0.34%** | **0.63%** | **0.57%** | **99%** | **100%** | **99%** | **100%** |
| **BDOF** | **0.60%** | **0.21%** | **0.17%** | **96%** | **98%** | **96%** | **98%** |
| **PROF** | **0.14%** | **0.04%** | **0.04%** | **100%** | **99%** | **99%** | **100%** |
| **CIIP** | **0.18%** | **-0.32%** | **-0.45%** | **98%** | **100%** | **97%** | **100%** |
| **MMVD** | **0.19%** | **0.29%** | **0.56%** | **89%** | **100%** | **89%** | **100%** |
| **BCW** | **0.21%** | **0.18%** | **0.23%** | **92%** | **102%** | **92%** | **102%** |
| **MRLP** | **0.06%** | **0.05%** | **0.06%** | **100%** | **100%** | **97%** | **100%** |
| **IBC on** | **0.11%** | **0.13%** | **-0.13%** | **106%** | **100%** | **102%** | **100%** |
| **ISP** | **0.21%** | **0.29%** | **0.17%** | **99%** | **100%** | **98%** | **100%** |
| **DMVR** | **0.83%** | **1.06%** | **0.91%** | **101%** | **96%** | **101%** | **98%** |
| **SBT** | **0.30%** | **-0.20%** | **-0.34%** | **97%** | **100%** | **97%** | **100%** |
| **LMCS** | **0.95%** | **1.35%** | **1.10%** | **97%** | **98%** | **98%** | **98%** |
| **SMVD** | **0.20%** | **0.05%** | **0.15%** | **92%** | **100%** | **90%** | **100%** |
| **RDPCM on** | **0.02%** | **0.12%** | **0.05%** | **102%** | **100%** | **101%** | **100%** |
| **MIP** | **0.46%** | **0.95%** | **0.08%** | **98%** | **100%** | **97%** | **99%** |
| **LFNST** | **0.41%** | **-0.26%** | **-0.78%** | **95%** | **99%** | **96%** | **101%** |
| **JCCR** | **0.21%** | **0.12%** | **7.06%** | **99%** | **99%** | **100%** | **101%** |
| **SAO** | **0.06%** | **0.32%** | **1.81%** | **100%** | **97%** | **101%** | **100%** |
| **SIF** | **0.12%** | **0.14%** | **0.23%** | **96%** | **99%** | **97%** | **100%** |



Figure 4. PSNR-Y vs encoding runtime ratio of VTM with VTM tool tests (Class H2)



Figure 5. PSNR-Y vs decoding runtime ratio of VTM with VTM tool tests (Class H2)



Figure 6. PSNR-Y vs weighted runtime ratio (a = 6) of VTM with VTM tool tests (Class H2)

2.3 Preparations for Expert Viewing at the 16th JVET meeting

The AhG coordinated the availability of an HDR display for the 16th meeting in order to better support the visual evaluation of HDR content. This includes the planned viewing of HDR content in CE5. A SONY BVM X 300 will be available for this activity. Currently, it is planned to be located at the EBU, to ensure that the necessary playback equipment is available to drive the display.

It is noted that the BVM X 300 is able to show HLG content natively. However, tone mapping will be required to display PQ content.

The AhG also wishes to thank Frans De Jong and Paola Sunna from EBU for providing support for the activity.

2.4 Investigate the implications of chroma sampling process

During the 15th meeting, it was decided to change the HDR common test conditions for Class H1 (PQ) to reflect that the chroma type of the content was Type 2. This resulted in changing the configuration file to include the following parameter “CclmCollocatedChroma: 1”

During the AhG period, the AhG investigated if a similar change was needed for the Class H2 (HLG) content. Simulations were performed measuring the improvement in coding efficiency by setting the chroma type to Type 2 for the CCLM coding tool. The results are provided below, and the AhG concluded that a change was not needed for Class H2.

**VTM-5.0 with CclmCollocatedChroma:1 versus VTM-5.0**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | | | | |
|  | **Over VTM-5.0** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | #VALUE! | -0.23% | -0.19% | -5.14% | -10.59% | -0.19% | -4.32% | -8.33% | - | - |
| Class H2 |  |  |  |  |  | 0.14% | 3.55% | 4.28% | - | - |
| **Overall** | #VALUE! | -0.23% | -0.19% | -5.14% | -10.59% | -0.07% | -1.46% | -3.75% | - | - |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access** | | | | | | | | | |
|  | **Over VTM-5.0** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | #VALUE! | -0.17% | -0.11% | -4.82% | -7.39% | -0.13% | -3.80% | -5.60% | - | - |
| Class H2 |  |  |  |  |  | 0.09% | 2.73% | 6.97% | - | - |
| **Overall** | #VALUE! | -0.17% | -0.11% | -4.82% | -7.39% | -0.05% | -1.43% | -1.03% | - | - |

2.5 Coordinate implementation of HDR anchor aspects in the test model software with AHG3

2.5.1 Integration of HDR metric calculation into the VTM

Prior to this AhG period, the calculation of HDR specific metrics required use of an external HDRMetrics application. This also required the management of additional configuration files to control the conversion of decoded YUV sequences to float point representations in linear light. Software to address this issue was provided at the 15th meeting in JVET-O0756.

During the AhG period, the AhG worked to coordinate and support the integration of the HDRMetrics functionality into the VTM software. The functionality was provided as part of the VTM6.0. The timeline for the release was as follows:

o 2019/08/09

 VTM 6.0 released including support for calling external HDRLib for metric calculation

 HDRTools 0.19-dev branch available to support linking HDRLib into VTM 6.0

o 2019/09/24

 HDRTools 0.19 released with official support for linking HDRLib into VTM. However, it was later determined that the release included a change in the API that effected the linking process.

o 2019/09/27

 HDRTools 0.19.1 released with bugfix to support linking HDRLib into VTM

Enabling the HDRLib functionality in the VTM software is accomplished by doing the following:

1. Create a local copy of the VTM Version 6 or newer software.

2. Create a local copy of the HDRTools v0.19.1 or newer utility available at https://gitlab.com/standards/HDRTools. More recent versions are encouraged where applicable.

3. Copy the HDRTools/common directory from the HDRTools utility into the source/Lib/HDRLib directory of the VTM software.

Example: On a Linux system, this could be accomplished with the command:

ln -s <HDRTools\_dir>/HDRTools/common <VTM\_dir>/souce/Lib/HDRLib

4. Append “-DEXTENSION\_HDRTOOLS=on” when building the VTM software using CMake.

Example: If the VTM is normally built using the command:

cmake -DCMAKE\_BUILD\_TYPE=Release

The HDRLib functionality is enabled by using the command:

cmake -DCMAKE\_BUILD\_TYPE=Release -DEXTENSION\_HDRTOOLS=on

The class specific parameters and sequence specific parameters provided with the VTM will then enable and configure the metric calculation parameters appropriately. Note that these instructions are also available in the HDR CTC.

It was observed that most participants interested in performing HDR experiments used the integrated HDRTool functionality to calculate the HDR metric. However, as the functionality was only officially released a week before the meeting, it is possible that some proponents chose to use the previous, standalone approach for calculating the metric. The AhG compared the performance of using the integrated metric calculation and the (previously defined) external metric calculation to determine the significance of using the different approaches.

Results are provided below and show that the objective difference between the two approaches is less than .025%.

**VTM-6.0 External Metric Calculation vs Integrated Metric Calculation**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | | | | |
|  | **Over VTM 6.0 (with external metric calculation)** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | 0.010% | 0.020% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access** | | | | | | | | | |
|  | **Over VTM 6.0 (with external metric calculation)** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | -0.006% | 0.024% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |  |  |

2.5.2 Addressing chroma loss observation in previous AhG period

As part of the AhG report provided to the 15th meeting of JVET, it was observed that there was a rather large chroma loss between VTM 4.0 and VTM 5.0. It was identified that the integration of JVET-M0091 resulted in the loss (commit: 65c9bacdf38).

During this AhG activity, merge request 857 addressed this chroma loss issue. The merge request was integrated into the VTM (commit: 95246223) and provided as part of the VTM 6.0 release.

3 Contributions

There are two contributions related to HDR video coding. While not listed here, it is noted that responses to CE5-1 and CE5-2 sub-categories consider the performance of in-loop filtering on HDR content:

JVET-P0335 AHG15: Chroma QP mapping table for HDR T. Lu, F. Pu, P. Yin, S. McCarthy, W. Husak, T. Chen (Dolby)

JVET-P0371 AHG7/AHG15: Signalling of corrective values for chroma residual scaling

E. François, F. Galpin, K. Naser, P. de Lagrange (InterDigital)

JVET-P0623 Crosscheck report of JVET-P0335 on Chroma QP mapping table for HDR E. François (InterDigital)

JVET-P0711 Crosscheck of JVET-P0371 (AHG7/AHG15: signalling of corrective values for chroma residual scaling) T. Lu (Dolby)

4 Recommendations

The AHG recommends the following:

• Identify HDR visual testing to be performed at the 16th meeting

• Review all input contributions

It is commented that the results for HLG show similar tendency like for SDR in terms of the improvements of VTM6.

LMCS is also working appropriately for HLG, but should stay turned off for PQ CTC.

The results on CCLM collocated chroma indicate that the CTC is appropriate (not needed for HLG, only for PQ)

Plans for viewing session at EBU:

- PQ with LMCS switched on/off

- VTM5 vs. VTM6 (in terms of chroma quality)

- VTM6 vs. HM at approximately same quality (if possible)

The two contributions are currently allocated under “quantization”. It is commented that, in case that subjective viewing would be needed for assessment, this should be decided early in the meeting.

[JVET-P0008](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8501) JVET AHG report: Layered coding and resolution adaptivity (AHG8) [S. Wenger, A. Segall, M.M. Hannuksela, Hendry, S. McCarthy, Y.-C. Sun, P. Topiwala, M Zhou]

Discussed Tuesday 1550 (GJS)

AHG8 was established by the 15th meeting (Gothenburg) to study layered coding and resolution adaptivity. Except for the kickoff message, no emails were exchanged on the reflector. Approximately 44 documents related to the subject matter of this ad hoc group were identified.

Approximately 43 documents were identified by the submitting organizations as related to AHG8’s mandates. An additional 5 documents marked as relating to AHG17 were also identified as relating to AHG8. Of these 48 total documents, 27 were allocated to scalability; 8 were allocated to reference picture resampling (RPR); and 13 were allocated to other parts of the meeting agenda (mostly CE1, AHG12, and AHG17)

The AHG recommended reviewing the related input contributions and to study layered coding and resolution adaptivity aspects.

[JVET-P0009](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8469) JVET AHG report: Neural Networks in Video Coding (AHG9) [S. Liu, Y.M. Li, B. Choi, K. Kawamura, Y. Li, L. Wang, P. Wu, H. Yang]

The AHG was established at Gothenburg, Sweden with the following mandates:

• Investigate the benefit of using neural networks in video compression such as CNN loop filter, intra prediction, resampling in adaptive resolution coding, and encoder-side partition mode decisions.

• Investigate the complexity impact of using neural networks in video compression.

• Investigate the complexity measurement of neural network coding tools.

• Investigate benefit of universal versus selectable networks, both in terms of compression benefit and complexity.

• Investigate how CNN parameters can be established for operation of the decoding process.

• Investigate the impact of training materials on the performance of neural network coding tools.

• Investigate the impact of the training process on performance and complexity.

2. Activities

Email activity for the AHG was conducted on the main jvet reflector, jvet@lists.rwth-aachen.de, with an [AHG9] indication on message headers. There was no email activity on the reflector during this period.

3. Related contributions

AHG9 related input documents for this meeting are summarized as follows.

• H.Yin, R.Yang, X.Fang, Z.Gao, R.Yang, “AHG9: Multiple Convolution Neural Networks For Sequence-Independent Processing,” JVET-P0489

4. Recommendations

The AHG recommends:

• To review all related contributions

• To continue investigating the benefits and complexity of using neural networks in video coding

It was discussed that the AHG has fulfilled its mandates by studying the potential of NN technology over several meeting cycles. Currently, there is no evidence that non-shallow NN based technology provides a good tradeoff of complexity vs. compression (at least w.r.t. need of normative elements).

At this point of VVC development, and the low amount of recent contributions, it is suggested to discontinue the AHG.

[JVET-P0010](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8570) JVET AHG report: Encoding algorithm optimization (AHG10) A. Duenas, A. Tourapis, S. Ikonin, A. Norkin, R. Sjöberg, J. Le Tanou, J.-M. Thiesse]

1 Introduction

At the 15th JVET meeting, the AHG on Encoding algorithm optimizations was established with the following mandates:

• Study the impact of using techniques such as GOP structures and perceptually optimized adaptive quantization for encoder optimization.

• Study the impact of adaptive quantization on individual tools in the test model.

• Study the quantization adaptation tool in the test model.

• Investigate the feasibility of adding a CTC test category in which adaptive quantization is turned on.

• Study quality metrics for measuring subjective quality using e.g. the CfP response MOS scores.

• Investigate other methods of improving objective and/or subjective quality, including adaptive coding structures, adaptive quantization without signalling, and multi-pass encoding.

• Study methods of rate control and their impact on performance, subjective and objective quality.

The regular JVET e-mail reflector was used for discussions (jvet@lists.rwth-aachen.de). No e-mail related to AHG10 activity was sent to the JVET reflector during the AHG period.

2 Overview of input documents related to the AHG

The following input documents were identified to be related to the AHG:

2.1 JVET-P0328: AHG10: Performance of the GOP-based temporal filter in VTM-6.1

The encoder-only GOP-based temporal filter proposed in JVET-O0549 was adopted in the previous meeting in Gothenburg. This contribution provides performance numbers by enabling the filter on top of VTM-6.1. The average Y/U/V BD-rates for the common test conditions (CTC) for the filter on top of VTM-6.1 are reported to be −3.91%/−6.63%/−6.56% (RA), −0.96%/−1.30%/−2.18% (LDB) and −1.48%/−1.61%/−2.23% (LDP). This can be compared to the numbers compared in JVET-O0549-v2: −3.49%/−6.96%/−6.53% (RA), −1.00%/−1.24%/−2.24% (LDB) and −1.47%/−1.95%/−2.78% (LDP).

The proponents are willing to arrange a subjective viewing at the meeting.

2.2 JVET-P0570: AHG10/Non-CE5: Performance of encoder-side deblocking optimization in VTM-6.0

The encoder-only deblocking optimization is tested on top of VTM-6.0. The average Y/U/V BD-rates and encoding time for the common test conditions for the filter on top of VTM-6.0 are reported to be −0.77%/−1.53%/−1.56%/105% for all intra, −0.92%/−1.94%/−1.93%/103% for random access and −0.78%/−0.90%/−0.88%/102% for low delay B.

2.3 JVET-P0163: CE5-related: SAO encoder-only improvements

In this contribution, three encoder-only improvements for sample adaptive offset (SAO) are reported. First, the greedy SAO merge encoding algorithm, which is in VTM6.0 but disabled in common test conditions (CTC), is enabled to optimize SAO parameters for multiple coding tree units (CTUs) within one CTU row. Second, to explore more SAO merge possibilities across CTU rows, a picture-based SAO merge encoding algorithm is proposed. For each picture, the best SAO parameters, derived by either the picture-based SAO merge encoding algorithm or the greedy SAO merge encoding algorithm, are signalled. Third, the SAO picture-level on-off decision algorithm for the current picture using statistics from a previous picture, which is enabled in VTM6.0CTC, is disabled, and it is proposed to further allow changing the picture-level decision from on to off after SAO is tested for all CTUs in the picture. YCbCr BD-rates (using the AHG13 YCbCr BD-rate calculation method: (BD-Rate\_Y\*8+ BD-Rate\_U+ BD-Rate\_V)/10) under adaptive loop filter (ALF) on/off cases are summarized as follows.

Anchor: VTM6.0 + SAO off + ALF on

Test: anchor + SAO on

AI: -0.04%; RA: -0.13%; LB: -0.24%; LP: -0.26%

Anchor: VTM6.0 + SAO off + ALF on

Test: anchor + SAO on + SAO encoder-only improvements

AI: -0.15%; RA: -0.29%; LB: -0.52%; LP: -0.52%

Anchor: VTM6.0 + SAO off + ALF off

Test: anchor + SAO on

AI: -0.36%; RA: -0.78%; LB: -1.21%; LP: -2.74%

Anchor: VTM6.0 + SAO off + ALF off

Test: anchor + SAO on + SAO encoder-only improvements

AI: -0.56%; RA: -1.10%; LB: -1.70%; LP: -3.35%

It is known that SAO and ALF overlap in coding gains. Small coding losses are observed by disabling SAO when ALF is on, while large coding losses are observed by disabling SAO when ALF is off. Given that SAO has low complexity and is deployed in one billion HEVC devices per year, it is asserted that keeping SAO is beneficial for VVC, especially for real-time low complexity encoding applications.

2.4 JVET-P0345: Low-Delay B encoder configuration proposal

The coding gain of VVC over HEVC much higher in random access configuration than in low-delay B. This contribution proposes a new low-delay B encoder configuration, targeting improved coding efficiency. Basically, the GOP size is extended to 8 instead of 4. The proposed LDB GOP structure reportedly leads to -4.87%, -5.87%, -5.56% BD-rate gain in Y, Cb and Cr components respectively, over the current CTC LDB configuration.

2.5 JVET-P0445: Non-CE4: Encoder optimization for subblock-based merge candidate search

In this contribution, an encoder optimization method is proposed to separate luma and chroma components in motion compensation process. With this support, chroma motion compensation can be avoided during luma SATD based subblock merge candidate search so that encoding time is reduced. It is asserted that the proposed changes do not have any impact in coding performance. The proposed method was implemented based on VTM-6.0, and simulations were conducted with common test conditions. It is reported that there’s no BD-rate change with 98% encoding time for RA, and 99% encoding time for LB.

3 Recommendation

The AHG recommends that the related input contributions are reviewed and to further continue the study of encoding algorithm optimizations in JVET.

It is suggested performing subjective viewing on some of the contributions (if possible).

[JVET-P0011](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8571) JVET AHG report: Screen content coding (AHG11) [S. Liu, J. Boyce, A. Filippov, Y.-C. Sun, J. Xu, H. Yang]

1 Introduction

The AHG was established at Gothenburg, SE with the following mandates:

• Investigate coding tools targeted at screen content in terms of compression benefit and implementation complexity.

• Identify test materials, discuss testing conditions for screen content coding, and propose associated updated common test conditions.

• Study the impact of loop filters on screen content coding.

2 Activities

The AHG used the main JVET reflector, jvet@lists.rwth-aachen.de, with [AHG11] in message headers. There were a few emails exchanged regarding SCC testing sequences downloading locations in the ftp site. There were many email exchanges among CE8 participants using jvet-ce@lists.rwth-aachen.de reflector with tool specific discussions.

In total there are 44 SCC related technical contributions identified so far, among which there are 8 IBC related technical contributions, 27 Palette related technical contributions, 4 Transform Skip/BDPCM related technical contributions, 3 SCC tool deblocking settings related technical contributions and 2 other SCC tools contributions identified for this meeting.

4 Recommendations

The AHG recommends:

• To review all related contributions.

• To continue investigating SCC coding tool performance, complexity and interactions between themselves and with other coding tools.

• To continue evaluating new test materials.

[JVET-P0012](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8551) JVET AHG report: High-level parallelism and coded picture regions (AHG12) [S. Deshpande, M. M. Hannuksela, R. Sjöberg, R. Skupin, W. Wan, Y.-K. Wang, S. Wenger]

Discussed Tuesday 1530 (GJS)

The document summarizes activities of AHG on high-level parallelism and coded picture regions between the 15th and the 16th JVET meetings.

Relevant input documents (total 52) related to AHG12 were listed in the AHG report. An email conversation was conducted on the reflector based on a slide deck submitted by a member company regarding analysis of subpicture grip approach. A total of 9 emails were exchanged on this topic on the JVET email reflector between 2019-08-26 and 2019-09-06.

Contributions that summarize input contributions were noted:

* JVET-P0686 summarizes HLS proposal on slices, tiles and bricks
* JVET-P0693 summarizes some categories of the HLS proposals on subpictures

The AHG recommended:

* To review the related contributions
* To continue to study VVC high-level parallelism and coded picture regions aspects.

[JVET-P0013](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8572) JVET AHG report: Tool reporting procedure (AHG13) [W.-J. Chien, J. Boyce, W. Chen, Y.-W. Chen, R. Chernyak, K. Choi, R. Hashimoto, Y.-W. Huang, H. Jang, R.-L. Liao, S. Liu]

1 Mandates

The AHG was established with the following mandates:

• Prepare output document JVET-O2005, which describes the methodology of tool-off testing and a list of tools to be tested by identified testers.

• Provide configurations files, bitstreams, and results of the tool-on/tool-off testing.

• Use the tool usage counts and memory bandwidth usage to study the decoder complexity of features in on/off testing.

• Prepare a report with results of the tests.

2 Activities

The initial version of JVET-O2005 “Methodology and reporting template for tool testing” was provided on August 4th.

All tests described in JVET-O2005 were conducted. VTM tool tests were conducted on VTM-6.0 software with VTM configuration by switching off or on specific tool either in configuration files or macros.

The tested tools, testers, and cross-checkers are listed in the tables below.

2.1 Tools included in VTM (Tool off test vs VTM Anchor)

Table 1 List of adoptions included in VTM (Tool off test (unless specified) vs VTM anchor)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Tool Name** | **Acronym** | **Document reference(s)** | **AI** | **RA** | **LD** | **Tester** | **Crosscheck** |
| Chroma separate tree | CST | JVET-N0137 | X | X | X | Tzu-Der Chuang (peter.chuang@mediatek.com) | Wei-Jung Chien (wchien@qti.qualcomm.com) |
| Dependent quantization\* | DQ | JVET-M0173, JVET-M0251, JVET-M0470, | X | X | X | Tzu-Der Chuang (peter.chuang@mediatek.com) | Wei Chen (wei.chen@interdigital.com) |
| Cross-component linear model | CCLM | JVET-N0271, JVET-O1124 | X | X | X | Roman Chernyak (chernyak.roman@huawei.com) | Shan Liu (shanl; leolzhao@ tencent.com) |
| multiple transform set | MTS | JVET-N0866, JVET-O0294, JVET-O0474, JVET-O0541, | X | X | X | Kiho Choi (kiho14.choi@samsung.com) | Shan Liu (shanl; xinzzhao@ tencent.com) |
| Adaptive loop filter | ALF | JVET-N0242, JVET-N0415, JVET-N0180, JVET-O0064, JVET-O0090, JVET-O0216, JVET-O0228, JVET-O0247, JVET-O0625, JVET-O0662, JVET-O0669 | X | X | X | Wei-Jung Chien (wchien@qti.qualcomm.com) | Wei Chen (wei.chen@interdigital.com) |
| Affine motion model | AFF | JVET-N0068, JVET-N0194, JVET-N0334, JVET-N0481, JVET-O0070 |  | X | X | Roman Chernyak (chernyak.roman@huawei.com) | Shan Liu (shanl; guichunli@ tencent.com) |
| subblock-based temporal merging candidates | SbTMC | JVET-M0273, JVET-O0163, JVET-O0220 |  | X | X | Shan Liu  (shanl; guichunli@ tencent.com) | Wei-Jung Chien (wchien@qti.qualcomm.com) |
| Adaptive motion vector resolution | AMVR | JVET-M0246, JVET-O0057 |  | X | X | Shan Liu (shanl; guichunli@ tencent.com) | Wei-Jung Chien (wchien@qti.qualcomm.com) |
| Triangular partition mode | TPM | JVET-N0340, JVET-N0483, JVET-O0265 | X | X | X | Kiho Choi (kiho14.choi@samsung.com) | Shan Liu (shanl; leolzhao@ tencent.com) |
| Bi-directional optical flow | BDOF | JVET-N0444,  JVET-N0146, JVET-N0325, JVET-O0055, JVET-O0304, JVET-O0570, JVET-O0594 |  | X |  | Kiho Choi (kiho14.choi@samsung.com) | Tzu-Der Chuang (peter.chuang@mediatek.com) |
| Combined intra/inter prediction | CIIP | JVET-N0302, JVET-O0108, JVET-O0681 |  | X | X | Kiho Choi (kiho14.choi@samsung.com) | Tzu-Der Chuang (peter.chuang@mediatek.com) |
| Merge with MVD | MMVD | JVET-N0127,  JVET-N0332, JVET-N0448, JVET-N0380 |  | X | X | Kiho Choi (kiho14.choi@samsung.com) | Hyeongmun Jang ([hm.jang@lge.com](mailto:hm.jang@lge.com)) |
| Bi-predictive with CU weights | BCW | JVET-N0481, JVET-O0366 |  | X | X | Wei Chen (wei.chen@interdigital.com) | Tzu-Der Chuang (peter.chuang@mediatek.com) |
| Multi-reference line prediction | MRLP | JVET-L0283, JVET-O0426 | X | X | X | Shan Liu (shanl; leolzhao@ tencent.com) | Hyeongmun Jang (hm.jang@lge.com) |
| Intra block copy mode\*\* | IBC | JVET-N0383,  JVET-N0175,  JVET-N0251, JVET-N0384,  JVET-N0317,  JVET-N0383, JVET-N0251,  JVET-N0318, JVET-N0467, JVET-N0843, JVET-O0078, JVET-O0162, JVET-O0258, JVET-O0455, JVET-O1170 | X | X | X | Shan Liu (shanl; xiaozhongxu@ tencent.com) | Wei-Jung Chien (wchien@qti.qualcomm.com) |
| Intra sub-partitioning | ISP | JVET-N0308, JVET-O0106, JVET-O0341, JVET-O0502 | X | X | X | Roman Chernyak (chernyak.roman@huawei.com) | Hyeongmun Jang (hm.jang@lge.com) |
| Decoder motion vector refinement | DMVR | JVET-N0407,  JVET-N0178,  JVET-N0146, JVET-N0153, JVET-N0442, JVET-N0162, JVET-N0262, JVET-N0440, JVET-N0086, JVET-O0297, JVET-O0590, JVET-O0634 |  | X |  | Wei Chen (wei.chen@interdigital.com) | Roman Chernyak  ([chernyak.roman@huawei.com](mailto:chernyak.roman@huawei.com)) |
| Sub-block transform | SBT | JVET-M0140 |  | X | X | Roman Chernyak (chernyak.roman@huawei.com) | Shan Liu (shanl; xinzzhao@ tencent.com) |
| Luma mapping with chroma scaling | LMCS | JVET-N0220, JVET-N0477, JVET-O0272, JVET-O0428, JVET-O1109 | X | X | X | Taoran Lu (tlu@dolby.com) | Hyeongmun Jang (hm.jang@lge.com) |
| Symmetric motion vector difference | SMVD | JVET-M0444, JVET-O0284, JVET-O0414, JVET-O0567, JVET-O0572 |  | X |  | Yi-Wen Chen(yiwenchen@kwai.com) | Hyeongmun Jang (hm.jang@lge.com) |
| Quantized residual DPCM | BDPCM | JVET-N0413, JVET-O0315, JVET-O1136 | X | X | X | Ru-Ling Liao (ruling.lrl@alibaba-inc.com) | Yi-Wen Chen(yiwenchen@kwai.com) |
| Matrix based intra prediction | MIP | JVET-N0217, JVET-O0925 | X | X | X | Ru-Ling Liao (ruling.lrl@alibaba-inc.com) | Yi-Wen Chen(yiwenchen@kwai.com) |
| Low frequency non-separable transform | LFNST | JVET-N0105, JVET-N0193, JVET-O0094, JVET-O0213, JVET-O0219, JVET-O0368, JVET-O0472, JVET-O0529 | X | X | X | Ru-Ling Liao (ruling.lrl@alibaba-inc.com) | Yi-Wen Chen(yiwenchen@kwai.com) |
| Joint coding of chrominance residuals | JCCR | JVET-N0054, JVET-O0105, JVET-O0543 | X | X | X | Ru-Ling Liao (ruling.lrl@alibaba-inc.com) | Yi-Wen Chen(yiwenchen@kwai.com) |
| Sampled-adaptive offset | SAO | HEVC | X | X | X | Tzu-Der Chuang (peter.chuang@mediatek.com) | Wei Chen (wei.chen@interdigital.com) |
| Prediction refinement using optical flow | PROF | JVET-O0070 |  | X | X | Wei Chen (wei.chen@interdigital.com) | Ru-Ling Liao (ruling.lrl@alibaba-inc.com) |
| Switched interpolation filter | SIF | JVET-O0057 |  | X | X | Wei Chen (wei.chen@interdigital.com) | Wei-Jung Chien (wchien@qti.qualcomm.com) |

\* Test was conducted by disabling DQ and enabling Sign Data Hiding

\*\* Test was conducted with disabling IBC on class F in anchor

\*\*\* Test was conducted by disabling BDPCM on class F in anchor

3 Results

The results of the tests are summarized in Table 2-6 below. The attached spreadsheet provides additional data. Table 7 shows tool test results across several VTM versions. The combined BD-Rate is computed based on (BD-Rate\_Y\*8+ BD-Rate\_U+ BD-Rate\_V)/10. Scatter plots are also provided for the tested tools in random access configuration, comparing PSNR-Y based bd-rate on the Y axis vs. each of Enc runtime ratio, Dec runtime ratio, and a weighted average of Enc and Dec runtime ratio, (Enc + a\*Dec)/(a+1), with a configurable weight, a. The exemplary weighting is set to 6 and can be adjusted in the spreadsheet attached to this report.experimental results and configuration files can be found at the link below:

https://hevc.hhi.fraunhofer.de/svn/svn\_VVCTestConfig/branches/VTM-6.0/

There was no bitrate or PSNR differences between testers and cross-checkers.

Encoder and Decoder runtime ratios provided by both the testers and cross-checkers are included in the reporting template, to identify if there were significant runtime differences.

Table 3 Simulation results in all intra configuration (AI) of VTM tool tests. (VTM anchor)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | **AI** |  |  |  |
| **Acronym** | **BDR-Y** | **BDR-U** | **BDR-V** | **Tester EncTime** | **Tester DecTime** | **XChecker EncTime** | **XChecker DecTime** |
| CST | 0.43% | 9.85% | 9.79% | 154% | 104% | 156% | 101% |
| DQ | 2.03% | -0.84% | -0.91% | 97% | 106% | 96% | 104% |
| CCLM | 1.60% | 14.79% | 15.90% | 99% | 100% | 99% | 99% |
| MTS | 1.25% | 0.73% | 0.77% | 85% | 98% | 84% | 96% |
| ALF | 2.38% | 2.94% | 3.65% | 97% | 88% | 98% | 86% |
| MRLP | 0.39% | 0.18% | 0.22% | 99% | 101% | 98% | 100% |
| IBC | 0.64% | 0.62% | 0.69% | 62% | 100% | 65% | 99% |
| ISP | 0.41% | 0.29% | 0.32% | 86% | 97% | 85% | 98% |
| LMCS | 1.09% | -1.03% | -0.67% | 99% | 99% | 97% | 97% |
| BDPCM | 0.00% | -0.02% | 0.03% | 107% | 100% | 97% | 105% |
| MIP | 0.54% | 0.16% | 0.16% | 91% | 101% | 89% | 97% |
| LFNST | 0.96% | 0.19% | 0.44% | 105% | 101% | 104% | 100% |
| JCCR | 0.56% | 0.35% | 0.46% | 99% | 101% | 94% | 97% |
| SAO | 0.01% | 0.14% | 0.17% | 100% | 99% | 100% | 97% |

Table 4 Simulation results in random access configuration (RA) of VTM tool tests. (VTM anchor)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | **RA** |  |  |  |
| **Acronym** | **BDR-Y** | **BDR-U** | **BDR-V** | **Tester EncTime** | **Tester DecTime** | **XChecker EncTime** | **XChecker DecTime** |
| CST | 0.10% | 4.27% | 4.81% | 104% | 100% | 101% | 100% |
| DQ | 1.76% | -0.24% | -0.61% | 102% | 103% | 99% | 102% |
| CCLM | 0.94% | 11.95% | 13.87% | 99% | 100% | 99% | 100% |
| MTS | 0.70% | 0.62% | 0.56% | 93% | 100% | 92% | 98% |
| ALF | 4.53% | 5.14% | 5.10% | 97% | 87% | 98% | 83% |
| AFF | 3.02% | 2.15% | 2.01% | 86% | 98% | 86% | 98% |
| SbTMC | 0.50% | 0.40% | 0.42% | 101% | 101% | 101% | 100% |
| AMVR | 1.39% | 2.36% | 2.41% | 81% | 101% | 81% | 101% |
| TPM | 0.34% | 0.63% | 0.51% | 99% | 101% | 99% | 101% |
| BDOF | 0.77% | 0.35% | 0.29% | 98% | 97% | 100% | 95% |
| CIIP | 0.29% | 0.12% | 0.02% | 99% | 101% | 100% | 100% |
| MMVD | 0.52% | 0.55% | 0.55% | 93% | 103% | 91% | 100% |
| BCW | 0.41% | 0.49% | 0.52% | 93% | 101% | 94% | 102% |
| MRLP | 0.20% | 0.13% | 0.09% | 100% | 100% | 98% | 99% |
| IBC | -0.03% | 0.02% | 0.06% | 93% | 100% | 93% | 99% |
| ISP | 0.20% | 0.25% | 0.19% | 97% | 100% | 96% | 99% |
| DMVR | 0.81% | 1.11% | 1.11% | 100% | 97% | 100% | 96% |
| SBT | 0.39% | 0.06% | 0.01% | 95% | 100% | 95% | 98% |
| LMCS | 1.63% | -1.30% | -1.42% | 94% | 100% | 94% | 97% |
| SMVD | 0.27% | 0.26% | 0.28% | 88% | 98% | 90% | 100% |
| RDPCM on | -0.03% | -0.07% | -0.02% | 99% | 100% | 100% | 101% |
| MIP | 0.30% | 0.39% | 0.41% | 97% | 101% | 94% | 99% |
| LFNST | 0.67% | 0.20% | 0.56% | 94% | 100% | 91% | 98% |
| JCCR | 0.49% | 0.46% | -0.15% | 99% | 101% | 98% | 100% |
| SAO | 0.08% | 0.28% | 0.35% | 100% | 98% | 100% | 99% |
| PROF | 0.48% | 0.16% | 0.09% | 99% | 99% | 100% | 100% |
| SIF | 0.28% | 0.72% | 0.69% | 96% | 100% | 96% | 100% |

Table 5 Simulation results in low delay B configuration (LDB) of VTM tool tests. (VTM anchor)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | **LDB** |  |  |  |
| **Acronym** | **BDR-Y** | **BDR-U** | **BDR-V** | **Tester EncTime** | **Tester DecTime** | **XChecker EncTime** | **XChecker DecTime** |
| CST | 0.05% | 1.65% | 2.43% | 101% | 103% | 100% | 100% |
| DQ | 1.33% | 1.49% | 1.45% | 99% | 103% | 99% | 102% |
| CCLM | 0.02% | 3.70% | 4.48% | 100% | 100% | 100% | 100% |
| MTS | 0.57% | 0.46% | 0.40% | 96% | 101% | 95% | 97% |
| ALF | 4.07% | 5.88% | 5.12% | 95% | 87% | 97% | 85% |
| AFF | 2.50% | 1.98% | 1.94% | 78% | 95% | 78% | 95% |
| SbTMC | 0.71% | 0.81% | 0.74% | 101% | 100% | 101% | 100% |
| AMVR | 0.55% | 0.96% | 0.89% | 88% | 101% | 88% | 101% |
| TPM | 0.71% | 1.04% | 0.91% | 97% | 101% | 97% | 102% |
| CIIP | 0.35% | 0.51% | 0.45% | 96% | 96% | 98% | 102% |
| MMVD | 0.46% | 0.56% | 0.23% | 93% | 97% | 93% | 100% |
| BCW | 0.29% | 0.56% | 0.48% | 96% | 101% | 97% | 102% |
| MRLP | 0.02% | 0.38% | 0.22% | 100% | 99% | 99% | 100% |
| IBC | -0.03% | -0.23% | 0.08% | 87% | 100% | 88% | 101% |
| ISP | 0.10% | 0.39% | 0.23% | 98% | 100% | 98% | 100% |
| SBT | 0.64% | 0.13% | 0.24% | 93% | 99% | 92% | 97% |
| LMCS | 0.80% | -0.32% | -1.06% | 94% | 98% | 95% | 96% |
| RDPCM on | -0.02% | -0.07% | -0.30% | 99% | 101% | 99% | 100% |
| MIP | 0.11% | 0.33% | 0.45% | 96% | 102% | 96% | 103% |
| LFNST | 0.38% | -2.00% | -2.00% | 91% | 100% | 94% | 102% |
| JCCR | 0.14% | 1.96% | 3.00% | 100% | 101% | 99% | 99% |
| SAO | 0.07% | 0.58% | 1.24% | 101% | 101% | 100% | 99% |
| PROF | 0.33% | 0.36% | 0.35% | 98% | 99% | 99% | 100% |
| SIF | 0.13% | 0.21% | 0.03% | 96% | 100% | 97% | 101% |

Table 6 Luma sample usage and memory bandwidth results of VTM tool “off” test. (VTM anchor)   
(needs update)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | AI |  | RA |  |  | LDB |  |
| Acronym | Sample usage | Sample usage | Ave mem BW | Max mem BW | Sample usage | Ave mem BW | Max mem BW |
| CCLM | 49.40% | 3.76% |  |  | 1.18% |  |  |
| ALF | 99.00% | 56.78% |  |  | 54.46% |  |  |
| AFF |  | 22.83% |  |  | 30.30% |  |  |
| SBTMC |  | 14.93% |  |  | 15.99% |  |  |
| AMVR |  | 5.43% |  |  | 2.61% |  |  |
| TPM |  | 2.00% |  |  | 5.03% |  |  |
| BDOF |  | 42.42% |  |  |  |  |  |
| CIIP |  | 0.88% |  |  | 1.39% |  |  |
| MMVD |  | 6.96% |  |  | 8.51% |  |  |
| BCW |  | 9.98% |  |  | 8.61% |  |  |
| MRLP | 6.93% | 0.68% |  |  | 0.28% |  |  |
| DMVR |  | 36.65% |  |  |  |  |  |
| SBT |  | 2.50% |  |  | 4.06% |  |  |
| SMVD |  | 2.80% |  |  |  |  |  |
| MIP | 21.29% | 4.86% |  |  | 2.43% |  |  |
| LFNST | 7.90% | 0.69% |  |  |  |  |  |
| JCCR | 10.84% | 0.50% |  |  | 0.17% |  |  |
| SAO | 31.14% | 7.04% |  |  | 9.07% |  |  |
| SIF |  | 0.98% |  |  | 0.66% |  |  |

Table 7 test results of VTM tool “off” test on various VTM versions (needs update)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **VTM RA** |  |  |
| **Abbreviation** | **VTM3** | **VTM4** | **VTM5** | **VTM6** |
| CST | 0.74% | 1.25% | 1.47% | 0.99% |
| DQ | 1.39% | 1.36% | 1.24% | 1.32% |
| CCLM | 4.09% | 4.20% | 4.00% | 3.33% |
| MTS | 1.25% | 0.80% | 0.36% | 0.68% |
| ALF | 3.61% | 3.73% | 4.79% | 4.65% |
| AFF | 2.42% | 2.46% | 2.38% | 2.84% |
| SbTMVP | 0.52% | 0.43% | 0.40% | 0.48% |
| AMVR | 0.98% | 1.13% | 1.14% | 1.59% |
| TPM | 0.43% | 0.43% | 0.41% | 0.39% |
| BDOF | 1.02% | 0.63% | 0.66% | 0.68% |
| CIIP | 0.43% | 0.51% | 0.31% | 0.24% |
| MMVD | 0.81% | 0.52% | 0.59% | 0.52% |
| BCW | 0.48% | 0.45% | 0.45% | 0.43% |
| MRLP | 0.24% | 0.18% | 0.16% | 0.18% |
| IBC | 0.07% | 0.00% | 0.05% | -0.01% |
| ISP |  | 0.24% | 0.12% | 0.20% |
| DMVR |  | 0.80% | 0.87% | 0.87% |
| SBT |  | 0.33% | 0.33% | 0.32% |
| LMCS |  | 0.62% | 0.57% | 1.03% |
| SMVD |  | 0.26% | 0.24% | 0.27% |
| BDPCM |  |  | -0.02% | -0.03% |
| MIP |  |  | 0.27% | 0.32% |
| LFNST |  |  | 0.75% | 0.61% |
| JCCR |  |  | 0.34% | 0.42% |
| SAO | 0.81% | 0.64% | 0.17% | 0.13% |

Figure 1. PSNR-Y vs encoding runtime ratio of VTM with VTM tool tests (VTM anchor)

Figure 2. PSNR-Y vs decoding runtime ratio of VTM with VTM tool tests (VTM anchor)

Figure 3. PSNR-Y vs weighted runtime ratio (a = 6) of VTM with VTM tool tests (VTM anchor)

4 Related contributions

JVET-P0092 AHG13: Encoder speed-up for SMVD H. Chen, H. Yang (Huawei)

JVET-P0394 AHG13: Luma Clipping instead of LMCS S. Keating, K. Sharman, A. Browne (Sony)

JVET-P0417 AHG13: Removal of ISP T. Hellman, B. Heng, W. Wan (Broadcom)

JVET-P0616 AHG13: Compression performance analysis for 8K HLG sequences S. Nemoto, S. Iwamura, A. Ichigaya (NHK), K. Kazui (Fujitsu)

JVET-P0622 AHG13: Low Delay results for Affine, ALF and DBF (Class A included) M. Sychev (Huawei)

5 Recommendations

The AHG recommends the following:

• Consider the reported tool test results during tool adoption decision making

• Review related contributions

• Refine list of tested tools and test methodology for the next meeting cycle

o Consider the reported tool test results as a benchmark for CE tests

o Consider including reporting of compute system information for testers and cross-checkers

o Consider additional performance or complexity metrics

The gain of SAO has gone low, but it is suggested to provide mainly subjective benefit, and also is attractive when ALF is off.

Bandwidth measurements tool in DMVR SW requires bug fix.

Decision (CTC): It is agreed to disable MIP for the LD configurations, as the runtime increase for some sequences is high.

The chroma loss in LMCS is likely due to the increase in rate due to LM. Results show that the chroma SNR is still increased at same QP.

It is mentioned that LFNST shows loss on chroma (also in PSNR) for the LB case. Some concern is raised that this may be due to the fact that LB was not included in the training of the matrices.

[JVET-P0014](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8529) JVET AHG report: Operation modes for low latency support (AHG14) [J.-M. Thiesse, S. Deshpande, A. Duenas, Hendry, K. Kazui, R. Sjöberg, A. Tourapis]

1 Introduction

At the 15th JVET meeting, the AHG on Operation modes for low latency support was established with the following mandates:

• Define relevant test conditions for the study of low latency modes

• Study and propose low-latency performance assessment criteria/metrics

• Update the implementation in the VTM model for supporting GRA as in JVET-N0865.

• Study a parallel framework for GRA assessment

The regular JVET email reflector was used for discussions (jvet@lists.rwth-aachen.de). There was no discussion on the email reflector regarding AHG14.

2 Related contributions

The following contributions (5) are identified for the AHG.

1. Contribution in CE 2 (3)

JVET-P0022 CE2: Summary Report on Gradual Decoding Refresh [K. Kazui, J.-M. Thiesse, Hendry, L. Wang, K. Kawamura]

JVET-P0112 CE2-3: Wavefront-Based GRA [L. Wang, S. Hong, K. Panusopone (Nokia)]

JVET-P0193 CE2: Gradual Random Access (GRA) using encoder and normative restrictions (Tests 2.1.a, 2.1.b and 2.1.c) [D. Gommelet, J.-M. Thiesse, D. Nicholson (VITEC)]

2. Contributions within AHG8 and AHG17 (2)

JVET-P0128 AHG8: Scalability - GDR [Y. He, A. Hamza (InterDigital)]

JVET-P0356 AHG17: Bitstream constraints on RPL and GDR [R. Sjöberg, M. Pettersson, M. Damghanian (Ericsson)]

3 Recommendations

The AHG recommends to review all related contributions.

AHG was determined no longer be needed.

[JVET-P0015](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8573) JVET AHG report: Quantization control (AHG15) [R. Chernyak, E. François, C. Helmrich, S. McCarthy, A. Segall]

1 Introduction

At the 15th JVET meeting, the AHG on Quantization control was established with the following mandates:

• Identify methods for quantization step size control for luma and chroma, including spatially and frequency-adaptive approaches

• Develop methods for evaluating quantization step size control operation

• Study the association between transforms and quantization matrices

• Develop testing conditions for evaluating QP signalling improvements including rate control and perceptual optimization strategies as appropriate

• Evaluate the performance of the current VVC QP design using the adaptive quantization control techniques currently available in the VTM

2 Activities

The regular JVET e-mail reflector was used for discussions (jvet@lists.rwth-aachen.de) with [AHG15] in message headers. There was one email besides AHG kickoff message sent to the JVET reflector during the AHG period.

3 Related contributions

Input documents related to AHG15 are summarized in 6.9.

4 Recommendations

The AHG recommends to:

• Review all related contributions;

• Continue investigating VTM Quantization control techniques.

•

[JVET-P0016](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8443) JVET AHG report: Implementation studies (AHG16) [M. Zhou, J. An, E. Chai, K. Choi, S. Sethuraman, T. Hsieh, X. Xiu]

The AHG was established with the following mandates:

• Study draft and proposed coding tools to identify implementation issues relating to decoder pipelines, decoder throughput, and other aspects of implementation difficulty.

• Solicit hardware analysis of complex tools.

• Provide feedback on potential solutions to address identified issues.

1 Activities

Active email discussions were held on the main JVET email reflector (jvet@lists.rwth-aachen.de) with an [AHG16] indication on message headers. A summary of the AHG activities is provided as follows:

1.1 Topics discussed on the email reflector

1) VVC subpicture support (also for AHG12/AHG17)

a. Confirm understanding of the adoption and design philosophy.

b. Provide feedback on the implementation implications.

c. Motivate development of alternative approaches to reduce the implementation impact while still satisfying the general subpicture functionality.

2) Design inconsistency in the de-blocking of the affine mode and TPM mode.

a. In the affine mode, two 4x4 subblock edges can be treated differently even if they have the exactly same conditions (i.e. having no non-zero coefficients and the same amount of large enough MV differences that can trigger de-blocking along the edge).

b. In the TPM mode, an inner TU edge with no non-zero coefficients can still be de-blocked if the edge is located along the diagonal TPM boundary and the triangle block MV difference is large enough to trigger de-blocking.

1) 16-bit overflow issue in the newly adopted PROF (Prediction Refinement with Optical Flow)

a. The adopted version of PROF does not include the clipping of the refinement offset to 14-bit that was in the original PROF proposal.

b. The prediction samples after the PROF refinement can exceed 16-bit, which overflows the 16-bit multiplication logic in the weighted prediction.

2) Tile column boundary processing

a. It was proposed to disable the longer-tap de-blocking filtering along the vertical CTU boundary as well, to reduce the column buffer size for decoder implementations that run in the tile-scan order (instead of raster scan order).

b. It was commented that such a change is not needed from the decoder point of view, as there is already an existing standard to support that requires 18-sample wide column buffers for in-loop filters. The VVC so far requires 15-sample wide column buffers.

c. It was commented that the is not required from the encoder point of view, as there are multiple ways to achieve quality and cost trade-offs on the encoder side.

3) ALF sample padding

a. There two padding methods defined in the current draft, i.e. the repetitive padding and the ALF virtual boundaries (VB) mirrored padding.

b. For the ALF filtering, the repetitive padding is applied to the picture boundaries and to the 360 video VBs that are not CTU boundary aligned.

c. For the ALF filtering, the ALF VB mirrored padding is applied to the sub-picture/slice/tile/brick boundaries and to the 360 video VBs that are CTU boundary aligned.

d. For the 4x4 based ALF classifications, the repetitive padding is applied along all the boundaries.

e. It was asserted that the current design causes implementation difficulties.

f. To simply the design and to improve the design consistency, it was advocated using the ALF VB mirrored padding along the ALF VBs only and the repetitive padding everywhere else, and considering the removal of the 360 VBs that are not CTU boundary aligned.

1.2 Feedback provided on tools being tested in CEs

1) RPR (Reference Picture Resampling)

a. Recommended modifying the down-sampling filter coefficients to avoid overflowing the 16-bit weighted prediction logic.

b. Recommended using the 6-tap filters for affine motion compensation.

2) GEO (Geometric partitions)

a. The partial transform is sort of “generalized SBT”, populating the residual data from the received partial transform block (which also includes the residual padding to mitigate potential visual artefacts in de-blocking) to the coding unit creates an additional processing step in the inverse transform.

b. Using the sample weights to select motion vectors for the GEO motion context storage requires a decoder either to compute the sample weights twice or to carry the sample weights through multiple pipeline stages until they are consumed by the GEO MC.

c. The need of supporting up to 140 GEO partitioning types is likely a concern too (the current TPM has only two partitioning types).

3) Using DMVR-refined MVs in de-blocking

a. Recommended to use the refined MVs along the both sides of a vertical CTU boundary. Otherwise, the un-refined MVs along the vertical CTU boundary would also need to be passed from the MV reconstruction block to the DMVR block.

4) Combined bilateral and SAO filter

a. Recommended to use the repetitive padding (as opposed to the ALF VB mirrored padding) to simply the design.

5) Cross-component ALF (CCALF)

a. Suggested to cut the filter coefficient precision from 11-bit to 8-bit, to reduce the number of multiplications, and to align the CCALF on/off granularity with the existing ALF design (i.e. CTU based on/off).

1.3 Additional comments posted on the email reflector

1) The newly adopted CU level dual tree that removes the 2x2/4x2/2x4 chroma intra prediction blocks has re-introduced 4x4 inter PUs back into the design. This should be fixed.

2) It is desirable to lower the worst case number of context coded bins per residual from 2 to 1.75 in the transform skip residual coding. This change would improve the overall CABAC throughput and make the CABAC design more consistent. Currently the worst case number in the transform coefficients coding is 1.75 context coded bins per coefficient.

3) It is worth taking a second look whether the shared merge is absolutely essential for the small block size IBC merge list derivation. The shared merge requires more conditional checks and more bookkeeping to keep up with the required throughput.

4) The multiplication overhead of the CCALF being tested in the CE is about 50% of the current luma and chroma ALF design, while the expected gain is about 1% (on the top of existing ~5% ALF gain in RA). It would be desirable to study whether a better trade-off exists outside the CE.

1.4 Memory bandwidth study for VTM6.0

Broadcom conducted a memory bandwidth study by running both the VTM6.0 and VTM5.0 for CTC with a commercial motion compensation cache model integrated. The summary results of the random access configuration are provided in the Table 1 (for informational purposes).

For class A1 and A2 4K video both the average (see ABW\_diff column) and the peak memory bandwidth consumption (see MBW\_diff column) are slightly increased. Changing the DMVR reference block padding to 16x16 based and the adoption of PROF do not have a noticeable impact on the memory bandwidth consumption as expected.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access Main 10** | | | | | | | |
|  | **Over VTM-5.0** | | | | | | | |
|  | Y | U | V | TCM\_diff | ABW\_diff | MBW\_diff | EncT | DecT |
| Class A1 | -3.36% | -0.91% | -5.52% | 0.38% | 1.29% | 1.29% | 93% | 112% |
| Class A2 | -3.81% | -4.62% | -4.39% | 0.88% | 1.82% | 1.60% | 94% | 113% |
| Class B | -1.74% | -8.44% | -7.61% | 0.43% | 1.18% | -3.30% | 95% | 117% |
| Class C | -0.97% | -8.36% | -6.25% | -0.25% | 0.46% | -0.71% | 91% | 115% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -2.27% | -6.15% | -6.19% | 0.36% | 1.19% | -0.28% | 93% | 115% |
| Class D | -0.43% | -6.82% | -3.99% | -0.71% | -0.09% | 1.49% | 92% | 127% |
| Class F (optional) | -1.10% | -7.65% | -6.59% | -1.27% | -0.16% | -0.31% | 89% | 125% |

***Table 1. Memory bandwidth comparison (VTM6.0 vs. VTM5.0, RA)***

Where

• TCM\_diff : Total cache misses (over all the frames coded), percentage difference relative to VTM5.0.

• ABW\_diff: Average memory bandwidth (over all the frames coded), percentage difference relative to VTM4.0.

• MBW\_diff : Worst case (Max) memory bandwidth (among all the frames coded), percentage difference relative to VTM5.0.

MBW\_diff is the most important measure, which shows the worst case memory bandwidth consumption difference of VTM6.0 relative to VTM5.0.

1.5 Bin to bit ratio study for VTM6.0

It has been reported that the bin to bit ratio has decreased from VTM5.0 to VTM6.0, and returned to a similar level as VTM4.0, thanks to the reduction of the maximum number of context coded bins from 2 to 1.75 per coefficient in the transform coefficient coding. The summary results are provided in Table 2 and Table 3 for informational purposes (data from JVET-P0050).

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***Bin2bit ratio (peak, weighted)*** | | | | | | | | | | |
|  | HM16.19 | VTM4.0 | VTM5.0 | VTM6.0 | diff (%, VMT4.0 vs. HM16.19) | diff (%, VMT5.0 vs. HM16.19) | diff (%, VMT6.0 vs. HM16.19) | diff\* (%, VMT5.0 vs. VTM4.0) | diff\* (%, VMT6.0 vs. VTM5.0) | diff\* (%, VMT6.0 vs. VTM4.0) |
|  | ***QP = (22, 27, 32, 37), CTC*** | | | | | | | |  |  |
| ***AI*** | 0.95 | 1.10 | 1.13 | 1.14 | 15.72% | 19.71% | 19.89% | 3.99% | 0.18% | 4.17% |
| ***RA*** | 0.93 | 1.09 | 1.12 | 1.13 | 17.39% | 20.88% | 21.70% | 3.49% | 0.82% | 4.31% |
| ***LDB*** | 0.96 | 1.09 | 1.13 | 1.13 | 13.34% | 16.99% | 17.14% | 3.64% | 0.16% | 3.80% |
| ***LDP*** | 0.96 | 1.09 | 1.13 | 1.13 | 13.24% | 17.30% | 17.21% | 4.06% | -0.09% | 3.97% |
|  | ***QP = (2, 7, 12, 17), 100 frames*** | | | | | | | |  |  |
| ***AI*** | 0.79 | 0.94 | 0.95 | 0.93 | 18.11% | 20.24% | 17.71% | 2.12% | -2.53% | -0.40% |
| ***RA*** | 0.74 | 0.87 | 0.88 | 0.86 | 17.17% | 19.00% | 15.15% | 1.83% | -3.85% | -2.02% |
| ***LDB*** | 0.78 | 0.92 | 0.93 | 0.92 | 17.67% | 19.67% | 17.73% | 2.00% | -1.94% | 0.06% |
| ***LDP*** | 0.78 | 0.92 | 0.93 | 0.92 | 17.46% | 19.46% | 17.52% | 2.00% | -1.94% | 0.06% |
| ***Note\*: Percentage difference is measured against HM16.19*** | | | | | | | | |  |  |

***Table 2. Bin to bit ratio in VTM4.0, VTM5.0 and VTM6.0 (weighted)***

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***Bin2bit ratio (peak, unweighted)*** | | | | | | | | | | |
|  | HM16.19 | VTM4.0 | VTM5.0 | VTM6.0 | diff (%, VMT4.0 vs. HM16.19) | diff (%, VMT5.0 vs. HM16.19) | diff (%, VMT6.0 vs. HM16.19) | diff\* (%, VMT5.0 vs. VTM4.0) | diff\* (%, VMT6.0 vs. VTM5.0) | diff\* (%, VMT6.0 vs. VTM4.0) |
|  | ***QP = (22, 27, 32, 37), CTC*** | | | | | | | |  |  |
| ***AI*** | 1.23 | 1.38 | 1.40 | 1.38 | 12.38% | 14.21% | 12.91% | 1.82% | -1.30% | 0.53% |
| ***RA*** | 1.21 | 1.38 | 1.40 | 1.39 | 13.75% | 15.25% | 14.36% | 1.50% | -0.89% | 0.61% |
| ***LDB*** | 1.24 | 1.37 | 1.39 | 1.38 | 11.25% | 12.88% | 11.57% | 1.63% | -1.30% | 0.32% |
| ***LDP*** | 1.23 | 1.37 | 1.39 | 1.38 | 11.08% | 13.02% | 11.49% | 1.94% | -1.53% | 0.42% |
|  | ***QP = (2, 7, 12, 17), 100 frames*** | | | | | | | |  |  |
| ***AI*** | 1.19 | 1.31 | 1.33 | 1.31 | 10.45% | 11.40% | 9.85% | 0.95% | -1.55% | -0.60% |
| ***RA*** | 1.18 | 1.28 | 1.28 | 1.27 | 7.63% | 8.39% | 6.87% | 0.76% | -1.52% | -0.76% |
| ***LDB*** | 1.18 | 1.30 | 1.31 | 1.29 | 9.54% | 10.28% | 8.98% | 0.74% | -1.30% | -0.56% |
| ***LDP*** | 1.18 | 1.30 | 1.31 | 1.29 | 9.50% | 10.24% | 8.94% | 0.74% | -1.30% | -0.56% |
| ***Note\*: Percentage difference is measured against HM16.19*** | | | | | | | | | | |

***Table 3. Bin to bit ratio in VTM4.0, VTM5.0 and VTM6.0 (un-weighted)***

In Table 2 and Table 3, a bypass bin is counted as 0.25 context coded bins in the weighted measurements; and a bypass bin and a context coded bin carry an equal weight (1:1) in the unweighted measurements.

As far as low-QP AI configuration is concerned, the weighted and un-weighted bin to bit ratio of the VTM6.0 is roughly 18% and 10% higher than that of VTM16.19, respectively.

2 Related contributions

Various contributions in different categories are identified being relevant to the AHG.

3 Recommendations

The AHG recommends reviewing the input contributions.

[JVET-P0017](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8503) JVET AHG report: High-level syntax (AHG17) [R. Sjöberg, J. Boyce, S. Deshpande, M. Hannuksela, R. Skupin, A. Tourapis, Y.-K. Wang, W. Wan, S. Wenger]

Discussion Tuesday 1545 (GJS)

This AHG report summarizes the activities of the AHG on High-level syntax (HLS) between the 15th JVET meeting in Gothenburg, SE (3–12 July 2019).and the 16th JVET meeting in Geneva, CH (1–11 October 2019).

It was reported that the estimated number of input contributions related to high-level syntax has increased from 123 at the 15th JVET meeting to 137 at this 16th meeting (10%).

The number of related contributions in particular categories was summarized as:

|  |  |
| --- | --- |
| **Category** | **HLS inputs (AHG estimation)** |
| Layered coding and resolution adaptivity (AHG8) | 36 |
| High-level parallelism and coded picture regions (AHG12) | 46 |
| Gradual random access (CE2) | 3 |
| High level tool control | 5 |
| SEI messages | 6 |
| Other general high-level syntax (AHG17) | 41 |
| Total | 137 |

It is noted that the first two days of the 16th meeting in Geneva were previously announced to be devoted to high-level syntax related topics.

An email conversation was conducted on the reflector labeled AHG12/AHG16/AHG17 based on a slide deck submitted by a member company regarding analysis of subpicture grid approach.

The AHG noted the following summary contribution

* JVET-P0687 contains a summary of HLS proposals on access unit delimiter, picture header, and slice header parameters signalling

The AHG recommended that this JVET meeting is planned such that there is enough time allocated to review high-level syntax related contributions.

[JVET-P0018](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8574) JVET AHG report: Lossless and near-lossless coding tools (AHG18) [T. Nguyen, T.-C. Ma, M. Ikeda, S. Iwamura, H. Jang, X. Zhao]

1 Introduction

The JVET established the AHG 18 at the Gothenburg meeting with the following mandates:

• Study coding tools for lossless and near-lossless coding, including transform skip, BDPCM, and other potential technologies

• Consider the interaction between coding tools and other processing such as loop filtering and LMCS for lossless and near-lossless coding

• Develop proposals for lossless and near-lossless coding for chroma and non-YCbCr colour space content

• Consider throughput bottlenecks for lossless and near-lossless coding at high resolutions and frame rates

2 Activities

Discussions related to AHG18 used the JVET email reflector (jvet@lists.rwth-aachen.de), and the AHG chairs sent a kick-off message on 27th August 2019. In total, the participants exchanged 18 emails related to the AHG.

The AHG identified the following issues:

• Design of the lossless support in VVC

• Mixed lossy/lossless

• BDPCM not activated (due to implementation) for lossless

The AHG chairs provided a reference implementation that reused the existing cu\_transquant\_bypass syntax in the VTM-6.0 software. Note that the syntax is not part of the current VVC Draft. The AHG chairs also provided lossless results using the sequences specified for the CTC, generated with HM-16.20 as representative for HEVC Main/Main10 and HEVC RExt.

The results for HEVC RExt relative to HEVC Main/Main10 are as follows.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | **Random Access** | | |
| **ratio** | | bit-rate savings | **ratio** | | bit-rate savings |
| HM-16.20 | HM-16.20 RExt | HM-16.20 | HM-16.20 RExt |
| Class A1 | 2.1 | 2.2 | -5.25% | 2.2 | 2.3 | -4.07% |
| Class A2 | 1.7 | 1.8 | -5.87% | 1.8 | 1.9 | -4.51% |
| Class B | 2.0 | 2.1 | -4.84% | 2.2 | 2.3 | -2.00% |
| Class C | 2.0 | 2.1 | -5.34% | 2.5 | 2.6 | -1.93% |
| Class D | 1.8 | 2.0 | -7.45% | 2.6 | 2.7 | -2.64% |
| Class E | 2.7 | 3.0 | -8.19% |  |  |  |
| Class F | 4.5 | 5.2 | -11.93% | 30.3 | 35.5 | -9.73% |
| TGM | 6.2 | 8.2 | -23.29% | 81.3 | 106.3 | -20.34% |
| **Overall** | **2.1** | **2.2** | **-5.75%** | **2.2** | **2.3** | **-2.89%** |
| Enc Time[%] | 94% | | | 106% | | |
| Dec Time[%] | 94% | | | 94% | | |

The results for VVC VTM-6.0 relative to HEVC Main/Main10 are as follows.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | **Random Access** | | |
| **ratio** | | bit-rate savings | **ratio** | | bit-rate savings |
| HM-16.20 | VTM6 | HM-16.20 | VTM6 |
| Class A1 | 2.1 | 2.2 | -5.97% | 2.2 | 2.3 | -4.87% |
| Class A2 | 1.7 | 1.7 | -3.63% | 1.8 | 1.9 | -3.18% |
| Class B | 2.0 | 2.1 | -4.21% | 2.2 | 2.3 | -3.20% |
| Class C | 2.0 | 2.1 | -5.47% | 2.5 | 2.6 | -3.52% |
| Class D | 1.8 | 1.9 | -5.69% | 2.6 | 2.8 | -3.87% |
| Class E | 2.7 | 2.9 | -7.62% |  |  |  |
| Class F | 4.5 | 5.5 | -16.21% | 30.3 | 39.4 | -13.89% |
| TGM | 6.2 | 12.3 | -45.77% | 81.3 | 112.6 | -29.01% |
| **Overall** | **2.1** | **2.2** | **-5.26%** | **2.2** | **2.3** | **-3.62%** |
| Enc Time[%] | 5667% | | | 1613% | | |
| Dec Time[%] | 193% | | | 157% | | |

The results for VVC VTM-6.0 relative to HEVC RExt are as follows.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | **Random Access** | | |
| **ratio** | | bit-rate savings | **ratio** | | bit-rate savings |
| HM-16.20 RExt | VTM6 | HM-16.20 RExt | VTM6 |
| Class A1 | 2.2 | 2.2 | -0.75% | 2.3 | 2.3 | -0.83% |
| Class A2 | 1.8 | 1.7 | 2.41% | 1.9 | 1.9 | 1.44% |
| Class B | 2.1 | 2.1 | 0.71% | 2.3 | 2.3 | -1.21% |
| Class C | 2.1 | 2.1 | -0.13% | 2.6 | 2.6 | -1.62% |
| Class D | 2.0 | 1.9 | 1.95% | 2.7 | 2.8 | -1.25% |
| Class E | 3.0 | 2.9 | 0.62% |  |  |  |
| Class F | 5.2 | 5.5 | -5.07% | 35.5 | 39.4 | -4.80% |
| TGM | 8.2 | 12.3 | -29.76% | 106.3 | 112.6 | -10.17% |
| **Overall** | **2.2** | **2.2** | **0.55%** | **2.3** | **2.3** | **-0.71%** |
| Enc Time[%] | 6022% | | | 1529% | | |
| Dec Time[%] | 205% | | | 167% | | |

3 Related contributions

Contributions are listed in 6.13. The AHG chairs also found out that several contributions related to the interaction between deblocking filter and other coding tools were input to this meeting. It is recommended that these contributions are reviewed in combination with CE5 and AHG16 discussions which also focus on deblocking filter process.

4 Recommendations

The AHG recommends:

• To review all related contributions

• Solving the aspect on the design for lossless support

• To continue the investigation on lossless and near-lossless performance of VVC

Current results show that current VTM6 anchor of the AHG does not have benefit over RExt.

Screen content probably benefits from IBC.

Further actions to be decided after review of input contributions. Would be desirable to support lossless coding in a non-specific profile if it comes for free without substantial change of tools.

# Project development (X)

Contributions in this category were discussed XXday X Oct. XXXX–XXXX (chaired by XXX)

## Text and software development and general guidance (1)

[JVET-P0113](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7902) AHG2: Editorial input on VVC draft text [Y.-K. Wang (Futurewei), B. Bross (HHI), J. Chen (Futurewei), G. J. Sullivan (Microsoft)] [late]

Discussed Thursday 0925 (GJS & JRO)

This is input from editors which should be checked for issues and used as the basis for integration of proposals.

Discussed Thursday 10 Oct ~2000 Track B (GJS). Decision (editorial & BF): Adopted as the text basis.

USNB comment 1: Decision (Ed.): Move VUI except field sequence flag to the SEI spec (fixing bracket problem in VUI).

US 3: Decision (Ed.): Editors check/ensure that prior constraints for SEI interface have been preserved.

It was noted that AVC and HEVC support having different chroma location types for top and bottom fields when the pictures are frames (only providing chroma\_sample\_loc\_type\_frame), but VVC current does not. Further study was encouraged to determine if this should be changed.

## Test conditions (1)

[JVET-P0345](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8134) Low-Delay B encoder configuration proposal [F. Le Léannec, R. Jullian, E. François (InterDigital)]

Discussed in plenary Fri. 1000 (GJS & JRO).

Proposes extending GOP to 8 (which provides significant coding gain ~4.9% and reduces encoder runtime ~7%).

There had been no subjective observation by the contributor.

Decision (CTC): Adopted.

[JVET-P0958](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8773) Crosscheck of JVET-P0345: Low-Delay B encoder configuration proposal [S. Yoo, J. Lim (LGE)]

## Performance assessment (3)

[JVET-P0328](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8117) AHG10: Performance of the GOP-based temporal filter in VTM-6.1 [J. Enhorn, R. Sjöberg, J. Ström, P. Wennersten (Ericsson)]

[JVET-P0616](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8410) AHG13: Compression performance analysis for 8K HLG sequences [S. Nemoto, S. Iwamura, A. Ichigaya (NHK), K. Kazui (Fujitsu)] [late] [miss]

[JVET-P0622](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8417) AHG13: Low Delay results for Affine, ALF and DBF (Class A included) [M. Sychev (Huawei)] [late]

## Coding studies on specific use cases (0)

## Test material (0)

## Conformance (6)

[JVET-P0388](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8177) On VVC Conformance [J. Boyce, I. Moccagatta (Intel), L. Litwic (Ericsson), A. Stein (Technicolor), S. McCarthy, W. Husak, B. Lee (Dolby)]

Discussed in plenary Sunday 6 October 1645 (GJS & JRO)

Successful market adoption of VVC will be facilitated by timely availability of conformance bitstreams and a conformance specification for VVC.

This contribution proposes to form an ad hoc group on VVC conformance with the following mandates:

* Study the requirements of VVC conformance testing to ensure interoperability.
* Draft a work plan, including timeline, for preparation of a conformance specification.
* Study potential testing methodology to fulfill the requirements of VVC conformance testing.
* Draft a work plan, including timeline, for preparation of a conformance bitstream.

The above mandates are adapted from the initial mandates of the ad hoc group on HEVC conformance (JCTVC-I\_Notes\_dI, Geneva, 2012).

The first version of VVC is expected to include capabilities that were not included in the first version of HEVC, but were added in later HEVC extensions. Some of these VVC capabilities are not included in the JVET common test conditions. It is noted that the conformance specifications for some of the HEVC extensions were significantly delayed relative to the corresponding specification text and reference software. Therefore, this contribution also proposes a provisional timeline for delivery of initial and final conformance bitstreams, which is proposed to include identification of responsible experts for providing bitstreams to test particular tools prior to finalization of the VVC standard.

Preliminary timeline agreement:

* 16th meeting Oct. 2019: Form ad hoc group on VVC conformance, first draft list of conformance bitstreams
* 17th meeting Jan. 2020: Preliminary guidelines for bitstream preparation (e.g., naming conventions), improved list of conformance bitstreams
* 18th meeting Apr. 2020: Final guidelines for bitstream preparation and improved list of conformance bitstreams with identified responsible experts, initial bitstreams provided
* 19th meeting July 2020: Confirmed list of bitstreams to be included in v1, collection of bitstream candidates for CD ballot at next meeting
* 20th meeting Oct. 2020: CD of conformance specification
* 21st meeting Jan. 2021: Final bitstreams provided, DIS ballot in ISO/IEC
* 22nd meeting April 2021: No action pending DIS ballot
* 23rd meeting July 2021: Final conformance specification

[JVET-P0894](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8709) Preliminary text for Annex A: Profiles, tiers and levels [J. Boyce (Intel)] [late]

Discussed in plenary Sunday 6 October 1645 (GJS & JRO)

Preliminary text is proposed for Annex A: Profiles, tiers and levels, as a starting point for further discussion and study. Two initial profiles are proposed: Main 10 and Main 4:4:4 10. Tiers and levels are copied from HEVC.

The proposed Main 10 profile includes support for 4:2:0 and monochrome, and the proposed Main 4:4:4 10 profile adds support for 4:2:2 and 4:4:4.

No coding tools currently included within the specification are excluded from the proposed profiles.

The two tiers from HEVC are included – High and Main. The levels parameters are copied from HEVC, and have the same resolutions and bitrates. maxDpbPicBuf is increased to 7 from 6 in HEVC.

Some issues requiring additional discussion (not comprehensive):

* Level bitrate limits
* Subpictures
  + Max number and/or minimum size
  + Bitrate limits per subpicture
* Bin limits (based on bitrate or absolute?)
* Reference picture list size limits
* Reference picture resampling ratio restrictions
* Numbering scheme for profiles. (Share general\_profile\_idc value for multiple profiles, as in RExt?)

It was discussed whether 4:2:2 should be supported in a 4:4:4 profile.

Decision: Adopt, but with a maxDpbPicBuf of 8 rather than 7 (see notes for P0133).

[JVET-P0133](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7922) AHG17: DPB size analysis of VTM6.0 using RA configuration in current CTC [X. Ma, H. Yang (Huawei)]

Discussed in plenary Sunday 6 October 1745 (GJS & JRO)

Other contributions on this topic JVET-O0667, JCTVC-AJ0030, JCTVC-AK0030.

This contribution provides an analysis of the decoded picture buffer (DPB) size of VTM6.0 using RA configuration in current CTC. It is found that the DPB size can achieve 7 in VTM, which is different from the value of high level syntax sps\_max\_dec\_pic\_buffering\_minus1+1. It is suggested to modify the GOP structure to constrain the DPB size to be consistent with the syntax value.

The content of this contribution basically is the same as JVET-O0667, only the test result is updated using VTM6.0.

It was commented that the software does things a bit differently and does not provide output timing analysis. Only a few people had tried to check the validity of the problem, but it did appear that the current configuration is a problem for HEVC.

With the alternative proposed structure, the overall impact was 0.70% in RA (more impact at lower resolutions).

It was noted that Q15-C-11 had a proposal of up to 50 reference pictures.

It was commented that GOP size of 32 was subjectively even better.

It was suggested that, considering that memory is not as difficult to support as it once was, to go ahead and specify maxDpbPicBuf equal to 8 at this time. See notes above for P0894.

[JVET-P0099](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7888) Level limits for number of luma samples, tiles, and subpictures [M. M. Hannuksela (Nokia)]

[JVET-P0295](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8084) Level restrictions on maximum tile width for line buffer reduction [M. Ikeda, Y. Yagasaki, T. Suzuki (Sony)]

[JVET-P0389](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8178) Proposal of preliminary list of VVC conformance bitstreams [I. Moccagatta, J. Boyce (Intel)]

## Implementation (3)

[JVET-P0207](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7996) Mobile based heterogeneous multi-core for a VVC Decoder [W. Liu, Y. B. Cho (??)]

[JVET-P0307](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8096) Early Implementation of VVC software player and Demonstration on Mobile devices [J. R. Arumugam, S. Kotecha, S. Ramamurthy, A. Chelawat, Jayasanker J., A. K. Bedgujar, N. M. Thomas, S. Agrawal, Vijayakumar G. R., K. Patankar (Ittiam)]

[JVET-P0973](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8788) Development of a VVC Live Software Decoder [A. Wieckowski, G. Hege, C. Bartnik, C. Lehmann, C. Stoffers, J. Brandenburg, T. Hinz, B. Bross, H. Schwarz, D. Marpe, T. Schierl, T. Wiegand (HHI)] [late]

# Core Experiments

## CE1: Reference picture resampling filters (4)

Contributions in this category were discussed XXday X Oct. XXXX–XXXX in Track X (chaired by XXX).

[JVET-P0021](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8424) CE1: Summary report on reference picture resampling filters [J. Luo, V. Seregin, W. Wan]

Discussed Thursday 3 October Track B (GJS).

This contribution provides a summary report of Core Experiment 1 on reference picture resampling filters.

All techniques as planned in the context of CE1 are implemented on top of and tested against VTM-6.1 with the affine patch distributed with the CE1 description. Simulation results and crosschecking reports of each test specified in this document are provided.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test #** | **Description** | **Source** | **Tester** | **Cross-checker** |
| CE1-1.1 | Use integer version of 8-tap Lanczos2 filter when reference picture is larger than current picture | JVET-O0240 | Jonatan Samuelsson  samuelssonj@sharplabs.com | Peisong Chen  [peisong.chen@broadcom.com](mailto:peisong.chen@broadcom.com)  Krishna Rapaka  [krapaka@apple.com](mailto:krapaka@apple.com) |
| CE1-1.2 | Use integer version of 8-tap Lanczos1 filter when reference picture is larger than current picture | JVET-O0240 | Jonatan Samuelsson  samuelssonj@sharplabs.com | Peisong Chen  [peisong.chen@broadcom.com](mailto:peisong.chen@broadcom.com)  Krishna Rapaka  [krapaka@apple.com](mailto:krapaka@apple.com) |
| CE1-1.3 | Use integer version of 8-tap Lanczos2.67 filter when reference picture is larger than current picture | JVET-O0240 | Jonatan Samuelsson  samuelssonj@sharplabs.com | Peisong Chen  [peisong.chen@broadcom.com](mailto:peisong.chen@broadcom.com)  Krishna Rapaka  [krapaka@apple.com](mailto:krapaka@apple.com) |
| CE1-2.1 | Use 9-tap downsampling when the reference picture is larger than the current picture, and extended SHVC filters for upsampling when it is smaller. Resampling and motion compensation are done in one stage as in VTM. | JVET-O0319 | Pankaj Topiwala  pankajtva@gmail.com |  |
| CE1-2.2 | Use 9-tap downsampling when the reference picture is larger than the current picture, and extended SHVC filters for upsampling when it is smaller. Resampling is done separately from motion compensation.  The tester clarified that this test is not conforming to the agreed CTC of CE1. It is agreed that this test is removed from CE1. | JVET-O0319 | Pankaj Topiwala  pankajtva@gmail.com |  |
| CE1-3 | Use SHM filters for downsampling | JVET-O0641 | Mohammed Golam Sarwer  m.sarwer@alibaba-inc.com | Vadim Seregin  [vseregin@qti.qualcomm.com](mailto:vseregin@qti.qualcomm.com) |

CE 1-1.X is to test downsampling filters

It was commented that arbitrary scaling ratios are not especially difficult to support (e.g., versus supporting only 2x or only 2x and 1.5x).

An extreme ratio could be an issue. Currently the text restrict the ratio range of the reference picture relative to the current picture from 1/8 (upsampling) to 2 (downsampling).

Test cases:

* 1.5:1
* 2:1
* 4:1 optional

PSNR1 is "codec PSNR"

PSNR2 is high-res to high-res end-to-end.

Resampling ratio 1.5 : 1

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay Main 10 PSNR1** | | | | | **Low delay B Main10 PSNR2** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 1-1.1  Lanczos2 (8) | 1.12% | 1.00% | 1.19% | 100% | 102% | 0.97% | 0.76% | 0.97% | 100% | 102% |
| 1-1.2  Lanczos1 (8) | - | - | - | - | - | - | - | - | - | - |
| 1-1.3  Lanczos2.67 (8) | -2.23% | -1.23% | -1.06% | 100% | 102% | -1.85% | -1.68% | -1.34% | 100% | 102% |
| 1-2.1 (9) | - | - | - | - | - | - | - | - | - | - |
| 1-3  SHM-A (12) | -3.13% | -2.50% | -2.28% | 99% | 101% | -2.23% | -2.21% | -1.87% | 99% | 101% |

Resampling ratio 2 : 1

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay Main 10 PSNR1** | | | | | **Low delay B Main10 PSNR2** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 1-1.1 Lanczos2 | -4.45% | -2.70% | -2.47% | 100% | 100% | -2.89% | -1.79% | -1.72% | 100% | 100% |
| 1-1.2 Lanczos1 | 2.97% | 1.74% | 1.63% | #DIV/0! | #DIV/0! | 2.18% | 1.43% | 1.27% | #DIV/0! | 99% |
| 1-1.3 Lanczos2.67 | -2.80% | -1.95% | -1.83% | 99% | 99% | -1.77% | -1.28% | -1.25% | 99% | 99% |
| 1-2.1 | -2.05% | 1.17% | 0.77% | N/A | N/A | -0.25% | 1.39% | 1.02% | N/A | N/A |
| 1-3  SHM-B | -6.47% | -4.55% | -4.62% | 99% | 102% | -3.98% | -2.67% | -3.00% | 99% | 102% |

Resampling ratio 4 : 1 (Optional)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay Main 10 PSNR1** | | | | | **Low delay B Main10 PSNR2** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 1-1.1 Lanczos2 | -3.48% | -6.81% | -6.77% | 99% | 99% | -1.63% | -3.36% | -3.30% | 99% | 99% |
| 1-1.2 Lanczos1 | -9.47% | -9.10% | -9.16% | 99% | 99% | -4.57% | -4.74% | -4.76% | 99% | 99% |
| 1-1.3 Lanczos2.67 | - | - | - | - | - | - | - | - | - | - |
| 1-2.1 | - | - | - | - | - | - | - | - | - | - |
| 1-3  SHM-C | - | - | - | - | - | - | - | - | - | - |

The resampling assumed type 2 (collocated), although the content was actually type 0.

It was agreed in principle that the design needs to support adjusting the phase to match the chroma location. This is more relevant to a case where you would actually watch the lower resolution video without upsampling it back to the higher resolution, and what matters most is just whether the upsampling is matched to the downsampling.

The SHM has 12 taps.

It was commented that dynamic range analysis confirmed that there is no problem with the proposed filters (which are all 8 taps with 6 bit magnitude coefficients) – they fit within 16 bit – see JVET-P0855.

Decision: Adopt CE1-1.3 for the 1.5:1 case (after non-CE consideration). When resampling, the same filter is applied for all positions with no special treatment of half-pel positions. Switching points are 1.25 and 1.75 – see P0088 for details (it needs a fix for the half pel case).

(For the 2:1 case, see notes for P0353.)

[JVET-P0083](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7872) CE1-3: Reference picture resampling filters [J. Luo, M. Sarwer, Y. Ye, (Alibaba)] [late]

[JVET-P0088](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7877) CE1-1: RPR downsampling filter [J. Samuelsson, S. Deshpande, A. Segall (Sharp Labs of America)] [late]

[JVET-P0563](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8353) Crosscheck of JVET-P0088: CE1-1: RPR downsampling filter [W. Wan, M. Zhou, P. Chen (Broadcom)] [late]

[JVET-P0628](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8423) CE1-2: RPR Resampling Filters [P. Topiwala, M Krishnan, W. Dai (FastVDO)] [late]

## CE2: Gradual decoding refresh (3)

Contributions in this category were discussed XXday X July XXXX–XXXX in Track X (chaired by XXX).

[JVET-P0022](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8403) CE2: Summary Report on Gradual Decoding Refresh [K. Kazui, J.-M. Thiesse, Hendry, L. Wang, K. Kawamura]

Discussed in Track B Thursday 3 October 1620 (GJS)

A summary of Core Experiment 2 (CE2) on gradual decoding refresh (GDR) is reported. The goal of CE2 is to study GDR tools/methods, for potential inclusion into the VVC standard.

Seven tests were defined in CE2:

– CE2-1: Virtual boundary-based method (4 tests)

– CE2-2: Slice boundary-based method (2 tests) (withdrawn)

– CE2-3: Wavefront-based method (1 test)

All tests are evaluated based on the common test conditions defined in JVET-O2022. All tests and crosscheck results are integrated in this report.

CTC conditions for SDR as agreed at the 15th JVET meeting are used for the evaluation of objective performance. The following constraints are further applied as specified in the CE2 document.

* Low-delay B configuration only
* Interval of GDR or IRAP picture (1.0 second)
* QP setting (no offset for IDR and B picture)
* The GOP size is 1. Each picture refers up to 4 immediately preceding pictures in decoding order

The anchor is the ‘VVC Test Model’ or VTM. The VTM version 6.0 software is used with ‘vtm’ configuration files to produce the VTM anchor. Tools are implemented into the VTM version 6.0 software. Proposals are primarily compared with respect to objective compression efficiency while bitrate fluctuation and “exact match” aspects are also assessed.

Source codes corresponding with the test descriptions contained in this document are uploaded to the following CE2 GitLab project:

<https://vcgit.hhi.fraunhofer.de/jvet-o-ce2/VVCSoftware_VTM.git>

The current draft standard has "virtual boundary" support (vertical or horizontal) for disabling in-loop filtering.

List of tested tools in CE2

|  |  |  |  |
| --- | --- | --- | --- |
| Test # | Short description | Doc. # | Cross-checker |
| CE2-1.a | Virtual boundary-based method   * Vertical virtual boundary * Position accuracy: 8 samples * Encoder-side control on MV search range * Encoder-side control on intra prediction mode restriction * Virtual boundary position signaled in PPS header send at every picture * Filters disabled across virtual boundary * LMCS disabled / CE2-1.a.bis: virtual boundary for LMCS chroma residue scale computation. | [JVET-O0](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5038)100  [JVET-O1048](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5038)  (VITEC) | KDDI |
| CE2-1.b | Virtual boundary-based method, variation of CE2-1.a   * Virtual boundary position signaled in slice header * Encoder-side control on intra prediction mode restriction * Filters disabled across virtual boundary * Encoder-side control on MV search range | [JVET-O0](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5038)100  [JVET-O1048](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5038)  (VITEC) | Nokia |
| CE2-1.c | Virtual boundary-based method, variation of CE2-1.b   * Normative reference sample restriction at virtual boundary for intra prediction * Filters disabled across virtual boundary * Encoder-side control on MV search range | [JVET-O0](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5038)100  [JVET-O1048](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5038)  (VITEC) | Futurewei |
| CE2-1.d *withdrawn* | Virtual boundary-based method, variation of CE2-1.c   * Normative reference sample restriction at virtual boundary for intra prediction * Filters disabled across virtual boundary * Treating virtual boundary as picture boundary for motion compensation | [JVET-O0](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5038)100  [JVET-O1048](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5038)  (VITEC) | Fujitsu |
| CE2-2.a  *withdrawn* | Slice boundary-based method   * Vertical slice boundary * Position accuracy: CTU width * Encoder-side control on MV search range | JVET-O0124  (Futurewei) |  |
| CE2-2.b  withdrawn | Slice boundary-based method, variation of CE2-2.a   * Treating slice boundary as picture boundary for motion compensation | JVET-O0124  (Futurewei) |  |
| CE2-3 | Wavefront-based method   * MV restrictions and in-loop filtering disabled * Virtual boundary syntax is moved to slice header * Virtual boundary syntax signals the start address and the length of intra coded area on wavefront | JVET-O0976  JVET-O0979  (Nokia) | VITEC |

**Refreshing scheme**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Test # | Shape of refreshed area | Signalling of area | Precision of boundary position | Spatial direction of refresh |
| CE2-1.a | Vertically striped | PPS | 8 luma samples | Left to right |
| CE2-1.b | Vertically striped | Slice | 8 luma samples | Left to right |
| CE2-1.c | Vertically striped | Slice | 8 luma samples | Left to right |
| CE2-3 | Diagonally striped | Virtual boundary | GDR block size dependent upon picture size and refresh cycle | Upper left to lower right |

**Method for avoiding contamination of sample from dirty area to clean area**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Test # | In intra prediction | In inter prediction | In MV prediction | In in-loop filtering |
| CE2-1.a | Encoder-side mode restriction | Encoder-side MV restriction | Constrained by limiting the reference frame buffer when recycling (encoder-side restriction) | Disabled at virtual boundary (PPS level) |
| CE2-1.b | Encoder-side mode restriction | Encoder-side MV restriction | Constrained by limiting the reference frame buffer when recycling (encoder-side restriction) | Disabled at virtual boundary (Slice level) |
| CE2-1.c | Avoid the use of reference samples across the virtual boundary (normative) | Encoder-side MV restriction | Constrained by limiting the reference frame buffer when recycling (encoder-side restriction) | Disabled at virtual boundary (Slice level) |
| CE2-3 | Not necessary due to its boundary shape. | Encoder-side MV restriction | TMVP is not used if a CU is inside the clean region. | Disabled at virtual boundary (Slice level) |

**Other aspects**

|  |  |  |
| --- | --- | --- |
| Test # | Additional normative changes | Decoding unit |
| CE2-1.a | Only on CE2-1.a.bis: Picture reconstruction with luma dependent chroma residual scaling process for chroma samples in LMCS – prevent use of pixels across the virtual boundaries | If DU operation is desired, each CTU column can be coded as one tile. One tile one slice. |
| CE2-1.b | Picture reconstruction with luma dependent chroma residual scaling process for chroma samples in LMCS – prevent use of pixels across the virtual boundaries | If DU operation is desired, each CTU column can be coded as one tile. One tile one slice. |
| CE2-1.c | Picture reconstruction with luma dependent chroma residual scaling process for chroma samples in LMCS – prevent use of pixels across the virtual boundaries | If DU operation is desired, each CTU column can be coded as one tile. One tile one slice. |
| CE2-3 | Signalling of the length of intra coded area on wavefront | If DU operation is desired, each CTU column can be coded as one tile. One tile one slice. |

**Other aspects**

|  |  |  |
| --- | --- | --- |
| Test # | Encoding condition | Cross-checker’s comment |
| CE2-1.a | Disabling of LMCS at PPS level. |  |
| CE2-1.b |  | For class F, HashME is disabled. |
| CE2-1.c |  |  |
| CE2-3 | ALF, LMCS and local dual tree are disabled. | ALF, LMCS and local dual tree are disabled.  For class F, IBC, HashME and BDPCM are disabled |

**BD-rate and runtime**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Low-delay B Main10 – Over VTM-6.0 with CE2 condition | | | | | | | | | |
|  | Tester | | | | | Cross-checker | | | | |
| Test # | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| CE2-1.a | Class-C 6.34% | Class-C 5.27% | Class-C 5.61% | Class-C 100% | Class-C 105% |  |  |  |  |  |
| CE2-1.a.bis | Class-C  5.88% | Class-C  6.98% | Class-C  7.58% | Class-C  102% | Class-C  104% | Class-C 5.88% | Class-C 6.98% | Class-C 7.58% |  |  |
| CE2-1.b | 6.54% | 8.86% | 11.14% | 107% | 102% | 6.54% | 8.86% | 11.14% |  |  | |
| CE2-1.c | 5.92% | 8.46% | 10.6% | 108% | 102% |  |  |  |  |  | |
| CE2-3 | Class-C  9.69% | Class-C  10.88% | Class-C  11.43% | Class-C  152% |  | Class-C  9.69% | Class-C  10.88% | Class-C  11.43% |  |  | |

CE2-1.a is basically the anchor. It uses virtual boundary disabling.

CE2-1.b is an encoder-side restriction. There were some indications that there was a bug in this, and an exact match was not achieved.

CE2-1.c considers changing intra prediction at virtual boundary. This did not have a lot of gain relative to the anchor (0.6%), but was suggested by the proponent to be helpful from the encoder perspective).

In CE2-3, ALF, LMCS and local dual tree were disabled, which may be causing the result. There was also a mismatch observed in this case.

An interaction was described between the virtual boundary case and LMCS.

A proponent of CE2-1.c said it could also have a subjective benefit that may exceed the measured PSNR benefit, although this had not been demonstrated to the group.

It was commented that the GDR functionality already has a very large penalty relative to not using it.

It was suggested that virtual boundary signalling be supported in the PH.

Decision: Put virtual boundary signalling in the SPS; if present there, it cannot change. If not present there, it becomes a gated presence in the PPS or PH. J.-M. Thiesse volunteered the text work (and software for handling the syntax). Text for this is in P1006, which puts it in the SPS or PH (not in the PPS). Further study is encouraged for whether to allow it to be indicated in the PPS.

[JVET-P0112](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7901) CE2-3: Wavefront-Based GRA [L. Wang, S. Hong, K. Panusopone (Nokia)] [late]

[JVET-P0193](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7982) CE2: Gradual Random Access (GRA) using encoder and normative restrictions (Tests 2.1.a, 2.1.b and 2.1.c) [D. Gommelet, J.-M. Thiesse, D. Nicholson (VITEC)] [late]

[JVET-P0842](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8657) Crosscheck of JVET-P0193: Gradual Decoding Refresh (GDR) using encoder and normative restrictions (Test 2.1.b) [L. Wang, S. Hong (Nokia)]

## CE3: Intra prediction and mode coding (4)

Contributions in this category were discussed Thursday 3 July 1445–1645 in Track A (chaired by JRO).

[JVET-P0023](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8369) CE3: Summary Report on Intra Prediction and Mode Coding [G. Van der Auwera, L. Li, A. Filippov]

This is the summary report of the third Core Experiment (CE3) [1]. The goal of CE3 is to study intra prediction tools, including mode coding, for potential inclusion into the VVC standard.

A total of 6 tests are defined on the matrix intra prediction (MIP) topic:

• CE3-1: MIP down-sampling process (2 tests)

• CE3-2: On rounding shift of MIP (2 tests)

• CE3-3: Up-sampling with fixed order in MIP (2 tests)

This document summarizes the objective results (BD-rates, runtimes), cross-check reports, and related input contributions.

Each test is covered by at least one cross-checker and the cross-check reports are included within the respective sub-test sections. Within CE3 it was agreed that cross-checkers answer the following questions:

• Did the cross-checker study the software? If so, did the cross-checker find any inconsistencies between the test description, the provided final software, and the VVC spec text changes?

• Do the cross-checked results match the proponent results for the test conditions? Were additional results cross-checked?

• Additional comments that may be helpful to the group?

This report summarizes the answers in tables reporting whether the objective test results match in one table column and all other comments in a second table column. The spreadsheets with cross-checked results are attached to this summary report.

The deadline for providing the cross-check reports to the CE coordinators was 21 September 2019. The following cross-check reports were received late or were missing spreadsheets with cross-checked results:

Test # Date received Comment

CE3-1 27 Sept. 2019 one report Result excels missing for second cross-check of CE3-1.1 and CE3-1.2

|  |  |  |
| --- | --- | --- |
| **Test #** | **Short description** | **Doc. #** |
| 3-1.1 | MIP downsampling by averaging two samples from the original boundary | JVET-P0064 (Ericsson) |
| 3-1.2 | MIP downsampling by N-tap filtering N samples from the original boundary |

CE3-1.1

MIP downsampling process derives reduced boundary *bdryred* for matrix multiplication by averaging two samples from the original boundary.



Figure 1. An example of *bdryred* derivation for a 32 × 16 block.

CE3-1.2

In CE3-1.2, four different M-tap low-pass boundary filters are designed depending on the boundary size.

* For boundary size is equal to 8, M = 2, the filter coefficients to use are [1 1] / 2
* For boundary size is equal to 16, M = 3, the filter coefficients to use are [1 2 1] / 4
* For boundary size is equal to 32, M = 5, the filter coefficients to use are [1 2 2 2 1] / 8
* For boundary size is equal to 64, M = 9, the filter coefficients to use are [1 2 2 2 2 2 2 2 1] / 16



Figure 2. An example of *bdryred* derivation for a 32 × 8 block.



Figure 3. An example of *bdryred* derivation for a 64 × 16 block.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra - Over VTM-6.0** | | | | | **Random Access - Over VTM-6.0** | | | | |
| **Test #** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 3-1.1 | 0.02% | -0.02% | -0.01% | 100% | 100% | 0.01% | 0.07% | 0.04% | 100% | 100% |
| 3-1.2 | 0.03% | 0.01% | 0.03% | 100% | 100% | 0.01% | 0.02% | -0.02% | 100% | 100% |

The original proposal (CE3-1.1) was claiming compression benefit, which is no longer the case from the results of the CE. It is somewhat simpler by using less samples than the current design for block sides >8. It does not reduce the worst case complexity of MIP, therefore not a relevant simplification.

CE3-1.2 is an extension which has similar complexity as current MIP, but does not show compression gain.

CE3-2.1

In this method, a variable (sW), the number of shifts to compute a variable predMip is fixed to 5. The equations are changed as below. Also, the weighting parameters (mWeight) and the offset factor (fO) are modified because the number of shifts was changed from the original design.

oW = ( 1 << 4~~( sW − 1 )~~ ) −( (fO \* ()+1) >> 1)

predMip[ x ][ y ] = ( ( ( ) +   
 oW ) >> 5~~sW~~ ) + pTemp[ 0 ]

Memory storage reduction: 102 bits (= 3 bits \* 34 elements)

CE3-2.2

In this method, the variable (sW) depends on MipSizeId. the sW is set to 6 when MipSizeId is equal to 1. Otherwise, it is set to 5. Thus, the equations are changed as below.

oW = ( 1 << ((MipSizeId==1)? 5:4) ) −( (fO \* ()+1) >> 1)

predMip[ x ][ y ] = ( ( ( ) +   
 oW ) >>  ((MipSizeId==1)? 6:5)~~sW~~ ) + pTemp[ 0 ]

Memory storage reduction: 102 bits (=3 bits \* 34 elements); additional conditions

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra - Over VTM-6.0** | | | | | **Random Access - Over VTM-6.0** | | | | |
| **Test #** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 3-2.1 | 0.03% | -0.01% | 0.02% | 100% | 100% | 0.02% | 0.05% | 0.01% | 101% | 99% |
| 3-2.2 | 0.03% | 0.01% | 0.00% | 100% | 100% | 0.02% | 0.08% | 0.01% | 100% | 100% |

Several experts expressed that CE3-2.1 could be regarded as a desirable cleanup in various aspects. However, it is also noted that there are numerous non-CE proposals that suggest other ways of cleanup. Need to get a better picture which are the aspects desirable to be resolved. This was later done in context of reviewing non-CE contributions. From follow-up discussion Mon 7 Oct.: It removes a table lookup, which would be nice for software. Further, the formula may not be best optimized as this should better be based on the floating point result of the matrix optimization (rather than the quantized version). The current version would not be a candidate for adoption.

CE3-2.2 does not appear to have any benefit.

CE3-3:

|  |  |  |
| --- | --- | --- |
| **Test #** | **Short description** | **Doc. #** |
| 3-3.1 | Up-sampling is performed firstly in the vertical direction and secondly in the horizontal direction | JVET-P0054 (Bytedance) |
| 3-3.2 | Up-sampling is performed firstly in the horizontal direction and secondly in the vertical direction |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test #** | **All Intra - Over VTM-6.0** | | | | | **Random Access - Over VTM-6.0** | | | | |
| **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 3-3.1 | 0.00% | 0.02% | -0.01% | 99% | 100% | -0.01% | 0.04% | 0.01% | 100% | 100% |
| 3-3.2 | 0.00% | -0.01% | 0.01% | 100% | 100% | 0.00% | 0.11% | 0.02% | 100% | 100% |

Current MIP is performing the order of upsampling filters depending on the block shape (upsampling is applied for blocks >8x8 where the prediction is first generated in a downsampled version). The results show that switching the order is not necessary, no compression loss.

CE3-3.2 is the desirable solution, also aligned with the order of filtering in motion comp.

Decision: Adopt JVET-P0054, version of CE3-3.2.

[JVET-P0054](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7843) CE3-3: Up-sampling with a fixed order in MIP [H. Liu, L. Zhang, K. Zhang, Z. Deng, J. Xu, Y. Wang (Bytedance)]

[JVET-P0056](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7845) CE3-2: On rounding shift of MIP [K. Kondo (Sony), J.-Y. Huo (Xidian Univ.)]

[JVET-P0064](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7853) CE3-1: MIP downsampling process – align positions of reduced boundary samples with positions of reduced prediction samples [Z. Zhang, K. Andersson, D. Saffar, R. Sjöberg, J. Ström, R Yu (Ericsson)]

## CE4: Inter prediction (8)

Contributions in this category were discussed XXday X July XXXX–XXXX in Track X (chaired by XXX).

[JVET-P0024](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8416) CE4: Summary report on inter prediction [C.-C. Chen, H. Yang, X. Xiu]

Planning of viewing CE4:

- Viewing sessions can have 10-12 cases (A/B comparison)

1. GEO without adaptive blending - one session 2 rate points, 5 sequences

2. CIIP with triangular - one session 2 rate points, 5 sequences

3. Adaptive blending for screen content a) with TPM b) with TPM+GEO - one session 2 rate points, 3 sequences

In total 3 viewing sessions (3 experts each), 5 groups, 15x10min, approx. 3 hrs.

Anchor is always VTM6 CTC

Discussed Track B Wednesday 3 Oct 1715 GJS

This contribution provides a summary report of Core Experiment 4 on inter prediction. This CE comprises two categories,

1. Geometric partition related merge modes,
2. Simplification on PROF and BDOF.

All techniques as planned in the context of CE4 are implemented on top of and tested against VTM-6.0. Simulation results and crosschecking reports of each test specified in this document are provided.

Subjective evaluation of representative CE4-1 tests is planned to identify whether there is an observable subjective improvement. Test materials are provided for consideration.

There are four tools for CE4-1, geometric partition, partial transform for geometric partition, adaptive blending for screen content and CIIP with triangle partition.

Variants of the four tools and the combination are tested.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test #** | **Description** | | | | | | | | | | **Source** | | |
| 4-1.1\* | Geometric (GEO) merge mode as proposed in JVET-O0489 with 32 angles and 5 distance values | | | | | | | | | | JVET-P0068 | | |
| 4-1.2a | Geometric (GEO) merge mode with reduced number of partitions with N angles and 4 distance values, i.e., N=32 | | | | | | | | | | JVET-P0068 | | |
| 4-1.2b | Geometric (GEO) merge mode with reduced number of partitions with N angles and 4 distance values, i.e., N=24 | | | | | | | | | | JVET-P0068 | | |
| 4-1.5 | GEO + ¼ and ½ adaptive-size partial transform | | | | | | | | | | JVET-P0074 | | |
| 4-1.6 | GEO + ½ fixed-size partial transform | | | | | | | | | | JVET-P0074 | | |
| 4-1.7 | Adaptive blending filtering for TPM | | | | | | | | | | JVET-P0069 | | |
| 4-1.8 | Test 4-1.7 + GEO | | | | | | | | | | JVET-P0069 | | |
| 4-1.9 | CIIP with triangular partitions | | | | | | | | | | JVET-P0071 | | |
| 4-1.10 | Test 4-1.9 + GEO | | | | | | | | | | JVET-P0070 | | |
| 4-1.12 | Test 4-1.9 + Partial transform as in Test 4.1.5 | | | | | | | | | | JVET-P0075 | | |
| 4-1.13 | Test 4-1.12 + Test 4.1.5 (GEO with partial transform) | | | | | | | | | | JVET-P0075 | | |
| 4-1.14 | GEO with TPM-like motion storage method vs GEO with the proposal motion storage method in JVET-O0489 | | | | | | | | | | JVET-P0068 | | |
|  | | **Random Access** | | | | | **Low delay B** | | | | | |
| **Test#** | | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | | **DecT** |
| 4-1.1\* | | -0.36% | -0.45% | -0.54% | 104% | 100% | -0.72% | -0.66% | -0.76% | 105% | | 100% |
| 4-1.2a | | -0.34% | -0.42% | -0.54% | 104% | 100% | -0.73% | -0.69% | -0.76% | 104% | | 99% |
| 4-1.2b | | -0.34% | -0.39% | -0.52% | 103% | 100% | -0.68% | -0.46% | -0.60% | 103% | | 99% |
| 4-1.5 | | -0.35% | -0.41% | -0.49% | 104% | 100% | -0.83% | -0.67% | -0.67% | 105% | | 100% |
| 4-1.6 | | -0.34% | -0.43% | -0.49% | 104% | 100% | -0.87% | -0.56% | -0.60% | 105% | | 100% |
| 4-1.7 | | / | / | / | / | / | / | / | / | / | | / |
| 4-1.8 | | / | / | / | / | / | / | / | / | / | | / |
| 4-1.9 | | -0.07% | -0.05% | -0.05% | 101% | 100% | -0.18% | -0.14% | -0.15% | 103% | | 99% |
| 4-1.10 | | -0.39% | -0.48% | -0.49% | 104% | 100% | -0.77% | -0.84% | -0.62% | 106% | | 98% |
| 4-1.12 | | -0.09% | -0.05% | -0.01% | 103% | 100% | -0.31% | 0.02% | -0.08% | 103% | | 100% |
| 4-1.13 | | -0.41% | -0.47% | -0.47% | 106% | 100% | -0.97% | -0.79% | -0.63% | 108% | | 100% |
| 4-1.14 | | -0.37% | -0.40% | -0.53% | 104% | 100% | -0.71% | -0.71% | -0.59% | 105% | | 100% |

Results for Class F and Class SCC is shown for CE4-1.7 and CE4-1.8 since the two tests applies to screen content only.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Random Access Main 10** | | | | | **Low delay B Main10** | | | | |
| **Test#** | **Sequence** | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| CE4-1.7 | Class F | -0.02% | -0.02% | -0.03% | 100% | 100% | 0.02% | 0.00% | 0.48% | 99% | 100% |
| Class SCC | -0.73% | -0.58% | -0.55% | 100% | 100% | -0.94% | -0.69% | -0.68% | 98% | 100% |
| CE4-1.8 | Class F | -0.47% | -0.55% | -0.48% | 101% | 100% | -0.70% | -0.83% | -0.49% | 102% | 99% |
| Class SCC | -2.35% | -2.01% | -1.98% | 100% | 100% | -3.11% | -2.77% | -2.72% | 99% | 100% |

GEO would extend the triangle mode to support different paritionings.

TM mode has been about 0.4% gain. (It had 1% gain for LB and more gain for low resolution.)

The masking for this mode is somewhat different from GEO.

It was commented that we should check visual results.

The proponents suggested a combination in P0884 rather than the CE tested method. A particant commented that 4-1.14 is probably better understood.

It was agreed to do this test. If not subjective gain is evident, we do not plan to adopt this feature.

It was also suggested to subjectively test 4-1.9, combining CIIP with triangle mode.

It was also suggested to subjectively test CE4-1.7 and CE4-1.8 for SCC, disabling of blending in TPM and GEO for SCC.

Follow-up discussion for CE4 was held in Track B on Thursday 10 October 2019 (GJS)

[JVET-P1036](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8851) Results of CE4-related visual tests [M. Wien]

Vittorio Baroncini and Matthias Wien and Kenneth Andersson had coordinated work on subjective testing for CE4 and had also been working on some CTC-style comparisons of VVC versus HEVC.

Some of the tests had used forced-choice comparisons (-3, -1, +1, +3).

Mr. Baroncini indicated that Pearson correlation index scores were poor for the test (note JO: clarify what exactly was correlated ?), and that the viewing distance and upsampling was an issue (some test sequences were low resolution, and upsampling very low resolution test sequences for display on the screen had been done in some cases – e.g., 5 sequences with 3 different resolutions in the same session, which he said was not recommended) and that many of the differences were likely not to be visible to a naïve viewer, although he had found some benefit in favour of the proposed technologies on personal close analysis as an expert viewer. He said the test results that had used a group of viewers should be considere inconclusive.

Mr. Andersson also did some statistical analysis of the group viewing test, with removal of outlier viewers and said this did not seem to much affect the relative scoring.

Screen content was excluded from the formal viewing since it was clear that this would produce no visible difference.

It was commented that for all cases used in the viewing, the proposal had lower bit rate than the anchor (except one case for ParkScene with about a 0.1% higher bit rate).

Notes from Mr. Baroncini's personal viewing were as follows:

Session 1 (single expert viewer, non-blind comparison):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sequence | QP 32 | | QP 37 | | Additional Comments made by Test Chair |
| Anchor | Test | Anchor | Test |
| BQ Mall | 4 | 4.1 | 3 | 4.5 | For QP 32 there was no visible differences found.  For QP 37 evidence differences were observed all over the sequence. |
| Cactus | 6 | 6.6 | 4.5 | 4.9 | Evident differences were observed on the tiger and the bricks. |
| Johnny | 3.9 | 4.9 | 3.2 | 3.7 | Evident differences were observable across the teeth. |
| ParkScene | 4.5 | 5.0 | 4.3 | 4.7 | Evident differences all over the sequences, especially on the wheels of the bike. |
| Race horsesC | 3.0 | 4.3 | 2.5 | 3.2 | Evident differences were observed especially at the face and tail of the horse. |

Session 2 (single expert viewer, non-blind comparison):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sequence | QP 32 | | QP 37 | | Additional Comments made by Test Chair |
| Anchor | Test | Anchor | Test |
| BQ Mall | 3.5 | 3.8 | 3.3 | 4.0 | Colour mismatch was corrected by the proposal. Some details came up for QP32. |
| Cactus | 5.3 | 5.9 | 4.8 | 5.4 | Evident details on the bricks and the tiger were observed |
| Johnny | 4.5 | 4.8 | 3.5 | 3.8 | Evident differences on the teeth |
| ParkScene | 4.5 | 4.8 | 4.3 | 4.7 | Smaller differences compared to session 1 |
| Race horses | 3.0 | 3.8 | 2.5 | 2.9 |  |

Session 3 (single expert viewer, non-blind comparison):

* All sequences except for Desktop444 showed no visual difference.
* Desktop444, QP32, Test2
  + Anchor: 8.5 Proposal: 8.7. Comment: Visual difference were not so evident.
* Desktop444, QP32, Test2
  + Anchor: 7.8 Proposal: 8.3. Comment: Visual difference were evident.

There were 8 people who accompanied Mr. Baroncini for the viewing, and they confirmed his opinions (although they were proponents).

The cross-checker P0895 said they concurred with the described subjective benefit.

For the group viewing tests, the test setup was as follows:

Procedure as tests at last meeting [JVET-O1118]

* LG OLED 55” display used, three test subjects per session  
  at 1.6 × screen height distance
* A-B-A-B presentation, assessment:
  + “A was much better than B”
  + “A was better than B”
  + “B was better than A”
  + “B was much better than A”.
* Test cell design
  + “A” – Video A – “B” – Video B – “A” – Video A – “B” – Video B – “Vote *N*”
  + “A” / “B” presentation for 0.5sec
  + Voting for 5sec

Test design

* Placement of anchor and proposal as “A” and “B” randomized over test cells
* Fixed order of sequences, looped over available test cells
* Mix of (few) sequences which have resolutions 480p, 720p, 1080p
  + Decision to present all sequences up-scaled to UHD screen resolution using nearest neighbor interpolation
  + Viewing performed at 3.2xh distance from screen

Test evaluation:

* Viewing votes mapping
  + +3 : “Proposal much better than anchor”
  + +1 : “Proposal better than anchor”
  + -1 : “Anchor better than proposal”
  + -3 : “Anchor much better than proposal”
* Calculation of Mean Opinion Score (MOS) on this scale
* Calculation of 95% confidence intervals were based on MOS and standard deviation

Session setup:

* Tests conducted Tue. 2019-10-09 15:00h
  + Session 1: JVET-P0884/JVET-P0885
  + Session 2: JVET-P0071
* Sequences selected by proponents
* Six groups of three experts = 18 test subjects
* Presentation of 10 test cells per session
  + Less than 9 min viewing time each
* Interleaving of two groups each
  + One testing, one resting / entering results

The error bars on the data showed one confidence interval above and one below, versus some tests that have shown half this distance above and half below.

The Pearson correlation issue was further discussed.

Looking at the graphs, the results of this test were not at all consistent with the results of Mr. Baroncini's viewing.

The report of the group test was suggested to be uploaded [Add doc number]

With the results being inconsistent and inconclusive, further study would be necessary.

It was then agreed to review P0884/P0885, which are combination proposals that propose the same technology.

Notes below are continuation of the notes of the initial review.

**Test 4-2.1 and 4-1.2 in JVET-P0057 (Kwai, Qualcomm, Mediatek, InterDigital)**

Common modifications in both tests,

* The range of BDOF motion refinements is changed from [-32, 32] to [-32, 31],

Modifications specific to test 4-2.1,

* PROF motion refinement is clipped into the range of [-32, 31], and
* The precision of the PROF motion refinement is changed from 1/64-pel to 1/32-pel.

Modifications specific to test 4-2.2,

* PROF motion refinement is clipped into the range of [-32, 31].

|  |  |  |
| --- | --- | --- |
| **Test #** | **Description** | **Source** |
| 4-2.1 | 1/32-pel precision of PROF motion refinement + [-32, 31] for PROF clipping range | JVET-P0057 |
| 4-2.2 | [-32, 31] for PROF clipping range | JVET-P0057 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access Main 10** | | | | | **Low delay B Main10** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 4-2.1 | 0.01% | 0.02% | 0.01% | 100% | 99% | 0.02% | 0.01% | 0.04% | 100% | 100% |
| 4-2.2 | 0.01% | 0.05% | -0.05% | 101% | 101% | 0.02% | 0.00% | 0.04% | 100% | 101% |

The motivation is unification/harmonization of PROF and BDOF schemes.

Decision: Adopt CE4-2.1 JVET-P0057.

[JVET-P0057](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7846) CE4: Harmonization of BDOF and PROF (Test 4-2.1 and 4-2.2) [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai), H. Huang, W.-J. Chien, V. Seregin, M. Karczewicz (Qualcomm), C.-Y. Lai, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek), Y. He, W. Chen (InterDigital)

[JVET-P0068](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7857) CE4: CE4-1.1, CE4-1.2 and CE4-1.14: Geometric Merge Mode (GEO) [H. Gao, S. Esenlik, E. Alshina, A. M. Kotra, B. Wang (Huawei), M. Bläser, J. Sauer (RWTH Aachen Univ.)]

[JVET-P0069](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7858) CE4: CE4-1.7, CE4-1.8: GEO and TPM Blending Off for SCC [H. Gao, S. Esenlik, E. Alshina, A. M. Kotra, B. Wang (Huawei), M. Bläser, J. Sauer (RWTH Aachen Univ.)]

[JVET-P0070](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7859) CE4-1.10: CIIP with triangular partitions + GEO [S. Blasi, A. Seixas Dias, G. Kulupana (BBC), H. Gao, S. Esenlik, E. Alshina, A. M. Kotra, B. Wang (Huawei)]

[JVET-P0071](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7860) CE4-1.9: CIIP with triangular partitions [S. Blasi, A. Seixas Dias, G. Kulupana (BBC)]

[JVET-P0074](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7863) CE4: Geometric merge mode (GEO) with partial transform (tests CE4-1.5 and CE4-1.6) [A. Filippov, V. Rufitskiy (Huawei)]

[JVET-P0075](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7864) CE4: CIIP with triangular partitions and partial transform (tests CE4-1.12 and CE4-1.13) [A. Filippov, V. Rufitskiy (Huawei), S. Blasi, A. Seixas Dias, G. Kulupana (BBC)]

[JVET-P0808](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8623) Cross-check of CE4-1.1 and CE4-1.2: Geometric Merge Mode (GEO) (JVET-P0068), and CE4-1.2 restricted to 64 modes (JVET-P0107) [A. Wieckowski (HHI)]

## CE5: Loop filtering (8)

Contributions in this category were discussed Monday 7 Oct. 1745–1945 in Track A (chaired by JRO).

[JVET-P0025](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8425) CE5: Summary Report on Loop filtering [C.-Y. Chen, A. Norkin]

Initial Planning of viewing for CE5 (Thursday 3 Oct. afternoon):

- Viewing sessions can have 10-12 cases (A/B comparison)

1. cross component ALF (only in loop) – one session 2 rate points, 5 sequences

2. DMVR deblocking: one session, test DMVR off and one version of deblocking with DMVR vectors, 2 rate points, 3 sequences

3. a) Aligning deblocking chroma decisions and b) longer tap filter at CTU, 2 rate points, 3 sequences

4. Hadamard+SAO, bilateral+SAO, 2 rate points, 3 sequences, RDO on

Anchor is always VTM6 CTC (with ALF on)

In total 4 viewing sessions (3 experts each), 5 groups, 20x10min, approx. 4 hrs.

This document provides a summary report of Core Experiment 5 on Loop Filtering. There are three categories of the tests: deblocking filter (CE5-1), adaptive loop filter (CE5-2), and bilateral filter, Hadamard filter, and SAO (CE5-3). The subjective testing is planned to be performed at the meeting.

The corresponding compression performance of each coding tool evaluated in CE5 is summarized in this contribution. In addition, analysis of complexity of the proposals and cross-checking results are provided.

The software basis for this CE was VTM-6.0. Configurations and test conditions in JVET-N1010 [1] for SDR sequences are used. Results for additional configuration with ALF turned off and SAO turned off are also reported where applicable. For the subjective viewing of deblocking proposals, additional encodes with different QPs have been generated, including two sequences in 4:4:4 chroma format, and two HDR sequences.

CE5-1.1

Proposal in this sub-CE investigates effect of using DMVR refined motion for deblocking decisions and also the effect of turning off DMVR.

CE5-1.1.1 Deblocking based on DMVR refined motion [JVET-P0062](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7851)

It has been shown in JVET-O0158 that block artifacts can occur for CU and subblock boundaries of DMVR. The reason is that VVC uses unrefined motions for deblocking decisions.

The test investigates the effect of using the DMVR refined motion for deblocking decisions to make deblocking aware of actual differences in motion of DMVR predicted subblocks.

CE5-1.1.2 Restriction of CE5-1.1.1 [JVET-P0062](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7851)

This test is the same as CE5-1.1.1 with the restriction to not use refined motion across horizontal CTU boundary.

CE5-1.1.3 DMVR off [JVET-P0062](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7851)

The test disables DMVR for comparison with tests CE5-1.1.1 and CE5-1.1.2.

CE5-1.2

Proposal in this sub-CE investigates changes to simplify the chroma deblocking filter.

CE5-1.2 Aligning deblocking chroma decisions [JVET-P0061](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7850)

In the current VVC design, when one side of the chroma blocks is of intra, the boundary strength is set to 2. Otherwise, when one chroma block has non-zero transform coefficients, the boundary is set to 1. Thus, it is possible that the bS=1 for Cb and bS=0 for Cr. The test sets bS=1 for both Cb and Cr when one component has non-zero transform coefficients at least.

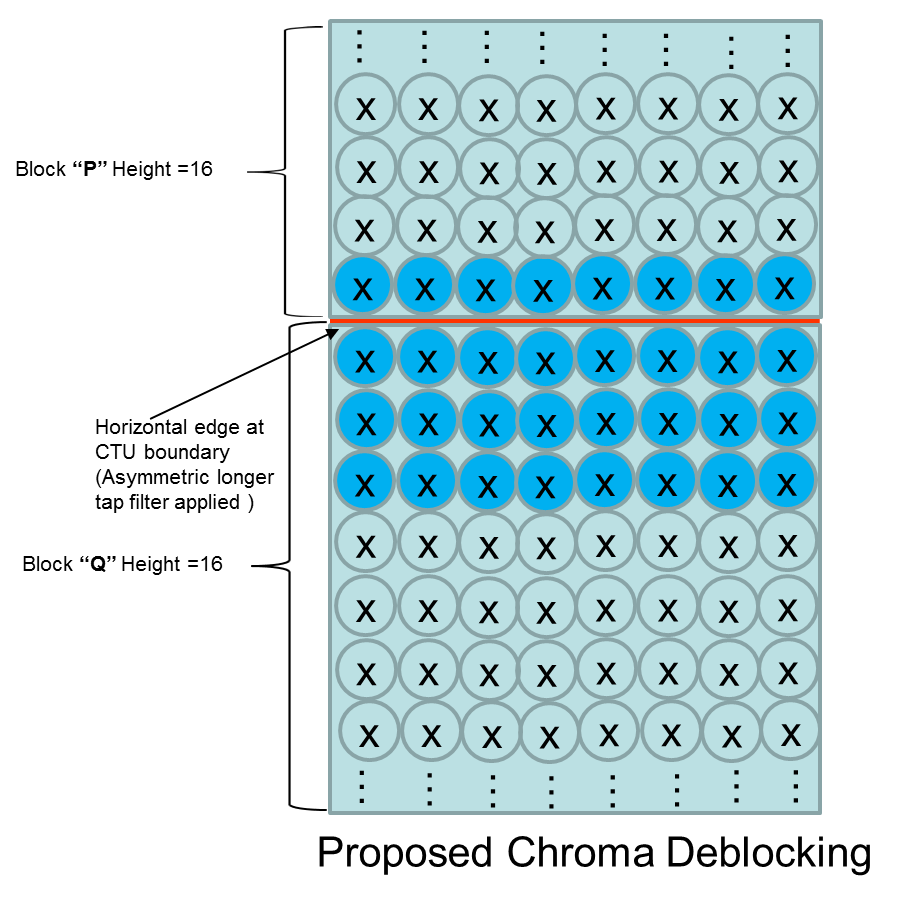
Performance of the proposal on HDR material is also to be tested.

CE5-1.3

CE5-1.3 Longer tap filter application at Chroma CTB boundaries [JVET-P0081](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7870)

In VTM-5.0, longer tap filter is turned off at the Chroma CTB boundaries, unlike the Luma CTB boundaries where a longer tap asymmetric filter (3+7) is applied.

This test proposes unification of deblocking design by also applying a longer tap asymmetric filter (1+3) at the Chroma CTB boundaries as shown in the figure below.



At the horizontal CTU boundaries the modified longer tap filter decisions are as follows: (p2,0, p2,1  are simply replaced with p1,0  and  p1,1)

dp0 = Abs( p~~2~~1,0 − 2 \* p1,0 + p0,0 )

dp1 = Abs( p~~2~~1,1 − 2 \* p1,1 + p0,1 )

dq0 = Abs( q2,0 − 2 \* q1,0 + q0,0 )

dq1 = Abs( q2,1 − 2 \* q1,1 + q0,1 )

At the horizontal CTU boundaries the modified longer tap deblocking equations are as follows:

p0′ = Clip3( p0 − tC, p0 + tC, ( ~~p~~~~3~~~~+ p~~~~2~~~~+~~ 3 \* p1 + 2 \* p0 + q0 + q1 + q2  + 4 )  >>  3 )

q0′ = Clip3( q0 − tC, q0 + tC, ( ~~p~~~~2~~~~+~~ 2 \* p1 + p0 + 2 \* q0 + q1 + q2 + q3  + 4 )  >>  3 )

q1′ = Clip3( q1 − tC, q1 + tC, ( p1 + p0 + q0 + 2 \* q1 + q2 + 2 \* q3  + 4 )  >>  3 )

q2′= Clip3( q2 − tC, q2 + tC, ( p0 + q0 + q1 + 2 \* q2 + 3 \* q3 + 4 )  >>  3 )

VTM6.0 CTC (ALF on)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | **Random Access** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-1.1.1 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | 0.05% | 0.05% | 0.03% | 0.02% | 101% | 102% |
| CE5-1.1.2 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | 0.05% | 0.06% | 0.02% | 0.02% | 100% | 109%\* |
| CE5-1.1.3 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | 0.87% | 0.81% | 1.11% | 1.11% | 101% | 97% |
| CE5-1.2 | -0.02% | 0.00% | -0.07% | -0.09% | 99% | 99% | -0.01% | 0.00% | -0.02% | -0.09% | 100% | 97% |
| CE5-1.3 | 0.00% | 0.00% | 0.00% | 0.00% | 100% | 102% | 0.00% | 0.00% | 0.03% | -0.01% | 100% | 101% |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low Delay B** | | | | | | | **Low Delay P** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-1.1.1 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 |
| CE5-1.1.2 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 |
| CE5-1.1.3 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 |
| CE5-1.2 | 0.03% | -0.01% | 0.12% | 0.25% | 101% | 99% | 0.07% | | 0.06% | 0.01% | 0.17% | 98% | 98% |
| CE5-1.3 | -0.01% | -0.01% | 0.10% | -0.16% | 100% | 100% | -0.02% | | 0.00% | -0.13% | -0.03% | 100% | 100% |

VTM6.0 CTC + ALF off

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | **Random Access** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-1.1.1 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | 0.02% | 0.03% | 0.00% | 0.00% | 98% | 103% |
| CE5-1.1.2 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | 0.03% | 0.04% | -0.01% | 0.00% | 99% | 109%\* |
| CE5-1.1.3 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | 0.82% | 0.75% | 1.09% | 1.12% | 100% | 93% |
| CE5-1.2 | 0.00% | 0.00% | 0.01% | -0.04% | 100% | 99% | 0.00% | 0.01% | 0.02% | -0.06% | 100% | 99% |
| CE5-1.3 | 0.00% | 0.00% | -0.03% | -0.02% | 100% | 100% | 0.00% | 0.01% | 0.01% | -0.04% | 100% | 100% |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low Delay B** | | | | | | **Low Delay P** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-1.1.1 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 |
| CE5-1.1.2 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 |
| CE5-1.1.3 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 |
| CE5-1.2 | -0.02% | -0.02% | -0.06% | 0.05% | 101% | 100% | -0.01% | -0.03% | 0.13% | 0.02% | 99% | 101% |
| CE5-1.3 | -0.06% | -0.01% | -0.15% | -0.33% | 100% | 100% | -0.07% | -0.03% | -0.15% | -0.24% | 100% | 100% |

Luma deblocking complexity

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Tests** | **Samples from block boundary modified** | **Samples from block boundary for deblocking decision** | **Max number of operations for filtering per line (add/mult/compar/shift)** | **Max number of operations for filtering per \*sample\* (add/mult/compar/shift)** | **Max. num. oper., filtering and decsion (Per \*Sample\*)** | **Max oper. for decis. per line (add/mult/compar/shift)** | **Number of line buffers** | **Worst case complexity increased (Y/N)** |
| CE5-1.1.1 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | N |
| CE5-1.1.2 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | N |
| CE5-1.1.3 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | N |
| CE5-1.2 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | N |
| CE5-1.3 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | N |

Chroma deblocking complexity

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Tests** | **samples from block boundary modified** | **samples from block boundary for deblocking decision** | **Max number of operations for filtering per line (add/mult/compar/shift)** | **Max number of operations for filtering per \*sample\* (add/mult/compar/shift)** | **Max number of operations including filter and decision per \*sample\* (add/mult/compar/shift)** | **Max number of oper. for decision for 8-sample boundary (add/mult/compar/shift)** | **Number of line buffers** | **Worst case complexity increased (Y/N)** |
| CE5-1.1.1 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | N |
| CE5-1.1.2 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | N |
| CE5-1.1.3 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | N |
| CE5-1.2 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | N |
| CE5-1.3 | VTM6, except  at chroma CTB boundaries where (1 + 3) filter may be applied | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | VTM6 | N |

Subjective results in JVET-P1032:

* 5-1.1: Confidence intervals always include zero line, no clear tendency (only for Kimono average >0 for both QPs). No obvious benefit.
* 5-1.2: has clear degradation for Cactus QP37, it is better for Campfire (which however is more homogeneous in color, such that the joint deblocking decision for both color components may not be critical). Considering that the original claim of the proposal was that there would be no visual difference, this seems not to be proven.
* 5-1.3: Confidence intervals always include zero line, for QP37 all 3 sequences have average >0, for QP32 only Kimono. If there is a subjective benefit, it could not be large.

The complexity impact of CE5-1.3 is not large, but it requires a special handling of chroma at CTB boundary (padding, and invoking the longer filter for large blocks which is already used within the CTB). The same method of asymmetric filtering is used for luma. It is unlikely that this would cause artifacts, and at least a certain tendency can be concluded from the test.

Decision: Adopt JVET-P0081

CE5-2: CCALF

CE5-2.1 Cross-component adaptive loop filter for chroma [JVET-P0080](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7869)

The contribution proposes a tool called the Cross-Component Adaptive Loop Filter (CC-ALF). CC-ALF operates as part of the adaptive loop filter process and makes use of luma sample values to refine each chroma component.

CE5-2.2 Cross-component adaptive post-processing filter for chroma [JVET-P0080](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7869)

This is the same proposal as in the CR5-2.1 implementing as post-processing filter.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | **Random Access** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-2.1 | -1.26% | 0.13% | -7.58% | -6.01% | 103% | 103% | -1.95% | 0.16% | -10.69% | -10.07% | 101% | 100% |
| CE5-2.2 | -1.23% | 0.15% | -7.54% | -5.93% | 100% | 107% | -0.84% | 0.78% | -7.50% | -7.10% | 101% | 105% |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low Delay B** | | | | | | **Low Delay P** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-2.1 | -2.60% | 0.17% | -15.62% | -11.75% | 101% | 99% | -2.59% | 0.21% | -15.89% | -11.72% | 102% | 101% |
| CE5-2.2 | -0.27% | 1.83% | -10.59% | -6.71% | 100% | 107% | -0.39% | 1.79% | -11.02% | -7.15% | 101% | 107% |

Subjective results in JVET-P1032:

The subjective results show improvement (non overlapping confidence interval) for Four People QP32, all other 9 cases can be categorized as equal quality. In terms of average values, the results seem slightly below zero for QP37. Note that the test was mainly performed with the goal of demonstrating that the method does not generate artifacts.

It is noted that, since the cross-component filter is by tendency a highpass filter, it might be observed that more artifacts would appear if the QP was even higher than 37 – an encoder would take care of that and turn it off.

It is noted that, as the method obviously increases the chroma PSNR, it might have been better using rate-shifted version for the test. It is however asserted that the effect would not be too large, as the PSNR difference is reported to be only 0.7 dB in some cases. Overall, the proponents report that the rate shift from chroma to luma would result in approx. 1% overall gain (provided in JVET-P0080).

There is no complexity analysis in the CE summary report, but JVET-P0165 and JVET-P0739 include a complexity analysis, which indicate approx. 46% increase of multiplications compared (for the ALF stage) compared to VTM6.

Rate gain of 1% versus the largely increased number of computations is not a good tradeoff. There are however various non-CE contributions with reduced complexity.

CE5-3: Bilateral/Hadamard/SAO-SEO

(SEO=signed edge offset, a version of SAO existing in an older HEVC draft)

In this sub-CE, the bilateral in-loop filter and the Hadamard in-loop filter are investigated under the same conditions. The sample adaptive offset (SAO) without edge offset (EO) sign constraint is also tested. The following tests are performed.

* **Test 1: Filtering in combination with SAO.** This will be the base-line implementation similar to test3 in JVET-O0548 and test3 in JVET-O1120 but implemented in VTM-6.0. Hence it will be allowed to apply the filtering on the reconstructed block in the RDO (mode selection part) of the encoder. It will also include the possibility to turn off the filter at the CTU level.
* **Test 2: Filtering without SAO.** In this implementation, SAO is turned off. Otherwise it is similar to test 1.
* **Test 3: Filtering in combination with SAO without RDO.** In this implementation, it will not be allowed to apply filtering on the reconstructed block in the RDO (mode selection part) of the encoder. Otherwise it is similar to test 1.
* **Test 4: Filtering as a post filter.** In this implementation, the filtering will be applied outside the coding loop, as if it was used as a post filter. Hence the sample input to the filter should be the same as the output yuv samples of the decoded anchor. Apart from the sample input, the filter may use information available to the decoder, such as QP and/or transform size. Only parameters available in the decoder anchor bit streams are allowed.

CE5-3.1 Bilateral filter [JVET-P0073](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7862)

This sub-CE will contain following tests based on JVET-O0548.

* CE5-3.1.1 This will follow the test 1 restrictions outlined in the previous section
* CE5-3.1.2 This will follow the test 2 restrictions outlined in the previous section
* CE5-3.1.3 This will follow the test 3 restrictions outlined in the previous section
* CE5-3.1.4 This will follow the test 4 restrictions outlined in the previous section

CE5-3.2 Hadamard filter [JVET-P0078](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7867)

This sub-CE will contain following tests based on JVET-O1120.

* CE5-3.2.1 This will follow the test 1 restrictions outlined in the previous section
* CE5-3.2.2 This will follow the test 2 restrictions outlined in the previous section
* CE5-3.2.3 This will follow the test 3 restrictions outlined in the previous section
* CE5-3.2.4 This will follow the test 4 restrictions outlined in the previous section

CE5-3.3 Sample adaptive offset [JVET-P0045](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7834)

In current VVC draft, the signs of SAO EO are inferred in order to allow smooth filtering only. In JVET-K0233, this constraint is removed. That is, for each non-zero EO offset, one flag is coded to indicate the sign is positive or negative, so both of smooth filtering and sharp filtering are allowed.

* CE5-3.3.1: Remove the sign constraint of SAO EO
* CE5-3.3.2: Remove SAO

CE5-3.4 Bilateral and Hadamard filter combination [JVET-P0078](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7867)

This sub-CE will evaluate whether combining CE5-3.1 and CE5-3.2 can provide additional improvement. Two filters are evaluated at encoder side then the best filter to be combined with SAO is signalled at CTU level. This sub-CE will contain following tests:

* CE5-3.4.1 This will follow the test 1 restrictions outlined in the previous section
* CE5-3.4.2 This will follow the test 2 restrictions outlined in the previous section
* CE5-3.4.3 This will follow the test 3 restrictions outlined in the previous section
* CE5-3.4.4 This will follow the test 4 restrictions outlined in the previous section

VTM6.0 CTC (ALF on) Test 1 – filtering in combination with SAO

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | **Random Access** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.1.1 | -0.28% | -0.40% | 0.20% | 0.20% | 106% | 104% | -0.30% | -0.44% | 0.29% | 0.23% | 103% | 102% |
| CE5-3.2.1 | -0.19% | -0.33% | 0.39% | 0.37% | 107% | 108% | -0.24% | -0.37% | 0.30% | 0.31% | 104% | 103% |
| CE5-3.4.1 | -0.21% | -0.35% | 0.35% | 0.32% | 109% | 105% | -0.19% | -0.34% | 0.45% | 0.39% | 104% | 102% |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low Delay B** | | | | | | **Low Delay P** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.1.1 | -0.12% | -0.32% | 0.67% | 0.71% | 102% | 102% | -0.19% | -0.39% | 0.52% | 0.67% | 103% | 102% |
| CE5-3.2.1 | 0.07% | -0.08% | 0.68% | 0.64% | 103% | 103% | -0.01% | -0.16% | 0.47% | 0.73% | 104% | 103% |
| CE5-3.4.1 | 0.02% | -0.17% | 0.78% | 0.80% | 103% | 102% | -0.05% | -0.23% | 0.53% | 0.82% | 104% | 102% |

VTM6.0 CTC (ALF on) Test 2 – filtering without SAO

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | **Random Access** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.1.2 | -0.24% | -0.40% | 0.38% | 0.41% | 109% | 104% | -0.19% | -0.38% | 0.56% | 0.55% | 103% | 103% |
| CE5-3.2.2 | -0.26% | -0.42% | 0.39% | 0.36% | 108% | 105% | -0.34% | -0.46% | 0.11% | 0.16% | 104% | 101% |
| CE5-3.4.2 | -0.21% | -0.35% | 0.36% | 0.34% | 109% | 106% | -0.22% | -0.36% | 0.37% | 0.35% | 104% | 103% |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low Delay B** | | | | | | | | **Low Delay P** | | | | | | | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | | **DecT** | | **YUV** | **Y** | | **U** | | **V** | | **EncT** | | **DecT** | |
| CE5-3.1.2 | 0.09% | -0.22% | 1.03% | 1.63% | | 105% | | 101% | 0.06% | | -0.27% | | 0.91% | | 1.84% | | 105% | | 101% | |
| CE5-3.2.2 | -0.12% | -0.25% | 0.47% | 0.31% | | 102% | | 101% | -0.14% | | -0.32% | | 0.59% | | 0.62% | | 103% | | 101% | |
| CE5-3.4.2 | -0.04% | -0.17% | 0.61% | 0.32% | | 103% | | 103% | -0.08% | | -0.27% | | 0.62% | | 0.76% | | 104% | | 103% | |

VTM6.0 CTC (ALF on) Test 3 – Filtering in combination with SAO without RDO

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | **Random Access** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.1.3 | -0.03% | -0.03% | -0.02% | -0.03% | 101% | 105% | -0.04% | -0.04% | 0.02% | -0.05% | 100% | 102% |
| CE5-3.2.3 | 0.00% | 0.00% | 0.02% | 0.02% | 100% | 107% | -0.03% | -0.03% | 0.00% | -0.01% | 99% | 103% |
| CE5-3.4.3 | -0.03% | -0.04% | 0.01% | 0.00% | 100% | 106% | 0.05% | 0.03% | 0.16% | 0.08% | 99% | 102% |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low Delay B** | | | | | | **Low Delay P** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.1.3 | -0.03% | -0.07% | 0.14% | 0.09% | 103% | 105% | -0.09% | -0.09% | -0.14% | -0.05% | 101% | 101% |
| CE5-3.2.3 | 0.01% | -0.02% | 0.20% | 0.09% | 99% | 103% | 0.00% | -0.02% | 0.00% | 0.15% | 99% | 103% |
| CE5-3.4.3 | 0.09% | 0.03% | 0.25% | 0.38% | 99% | 102% | 0.03% | -0.04% | 0.22% | 0.40% | 99% | 102% |

VTM6.0 CTC (ALF on) Test 4 – filtering as a post filter

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | **Random Access** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.1.4 | 0.48% | 0.60% | 0.00% | 0.00% | 100% | 109% | 0.18% | 0.23% | 0.00% | 0.00% | 100% | 106% |
| CE5-3.2.4 | 0.06% | 0.08% | 0.00% | 0.00% | 100% | 111% | 0.00% | 0.00% | 0.00% | 0.00% | 100% | 108% |
| CE5-3.4.4 |  |  |  |  |  |  |  |  |  |  |  |  |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low Delay B** | | | | | | **Low Delay P** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.1.4 | 0.18% | 0.23% | 0.00% | 0.00% | 100% | 107% | 0.22% | 0.28% | 0.00% | 0.00% | 100% | 106% |
| CE5-3.2.4 | -0.02% | -0.02% | 0.00% | 0.00% | 100% | 108% | -0.01% | -0.01% | 0.00% | 0.00% | 100% | 108% |
| CE5-3.4.4 |  |  |  |  |  |  |  |  |  |  |  |  |

VTM6.0 CTC (ALF on) tests of SAO (CE5-3.3)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | **Random Access** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.3.1 | 0.00% | 0.00% | 0.01% | 0.02% | 67%\* | 80%\* | 0.00% | 0.00% | 0.02% | 0.00% | 72%\* | 78%\* |
| CE5-3.3.2 | 0.04% | 0.01% | 0.14% | 0.17% | 100%\* | 99%\* | 0.13% | 0.08% | 0.28% | 0.35% | 100%\* | 98%\* |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low Delay B** | | | | | | **Low Delay P** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.3.1 | -0.02% | -0.03% | -0.02% | 0.07% | 73%\* | 77%\* | 0.06% | 0.02% | 0.13% | 0.29% | 72%\* | 79%\* |
| CE5-3.3.2 | 0.24% | 0.07% | 0.58% | 1.24% | 101%\* | 101%\* | 0.27% | 0.14% | 0.41% | 1.14% | 100%\* | 100%\* |

\*: the reported run time data are inaccurate in CE5-3.3.1. No SIMD optimization is used in CE5-3.3.

CE5-3 results with ALF off

VTM6.0 CTC (ALF off) Test 1 – filtering in combination with SAO

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | **Random Access** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.1.1 | -0.40% | -0.56% | 0.23% | 0.22% | 106% | 104% | -0.46% | -0.61% | 0.20% | 0.13% | 103% | 103% |
| CE5-3.2.1 | -0.28% | -0.46% | 0.44% | 0.42% | 108% | 110% | -0.42% | -0.60% | 0.28% | 0.32% | 104% | 105% |
| CE5-3.4.1 | -0.34% | -0.52% | 0.39% | 0.37% | 109% | 106% | -0.46% | -0.67% | 0.39% | 0.40% | 105% | 103% |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low Delay B** | | | | | | **Low Delay P** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.1.1 | -0.19% | -0.42% | 0.69% | 0.74% | 105% | 103% | -0.32% | -0.57% | 0.66% | 0.66% | 107% | 102% |
| CE5-3.2.1 | -0.26% | -0.49% | 0.70% | 0.61% | 103% | 104% | -0.28% | -0.58% | 0.97% | 0.91% | 105% | 105% |
| CE5-3.4.1 | -0.32% | -0.58% | 0.70% | 0.73% | 104% | 103% | -0.43% | -0.75% | 0.84% | 0.86% | 106% | 103% |

VTM6.0 CTC (ALF off) Test 2 – filtering with SAO off

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | **Random Access** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.1.2 | -0.21% | -0.47% | 0.64% | 0.98% | 106% | 106% | -0.09% | -0.35% | 1.02% | 0.86% | 102% | 101% |
| CE5-3.2.2 | -0.29% | -0.61% | 0.81% | 1.13% | 108% | 103% | -0.27% | -0.56% | 0.93% | 0.87% | 104% | 101% |
| CE5-3.4.2 | -0.12% | -0.38% | 0.78% | 1.11% | 109% | 104% | 0.01% | -0.29% | 1.25% | 1.13% | 105% | 102% |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low Delay B** | | | | | | | | | **Low Delay P** | | | | | | | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | | **DecT** | | **YUV** | | **Y** | | **U** | | **V** | | **EncT** | | **DecT** | |
| CE5-3.1.2 | 0.55% | -0.14% | 2.56% | 4.06% | | 105% | | 101% | | 1.13% | | 0.33% | | 3.77% | | 4.84% | | 108% | | 100% | |
| CE5-3.2.2 | 0.35% | -0.39% | 2.78% | 3.82% | | 103% | | 100% | | 0.85% | | -0.05% | | 3.90% | | 4.97% | | 105% | | 100% | |
| CE5-3.4.2 | 0.43% | -0.33% | 2.75% | 4.18% | | 105% | | 102% | | 1.02% | | 0.18% | | 3.83% | | 4.93% | | 107% | | 101% | |

VTM6.0 CTC (ALF off) Test 3 – Filtering in combination with SAO without RDO

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | **Random Access** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.1.3 | -0.11% | -0.13% | -0.02% | -0.02% | 100% | 105% | -0.13% | -0.13% | -0.16% | -0.14% | 99% | 102% |
| CE5-3.2.3 | -0.06% | -0.08% | 0.01% | 0.01% | 100% | 109% | -0.04% | -0.06% | 0.04% | 0.00% | 99% | 104% |
| CE5-3.4.3 | -0.17% | -0.21% | 0.01% | 0.01% | 100% | 107% | -0.14% | -0.18% | 0.05% | 0.02% | 99% | 103% |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low Delay B** | | | | | | **Low Delay P** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.1.3 | -0.15% | -0.17% | 0.01% | -0.10% | 103% | 104% | -0.25% | -0.29% | -0.06% | -0.15% | 103% | 102% |
| CE5-3.2.3 | -0.09% | -0.13% | 0.05% | 0.05% | 100% | 104% | -0.05% | -0.11% | 0.18% | 0.16% | 100% | 105% |
| CE5-3.4.3 | -0.15% | -0.23% | 0.13% | 0.18% | 99% | 103% | -0.33% | -0.43% | 0.08% | 0.03% | 99% | 103% |

VTM6.0 CTC (ALF off) Test 4 – filtering as a post filter

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | **Random Access** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.1.4 | 0.06% | 0.08% | 0.00% | 0.00% | 100% | 109% | 0.02% | 0.02% | 0.00% | 0.00% | 100% | 107% |
| CE5-3.2.4 | -0.10% | -0.13% | 0.00% | 0.00% | 100% | 113% | -0.06% | -0.08% | 0.00% | 0.00% | 100% | 109% |
| CE5-3.4.4 |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low Delay B** | | | | | | **Low Delay P** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.1.4 | 0.01% | 0.01% | 0.00% | 0.00% | 100% | 107% | 0.00% | 0.00% | 0.00% | 0.00% | 100% | 107% |
| CE5-3.2.4 | -0.07% | -0.09% | 0.00% | 0.00% | 100% | 109% | -0.08% | -0.10% | 0.00% | 0.00% | 100% | 110% |
| CE5-3.4.4 |  |  |  |  |  |  |  |  |  |  |  |  |

VTM6.0 CTC (ALF off) tests of SAO (CE5-3.3)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | | **Random Access** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.3.1 | 0.02% | 0.02% | 0.03% | 0.04% | 100%\* | 92%\* | 0.00% | | 0.03% | -0.09% | -0.14% | 100%\* | 89%\* |
| CE5-3.3.2 | 0.37% | 0.32% | 0.37% | 0.72% | 100%\* | 90%\* | 0.79% | | 0.80% | 0.81% | 0.73% | 100%\* | 98%\* |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low Delay B** | | | | | | **Low Delay P** | | | | | |
| **Test#** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** | **YUV** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE5-3.3.1 | -0.06% | -0.05% | -0.19% | 0.02% | 100%\* | 87%\* | 0.09% | 0.05% | 0.27% | 0.19% | 100%\* | 86%\* |
| CE5-3.3.2 | 1.24% | 0.96% | 1.77% | 2.98% | 101%\* | 98%\* | 2.83% | 2.68% | 3.19% | 3.65% | 100%\* | 97%\* |

\*: the reported run time data are inaccurate in CE5-3.3.1. No SIMD optimization is used in CE5-3.3.

Computational complexity

|  |  |  |  |
| --- | --- | --- | --- |
| **Test** | **Filter shape** | **Comp. complexity per sample**  **(add/shifts/compar./look-ups)** | **Memory requirements (bytes)** |
| CE5-3.1 | 3x3 | 18 adds (incl 5 rounding) / 8 shifts / 8 comp / 4 look-ups | 60 |
| CE5-3.2 | 3x3 | 19 adds +5 l-bit for rounding / 8 shifts / 6 comp / 3 look-up | 70 (14 bytes per QP group) |
| CE5-3.3 | Four 1D patterns in 3x3 | 2 adds / 0 shift / 4 comp / 1 LUT | 3.75 |

It was verbally reported that Samsung performed the crosscheck on CE5-3.2 successfully.

CE5-3.1 uses same samples from outside current CTU as SAO. CE5-3.2 does not use samples from outside the current CTU

Subjective results in JVET-P1032, 3 sequences tested with 2 QPs each:

* CE5-3.1 has one case with lower confidence interval boundary close to zero line (Arena of Valor QP32)
* CE5-3.2 has one case with lower confidence interval boundary above the zero line (BQ Terrace QP 37)

These three sequences were selected by proponents assuming that they would best demonstrate subjective benefit.

From the results above, it cannot be concluded that any of the two methods would have sufficient subjective benefit to justify the additional complexity.

[JVET-P0045](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7834) CE5-3.3: Signalling EO signs in SAO [C.-Y. Lai, C.-Y. Chen, T.-D. Chuang, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0639](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8436) CE5: Crosscheck of JVET-P0045 (CE5-3.3: Signalling EO signs in SAO) [E. Alshina, A.M. Kotra (Huawei)] [late]

[JVET-P0061](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7850) CE5-1.2: Consistent chroma deblocking [J. Xu, J. Wang, W. Zhu, L. Zhang, K. Zhang, H. Liu, Z. Deng (Bytedance)]

[JVET-P0062](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7851) CE5-1.1.1: DMVR deblocking, CE5-1.1.2: DMVR restricted deblocking and CE5-1.1.3: DMVR off [K. Andersson, J. Enhorn (Ericsson)]

[JVET-P0073](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7862) CE5-3.1: Combination of bilateral filter and SAO [J. Ström, P. Wennersten, J. Enhorn, D. Liu, K. Andersson, L. Litwic, D. Saffar, C. Hollmann, R. Yu, R. Sjöberg (Ericsson)]

[JVET-P0078](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7867) CE5-3: Combination of Hadamard filter and SAO (CE5-3.2, CE5-3.4) [S. Ikonin, V. Stepin, A. Karabutov, S. Nikolaeva (Huawei)]

[JVET-P0080](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7869) CE5-2.1, CE5-2.2: Cross Component Adaptive Loop Filter [K. Misra, F. Bossen, A. Segall (Sharp Labs of America)]

[JVET-P0081](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7870) CE5-1.3: Unified design for longer tap deblocking line buffer reduction [A. M. Kotra, S. Esenlik, B. Wang, H. Gao, E. Alshina (Huawei)]

[JVET-P0819](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8634) Cross-check of CE5.3.1, CE5.3.2, CE5.3.3, and CE5.3.4 [K. Choi, Y. Piao, W. Choi, K. P. Choi (Samsung)]

[JVET-P1032](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8847) Results of CE5 subjective test [A. Norkin]

## CE6: Transforms and transform signalling (6)

Contributions in this category were discussed Thursday 3 Oct. 1700–1815 in Track A (chaired by JRO).

[JVET-P0026](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8376) CE6: Summary Report on Transforms and Transform Signalling [X. Zhao, H. E. Egilmez, M. Salehifar]

This contribution summarizes the activities of Core Experiment (CE) on Transforms and Transform Signaling. The goal of this CE is to study transform design and signaling for the VVC standard. The CE studies were divided into two categories, including:

(1) CE6-1: LFNST with one mode (6 tests), targeting for encoder run-time saving.

(2) CE6-2: LFNST with reduced kernels (5 tests), targeting for memory cost reduction (all tests), unification (CE6-2.2 a/c/d) and multiplication reduction (CE6-2.2d, CE6-2.3).

In this CE all experiments were done using based on the VTM-6.0 SW. This document summarizes the test results, brief experiment definition, cross-check reports and complexity measurements, and also related contributions.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test #** | **Doc #** | **Description** | **Tester** | **Cross-checker** |
| 6-1.1a | JVET-P0041 | LFNST kernel selection according to the equation in JVET-O0292 with normative change | M.-S. Chiang (MediaTek)  J. Lainema (Nokia) | M. Koo (LGE) |
| 6-1.1b | JVET-P0041 | LFNST kernel selection according to the equation in JVET-O0292 with encoder-only change | M.-S. Chiang (MediaTek)  J. Lainema (Nokia) | M. Koo (LGE) |
| 6-1.1c | JVET-P0041 | LFNST kernel selection according to the equation in JVET-O0292 with encoder-only change and the last bit used to signal LFNST index is context coded. | M.-S. Chiang (MediaTek)  J. Lainema (Nokia) | M. Koo (LGE) |
| 6-1.1d | JVET-P0041 | LFNST kernel selection according to the equation in JVET-O0350 with normative change | J. Lainema (Nokia)  M.-S. Chiang (MediaTek) | M. Koo (LGE) |
| 6-1.1e | JVET-P0041 | LFNST kernel selection according to the equation in JVET-O0350 with encoder-only change | J. Lainema (Nokia)  M.-S. Chiang (MediaTek) | M. Koo (LGE) |
| 6-1.1f | JVET-P0041 | LFNST kernel selection according to the equation in JVET-O0350 with encoder-only change and the last bit used to signal LFNST index is context coded. | J. Lainema (Nokia)  M.-S. Chiang (MediaTek) | M. Koo (LGE) |
| CE6-2.1 | JVET- P0044 | Reduce 4 transform sets to 3 transform sets  - set 0 for DC / Planar  - set 1 for angular modes between 19 and 49  - set 3 for the other angular modes | Y. Zhao (Huawei) | M. Salehifar (LGE) |
| CE6-2.2a | JVET-P0051 | LFNST with the original 16x48 kernels defined in VTM-6.0 and apply them to all block sizes | X. Zhao (Tencent) | M.Siekmann (HHI)  M. Salehifar (LGE)  H. E. Egilmez (Qualcomm) |
| CE6-2.2c | JVET-P0051 | Combined test of CE6-2.2a and CE6-2.1 | X. Zhao (Tencent) | M.Siekmann (HHI)  M. Salehifar (LGE) |
| CE6-2.2d | JVET-P0052 | Combination of CE6-2.2a and CE6-2.3a - For larger block sizes, the new kernels in CE6-2.3a are applied - For 4xN and Nx4 blocks, the new kernels in CE6-2.3a are applied, but only pick the overlapping part with current block as output, as proposed in CE6-2.2a | X. Zhao (Tencent)  T. Zhou (Sharp) | M.Siekmann (HHI)  M. Salehifar (LGE)  H. E. Egilmez (Qualcomm) |
| CE6-2.3 | JVET-P0065 | Simplification of the low frequency separable transform using 36x16 RST matrices | T. Zhou (Sharp) | M.Siekmann (HHI)  M. Salehifar (LGE)  X. Zhao (Tencent)  C. Rosewarne (Canon) |

The following table summarizes the results of CE6 tests using CTC configuration and VTM-6.0 as anchor.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | **Random Access** | | | | |
| **Test #** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE6-1.1a | 0.11% | 0.66% | 0.82% | 90% | 101% | 0.09% | 0.49% | 0.50% | 97% | 102% |
| CE6-1.1b | 0.53% | 0.99% | 1.06% | 92% | 101% | 0.29% | 0.53% | 0.63% | 98% | 103% |
| CE6-1.1c | 0.48% | 0.99% | 1.11% | 91% | 101% | 0.27% | 0.50% | 0.56% | 98% | 103% |
| CE6-1.1d | 0.11 % | 0.64 % | 0.80 % | 90% | 99% | 0.07 % | 0.48 % | 0.49 % | 98% | 100% |
| CE6-1.1e | 0.53 % | 0.97 % | 1.10 % | 91% | 99% | 0.29 % | 0.53 % | 0.60 % | 98% | 99% |
| CE6-1.1f | 0.46 % | 0.97 % | 1.08 % | 91% | 99% | 0.27 % | 0.53 % | 0.56 % | 98% | 100% |
| CE6-2.1 | 0.03% | 0.06% | 0.11% | 100% | 101% | -0.01% | 0.06% | 0.03% | 100% | 100% |
| CE6-2.2a | -0.02% | 0.03% | 0.07% | 100% | 98% | -0.02% | 0.06% | 0.04% | 100% | 99% |
| CE6-2.2c | 0.01% | 0.12% | 0.14% | 100% | 98% | -0.01% | -0.01% | -0.01% | 100% | 99% |
| CE6-2.2d | -0.01% | 0.14% | 0.16% | 99% | 96% | -0.02% | 0.12% | 0.03% | 99% | 97% |
| CE6-2.3 | 0.02% | 0.09% | 0.10% | 100% | 100% | 0.03% | 0.11% | 0.05% | 100% | 101% |

Comparison on memory saving for CE6-2 tests:

|  |  |
| --- | --- |
| **Test** | **Memory cost** |
| VTM-6.0 | 8KB |
| CE6-2.1 | 6KB (25% reduction) |
| CE6-2.2a | 6KB (25% reduction) |
| CE6-2.2c (CE6-2.2a + CE6-2.1) | 4.6KB (44% reduction) |
| CE6-2.2d (CE6-2.2a + CE6-2.3) | 4.6KB (44% reduction) |
| CE6-2.3 | 6.7KB (19% reduction) |

The following table summarizes the results of CE6 tests using Low QP configuration and VTM-6.0, as specified in JVET-O2026.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | |
| **Test #** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE6-1.1a |  |  |  |  |  |
| CE6-1.1b |  |  |  |  |  |
| CE6-1.1c |  |  |  |  |  |
| CE6-1.1d |  |  |  |  |  |
| CE6-1.1e |  |  |  |  |  |
| CE6-1.1f |  |  |  |  |  |
| CE6-2.1 |  |  |  |  |  |
| CE6-2.2a | 0.02% | 0.04% | 0.04% | 98% | 98% |
| CE6-2.2c | 0.04% | 0.01% | 0.03% | 98% | 97% |
| CE6-2.2d | 0.03% | 0.03% | 0.04% | 98% | 97% |
| CE6-2.3 | 0.00% | -0.01% | 0.00% | 100% | 100% |

For CE6-1, both methods determine the transform kernel type from the intra mode rather than signalling it explicitly. The main motivation is reduction of encoding time (approx. 10% for AI, 2-3% for RA). Losses are in the range of 0.1% (slightly less for RA). It is reported that another simplification of LFNST adopted in the last meeting gave approx. 20% reduction in AI, penalizing 0.1%. Compared to that, the results of CE6-1 are not giving a similar good tradeoff, and some flexibility in the transform kernel selection is also lost (which more sophisticated encoders might want to use).

No action on CE6-1.

CE6-2.1 reduces the number of LFNST sets from 4 to 3 (no separate set for close to horizontal and vertical directions). This comes at very low loss. The memory for storing LFNST kernels is reduced by approx. 2 kByte. It is also reported that, if other tools are disabled in additional non-CTC tests, the loss becomes larger up to 0.2%.

CE6-2.2 replaces the 16x16 kernels (used for 4xN and Nx4) by using a part of the 16x48 kernels. One aspect of the proposal is that now a larger kernel is applied to 4x8 and 8x4 blocks, which however is confirmed that it does not increase worst case complexity (in number of multiplications). Picking the part of larger transform basis requires some additional logic, but the storage is reduced by approx. 2 kByte. It is also reported that, if other tools are disabled in additional non-CTC tests, the loss becomes larger up to 0.1%. Some concern is expressed that this is losing orthogonality.

The transforms for CE6-2.1 and CE6-2.2 were not retrained.

CE6-2.2.c is a combination of CE6-2.1 and CE6-2.2, saving a total of 3.4 kbyte of memory (about 44%)

CE6-2.3 reduces the 48x16 matrices into 36x16 matrices (applied in different shapes for the two transform types). There are several CE related proposals which propose different shapes, or even more reduction. Memory saving is slightly lower than for the other two proposals (32x16 would achieve that, which is proposed in a CE related proposal).

The opinion is expressed that the irregularity switching between two shapes might be undesirable, and it also does not reduce worst case of multiplications.

The 36x16 transform was retrained.

The main benefit of all three proposals is saving of memory. Hardware experts expressed that this is not a real problem (ROM, fixed table). No reason to change the existing design.

[JVET-P0041](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7830) CE6-1: LFNST with one mode [M.-S. Chiang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek), J. Lainema (Nokia)]

JVET-P0044 CE6-2.1: LFNST with 3 transform sets [Y. Zhao, H. Yang (Huawei)]

[JVET-P0051](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7840) CE6-2.2a/c: LFNST with unified kernels [X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-P0052](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7841) CE6-2.2d: Combination of CE6-2.2a and CE6-2.3 [X. Zhao, X. Li, S. Liu (Tencent), T. Zhou, T. Hashimoto, T. Ikai (Sharp)]

[JVET-P0065](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7854) CE6-2.3a: Simplification with new LFNST transform basis [T. Zhou, T. Hashimoto, T. Ikai (Sharp)] [late]

[JVET-P0594](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8386) Crosscheck of CE6-2.2a and CE6-2.2d: An Orthogonality Analysis [H. E. Egilmez]

[JVET-P0647](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8445) Crosscheck of CE6 Proposals, Under non-CTC Configuration [M. Koo (LGE)]

[JVET-P0899](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8714) Crosscheck of JVET-P0647: Crosscheck of CE6 Proposals, Under non-CTC Configuration [T. Zhou (Sharp)]

## CE7: Quantization and coefficient coding (9)

Contributions in this category were discussed Thursday 3 Oct. 1815–XXXX in Track A (chaired by JRO).

[JVET-P0027](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8396) CE7: Summary report on quantization and coefficient coding [H. Schwarz, M. Coban, C. Auyeung]

The CE report summarizes the test results and crosscheck reports for CE7 on quantization and coefficient coding. The CE includes 4 sub-CEs on the following topics:

• CE7-1: Coding order and bypass switch for transform skip residual coding

• CE7-2: Context modelling and binarization for transform skip residual coding

• CE7-3: Context reduction for regular transform coefficient coding

• CE7-4: Chroma cbf coding

**CE7-1: Summary of tests**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Tester** | **Tool** | **Cross checker** |
| CE7-1.1 | S.-T. Hsiang (Mediatek) | Re-positioning of parity flag (JVET-O0295) | M. Sarwer (Alibaba) |
| CE7-1.2a | Y.-H- Chao (Qualcomm) | 2-pass variant (JVET-O0623) | T. Nguyen (HHI) |
| CE7-1.2b | Y.-H- Chao (Qualcomm) | re-positioning of the parity flag after gtx scan (JVET-O0623) | T. Nguyen (HHI) |
| CE7-1.2c | Y.-H- Chao (Qualcomm) | Rice-Golomb coding after bypass switch (JVET-O0623) for 2 pass scan | T. Nguyen (HHI) |
| CE7-1.2d | Y.-H- Chao (Qualcomm) | Rice-Golomb coding after bypass switch (JVET-O0623) for 3 pass scan | T. Nguyen (HHI) |
| CE7-1.3a | M. Sarwer (Alibaba) | Swap position of parity\_flag and abs\_gt3\_flag (JVET-O0619) | S.-T. Hsiang (Mediatek) |
| CE7-1.3b | M. Sarwer (Alibaba) | Simplified bypass coding / unification of bypass switch for transform skip and regular transform coefficient coding (JVET-O0619) | S.-T. Hsiang (Mediatek) |
| CE7-1.3c | M. Sarwer (Alibaba) | Combination of CE7-1.3a and CE7-1.3b | S.-T. Hsiang (Mediatek) |

Remarks:

* One CE participant considered the test CE7-1.2d as new proposal and objected to include this test in the core experiment. There was no agreement among the CE participants regarding this point.
* One CE participant considered the alternative bypass coding for tests CE7-1.3b/c as new proposal and objected to include this alternative method in the core experiment. There was no agreement among the CE participants regarding this point.
* The starred versions “\*” in the result tables represent alternatives for the corresponding CE tests.
* One CE participant remarked that the CABAC initialization tables in CE tests CE7-1.2a/c/d were modified relative to VTM-6, which may have an impact on comparing the BD rate results.

During the drafting of the CE document, no consensus was reached on the bullets above. However, no such concern was raised when discussing the results in track A.

*Table 1: Average test results for CE7-1 and Common Test Conditions (CTC).*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Overall** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-1.1** | 0.00% | -0.01% | 0.01% | 100% | 99% | 0.01% | 0.06% | -0.04% | 100% | 100% | -0.02% | -0.14% | -0.23% | 101% | 106% |
| **CE7-1.2a** | 0.00% | 0.00% | 0.00% | 101% | 101% | 0.00% | 0.06% | 0.05% | 101% | 100% | -0.03% | 0.07% | -0.22% | 101% | 99% |
| **CE7-1.2b** | 0.00% | 0.00% | 0.00% | 101% | 101% | 0.01% | 0.04% | 0.02% | 101% | 100% | -0.02% | -0.01% | -0.23% | 100% | 99% |
| **CE7-1.2c** | 0.00% | -0.01% | -0.01% | 100% | 101% | 0.00% | 0.03% | 0.00% | 101% | 100% | -0.06% | 0.07% | 0.01% | 100% | 100% |
| **CE7-1.2c\*** | 0.00% | 0.00% | -0.02% | 101% | 101% | 0.00% | 0.05% | 0.02% | 101% | 100% | -0.04% | 0.13% | -0.11% | 100% | 99% |
| **CE7-1.2d** | 0.00% | -0.01% | 0.00% | 101% | 101% | 0.00% | 0.03% | 0.01% | 101% | 99% | -0.01% | 0.09% | -0.24% | 100% | 100% |
| **CE7-1.2d\*** | 0.00% | -0.01% | 0.00% | 101% | 100% | 0.00% | 0.04% | -0.04% | 101% | 100% | 0.00% | 0.17% | -0.22% | 100% | 99% |
| **CE7-1.3a** | 0.00% | -0.02% | -0.01% | 101% | 102% | -0.01% | 0.04% | 0.01% | 101% | 100% | -0.02% | -0.12% | -0.05% | 101% | 102% |
| **CE7-1.3b** | 0.00% | 0.01% | 0.00% | 101% | 102% | 0.01% | 0.06% | 0.04% | 101% | 101% | 0.01% | 0.00% | -0.06% | 101% | 102% |
| **CE7-1.3b\*** | 0.00% | 0.00% | -0.02% | 101% | 102% | 0.00% | 0.10% | 0.07% | 101% | 101% | 0.01% | 0.07% | -0.13% | 101% | 102% |
| **CE7-1.3c** | 0.00% | -0.02% | 0.01% | 100% | 102% | 0.00% | 0.03% | 0.07% | 101% | 100% | -0.06% | 0.16% | -0.11% | 101% | 102% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Class F** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-1.1** | -0.06% | -0.09% | -0.07% | 102% | 100% | -0.02% | -0.08% | -0.03% | 100% | 95% | -0.02% | -0.07% | 0.30% | 99% | 98% |
| **CE7-1.2a** | 0.02% | 0.00% | -0.13% | 100% | 98% | -0.01% | 0.02% | 0.13% | 102% | 101% | 0.06% | -0.25% | 0.28% | 102% | 99% |
| **CE7-1.2b** | -0.05% | -0.05% | 0.07% | 101% | 101% | -0.02% | 0.01% | 0.02% | 102% | 100% | 0.03% | 0.11% | 0.90% | 101% | 98% |
| **CE7-1.2c** | -0.03% | 0.04% | -0.05% | 99% | 98% | -0.07% | -0.10% | -0.06% | 101% | 100% | 0.08% | 0.07% | 0.08% | 100% | 100% |
| **CE7-1.2c\*** | -0.01% | 0.05% | -0.07% | 101% | 99% | 0.00% | -0.11% | 0.10% | 101% | 100% | -0.08% | 0.33% | 0.25% | 100% | 98% |
| **CE7-1.2d** | -0.05% | -0.05% | -0.15% | 99% | 99% | -0.03% | -0.11% | -0.04% | 101% | 100% | -0.15% | -0.03% | 0.15% | 100% | 98% |
| **CE7-1.2d\*** | -0.06% | -0.04% | -0.14% | 101% | 98% | -0.10% | -0.08% | -0.15% | 101% | 101% | 0.05% | -0.12% | 0.29% | 100% | 98% |
| **CE7-1.3a** | 0.00% | -0.06% | -0.01% | 102% | 101% | 0.02% | 0.01% | -0.05% | 101% | 100% | 0.08% | 0.05% | 0.54% | 101% | 102% |
| **CE7-1.3b** | 0.00% | -0.07% | -0.16% | 102% | 101% | -0.04% | 0.02% | 0.01% | 101% | 100% | 0.07% | 0.13% | 0.55% | 102% | 103% |
| **CE7-1.3b\*** | 0.00% | -0.05% | -0.02% | 102% | 101% | 0.01% | -0.04% | 0.14% | 101% | 101% | 0.10% | 0.26% | 0.54% | 102% | 103% |
| **CE7-1.3c** | 0.00% | -0.03% | -0.09% | 101% | 101% | -0.06% | 0.04% | 0.01% | 101% | 100% | 0.05% | -0.11% | 0.30% | 101% | 102% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **TGM** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-1.1** | -0.04% | -0.03% | -0.05% | 100% | 99% | -0.04% | -0.10% | -0.07% | 100% | 98% | -0.04% | 0.00% | 0.07% | 101% | 100% |
| **CE7-1.2a** | 0.01% | 0.06% | 0.05% | 101% | 99% | 0.02% | 0.02% | 0.01% | 102% | 100% | -0.02% | -0.02% | 0.06% | 99% | 101% |
| **CE7-1.2b** | -0.05% | -0.05% | -0.05% | 101% | 98% | -0.09% | -0.03% | -0.09% | 102% | 99% | -0.04% | -0.02% | 0.04% | 98% | 102% |
| **CE7-1.2c** | -0.04% | 0.02% | 0.00% | 99% | 100% | -0.07% | -0.05% | -0.05% | 102% | 98% | -0.06% | -0.02% | -0.05% | 99% | 98% |
| **CE7-1.2c\*** | 0.06% | 0.12% | 0.09% | 101% | 97% | 0.00% | 0.02% | 0.05% | 102% | 100% | -0.02% | 0.01% | 0.03% | 99% | 100% |
| **CE7-1.2d** | -0.15% | -0.11% | -0.12% | 99% | 100% | -0.10% | -0.07% | -0.12% | 101% | 99% | -0.10% | -0.06% | -0.04% | 99% | 100% |
| **CE7-1.2d\*** | -0.12% | -0.11% | -0.11% | 101% | 100% | -0.09% | -0.11% | -0.09% | 102% | 101% | -0.06% | -0.01% | -0.04% | 98% | 102% |
| **CE7-1.3a** | -0.04% | -0.03% | -0.03% | 101% | 101% | -0.05% | -0.07% | -0.08% | 101% | 100% | -0.04% | -0.08% | -0.03% | 102% | 100% |
| **CE7-1.3b** | -0.02% | 0.02% | 0.01% | 101% | 101% | -0.04% | -0.06% | -0.02% | 101% | 100% | -0.06% | -0.01% | 0.03% | 103% | 104% |
| **CE7-1.3b\*** | 0.04% | 0.08% | 0.05% | 102% | 101% | -0.03% | -0.01% | 0.03% | 101% | 101% | -0.09% | -0.07% | -0.05% | 103% | 101% |
| **CE7-1.3c** | -0.02% | -0.01% | 0.01% | 101% | 101% | -0.04% | -0.04% | -0.04% | 101% | 100% | -0.11% | -0.09% | -0.01% | 102% | 100% |

*Table 2: Average test results for CE7-1 and low QP (2, 7, 12, 17).*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Overall** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-1.1** | 0.00% | 0.00% | 0.00% | 97% | 98% | 0.00% | 0.00% | 0.00% | 96% | 98% | -0.01% | 0.00% | -0.01% | 97% | 97% |
| **CE7-1.2a** | 0.00% | 0.00% | 0.01% | 100% | 100% | 0.00% | -0.01% | 0.00% | 100% | 98% | -0.01% | -0.01% | -0.01% | 100% | 99% |
| **CE7-1.2b** | 0.00% | 0.00% | 0.00% | 99% | 98% | 0.00% | -0.01% | 0.00% | 99% | 100% | 0.00% | 0.01% | -0.01% | 99% | 98% |
| **CE7-1.2c** | -0.01% | -0.01% | 0.00% | 99% | 98% | 0.00% | 0.00% | -0.01% | 99% | 99% | -0.01% | 0.00% | -0.01% | 99% | 98% |
| **CE7-1.2c\*** | -0.03% | -0.03% | -0.01% | 99% | 98% | -0.02% | 0.00% | 0.00% | 99% | 99% | -0.03% | 0.00% | -0.01% | 99% | 99% |
| **CE7-1.2d** | -0.02% | -0.01% | 0.00% | 99% | 98% | -0.01% | -0.01% | -0.01% | 99% | 99% | -0.01% | 0.00% | -0.01% | 99% | 98% |
| **CE7-1.2d\*** | -0.03% | -0.02% | -0.02% | 100% | 98% | -0.01% | -0.01% | -0.01% | 99% | 99% | -0.01% | -0.01% | -0.03% | 99% | 98% |
| **CE7-1.3a** | 0.00% | 0.00% | 0.00% | 100% | 101% | -0.01% | -0.02% | 0.00% | 100% | 100% | -0.01% | 0.01% | -0.01% | 101% | 102% |
| **CE7-1.3b** | -0.01% | -0.02% | -0.01% | 100% | 98% | -0.01% | -0.01% | 0.00% | 100% | 100% | -0.02% | -0.01% | 0.00% | 100% | 98% |
| **CE7-1.3b\*** | -0.02% | -0.02% | 0.00% | 99% | 98% | -0.01% | -0.01% | -0.01% | 100% | 100% | -0.02% | 0.01% | -0.03% | 100% | 98% |
| **CE7-1.3c** | -0.01% | -0.02% | -0.01% | 99% | 99% | -0.01% | -0.01% | 0.00% | 100% | 100% | -0.02% | 0.01% | 0.01% | 100% | 98% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Class F** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-1.1** | -0.09% | -0.06% | -0.09% | 103% | 103% | -0.05% | -0.09% | -0.09% | 101% | 104% | -0.13% | -0.09% | -0.15% | 102% | 101% |
| **CE7-1.2a** | -0.10% | -0.07% | -0.06% | 100% | 99% | -0.11% | -0.16% | -0.13% | 99% | 100% | -0.16% | -0.19% | -0.17% | 100% | 97% |
| **CE7-1.2b** | -0.06% | -0.08% | -0.07% | 99% | 96% | -0.13% | -0.07% | -0.01% | 98% | 99% | -0.13% | -0.04% | -0.04% | 99% | 97% |
| **CE7-1.2c** | -1.02% | -0.54% | -0.49% | 98% | 95% | -0.99% | -0.63% | -0.50% | 98% | 98% | -0.48% | -0.41% | -0.38% | 98% | 96% |
| **CE7-1.2c\*** | -1.47% | -0.65% | -0.64% | 99% | 94% | -1.83% | -0.60% | -0.54% | 98% | 97% | -0.67% | -0.47% | -0.51% | 99% | 98% |
| **CE7-1.2d** | -1.33% | -0.71% | -0.71% | 97% | 94% | -1.28% | -0.78% | -0.80% | 98% | 97% | -0.50% | -0.41% | -0.54% | 98% | 98% |
| **CE7-1.2d\*** | -1.56% | -0.78% | -0.80% | 99% | 95% | -2.00% | -0.78% | -0.67% | 98% | 97% | -0.68% | -0.62% | -0.57% | 99% | 97% |
| **CE7-1.3a** | -0.04% | -0.04% | -0.06% | 100% | 100% | -0.08% | -0.11% | -0.10% | 100% | 99% | -0.15% | -0.20% | -0.13% | 101% | 100% |
| **CE7-1.3b** | -0.68% | -0.33% | -0.34% | 99% | 96% | -0.73% | -0.41% | -0.38% | 99% | 99% | -0.43% | -0.32% | -0.29% | 100% | 91% |
| **CE7-1.3b\*** | -1.21% | -0.50% | -0.51% | 99% | 96% | -1.51% | -0.57% | -0.67% | 100% | 99% | -0.49% | -0.28% | -0.27% | 100% | 91% |
| **CE7-1.3c** | -0.68% | -0.32% | -0.33% | 99% | 96% | -0.81% | -0.51% | -0.50% | 99% | 100% | -0.28% | -0.28% | -0.26% | 100% | 91% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **TGM** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-1.1** | -0.27% | -0.25% | -0.25% | 102% | 102% | -0.30% | -0.25% | -0.26% | 102% | 105% | -0.20% | -0.14% | -0.09% | 103% | 99% |
| **CE7-1.2a** | -0.31% | -0.19% | -0.19% | 99% | 102% | -0.20% | -0.21% | -0.26% | 100% | 100% | -0.30% | -0.20% | -0.16% | 100% | 98% |
| **CE7-1.2b** | -0.20% | -0.18% | -0.18% | 99% | 99% | -0.27% | -0.16% | -0.16% | 98% | 96% | -0.14% | -0.18% | -0.08% | 99% | 100% |
| **CE7-1.2c** | -1.82% | -1.47% | -1.47% | 97% | 98% | -2.26% | -1.29% | -1.28% | 98% | 96% | -1.33% | -1.06% | -1.00% | 97% | 99% |
| **CE7-1.2c\*** | -1.53% | -1.15% | -1.14% | 99% | 99% | -2.15% | -0.97% | -0.98% | 98% | 97% | -1.05% | -0.68% | -0.62% | 98% | 99% |
| **CE7-1.2d** | -2.03% | -1.67% | -1.66% | 97% | 98% | -2.56% | -1.32% | -1.30% | 98% | 97% | -1.33% | -1.17% | -1.15% | 97% | 99% |
| **CE7-1.2d\*** | -1.97% | -1.61% | -1.61% | 98% | 99% | -2.63% | -1.31% | -1.35% | 98% | 97% | -1.31% | -1.01% | -0.94% | 98% | 98% |
| **CE7-1.3a** | -0.20% | -0.15% | -0.15% | 100% | 99% | -0.17% | -0.17% | -0.18% | 100% | 99% | -0.20% | -0.11% | -0.05% | 101% | 98% |
| **CE7-1.3b** | -1.27% | -0.95% | -0.96% | 98% | 96% | -1.50% | -0.83% | -0.84% | 99% | 99% | -0.87% | -0.72% | -0.59% | 100% | 86% |
| **CE7-1.3b\*** | -1.41% | -1.03% | -1.02% | 98% | 96% | -2.02% | -0.90% | -0.90% | 100% | 99% | -1.00% | -0.57% | -0.47% | 100% | 85% |
| **CE7-1.3c** | -1.25% | -0.93% | -0.93% | 98% | 96% | -1.43% | -0.78% | -0.82% | 100% | 99% | -0.96% | -0.70% | -0.64% | 100% | 85% |

CE7-1.2c/d and CE7-1.3b are suggested to provide benefit in performing less checks for maximum allowed number of context coded bins in case of TS specific coding. Proponents and cross-checkers were asked to perform more analysis and reported back during the discussion of CE7 related proposals on Sat. 5 Oct.

It was reported that the 7-1.3b methods only need 2 checks per context coded bin in worst case, whereas the 7-1.2x methods require 8 checks.

7-1.3b has less changes compared to the current TS entropy coding, whereas 7-1.3b\* uses the same Rice-Golomb coding table as in regular TC entropy coding.

Additional results with limitation to 1.75 max number ctx coded bins are provided in JVET-P0072 as follows:

Table 14: results of CE7-1.3.b with reduced number of maximum context coded bins at CTC QP( Anchor: VTM-6.0 with 2 bins per coefficient; test: CE7-1.3b with 1.75 bins per coefficient) ( runtime is not accurate)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | |
|  | **Over VTM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class F | 0.12% | 0.10% | 0.15% | 101% | 106% |
| Class SCC | 0.28% | 0.26% | 0.26% | 101% | 105% |
|  |  |  |  |  |  |
|  | **Random access Main10** | | | | |
|  | **Over VTM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class F | 0.07% | 0.11% | 0.20% | 100% | 114% |
| Class SCC | 0.12% | 0.13% | 0.13% | 100% | 115% |
|  |  |  |  |  |  |
|  | **Low delay B Main10** | | | | |
|  | **Over VTM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class F | -0.01% | -0.02% | 0.46% | 101% | 120% |
| Class SCC | 0.07% | 0.11% | 0.10% | 101% | 119% |

Table 15: results of CE7-1.3.b-alt with reduced number of maximum context coded bins at CTC QP ( Anchor: VTM-6.0 with 2 bins per coefficient; test: CE7-1.3b-alt with 1.75 bins per coefficient) ( runtime is not accurate)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | |
|  | **Over VTM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class F | 0.12% | 0.04% | 0.09% | 101% | 106% |
| Class SCC | 0.33% | 0.33% | 0.31% | 100% | 106% |
|  |  |  |  |  |  |
|  | **Random access Main10** | | | | |
|  | **Over VTM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class F | 0.11% | 0.10% | 0.18% | 100% | 114% |
| Class SCC |  |  |  |  |  |
|  |  |  |  |  |  |
|  | **Low delay B Main10** | | | | |
|  | **Over VTM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class F | 0.14% | 0.44% | 0.64% | 101% | 119% |
| Class SCC | -0.02% | 0.16% | 0.17% | 102% | 119% |

Table 16: results of CE7-1.3.b with reduced number of maximum context coded bins under low QP( Anchor: VTM-6.0 with 2 bins per coefficient; test: CE7-1.3b with 1.75 bins per coefficient) ( runtime is not accurate)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | |
|  | **Over VTM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class F | -0.48% | -0.23% | -0.22% | 99% | 99% |
| Class SCC | -0.99% | -0.65% | -0.65% | 98% | 99% |
|  |  |  |  |  |  |
|  | **Random access Main10** | | | | |
|  | **Over VTM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class F | -0.27% | -0.20% | -0.14% | 100% | 110% |
| Class SCC | -1.14% | -0.55% | -0.55% | 100% | 114% |
|  |  |  |  |  |  |
|  | **Low delay B Main10** | | | | |
|  | **Over VTM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class F | -0.29% | -0.21% | -0.16% | 101% | 100% |
| Class SCC | -0.53% | -0.31% | -0.27% | 100% | 98% |

Table 17: results of CE7-1.3.b-alt with reduced number of maximum context coded bins at low QP ( Anchor: VTM-6.0 with 2 bins per coefficient; test: CE7-1.3b-alt with 1.75 bins per coefficient)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | |
|  | **Over VTM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class F | -1.08% | -0.38% | -0.34% | 99% | 99% |
| Class SCC | -1.16% | -0.73% | -0.72% | 98% | 99% |
|  |  |  |  |  |  |
|  | **Random access Main10** | | | | |
|  | **Over VTM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class F | -1.23% | -0.47% | -0.45% | 100% | 110% |
| Class SCC | -1.67% | -0.59% | -0.56% | 100% | 114% |
|  |  |  |  |  |  |
|  | **Low delay B Main10** | | | | |
|  | **Over VTM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class F | -0.44% | -0.27% | -0.19% | 100% | 101% |
| Class SCC | -0.74% | -0.38% | -0.31% | 100% | 98% |

The results indicate that both 7-1.3b and 7-1.3b\* have a slight loss against the current method under CTC (7-1.3b\* slightly worse than 7-1.3b), whereas in low QP range, both methods have clear gain (and 7-1.3b\* has more gain than 7-1.3b). The results have been cross-checked as well by Mediatek.

Decision: Adopt JVET-P0072, version 7-1.3b\* (aka 7-1.3alt), with limit 1.75.

It is also pointed out that the number of maximum number of context coded bins is still higher in TS specific coding than it is in regular coefficient coding. JVET-P0072 includes additional results on this aspect, and there are also non-CE contributions. Should be resolved at this meeting (was not investigated in CE).

CE7-2

**CE7-2: Summary of tests**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Tester** | **Tool** | **Cross checker** |
| CE7-2.1 | S.-T. Hsiang (Mediatek) | CE7-1.1 + Improved context modelling for abs\_gtx\_flags and par\_level\_flag (JVET-O0295) | M. Sarwer (Alibaba) |
| CE7-2.2a | Y.-H. Chao (Qualcomm) | QP dependent binarization (JVET-O0559) | Y. Chen (InterDigital) |
| CE7-2.2b | Y.-H. Chao (Qualcomm) | QP-dependent binarization + varying QP offset (JVET-O0559) | Y. Chen (InterDigital) |

Remarks:

* The starred versions “\*” in the result tables represent alternatives for the corresponding CE tests.

*Table 5: Average test results for CE7-2 and Common Test Conditions (CTC).*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Overall** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-2.1** | 0.00% | -0.02% | -0.01% | 102% | 101% | 0.00% | 0.02% | 0.07% | 103% | 99% | -0.06% | 0.19% | -0.13% | 101% | 100% |
| **CE7-2.2a** | 0.00% | -0.01% | 0.00% | 101% | 101% | 0.01% | 0.06% | 0.06% | 101% | 100% | -0.05% | 0.26% | 0.18% | 100% | 99% |
| **CE7-2.2a\*** | 0.00% | -0.01% | 0.01% | 101% | 101% | 0.00% | -0.01% | 0.04% | 101% | 100% | -0.05% | 0.16% | 0.01% | 100% | 99% |
| **CE7-2.2b** | 0.00% | 0.00% | -0.01% | 100% | 99% | 0.00% | -0.05% | 0.04% | 99% | 100% | 0.08% | 0.05% | -0.05% | 99% | 100% |
| **CE7-2.2b\*** | 0.00% | 0.00% | -0.02% | 100% | 98% | -0.01% | -0.07% | -0.03% | 100% | 99% | 0.01% | 0.12% | 0.14% | 99% | 101% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Class F** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-2.1** | -0.10% | -0.05% | -0.14% | 100% | 97% | -0.08% | -0.11% | -0.06% | 101% | 106% | -0.07% | -0.06% | 0.45% | 100% | 102% |
| **CE7-2.2a** | -0.03% | -0.18% | -0.23% | 102% | 99% | -0.22% | -0.20% | -0.22% | 103% | 100% | -0.13% | 0.12% | 0.40% | 102% | 97% |
| **CE7-2.2a\*** | -0.08% | -0.23% | -0.19% | 102% | 102% | -0.32% | -0.29% | -0.14% | 102% | 100% | -0.07% | 0.28% | 0.32% | 101% | 100% |
| **CE7-2.2b** | -0.14% | -0.28% | -0.05% | 101% | 98% | -0.28% | -0.23% | -0.31% | 100% | 100% | -0.13% | -0.20% | -0.58% | 100% | 101% |
| **CE7-2.2b\*** | -0.20% | -0.24% | -0.07% | 101% | 99% | -0.36% | -0.26% | -0.36% | 99% | 98% | -0.24% | -0.38% | -0.21% | 99% | 96% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **TGM** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-2.1** | -0.19% | -0.16% | -0.14% | 101% | 100% | -0.14% | -0.16% | -0.16% | 102% | 93% | -0.17% | -0.07% | -0.08% | 100% | 100% |
| **CE7-2.2a** | -0.01% | -0.09% | -0.08% | 102% | 103% | -0.11% | -0.14% | -0.13% | 103% | 100% | -0.09% | 0.01% | -0.05% | 98% | 101% |
| **CE7-2.2a\*** | -0.15% | -0.22% | -0.24% | 102% | 100% | -0.24% | -0.21% | -0.26% | 103% | 100% | -0.18% | -0.12% | 0.03% | 99% | 100% |
| **CE7-2.2b** | -0.26% | -0.24% | -0.26% | 102% | 101% | -0.30% | -0.31% | -0.33% | 100% | 100% | -0.14% | -0.14% | -0.10% | 100% | 99% |
| **CE7-2.2b\*** | -0.37% | -0.41% | -0.40% | 101% | 98% | -0.39% | -0.40% | -0.46% | 100% | 99% | -0.25% | -0.19% | -0.10% | 101% | 99% |

*Table 6: Average test results for CE7-2 and low QP (2, 7, 12, 17).*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Overall** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-2.1** | 0.00% | -0.01% | 0.00% | 100% | 100% |  |  |  |  |  | 0.00% | 0.00% | -0.01% | 97% | 96% |
| **CE7-2.2a** | 0.07% | 0.02% | 0.03% | 100% | 99% | 0.02% | 0.01% | 0.00% | 100% | 99% | 0.05% | -0.03% | -0.04% | 100% | 99% |
| **CE7-2.2a\*** | 0.03% | 0.01% | 0.01% | 99% | 98% | 0.00% | 0.00% | -0.01% | 99% | 99% | 0.03% | -0.01% | -0.01% | 99% | 98% |
| **CE7-2.2b** | 0.08% | 0.03% | 0.02% | 100% | 99% | 0.01% | 0.00% | 0.00% | 100% | 100% | 0.04% | 0.00% | -0.01% | 100% | 100% |
| **CE7-2.2b\*** | 0.03% | 0.01% | 0.01% | 100% | 98% | 0.00% | 0.00% | 0.00% | 100% | 101% | 0.02% | 0.00% | -0.01% | 99% | 98% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Class F** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-2.1** | -0.12% | -0.09% | -0.10% | 102% | 101% | -0.26% | -0.29% | -0.30% | 101% | 102% | -0.06% | -0.06% | -0.03% | 100% | 99% |
| **CE7-2.2a** | -1.01% | -1.57% | -1.60% | 101% | 96% | -1.04% | -1.71% | -1.65% | 100% | 101% | -1.06% | -1.00% | -1.05% | 101% | 100% |
| **CE7-2.2a\*** | -2.06% | -1.57% | -1.54% | 99% | 96% | -1.76% | -1.68% | -1.55% | 99% | 99% | -1.13% | -1.05% | -1.06% | 99% | 98% |
| **CE7-2.2b** | -1.46% | -1.57% | -1.53% | 101% | 98% | -1.64% | -1.67% | -1.71% | 101% | 102% | -1.10% | -1.10% | -1.18% | 100% | 102% |
| **CE7-2.2b\*** | -1.72% | -1.61% | -1.57% | 99% | 97% | -1.92% | -1.74% | -1.77% | 100% | 100% | -1.04% | -1.08% | -1.13% | 99% | 100% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **TGM** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-2.1** | -0.32% | -0.26% | -0.25% | 102% | 102% | -0.31% | -0.25% | -0.23% | 100% | 99% | -0.28% | -0.15% | -0.09% | 102% | 97% |
| **CE7-2.2a** | -5.60% | -4.88% | -4.86% | 101% | 98% | -5.28% | -3.92% | -3.94% | 101% | 99% | -3.56% | -2.89% | -2.85% | 102% | 101% |
| **CE7-2.2a\*** | -5.43% | -4.74% | -4.74% | 100% | 97% | -5.36% | -3.67% | -3.66% | 100% | 97% | -3.41% | -2.94% | -2.90% | 100% | 99% |
| **CE7-2.2b** | -5.69% | -4.96% | -4.97% | 102% | 97% | -4.62% | -3.90% | -3.88% | 102% | 100% | -3.51% | -3.10% | -3.14% | 101% | 99% |
| **CE7-2.2b\*** | -5.51% | -4.82% | -4.80% | 101% | 94% | -4.49% | -3.74% | -3.72% | 100% | 97% | -3.30% | -2.93% | -2.94% | 101% | 102% |

Modifications only for TS specific entropy coding case

CE7-2.1 requires an additional coding pass.

The proposed methods show no benefit in CTC for camera captured content, and small benefit for screen content in CTC range of QPs.

For low QP, this stays similar for CE7-2.1, whereas CE7-2.2 (QP dependent binarization in TS) has small loss for natural coding, while the gain is significant for screen content.

From the results of the CE, no immediate action, behavior of CE7-2.2 needs to be better understood (is it specifically good on screen content only?).

It is reported that the methods are also investigated in the context of lossless coding in the AHG18 investigation.

CE7-3

**CE7-3: Summary of tests**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Tester** | **Tool** | **Cross checker** |
| CE7-3.1a | S.-T. Hsiang (Mediatek) | Context reduction for sig\_coeff\_flag (JVET-O0928) on 6 context subsets | C. Auyeung (Tencent) |
| CE7-3.1b | S.-T. Hsiang (Mediatek) | Context reduction for sig\_coeff\_flag (JVET-O0928) on 9 context subsets | M. Sarwer (Alibaba) |
| CE7-3.2 | F. Le Léannec (InterDigital) | Context reduction by reducing the template for chroma blocks (JVET-O1098) | Y.-H. Chao (Qualcomm) |
| CE7-3.3a | S.-T. Hsiang (Mediatek),  F. Le Léannec (InterDigital) | Combination of CE7-3.1a and CE7-3.2 | Y.-H. Chao (Qualcomm) |
| CE7-3.3b | S.-T. Hsiang (Mediatek),  F. Le Léannec (InterDigital) | Combination of CE7-3.1b and CE7-3.2 | Y.-H. Chao (Qualcomm) |

Remarks:

* For the starred versions “\*” in the result tables, the CABAC initialization tables have been retrained (despite of that nothing was modified).

*Table 9: Average test results for CE7-3 and Common Test Conditions (CTC).*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Overall** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-3.1a** | 0.01% | -0.04% | 0.00% | 102% | 103% | 0.02% | 0.02% | 0.07% | 103% | 100% | -0.05% | 0.43% | -0.25% | 102% | 101% |
| **CE7-3.1b** | 0.02% | -0.05% | -0.03% | 103% | 102% | 0.01% | 0.02% | 0.06% | 103% | 100% | 0.00% | 0.05% | 0.10% | 101% | 99% |
| **CE7-3.2** | 0.01% | 0.17% | 0.21% | 103% | 103% | 0.02% | 0.22% | 0.20% | 99% | 103% | -0.02% | 0.17% | 0.03% | 106% | 108% |
| **CE7-3.2\*** | 0.00% | 0.26% | 0.24% | 103% | 104% | 0.01% | 0.32% | 0.26% | 99% | 103% | -0.03% | 0.39% | 0.26% | 100% | 100% |
| **CE7-3.3a** | 0.02% | 0.18% | 0.14% | 105% | 104% | 0.00% | 0.19% | 0.21% | 101% | 102% | -0.03% | 0.30% | 0.15% | 101% | 101% |
| **CE7-3.3a\*** | 0.01% | 0.22% | 0.27% | 101% | 101% | -0.01% | 0.33% | 0.36% | 101% | 103% | -0.06% | 0.50% | 0.11% | 101% | 101% |
| **CE7-3.3b** | 0.03% | 0.12% | 0.16% | 104% | 104% | 0.01% | 0.15% | 0.16% | 101% | 103% | -0.02% | 0.12% | 0.09% | 103% | 102% |
| **CE7-3.3b\*** | 0.02% | 0.22% | 0.25% | 102% | 101% | 0.00% | 0.30% | 0.29% | 101% | 103% | -0.01% | 0.30% | 0.39% | 101% | 102% |

*Table 10: Average test results for CE7-3 and low QP (2, 7, 12, 17).*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Overall** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-3.1a** | 0.01% | -0.01% | -0.01% | 101% | 100% | 0.01% | -0.01% | -0.02% | 102% | 100% | 0.01% | -0.01% | -0.01% | 99% | 98% |
| **CE7-3.1b** | 0.02% | -0.01% | 0.01% | 102% | 102% | 0.04% | -0.08% | -0.05% | 102% | 101% | 0.03% | -0.09% | -0.02% | 99% | 97% |
| **CE7-3.2** | 0.09% | 0.59% | 0.61% | 96% | 99% | 0.04% | 0.25% | 0.23% | 98% | 98% | 0.02% | 0.16% | 0.18% | 102% | 102% |
| **CE7-3.2\*** | 0.08% | 0.58% | 0.62% | 99% | 101% | 0.03% | 0.27% | 0.24% | 103% | 102% | 0.02% | 0.23% | 0.18% | 93% | 92% |
| **CE7-3.3a** | 0.10% | 0.59% | 0.61% | 99% | 100% | 0.05% | 0.23% | 0.23% | 104% | 101% | 0.03% | 0.17% | 0.17% | 94% | 94% |
| **CE7-3.3a\*** | 0.08% | 0.60% | 0.63% | 101% | 103% | 0.02% | 0.31% | 0.27% | 104% | 103% | 0.01% | 0.28% | 0.21% | 94% | 93% |
| **CE7-3.3b** | 0.12% | 0.55% | 0.61% | 101% | 103% | 0.08% | 0.17% | 0.19% | 104% | 102% | 0.06% | 0.08% | 0.13% | 93% | 94% |
| **CE7-3.3b\*** | 0.10% | 0.57% | 0.63% | 100% | 103% | 0.06% | 0.24% | 0.23% | 102% | 102% | 0.04% | 0.20% | 0.16% | 95% | 94% |

This relates to regular TC coding.

CE7-3.1 reduces number of context models, but makes calculation of context index more complicated (which is somehow reflected in the increased encoding and decoding time).

CE7-3.2 reduces the number of context models for chroma, but shows loss in particular for the low QP range.

Number of context models is not a critical issue – no need for action.

CE7-4

**CE7-4: Summary of tests**

|  |  |  |  |
| --- | --- | --- | --- |
| CE7-4.1 | S. Esenlik (Huawei) | Coding of chroma cbf’s and joint chroma residual coding flag (JVET-O0231) | C. Helmrich (HHI) |

Remarks:

* For the starred versions “\*” in the result tables, the Lagrange parameter was modified (no changes on normative aspects).

*Table 11: Average test results for CE7-4, Common Test Conditions (CTC) and low QP (2, 7, 12, 13).*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **CTC** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-4.1** | 0.08% | -0.67% | -0.48% | 103% | 103% | 0.14% | -1.15% | -1.39% | 103% | 102% | 0.03% | -0.41% | -2.08% | 103% | 102% |
| **CE7-4.1\*** | 0.08% | -0.67% | -0.48% | 100% | 100% | 0.01% | -0.52% | -0.89% | 100% | 100% | -0.06% | 1.37% | -0.64% | 100% | 100% |
| **CE7-4.1+** | 0.02% | -0.10% | 0.02% | 102% | 98% | 0.02% | -0.33% | -0.74% | 101% | 97% | 0.02% | 0.42% | -1.35% | 101% | 93% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **lowQP** | **All Intra (AI)** | | | | | **Random Access (RA)** | | | | | **Low Delay B (LB)** | | | | |
| Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec | Y | Cb | Cr | Enc | Dec |
| **CE7-4.1** | 0.04% | 0.03% | -0.01% | 101% | 99% | 0.08% | -0.07% | -0.16% | 101% | 99% | 0.05% | 0.22% | -0.40% | 101% | 99% |

Note: The version “CE7-4.1+” represents a test with lambda tuning (the one used in joint CbCr coding) done by the cross checker independently (different lambda tuning than that of the proponent).

*Table 12: Average test results for CE7-4 and HDR.*

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **AI** |  |  | **wPSNR** | | | **PSNR** | | |  |  |
| DE100 | L100 | Y | Cb | Cr | Y | Cb | Cr | Enc | Dec |
| **CE7-4.1** | -1.46% | 0.13% | 0.13% | -1.01% | -4.27% | 0.11% | -0.53% | -4.08% | 100% | 100% |
| **CE7-4.1+** | -0.90% | 0.07% | 0.07% | 0.40% | -2.20% | 0.05% | 0.63% | -2.36% | 100% | 101% |
|  |  |  |  |  |  |  |  |  |  |  |
| **RA** |  |  | **wPSNR** | | | **PSNR** | | |  |  |
| DE100 | L100 | Y | Cb | Cr | Y | Cb | Cr | Enc | Dec |
| **CE7-4.1** | -1.36% | 0.07% | 0.09% | -1.33% | -5.14% | 0.08% | -0.53% | -5.14% | 100% | 100% |
| CE7-4.1+ | -0.81% | 0.04% | 0.02% | 0.41% | -3.01% | 0.03% | 0.86% | -3.49% | 100% | 102% |

Note: The DE100 and L100 data are taken from the cross checker. The version “CE7-4.1+” represents a test with lambda tuning done by the cross checker.

The method is coding 3 flags instead of two, but the number of context coded bins is not increased (reduced on average if both Cb and Cr are zero). Due to the fact that selecting both Cb and Cr to be coded is cheaper, more rate would go into chroma (which explains the slight shift of bits from luma to chroma in the results above). In the results “7-4.1+” the cross-checkers tried to align this by changing lambda in RDO. This indicates that still benefit remains (at least in RA). However, one expert mentions that some effects of that specific lambda may interfere with the QP difference table that was adopted in the last meeting. It is notes that this may also be the reason that the coding gain is lower now than it was in the last meeting.

It is also not clear if this would have benefit in case of 4:4:4 coding.

Benefit is very low, and no support expressed by other experts.

No action.

[JVET-P0046](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7835) CE7-1.1 and CE7-2.1: Improving transform skip residual coding [S.-T. Hsiang, T.-D. Chuang, Y.-W. Huang, S.-M. Lei (MediaTek)

[JVET-P0047](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7836) CE7-3.1: Context reduction for sig\_coeff\_flag [S.-T. Hsiang, T.-D. Chuang, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0049](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7838) CE7-4.1: Coding of chroma cbf flags [S. Esenlik, B. Wang, A. M. Kotra, H. Gao, E. Alshina (Huawei)]

[JVET-P0066](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7855) CE7-3.2: Context reduction by reduced usage of local neighbourhood [Y. Chen, F. Le Léannec, T. Poirier, F. Galpin (InterDigital)]

[JVET-P0067](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7856) CE7-3.3: Context reduction for sig\_coeff\_flag, par\_level\_flag, abs\_level\_gtx\_flag [Y. Chen, F. Le Léannec, T. Poirier, F. Galpin (Intedigital), S.-T. Hsiang, T.-D. Chuang, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0072](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7861) CE7-1.3: Simplification of transform-skip residual coding [M. G. Sarwer, R. -L. Liao, J. Luo, Y. Ye (Alibaba)]

[JVET-P0985](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8800) Crosscheck of CE7-1.3b-Alt of JVET-P0072 with the maximum number of context coded bins reduced to 1.75 per coefficient [S.-T. Hsiang (MediaTek)]

[JVET-P0076](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7865) CE7-2.2: QP dependent binarization in TS residual coding [M. Karczewicz, H. Wang, Y.-H. Chao, M. Coban (Qualcomm)]

[JVET-P0079](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7868) CE7: Modifications to transform-skip residual coding (CE7-1.2) [M. Karczewicz, H. Wang, Y.-H. Chao, M. Coban (Qualcomm)]

## CE8: Screen content coding tools (6)

Contributions in this category were discussed Friday 4 Oct. 1130–1300 in Track A (chaired by JRO).

[JVET-P0028](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8287) CE8: Summary Report on 4:4:4 Screen Content Coding Tools [X. Xu, Y.-C. Chao, Y.-C. Sun, J. Xu]

This contribution provides a summary report of Core Experiment 8 on 4:4:4 screen content coding tools. 5 tests have been tested in CE8 in between JVET-O and JVET-P meetings, to study and evaluate technologies related to 4:4:4 screen content coding. In this report, coding performance and complexity of these tests are reported and analyzed. In particular, test results against VTM-6.0 anchors (4:4:4 settings) are provided to show the coding efficiency and complexity trade-off of each tool. Some of the tests are also evaluated under low QPs testing conditions. Crosschecking results for the performed tests are integrated in this contribution.

|  |  |  |  |
| --- | --- | --- | --- |
| **Test** | **Tester** | **Document** | **Tool description** |
| CE8-1.1 | Y.-C. Sun  (Alibaba) | JVET-P0060 | Palette mode neighboring pixel copy |
| CE8-1.2 | W. Zhu  (ByteDance) | JVET-P0055 | Palette and IBC combination |
| CE8-1.3 | Y.-H. Chao  (Qualcomm) | JVET-P0077 | Line-based CG Palette mode |
| CE8-2.1 | T. Tsukuba,  M. Ikeda, Y. Yagasaki (Sony) | JVET-P0058 | Chroma TS support with limited maximum number of TS residual context-coded bins |
| CE8-4.1 | F. Henry (Orange)  T. Tsukuba (Sony) | JVET-P0059 | Chroma TS and BDPCM support |

Note: In addition to 4:4:4 Testing condition with normal QP range, tests of CE8-2 and CE8-4 should be performed for low QP cases (2, 7, 12, 17) for 1st 100 frames of each sequence, which are also used in CE7 tests.

Note also that one element in CE8-4.1 is the chroma support of BDPCM. The original test was withdrawn but the combination with CE8-2.1 is still tested. This was reflected in the CE description JVET-O2028 v4.

The detailed description of each tools is provided in the next section.

The followings are summary tables of the tests in this CE.

Table 3: CE8 test results with VTM-6.0+IBC=1+PLT=1+DualTree=1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **AI Over VTM-6.0** | | | | | | **RA Over VTM-6.0** | | | | | |
|  | **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | | **U** | **V** | **EncT** | **DecT** |
| TGM 1080p | CE8-1.1 | -1.03% | -1.44% | -1.53% | 103% | 101% | -0.89% | | -1.44% | -1.20% | 101% | 97% |
| CE8-1.2 | -0.33% | 0.00% | -0.04% | 127% | 102% | -0.42% | | -0.25% | -0.19% | 114% | 102% |
| CE8-1.3 | -0.95% | -0.18% | -0.09% | 107% | 100% | -0.27% | | -0.06% | 0.22% | 105% | 100% |
| CE8-2.1 | -0.74% | -0.75% | -1.51% | 109% | 100% | -0.45% | | -2.36% | -2.53% | 110% | 102% |
| CE8-4.1 | -0.61% | -1.04% | -1.54% | 117% | 98% | -0.44% | | -2.62% | -2.66% | 112% | 102% |
| TGM 720p | CE8-1.1 | 0.03% | 0.07% | 0.15% | 102% | 97% | -0.05% | | -0.41% | -0.53% | 101% | 101% |
| CE8-1.2 | 0.02% | -0.01% | -0.12% | 127% | 100% | -0.05% | | -0.15% | -0.09% | 113% | 105% |
| CE8-1.3 | -0.47% | 0.03% | 0.29% | 105% | 100% | -0.49% | | 0.35% | 0.58% | 103% | 102% |
| CE8-2.1 | 0.24% | -0.68% | -0.54% | 105% | 99% | 0.07% | | -1.25% | -1.29% | 105% | 100% |
| CE8-4.1 | 0.31% | -0.57% | -0.44% | 110% | 96% | 0.31% | | -1.28% | -1.17% | 107% | 100% |
| Animation | CE8-1.1 | 0.07% | 0.05% | 0.09% | 99% | 97% | -0.11% | | -0.27% | -0.22% | 101% | 102% |
| CE8-1.2 | 0.00% | 0.00% | 0.04% | 132% | 102% | 0.04% | | 0.01% | -0.01% | 114% | 103% |
| CE8-1.3 | -0.14% | 0.11% | 0.05% | 104% | 100% | -0.26% | | -0.16% | -0.16% | 105% | 101% |
| CE8-2.1 | -0.11% | -0.79% | -0.32% | 105% | 100% | 0.17% | | -1.46% | -0.64% | 105% | 99% |
| CE8-4.1 | 0.38% | -0.33% | 0.27% | 110% | 97% | 0.40% | | -1.21% | -0.36% | 107% | 98% |
| Mixed Content | CE8-1.1 | -0.05% | -0.06% | -0.01% | 100% | 99% | 0.05% | | -0.32% | 0.04% | 100% | 99% |
| CE8-1.2 | 0.00% | -0.01% | 0.05% | 128% | 101% | 0.00% | | 0.01% | 0.04% | 112% | 100% |
| CE8-1.3 | -0.94% | -0.37% | -0.82% | 104% | 99% | -0.63% | | -0.14% | -0.48% | 104% | 100% |
| CE8-2.1 | -0.37% | -0.88% | -1.46% | 105% | 100% | -0.20% | | -2.14% | -2.48% | 104% | 99% |
| CE8-4.1 | -0.55% | -1.11% | -1.80% | 113% | 98% | -0.10% | | -2.54% | -2.65% | 105% | 99% |
| Camera-Captured | CE8-1.1 | -0.01% | 0.05% | -0.01% | 100% | 98% | -0.02% | | 0.01% | 0.08% | 99% | 101% |
| CE8-1.2 | 0.00% | 0.06% | -0.01% | 131% | 101% | 0.00% | | 0.09% | 0.11% | 113% | 102% |
| CE8-1.3 | 0.00% | 0.02% | 0.01% | 106% | 101% | -0.02% | | 0.01% | 0.05% | 102% | 100% |
| CE8-2.1 | 0.08% | 0.26% | 0.19% | 107% | 102% | 0.00% | | 0.25% | 0.15% | 103% | 101% |
| CE8-4.1 | 0.13% | 0.66% | 0.68% | 111% | 100% | 0.06% | | 0.34% | 0.48% | 105% | 102% |

Table 4: CE8 test results with VTM-6.0+IBC=1+PLT=1+DualTree=0

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **AI Over VTM-6.0** | | | | | | **RA Over VTM-6.0** | | | | | |
|  | **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | | **U** | **V** | **EncT** | **DecT** |
| TGM 1080p | CE8-1.1 | -1.66% | -1.88% | -1.95% | 102% | 102% | -1.13% | | -1.24% | -1.24% | 99% | 96% |
| CE8-1.2 | -1.31% | -1.55% | -1.69% | 124% | 103% | -0.94% | | -1.01% | -0.78% | 113% | 101% |
| CE8-1.3 | 0.03% | -0.23% | -0.16% | 103% | 99% | -0.12% | | -1.00% | -0.01% | 103% | 101% |
| CE8-2.1 | 0.46% | -1.58% | -1.69% | 115% | 100% | -0.36% | | -3.13% | -3.37% | 111% | 100% |
| CE8-4.1 | 0.71% | -1.87% | -1.95% | 121% | 98% | -0.21% | | -3.20% | -3.21% | 113% | 100% |
| TGM 720p | CE8-1.1 | 0.08% | -0.07% | -0.32% | 102% | 100% | -0.23% | | -0.20% | -0.13% | 101% | 101% |
| CE8-1.2 | -0.02% | -0.45% | -0.61% | 123% | 101% | -0.40% | | -0.80% | -0.68% | 114% | 103% |
| CE8-1.3 | -0.07% | -0.42% | 0.33% | 101% | 99% | -0.18% | | -0.01% | -0.15% | 102% | 101% |
| CE8-2.1 | 0.82% | -1.36% | -0.73% | 111% | 101% | 0.22% | | -2.38% | -1.51% | 107% | 100% |
| CE8-4.1 | 1.51% | -1.52% | -1.06% | 117% | 100% | 0.66% | | -2.81% | -1.73% | 109% | 100% |
| Animation | CE8-1.1 | 0.06% | 0.13% | 0.18% | 101% | 100% | -0.28% | | -0.25% | -0.21% | 101% | 100% |
| CE8-1.2 | 0.01% | 0.04% | 0.06% | 125% | 99% | -0.04% | | -0.08% | -0.04% | 114% | 101% |
| CE8-1.3 | 0.07% | 0.19% | 0.45% | 102% | 100% | -0.28% | | -0.21% | -0.20% | 105% | 100% |
| CE8-2.1 | 0.23% | -0.36% | 0.06% | 109% | 100% | 0.20% | | -1.21% | -0.43% | 107% | 100% |
| CE8-4.1 | 0.46% | -0.57% | -0.24% | 114% | 100% | 0.31% | | -1.36% | -0.68% | 109% | 100% |
| Mixed Content | CE8-1.1 | -0.36% | -1.04% | -1.06% | 100% | 97% | -0.28% | | -0.80% | -0.87% | 100% | 100% |
| CE8-1.2 | -0.21% | -1.02% | -0.93% | 125% | 102% | -0.31% | | -0.38% | -0.62% | 112% | 101% |
| CE8-1.3 | -0.35% | -0.57% | -0.74% | 103% | 99% | -0.32% | | -1.35% | -1.71% | 104% | 100% |
| CE8-2.1 | -0.15% | -3.69% | -4.03% | 111% | 100% | -0.91% | | -5.18% | -5.38% | 106% | 100% |
| CE8-4.1 | 0.67% | -4.04% | -4.22% | 117% | 98% | -0.52% | | -6.06% | -6.20% | 107% | 100% |
| Camera-Captured | CE8-1.1 | 0.00% | 0.00% | 0.00% | 99% | 100% | 0.00% | | 0.00% | 0.01% | 100% | 99% |
| CE8-1.2 | 0.00% | 0.00% | 0.00% | 127% | 101% | 0.00% | | 0.00% | 0.01% | 113% | 103% |
| CE8-1.3 | 0.00% | 0.00% | 0.00% | 101% | 100% | 0.00% | | -0.01% | -0.01% | 100% | 101% |
| CE8-2.1 | 0.02% | 0.45% | 0.22% | 108% | 100% | 0.04% | | 0.30% | 0.24% | 104% | 100% |
| CE8-4.1 | 0.24% | 0.31% | 0.15% | 114% | 101% | 0.08% | | 0.26% | 0.02% | 106% | 101% |

Table 5: CE8 test results with VTM-6.0+IBC=1+PLT=1+DualTree=1, LowQP

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **AI Over VTM-6.0** | | | | | | **RA Over VTM-6.0** | | | | | |
|  | **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | | **U** | **V** | **EncT** | **DecT** |
| TGM 1080p | CE8-1.1 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.2 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.3 | 0.21% | -1.18% | -1.38% | 107% | 102% | 0.11% | | -0.51% | -0.45% | 102% | 101% |
| CE8-2.1 | -0.12% | -3.00% | -3.10% | 115% | 103% | -4.07% | | -6.57% | -6.85% | 112% | 97% |
| CE8-4.1 | -0.71% | -4.08% | -3.96% | 117% | 98% | -4.22% | | -7.28% | -7.56% | 113% | 97% |
| TGM 720p | CE8-1.1 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.2 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.3 | -0.67% | -0.84% | -0.82% | 104% | 101% | -0.27% | | -0.21% | -0.15% | 102% | 106% |
| CE8-2.1 | -0.07% | -2.50% | -2.49% | 112% | 102% | 0.38% | | -4.95% | -5.21% | 107% | 100% |
| CE8-4.1 | -0.57% | -3.16% | -3.03% | 117% | 101% | 0.60% | | -8.31% | -8.47% | 111% | 101% |
| Animation | CE8-1.1 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.2 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.3 | -0.65% | -0.98% | -1.00% | 103% | 100% | 0.16% | | -0.32% | -0.21% | 101% | 101% |
| CE8-2.1 | -0.24% | -3.68% | -2.48% | 108% | 101% | -2.39% | | -8.29% | -7.37% | 110% | 98% |
| CE8-4.1 | -0.36% | -4.20% | -3.00% | 114% | 99% | -2.45% | | -8.68% | -7.77% | 110% | 98% |
| Mixed Content | CE8-1.1 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.2 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.3 | -1.02% | -2.53% | -2.59% | 103% | 97% | -0.02% | | -2.80% | -3.06% | 102% | 99% |
| CE8-2.1 | 0.59% | -5.25% | -5.98% | 112% | 102% | 1.06% | | -13.79% | -14.87% | 108% | 97% |
| CE8-4.1 | 0.10% | -5.97% | -6.70% | 123% | 103% | 1.41% | | -18.67% | -19.61% | 109% | 96% |
| Camera-Captured | CE8-1.1 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.2 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.3 | 0.00% | 0.00% | 0.00% | 101% | 100% | -0.01% | | 0.02% | -0.04% | 100% | 101% |
| CE8-2.1 | 0.03% | -0.04% | 0.00% | 106% | 101% | -0.04% | | -0.08% | -0.47% | 105% | 101% |
| CE8-4.1 | 0.02% | -0.03% | 0.00% | 111% | 99% | -0.03% | | -0.09% | -0.43% | 106% | 100% |

Table 6: CE8 test results with VTM-6.0+IBC=1+PLT=1+DualTree=0, LowQP

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **AI Over VTM-6.0** | | | | | | **RA Over VTM-6.0** | | | | | |
|  | **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | | **U** | **V** | **EncT** | **DecT** |
| TGM 1080p | CE8-1.1 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.2 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.3 | -1.40% | -1.96% | -1.82% | 103% | 99% | -0.28% | | -0.98% | -0.81% | 102% | 102% |
| CE8-2.1 | -4.48% | -5.32% | -5.71% | 120% | 101% | -6.03% | | -8.10% | -8.63% | 114% | 98% |
| CE8-4.1 | -4.77% | -5.67% | -6.09% | 124% | 99% | -6.40% | | -9.36% | -9.84% | 116% | 99% |
| TGM 720p | CE8-1.1 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.2 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.3 | -0.83% | -0.87% | -0.81% | 102% | 102% | -0.40% | | -0.53% | -0.56% | 101% | 108% |
| CE8-2.1 | -1.45% | -3.16% | -3.07% | 115% | 101% | -1.15% | | -6.29% | -6.77% | 109% | 99% |
| CE8-4.1 | -1.61% | -3.66% | -3.49% | 119% | 99% | -1.15% | | -9.33% | -9.98% | 111% | 99% |
| Animation | CE8-1.1 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.2 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.3 | -0.37% | -1.14% | -1.25% | 101% | 98% | 0.20% | | -0.44% | -0.44% | 101% | 99% |
| CE8-2.1 | -0.20% | -3.12% | -2.01% | 111% | 101% | -2.47% | | -8.32% | -7.30% | 110% | 98% |
| CE8-4.1 | -0.25% | -3.82% | -2.46% | 116% | 100% | -2.39% | | -8.31% | -7.66% | 112% | 98% |
| Mixed Content | CE8-1.1 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.2 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.3 | -1.04% | -1.66% | -1.79% | 102% | 98% | -0.37% | | -1.18% | -1.36% | 101% | 101% |
| CE8-2.1 | -3.38% | -6.97% | -7.83% | 117% | 99% | -1.07% | | -12.81% | -13.63% | 108% | 94% |
| CE8-4.1 | -3.56% | -7.42% | -8.39% | 122% | 98% | -1.38% | | -17.59% | -18.37% | 107% | 90% |
| Camera-Captured | CE8-1.1 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.2 |  |  |  |  |  |  | |  |  |  |  |
| CE8-1.3 | 0.00% | 0.00% | 0.00% | 100% | 99% | 0.01% | | -0.01% | 0.02% | 99% | 100% |
| CE8-2.1 | 0.03% | -0.02% | -0.01% | 107% | 99% | -0.01% | | -0.10% | -0.39% | 105% | 99% |
| CE8-4.1 | 0.03% | -0.01% | -0.02% | 112% | 100% | 0.00% | | -0.11% | -0.43% | 105% | 98% |

It is verbally reported that the base palette mode gives gives approx. 18% for TGM 1080p for the dual tree off case. For dual tree on, the gain is 16%. Dual tree off has about 28% gain for that class. It is noted that the benefit of disabling dual tree is only observed for 4:4:4 screen content. For camera captured 4:4:4, dual tree is still better. Compared to that, the additional benefit of those palette proposals targeting better compression by adding more palette options (8-1.1 and 8-1.2) is relatively low. Not sufficient benefit to take action.

8-1.3 allows handling of groups of 16 samples, such that reconstruction can already start before the palette indexes of the whole CU are decoded (escape flags are coded after the group of 16 samples, which is the same interleaving of context coded and bypass coded bins as in the current palette when Cus have size 4x4). The method also replaces the run length coding by signalling the identity or not-identity with the previous sample. It is noted that the worst case of context is not increased (it is 2 per pixel, but this is still less than for the case of transform coding, as in case of single tree all three component samples are covered, and in case of dual tree, the chroma components are coded jointly). Worst case number of context coded bins is less in palette than in residual coding for the 4:4:4 case.

It is asked why this method has benefit in compression. Proponents report that they have performed encoder optimization (RD decision) which can be implemented simpler due to the sample wise decision and would be more difficult with run length coding. The encoder run time increases by around 3% on average. Has also advantage on other classes than TGM 1080.

The method has advantages in terms of buffer saving, and better pipelining of reconstruction.

Decision: Adopt JVET-P0077.

CE8-2.1 enables transform skip and a variant of TS residual coding (with 1.75 maximum number of context coded bins) for the chroma components. In particular for RA case and low QP range, this shows gain for the screen content sequences.

It is suggested that enabling TS for chroma in case of 4:4:4 coding is useful for design consistency, in particular when RGB is encoded.

Decision: Adopt the aspect of JVET-P0058 that TS is enabled for chroma. This does not include the aspect of the modified bin limit in TS residual coding (which is to be further discussed in context of non-CE)..

For high-level syntax, the luma mechanisms of TS shall be applied for chroma, no separate signalling. Max TU size of TS inherited based on chroma sampling.

Note: The initial discussion had been to enable TS for chroma only for the 4:4:4 case. In follow-up discussions related to lossless coding, it was decided to enable TS for chroma in all chroma sampling formats, in particular to enable lossless coding in VTM7 / draft 7.

CE8-4.1 additionally enables BDPCM along with TS. This gives some additional gain for some classes of screen content. It was reported reported in the last meeting that the gain in case of RGB would be larger (JVET-O0166), whereas the CE only tested YCbCr 4:4:4 content. It is suggested during the discussion that enabling BDPCM for chroma in case of 4:4:4 coding is useful for design consistency, and would be useful in particular when RGB is encoded.

Decision: Adopt the aspect of JVET-P0059 that BDPCM is enabled for chroma in the case of 4:4:4. The syntax shall also include an SPS flag to turn it off.

[JVET-P0055](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7844) CE8-1.2: Compound Palette Mode [W. Zhu, J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)]

In this test, a combined IBC/Palette mode is tested. A special palette index indicates that the predictor for the current sample is copied from IBC prediction. Otherwise the sample is from palette predictor.

In this test, the first available merge candidate is always employed to generate the IBC prediction. Therefore, the signalling of IBC motion information could be avoided to reduce the overhead bits.

[JVET-P0058](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7847) CE8-2.1: Transform Skip for Chroma with limiting maximum number of context-coded bin in TS residual coding [T. Tsukuba, M. Ikeda, Y. Yagasaki, T. Suzuki (Sony)]

In this test, chroma transform skip (TS) is introduced and evaluated. The motivation is to unify TS and MTS signaling between luma and chroma by relocating transform\_skip\_flag and mts\_idx into residual\_coding part. One context model is added for chroma TS. No context model and no binarization are changed for the mts\_idx.

In addition, TS residual coding is also applied when chroma TS is used. According to the meeting note (JVET-O\_Notes\_dB sec 5.8 CE:8 Screen content coding tools), there is a concern on the maximum number of context coded bins in the TS residual coding. Therefore, the maximum number of context-coded bins in TS residual coding is limited to the same maximum number of non-TS residual coding (1.75 per coefficient).

**Semantics**

transform\_skip\_flag[ x0 ][ y0 ][ cIdx ] specifies whether a transform is applied to the associated ~~luma~~ transform block or not. The array indices x0, y0 specify the location ( x0, y0 ) of the top-left luma sample of the considered transform block relative to the top-left luma sample of the picture. transform\_skip\_flag[ x0 ][ y0 ][ cIdx ] equal to 1 specifies that no transform is applied to the current ~~luma~~ transform block. The array index cIdx specifies an indicator for the colour component; it is equal to 0 for luma, equal to 1 for Cb and equal to 2 for Cr. transform\_skip\_flag[ x0 ][ y0 ][ cIdx ] equal to 0 specifies that the decision whether transform is applied to the current transform block or not depends on other syntax elements. When transform\_skip\_flag[ x0 ][ y0 ][ cIdx ] is not present, it is inferred to be equal to 0.

mts\_idx[ x0 ][ y0 ][ cIdx ] specifies which transform kernels are applied to the residual samples along the horizontal and vertical direction of the associated ~~luma~~ transform block. The array indices x0, y0 specify the location ( x0, y0 ) of the top-left luma sample of the considered transform block relative to the top-left luma sample of the picture. The array index cIdx specifies an indicator for the colour component; it is equal to 0 for luma, equal to 1 for Cb and equal to 2 for Cr.

When mts\_idx[ x0 ][ y0 ][ cIdx ] is not present, it is inferred to be equal to 0.

If ChromaArrayType is larger than 0, mts\_idx[ x0 ][ y0 ][ 1] and mts\_idx[ x0 ][ y0 ][ 2] shall be equal to 0.

[JVET-P0059](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7848) CE8-4.1: BDPCM and Transform skip for Chroma [G. Clare (bcom), F. Henry (Orange), T. Tsukuba, M. Ikeda, Y. Yagasaki, T. Suzuki (Sony)]

In this CE test, in addition to chroma TS support as in CE8-2.1, BDPCM is added to chroma components.

In this test the use of BDPCM and Transform skip on the chroma components is to be tested as a straightforward evolution of the current luma-only BDPCM.

If sps\_bdpcm\_enable\_flag is 1, a further syntax element **sps\_bdpcm\_chroma\_enable\_flag** is added to the SPS.

The flags have the following behaviour, as indicated in table 1

|  |  |  |
| --- | --- | --- |
| **sps\_bdpcm\_enable\_flag** | **sps\_bdpcm\_chroma\_enable\_flag** | behaviour |
| 0 | not written | BPDCM is not used in the sequence |
| 1 | 0 | BDPCM is available for luma only |
| 1 | 1 | BDPCM is available for luma and chroma |

When BDPCM is available for luma only, the current behaviour is unchanged.

When BDPCM is also available for chroma, a **bdpcm\_chroma\_flag** is sent for each chroma block. This indicates whether BDPCM is used on the chroma blocks. When it is on, BDPCM is used for both chroma components, and an additional **bdpcm\_dir\_chroma** flag is coded, indicating the prediction direction used for both chroma components.

The deblocking filter is de-activated on a border between two Block-DPCM blocks, since neither of the blocks uses the transform stage usually responsible for blocking artifacts. This deactivation happens independently for luma and chroma components. A bdpcm deblocking bugfix (ticket #295) was also applied for the test as part of these bdpcm-chroma deblocking changes.

[JVET-P0060](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7849) CE8-1.1: Palette mode with neighboring pixel copy [Y.-C. Sun, T.-S. Chang, J. Lou (Alibaba)]

Palette mode with neighboring pixel copy

In this test, the method combining palette mode and neighboring pixel copy is tested. The new combined mode is disabled for small size CUs in order to reduce implementation complexity. If a CU is coded by palette mode, a flag (intra\_palette) is first encoded to indicate whether the neighboring pixel copy combination is used. If the flag is turned on, a pred\_dir flag is then signaled indicating whether horizontal or vertical intra prediction in used. On the decoder side, the decoder first decodes a palette and an index map. A specific index (0) is reserved to indicate the sample is reconstructed from intra prediction. When decoder reconstruct the palette coded block, samples with the index, 0, are reconstructed by the horizontal or vertical nearest samples across CU boundary, and samples with other indices are reconstructed by the colors in the palette. Figure 1 shows an example.



(a) vertical intra prediction combination (b) horizontal intra prediction combination

Figure 1. An example of palette mode and horizontal/vertical intra prediction combination.

[JVET-P0077](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7866) CE8-1.3: Line-based CG Palette Mode [Y.-H. Chao, C.-H. Hung, W.-J. Chien, T. Hsieh, M. Karczewicz (Qualcomm)]

In this CE, a line-based CG palette mode, which reduces the buffer to store index values, index maps in HEVC palette mode, is tested. A palette mode coded CU is divided into multiple line segments (line coefficient group (CG)) of *m* samples based on the traverse scan mode, as shown in Figure 2. The coefficient parsing, i.e., parsing the index runs, palette index values, and quantized colors, are done sequentially for each line CG.

The parsing of the palette index run in each line CG is as follows: a context coded bin (*index\_flag*)is parsed for each sample indicating if the sample is of the same run mode as the previously scanned sample, i.e., if the previous scanned sample and the current sample are both of run type COPY\_ABOVE or if the previous scanned sample and the current sample are both of run type INDEX with the same index value. If the pixel and the previous sample are of different mode, a context coded bin is parsed indicating the run type, i.e., INDEX or COPY\_ABOVE. Same as the HEVC palette, decoder doesn’t have to parse run type if the sample is in the first row (horizontal traverse scan) or in the first column (vertical traverse scan) since the INDEX mode is used by default. Also, decoder doesn’t have to parse run type if the previously parsed run type is COPY\_ABOVE.

The index values (for index runs of INDEX mode) and quantized escape colors are bypass coded and grouped apart from encoding/parsing of context coded bins, i.e., *index\_flag* and *run\_type*, to improve throughput within each line CG.

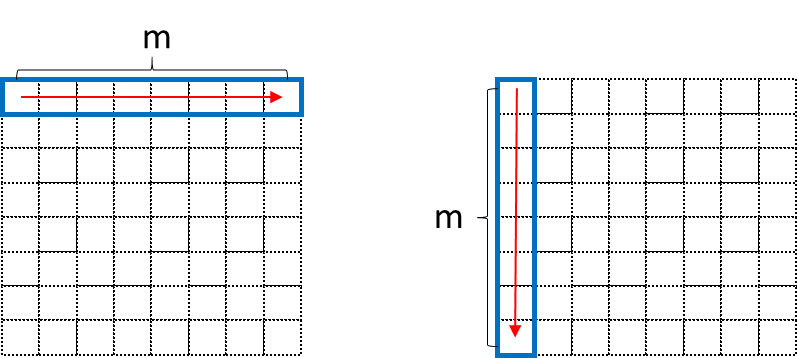


Figure 2: line CG segmentation for horizontal and vertical traverse scans

# Non-CE Technology proposals

## CE1 related – Reference picture resampling filters (12)

Contributions in this category were discussed Friday 4 Oct. 1430–1900 in Track B (chaired by GJS).

[JVET-P0119](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7908) AHG8: On reference picture resampling (RPR) [J. Chen (Futurewei)]

This contribution proposes to use the cropping window offsets in the reference sample location derivation of reference picture resampling process to avoid location misalignment of the reference sample block and the current block.

In the current spec, the scaling factor is based on the cropped picture.

It was commented that if we will

P0119 / P0241, P0381, P0590 are closely related.

[JVET-P0381](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8170) Non-CE1: A fix on reference sample offset for RPR [K. Zhang, L. Zhang, H. Liu, Z. Deng, J. Xu, Y. Wang (Bytedance)]

With RPR in VVC, a reference sample position is derived assuming that the offset between the top-left corner of the conformance window in the current picture and that in the reference picture is zero. However, the offset may be signalled to be non-zero. In this contribution, it is proposed to derive the reference sample position considering the non-zero offsets. Experimental results reportedly show that the proposed method achieves 16.91%, (PSNR1), 18.53%(PSNR2) BD-rate reductions for scaling ratio 1.5 and 14.89% (PSNR1), 15.25% (PSNR2) BD-rate reductions for scaling ratio 2.0, when the top-left corner of the conformance window in low-resolution pictures is at (64, 64).

P0119 / P0241, P0381, P0590 are closely related.

It was said that this proposal is the same as in P0119.

[JVET-P0938](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8753) Crosscheck of JVET-P0381 (Non-CE1: A fix on reference sample offset for RPR) [J. Samuelsson (Sharp)]

[JVET-P0241](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8030) AHG17/CE1-related: RPR [T. Hellman, W. Wan, P. Chen (Broadcom)]

Reference picture resampling functionality was adopted into the draft text at the Gothenburg July 2019 meeting. It was identified during the meeting that a potential issue that required further study is how to define the scaling ratio between pictures, especially for picture sizes that are not a multiple of 8 pixels. An approach using the conformance cropping window to determine the scaling ratio was agreed to be the starting point, but it was acknowledged this may not be the right approach.

This contribution proposes to redefine the semantics of the width and height transmitted in the PPS to represent the true picture dimensions, derive decode dimensions by rounding the true dimensions with the appropriate granularity, and using the true dimensions for scaling ratio computations. It is suggested that this approach provides a simple method to represent integer scaling ratios and avoids complications with the use of the conformance window for these calculations.

The contributions proposes to change the definition of the (uncropped) picture width and height, such that rather than these being required to be a multiple of 8, they would be allowed to have finer granularity. For the internal decoding process, the decoder would basically derive the multiple of 8 by rounding up, but the extra granularity would be used for the scaling process.

With this proposal, the conformance window would again be used only for cropping.

P0119 / P0241, P0381, P0590 are closely related.

[JVET-P0590](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8382) AHG8: Scaling window for scaling ratio derivation [V. Seregin, A. K. Ramasubramonian, M. Coban, M. Karczewicz (Qualcomm)]

In VVC draft 6, reference picture resampling and scalability support were adopted, where scaling ratio is derived based on the conformance cropping window and picture size. In this document, it is proposed to decouple scaling ratio derivation from the conformance cropping window and to signal a scaling window in the PPS to derive scaling ratio.

This proposes to send additional window parameters on each picture that are used for scaling and positioning when referring to that picture and when decoding that picture. (The HLS of the current picture does not select the area to reference in the reference picture; that area is what was indicated with the referenced picture.)

P0119 / P0241, P0381, P0590 are closely related.

[JVET-P0219](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8008) AHG8/AHG17: On signalling reference picture resampling [B. Choi, S. Wenger, S. Liu (Tencent)]

In the HLS BoG, the proponent indicated that this proposal is the same as P0590.

P0119 / P0241, P0381, P0590 as a group

It was concluded that even if we would like to enable a more elaborate functionality (e.g., per P0219, P0336, P0482), such as to support ROI scalability, we would like to have a default mode. These proposals are candidate approaches for that mode.

Decision: Adopt P0590.

Decision: Add an SPS-level reference\_picture\_resampling\_enabled\_flag (which was actually part of the prior proposal JVET-O0133), and constrain the picture width and height to be equal to the max values and constrain the presence flag for the new parameters to be 0 when that flag is 0.

[JVET-P0274](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8063) Non-CE1: Enabling TMVP in RPR [T.-S. Chang, Y.-C. Sun, L. Zhu, J. Lou (Alibaba)]

Currently, there is a constraint that TMVP can only be enabled if the collocated picture is the same size.

The contribution proposes to perform MV scaling when the current and reference pictures have different sizes.

In this proposal, TMVP is enabled for AMVP and SbTMVP by performing MV scaling when the current and collocated pictures have different sizes. The simulation results are summarized as follows:

* Y/Cb/Cr BD rate w/ PSNR1 and scaling ration 2.0x: -0.16%/-0.07%/-0.23%
* Y/Cb/Cr BD rate w/ PSNR2 and scaling ration 2.0x: -0.13%/-0.07%/-0.24%
* Y/Cb/Cr BD rate w/ PSNR1 and scaling ration 1.5x: -0.08%/-0.06%/0.26%
* Y/Cb/Cr BD rate w/ PSNR2 and scaling ration 1.5x: -0.07%/-0.08%/0.27%

It was commented that it is not the motion vector that is the problem with TMVP and RPR, but rather the lack of correspondence between the structures of the pictures.

[JVET-P0723](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8524) Crosscheck of JVET-P0274 (Non-CE1: Enabling TMVP in RPR) [Y.-W. Chen (Kwai Inc.)]

[JVET-P0353](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8142) CE1-related: Reference picture resampling filters [J. Luo, Y. Ye, M. Sarwer (Alibaba)]

CE1 test 3 in JVET-O2021 tests the application of a 12-tap SHM filter for reference picture down-sampling. In order to avoid an increase of complexity and memory access bandwidth, this contribution proposes to use cosine windowed sinc filters with the filter length, gain and number of phases matching those of the existing motion compensation interpolation filters (MCIF) in VVC. The simulation results reportedly show that comparing to the CE1 anchors which use existing MCIF for reference down-sampling, average BD rate deltas of PSNR1 are { -5.96%, -2.44%} for ratio 2:1 and 1.5:1, and average BD rate savings of PSNR2 are { -3.80%, -1.78%} for ratio 2:1 and 1.5:1.

In the CE, the filter for affine was not modified. In this proposal, the affine filter was modified. This probably doesn't make much of a difference, and the proponent was running tests to confirm that.

It was commented that the sequences that tend to benefit the most from affine are, at least mostly, not tested here.

The half pel position is not using the proposed filter. The proponent was running tests to confirm the effect of that. The same issue existed in the CE.

Compared to the CE1-1.1 result, for the 2x case, there is a reported benefit of about 1.5% for PSNR1 LB.

It was commented that the filter coefficients in the first and second versions were different.

There was discussion of whether it is a problem that the filter has a gain higher than 1 for some frequencies. Some participants indicated that since RPR is not applied in a cascaded manner, this should not be a problem.

A participant suggested that, regardless of what action is taken at this meeting, further study be conducted, perhaps including subjective viewing and alternative test sequences.

The SHVC filter also has a "bump".

Another participant commented that HDR testing may be desirable.

Focusing on the 2:1 case, it was commented that this filter has less aliasing than the one from the CE. The P0353 filter was submitted quite late, although the difference is only the values of the taps. Some tests for P0353 were still ongoing. The actual difference for the switching pictures is larger than what was measured here, and the difference was significant.

Decision: P0353-v5 2:1 8-tap & 4-tap filter, subject to checking for any issue in ongoing affine and half-pel tests.

For 1.5:1, stay with the CE1 result.

[JVET-P0836](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8651) Cross-check of JVET-P0353 on reference picture resampling filters [V. Seregin (Qualcomm)]

[JVET-P0390](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8179) CE1-related: Anti-aliasing motion compensation interpolation downsampling filters for reference picture resampling [A. Alshin, J. Boyce, P. Frolov, V. Aristarkhov (Intel)] [late]

VTM6.0 supports reference picture resampling, which is being studied in CE1. In VTM6, existing sub-pel interpolation filters for motion compensation are used to resample the reference picture for inter-picture prediction. Using these conventional “all pass” interpolation filters may encounter the well-known restrictions of Nyquist–Shannon sampling theorem and cause aliasing effect if the reference picture size is larger than the current picture size. This contribution proposes to reduce the aliasing effect by switching to a different set of filter coefficients, maintaining the 8-tap filter size and the filter coefficient sum of 64, when the reference picture size exceeds the current picture size by a 2x ratio per dimension or more.

This was not cross-checked.

It was asked what method was used for the filter design, and the proponent said it was a windowed DCTIF design.

There was also a 4-tap filter for chroma that was not mentioned in the proposal.

The proponent suggested that further study be done for the filtering.

It was commented that both high QP and low QP are worth studying.

[JVET-P0593](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8385) AHG8/CE1-related: Signalling filter coefficients for resampling [V. Seregin, M. Coban, M. Karczewicz (Qualcomm)]

In VVC draft 6, reference picture resampling process uses existed motion compensation filters. In CE1, depending on the scaling ratio alternative fixed filter coefficients for reference picture downsampling are tested.

In this contribution, it is proposed to signal filter coefficients in APS for luma and chroma components that are used for downsampling. In slice header, an APS index is signalled to indicate which filter coefficients set is applied for downsampling. This allows to specify the desired coefficients per picture, which can be scaling ratio dependent.

It was commented that there is definitely a complexity increase (and possibly dynamic range issues) for having downloadable filters.

[JVET-P0855](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8670) CE1 related: Dynamic range analysis in reference picture resampling process [E. Alshina (Huawei)] [late]

In VVC draft 6, reference picture resampling process uses existing motion compensation filters. In CE1 and related contributions, depending on the scaling ratio, alternative fixed filter coefficients for reference picture down-sampling have been tested. In this contribution, the dynamic range of re-sampling process is analysed for different filters in CE1 and CE1-related contributions. Except, JVET-P0083, all analysed filters with predefined coefficients have dynamic range not higher than HEVC motion compensation interpolation process (so this module can be re-used for resampling with only a change of filter coefficients). But non-restricted interpolation filter coefficients allowed by syntax proposed in JVET-P0593 might result in overflow of 16 bits temporal buffer. An additional restriction to the sum of interpolation filter positive coefficients to be not greater than 96 ensures dynamic range to be the same as HEVC motion compensation interpolation. Among all analysed re-sampling filters, non-CE1 conditions demonstrate up to 6% gain.

One aspect noted was that the tests done thus far does not use all phases of the filter.

The proponent expressed some worry over filters that have a "bump" in the frequency response and encouraged further study of the filters and discussed phase effects.

A participant remarked that it may be important to remember that the filters do not directly produce the output signal; the encoder can choose a different prediction signal and can also code a residual difference.

The filter also only gets used at resolution changes, which are not likely to be frequent.

[JVET-P0382](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8171) Non-CE1: Simplified motion compensation in RPR [K. Zhang, L. Zhang, H. Liu, Z. Deng, J. Xu, N. Zhang (Bytedance)]

With RPR in VVC, the bandwidth and computational complexity demanded by motion compensation is higher when the reference picture is larger than the current picture. In this contribution, it is proposed to apply the 6-tap interpolation filters used in the affine motion compensation on a luma M × N block satisfying certain conditions when the scaling ratio is larger than 1. Two tests are conducted with different conditions as below:

Test #1: The luma block is bi-predicted.

Test #2: The luma block is bi-predicted and (M × N <= 64 || M == 4 || N== 4)

For both tests with the scaling ratio equal to 2, the required bandwidth of motion compensation is asserted to be reduced to 82%, and the required number of multiplications is asserted to be reduced to 67% in the worst case. Experimental results reportedly show that the BD-rate changes are -0.01%, 0.00% for scaling ratio 1.5 and 0.11%, 0.06% for scaling ratio 2.0 in test #1, and 0.00%, 0.00% for scaling ratio 1.5 and 0.00%, 0.00% for scaling ratio 2.0 in test #2, respectively, under the CTC for RPR.

These test results are relative to the anchor that does not use anti-alising.

A participant commented that, from an implementation perspective, it does not seem necessary to consider trying to shorten the filter to be shorter than the ordinary MC filter.

[JVET-P0661](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8459) Crosscheck of JVET-P0382 (Non-CE1: Simplified motion compensation in RPR) [J. Chen (Alibaba)]

[JVET-P0409](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8198) CE1-related: Enable PROF for RPR [J. Chen, R.-L. Liao, J. Luo, Y. Ye (Alibaba)]

At the 15th JVET meeting in Gothenburg, reference picture resampling (RPR) (JVET-O1164) is adopted to support adaptive resolution change (ARC) in VVC. Since the existing process of prediction refinement with optical flow (PROF) does not support the case when the reference picture is of different spatial resolution with the current picture, PROF is disabled for this case in VTM-6.1. In this contribution, two alternative methods are proposed to enable PROF to support RPR.

It is reported that by enabling PROF in CE1 anchor with the proposed method 1 and method 2, the coding performance is as follows:

* Method 1 & 3
  + 2:1 ratio: {-0.09%, -0.05%, -0.15%} for PSNR1 and {-0.07%, -0.04%, -0.11%} for PSNR2
  + 1.5:1 ratio: {-0.04%, 0.20 %, 0.01%} for PSNR1 and {-0.02%, 0.17%, 0.00%} for PSNR2
* Method 2
  + 2:1 ratio: {-0.11%, -0.07%, -0.09%} for PSNR1 and {-0.08%, -0.08%, -0.07%} for PSNR2
  + 1.5:1 ratio: {-0.05%, 0.19%, 0.16%} for PSNR1 and {-0.02%, 0.14%, 0.17%} for PSNR2

It was commented that the intent was for PROF to be disabled. (PROF and RPR were adopted at the same meeting.)

"Method 1" and "Method 3" are effectively the same, since the only difference between them is for a case that is not allowed in the draft standard.

It was commented that the process involves accessing an extra sample around the prediction block, and getting that extra sample involves performing resampling. It would therefore have higher complexity than if the combination is prohibited. An analogous case exists for BDOF, and the combination was prohibited because of this. The extra fetch would not be not be needed with "Method 2", but it would require a change to how PROF works, in a way that would not otherwise be desirable.

It was commented that using RPR is not expected to be applied on every frame.

The benefit did not seem to justify the implementation difficulty.

Decision: Prohibit the combination.

[JVET-P0655](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8453) Crosscheck of JVET-P0409 (CE1-related: Enable PROF for RPR) [K. Zhang (Bytedance)]

[JVET-P0592](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8384) AHG8/Non-CE1: Phase shifts for resampling [V. Seregin, M. Coban, M. Karczewicz (Qualcomm)]

In VVC draft 6, reference picture resampling process assumes zero phase shift between luma and chroma components, while sequences may have other alignment between luma and chroma grids, such as in CTC half phase shift in the vertical direction is used.

In this contribution, it is proposed to signal luma and chroma phase shifts in PPS that are used for reference picture resampling and scalability by applying the phase shifts during motion compensation when scaling ratio is different from 1x.

Phase signalling is proposed on a per-picture basis.

Test results were provided, showing some gain when there is a phase mismatch between the source video and the processing phase.

|  |  |  |  |
| --- | --- | --- | --- |
| ⋅ | ⋅ | ⋅ | ⋅ |
| ⋅ | ⋅ | ⋅ | ⋅ |
| ⋅ | ⋅ | ⋅ | ⋅ |
| ⋅ | ⋅ | ⋅ | ⋅ |

It was commented that motion vectors can compensate, at least reasonably, for luma position shifts, although chroma relative to luma is a somewhat different matter.

It was noted that CCLM has a similar issue and supports only two phases (type 0 and type 1). For CCLM, there would be a complexity impact of supporting more phases.

It was discussed whether this would be adequate and whether it could be considered invariant for a CLVS.

Using two flags was suggested to be a good compromise.

Text was provided in a revision P0592 by V. Seregin and it was confirmed OK by some key participants.

It was commented that this could be relevant to TPM.

[JVET-P0902](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8717) Crosscheck of JVET-P0592 AHG8/Non-CE1: Phase shifts for resampling [J. Luo (Alibaba)]

## CE2 related – Gradual decoding refresh (0)

Contributions in this category were discussed XXday X Oct. XXXX–XXXX in Track X (chaired by XXX).

## CE3 related – Intra prediction and mode coding (48)

Contributions in this category were reviewed in BoG JVET-P0969 (G. v. d. Auweera), unless noted otherwise.

[JVET-P0111](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7900) CE3-related: Chroma intra prediction mode mapping for 4:2:2 format [B. Wang, S. Esenlik, A. M. Kotra, H. Gao, E. Alshina (Huawei)]

[JVET-P0915](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8730) Crosscheck of JVET-P0111 on Chroma intra prediction mode mapping for 4:2:2 format [S. Iwamura (NHK)]

[JVET-P0136](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7925) Non-CE3: MIP simplification [J.-Y. Huo, H.-X. Wang, Y. Sun, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.), S. Wan (NPU), Y.-F. Yu, Y. Liu (OPPO)]

[JVET-P0904](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8719) Crosscheck of JVET-P0136 (Non-CE3: MIP simplification) [X. Ma (Huawei)]

[JVET-P0150](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7939) CE3-related: Simplification of reference luma intra prediction mode derivation [Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0768](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8583) Crosscheck of JVET-P0150 (CE3-related: Simplification of reference luma intra prediction mode derivation) [Y.-W. Chen (Kwai)]

[JVET-P0194](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7983) CE3-related: Simplified MIP with reduced memory footprint [T. Biatek, A.K. Ramasubramonian, G. Van Der Auwera, M. Karczewicz (Qualcomm)]

[JVET-P0861](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8676) Crosscheck of JVET-P0194: Non-CE3: Simplified MIP with reduced memory footprint [Karam Naser (InterDigital)] [miss\_end\_meeting]

[JVET-P0198](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7987) Non-CE3: Enable MIP prediction for 64×N or N×64 blocks at maximum transform size 32 [Z. Zhang, K. Andersson, D. Saffar, R. Sjöberg, J. Ström, R. Yu (Ericsson)]

[JVET-P0199](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7988) Non-CE3: Align MIP matrix multiplication process [Z. Zhang, K. Andersson, D. Saffar, R. Sjöberg, J. Ström, R. Yu (Ericsson)]

[JVET-P0749](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8553) Crosscheck of JVET-P0199 (Non-CE3: Align MIP matrix multiplication process) [Y. Yasugi (Sharp)]

[JVET-P0208](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7997) Non CE3: Intra mode coding of non-MPM modes [S. Blasi, A. Seixas Dias, G. Kulupana (BBC)]

[JVET-P0919](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8734) Crosscheck of JVET-P0208 (Non CE3: Intra mode coding of non-MPM modes) [V. Rufitskiy, A. Filippov (Huawei)]

[JVET-P0265](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8054) CE3-related: CCLM with unified filter shape [D.-Y. Kim (Chips&Media), S.-C. Lim, J. Lee, J. Kang, H. Lee (ETRI)]

[JVET-P0812](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8627) Crosscheck of JVET-P0265 (CE3-related: CCLM with unified filter shape) [T. Toma, K. Abe (Panasonic)]

[JVET-P0277](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8066) Non-CE3: LFNST restriction based on MIP [A. Kumar, S. Shrestha, B. Lee (Chosun Univ.), Y. Lee, J. Park (Humax)]

[JVET-P0873](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8688) Crosscheck of JVET-P0277: Non-CE3: LFNST restriction based on MIP [J. Jung, D. Kim, G. Ko, J. Son, J. Kwak (WILUS)]

[JVET-P0289](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8078) Non-CE3: MIP simplification [Y. Yasugi, T. Ikai (Sharp)]

[JVET-P0888](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8703) Crosscheck of JVET-P0289 (Non-CE3: MIP simplification) [C.-C Kuo, C.-C. Lin (ITRI)]

[JVET-P0294](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8083) Non-CE3: Simplification of MPM derivation [D. Gwon, H. Han, H. Choi (HNU), H. Lee, J. Kang (ETRI)]

[JVET-P0822](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8637) Cross-check of JVET-P0294 (Non-CE3: Simplification of MPM derivation) [K. Choi (Samsung)]

[JVET-O0297](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6902) Non-CE3: On CCLM neighboring sample [M. Ikeda, Y. Yagasaki, T. Suzuki (Sony)]

[JVET-P0763](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8578) Cross-check of JVET-P0297 (Non-CE3: On CCLM neighboring sample) [S.-C. Lim, H. Lee, J. Lee, J. Kang (ETRI)]

[JVET-P0302](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8091) Non-CE3: PDPC without clipping [A. Filippov, V. Rufitskiy (Huawei)]

[JVET-P0782](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8597) Crosscheck of JVET-P0302 (Non-CE3: PDPC without clipping) [Y. Morigami, M. Ikeda (Sony)]

[JVET-P0303](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8092) Non-CE3: Removal of leaving out operation for 4×16 and 16×4 MIP blocks [X. Li, R.-L. Liao, Y. Chen, J. Chen, J. Luo, Y. Ye (Alibaba)]

[JVET-P0751](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8555) Crosscheck of JVET-P0303 (Non-CE3: Removal of leaving out operation for 4×16 and 16×4 MIP blocks) [Y. Yasugi (Sharp)]

[JVET-P0318](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8107) Non-CE3: Context reduction for intra\_luma\_not\_planar\_flag [D. Park, Y.-U. Yoon, J. Do, J.-G. Kim (KAU), J. Lee, J. Kang (ETRI)]

[JVET-P0780](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8595) Crosscheck of JVET-P0318 (Non-CE3: Context reduction for intra\_luma\_not\_planar\_flag) [M. Ikeda (Sony)]

[JVET-P0329](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8118) CE3-related: Simplification of Planar intra prediction [B. Wang, S. Esenlik, A. M. Kotra, H. Gao, E. Alshina (Huawei)]

[JVET-P0840](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8655) Cross-check of JVET-P0329 (CE3-related: Simplification of Planar intra prediction) [M. G. Sarwer (Alibaba)]

[JVET-P0352](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8141) Non-CE6 / Non-CE3: MIP UP TO 64x64 CU’s [K. Naser, T. Poirier, F. Le Léannec, F. Galpin (InterDigital)]

See notes under JVET-P0702 – was handled in CE3 context.

[JVET-P0831](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8646) Cross-check result of JVET-P0352: Non-CE6 / Non-CE3: MIP UP TO 64x64 CU’s [Z. Zhang (Ericsson)]

[JVET-P0355](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8144) Non CE3: Simplified coding of chroma intra modes [S. Blasi, A. Seixas Dias, G. Kulupana (BBC)]

[JVET-P0633](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8430) Crosscheck of JVET-P0355 (Non CE3: Simplified coding of chroma intra modes) [?? (??)]

[JVET-P0358](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8147) Non-CE3: Improved intra mode coding simplified [G. Rath, F. Galpin, F. Urban (InterDigital)]

[JVET-P0777](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8592) Crosscheck of JVET-P0358 (Non-CE3: Improved intra mode coding simplified) [J. Choi (LGE)]

[JVET-P0369](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8158) Non-CE3: MPM flag signaling with MRL [G. Rath, F. Galpin, F. Le Léannec (InterDigital)]

[JVET-P0685](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8484) Crosscheck of JVET-P0369 (Non-CE3: MPM flag signaling with MRL) [J. Yao (Fujitsu)]

[JVET-P0374](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8163) Non-CE3: One directional Intra planar mode [H. Yang, Y. He (InterDigital)]

[JVET-P0716](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8517) Crosscheck of JVET-P0374: Non-CE3: One directional Intra planar mode [Y.-H. Chao (Qualcomm)]

[JVET-P0398](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8187) Non-CE3: MIP Cleanup [J. Pfaff, B. Stallenberger, M. Schäfer, P. Merkle, T. Hinz, P. Helle, H. Schwarz, D. Marpe, T. Wiegand]

[JVET-P0832](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8647) Cross-check result of JVET-P0398: Non-CE3: MIP cleanup [Z. Zhang (Ericsson)]

[JVET-P0401](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8190) CE3-related: MIP downsampling process with re-trained MIP matrix [Z. Zhang, K. Andersson, D. Saffar, R. Sjöberg, J. Ström, R. Yu (Ericsson)]

[JVET-P0793](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8608) Crosscheck of JVET-P0401 (CE3-related: MIP downsampling process with re-trained MIP matrix) [J. Pfaff (HHI)]

[JVET-P0418](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8207) Non-CE3: Cleanup of MRLP Line Storage [T. Hellman, M. Zhou, B. Heng (Broadcom)]

[JVET-P0980](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8795) Crosscheck of JVET-P0418 (Non-CE3: Cleanup of MRLP Line Storage) [F. Bossen (Sharp)]

[JVET-P0500](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8290) Non-CE3: Multiple reference sample set for CCLM [P.-H. Lin, C.-Y. Teng (Foxconn)]

[JVET-P0718](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8519) Crosscheck of JVET-P0500 (Non-CE3: Multiple reference sample set for CCLM) [H.-J. Jhu (Kwai Inc.)]

[JVET-P0503](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8293) Non-CE3: Simplification of harmonization for LFNST and MIP [S. Shrestha, A. Kumar, B. Lee (Chosun Univ.), Y. Lee, J. Park (Humax)]

[JVET-P0952](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8767) Crosscheck of JVET-P0503 (Non-CE3: Simplification of harmonization for LFNST and MIP) [L. Li (Tencent)]

[JVET-P0507](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8297) Non-CE3: ISP simplifications [L. Zhao, X. Li, X. Zhao, S. Liu (Tencent)]

[JVET-P0725](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8526) Crosscheck of JVET-P0507 (Non-CE3: ISP simplifications) [Y.-W. Chen (Kwai Inc.)]

[JVET-P0509](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8299) CE3-related: Simplification for MIP matrix multiplication [L. Zhao, X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-P0726](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8527) Crosscheck of JVET-P0509 (CE3-related: Simplification for MIP matrix multiplication) [Y.-W. Chen (Kwai Inc.)]

[JVET-P0511](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8301) Non-CE3: ISP extension to avoid small Chroma intra blocks [L. Zhao, X. Li, X. Zhao, S. Liu (Tencent)]

[JVET-P0922](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8737) Crosscheck of JVET-P0511 on Non-CE3: ISP extension to avoid small Chroma intra blocks [S.H. Wang (PKU), Y. Wang, X. Zheng (DJI)]

[JVET-P0535](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8325) Non-CE3: Removal of block size restriction in MIP [J. Choi, J. Heo, J. Lim, S. Kim (LGE)]

[JVET-P0791](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8606) Crosscheck of JVET-P0535 (Non-CE3: Removal of block size restriction in MIP) [J. Pfaff (HHI)]

[JVET-P0536](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8326) Non-CE3: MRL with non-MPM intra modes [J. Choi, J. Heo, J. Lim, S. Kim (LGE)]

[JVET-P0787](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8602) Crosscheck of JVET-P0536 (Non-CE3: MRL with non-MPM intra modes) [F. Urban (InterDigital)]

[JVET-P0917](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8732) Crosscheck of JVET-P0537 on local dual tree for non-4:2:0 chroma formats [S. Iwamura (NHK)]

[JVET-P0548](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8338) Non-CE3: Removal of MRL restriction [J. Heo, H. Jang, J. Choi, J. Lim, S. Kim (LGE)]

[JVET-P0961](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8776) Crosscheck of JVET-P0548 (Non-CE3: Removal of MRL restriction) [I. Zupancic (HHI)]

[JVET-P0549](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8339) Non-CE3: Interpolation filter selection for chroma intra prediction [J. Heo, J. Choi, H. Jang, J. Lim, S. Kim (LGE)]

[JVET-P0772](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8587) Crosscheck of JVET-P0549 (Non-CE3 : Interpolation filter selection for chroma intra prediction) [Y.-W. Chen (Kwai)]

[JVET-P0550](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8340) Non-CE3: Cleanup of intra reference sample filter selection [J. Heo, J. Choi, J. Nam, H. Jang, J. Lim, S. Kim (LGE)]

[JVET-P0773](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8588) Crosscheck of JVET-P0550 (Non-CE3 : Cleanup of intra reference sample filter selection) [Y.-W. Chen (Kwai)]

[JVET-P0560](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8350) Non-CE3: Simplification on MIP and MPM context model [H.-J. Jhu, T.-C. Ma, X. Xiu, Y.-W. Chen, X. Wang (Kwai Inc.)]

[JVET-P0694](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8493) Cross-check of JVET-P0560: Non-CE3: Simplification on MIP and MPM context model [H. Sun, J. Li (Panasonic)]

[JVET-P0599](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8391) Non-CE3: Cleanup of interpolation filtering for intra prediction [A. Filippov, V. Rufitskiy (Huawei)]

[JVET-P0788](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8603) Crosscheck of JVET-P0599 (Non-CE3: Cleanup of interpolation filtering for intra prediction) [S. Blasi, (BBC)]

[JVET-P0615](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8409) Non-CE3: Intra chroma mode coding cleanup [B. Ray, G. Van der Auwera, M. Karczewicz (Qualcomm)]

[JVET-P0790](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8605) Crosscheck of JVET-P0615 (Non-CE3: Intra chroma mode coding cleanup) [S. Blasi (BBC)]

[JVET-P0625](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8420) Non-CE3: simplified MIP with power-of-two offsets [T. Biatek, A.K. Ramasubramonian, G. Van Der Auwera, M. Karczewicz (Qualcomm)] [late]

[JVET-P0835](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8650) Cross-check result of JVET-P0625: Non-CE3: simplified MIP with power-of-two offset [Z. Zhang (Ericsson)]

[JVET-P0626](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8421) Non-CE3: Cleanup of reference sample padding for intra prediction [A. Filippov, V. Rufitskiy (Huawei)] [late]

[JVET-P0781](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8596) Crosscheck of JVET-P0626 (Non-CE3: Cleanup of reference sample padding for intra prediction) [Y. Morigami, M. Ikeda (Sony)]

[JVET-P0638](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8435) CE3-related: Adaptive coding subset for intra mode [M. Bhat, D. Gommelet, J.-M. Thiesse, D. Nicholson (VITEC)] [late] [miss]

[JVET-P0803](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8618) Non-CE3: Combined cleanup of MIP [J. Pfaff, B. Stallenberger, M. Schäfer, P. Merkle, T. Hinz, P. Helle, H. Schwarz, D. Marpe, T. Wiegand (HHI), T. Biatek, A. K. Ramasubramonian, G. Van der Auwera, M. Karczewicz (Qualcomm), H. Liu, L. Zhang, K. Zhang, Z. Deng, J. Xu (Bytedance), J. Choi, J. Heo, J. Lim, S. Kim (LGE), K. Naser, T. Poirier, F. Le Leannec, F. Galpin (Inter Digital)] [late]

[JVET-P0982](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8797) Crosscheck of JVET-P0803: Non-CE3: Combined cleanup of MIP [J. Sauer (RWTH Aachen)]

[JVET-P0997](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8812) Crosscheck of JVET-P0803 (Non-CE3: Combined cleanup of MIP) [[L. Li (Tencent)](mailto:aurali@tencent.com)]

## CE4 related – Inter prediction (107)

Contributions in this category were discussed XXday X Oct. XXXX–XXXX in Track X (chaired by XXX).

[JVET-P0089](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7878) Non-CE4: DMVR control by reference picture type [H. Huang, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-P0090](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7879) Non-CE4: 32 bits coding for abs\_mvd\_minus2 [H. Huang, M. Coban, H. Wang, V. Seregin, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-P0673](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8472) Crosscheck of JVET-P0090 (Non-CE4: 32 bits coding for abs\_mvd\_minus2) [C.-Y. Lai (MediaTek)]

[JVET-P0091](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7880) CE4-related: Simplification of PROF and BDOF [H. Huang, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-P0094](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7883) AHG16: Fix on overflow issue in PROF [H. Chen, [H. Yang (Huawei)](mailto:haitao.yang@huawei.com)]

[JVET-P0932](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8747) Crosscheck of JVET-P0094 (AHG16/Non-CE4: Fix on overflow issue in PROF) [W. Chen (InterDigital)]

[JVET-P0107](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7896) CE4-Related: Geometric Merge Mode (GEO) Simplifications [H. Gao, S. Esenlik, E. Alshina, A. M. Kotra, B. Wang (Huawei), M. Bläser, J. Sauer (RWTH Aachen Uni.)]

Not reviewed in BoG.

[JVET-P0677](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8476) Crosscheck of JVET-P0107 (CE4-related: Geometric merge mode simplifications) [Y.-L. Hsiao (MediaTek)]

[JVET-P0728](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8530) Crosscheck of JVET-P0107 on reducing number of GEO modes and removing flipping [R.-L. Liao (Alibaba)]

[JVET-P0137](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7926) Non-CE4: On coding of merge triangle index [J.-Y. Huo, H.-X. Wang, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.), S. Wan (NPU), Y.-F. Yu, Y. Liu (OPPO)]

[JVET-P0905](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8720) Crosscheck of JVET-P0137 (Non-CE4: On coding of merge triangle index) [X. Ma (Huawei)]

[JVET-P0151](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7940) CE4-related: Simplification of half-pel switchable interpolation filter [Y.-L. Hsiao, C.-C. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0924](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8739) Crosscheck of JVET-P0151: CE4-related: Simplification of half-pel switchable interpolation filter [H. Gao (Huawei)]

[JVET-P0152](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7941) CE4-related: On maximum number of subblock-based merging candidates [O. Chubach, C.-C. Chen, C.-W. Hsu, C.-Y. Chen, T.-D. Chuang, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0153](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7942) CE4-related: Overlapped block optical flow [Y.-L. Hsiao, Y.-C. Lin, C.-C. Chen, C.-W. Hsu, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0784](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8599) Crosscheck of JVET-P0153 (CE4-related: Overlapped block optical flow) [H. Lee, S.-C. Lim, J. Lee, J. Kang (ETRI)]

[JVET-P0154](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7943) CE4-related: PROF prediction sample range reduction [T.-D. Chuang, Z.-Y. Lin, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0769](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8584) Crosscheck of JVET-P0154 TEST1, TEST3 (CE4-related: PROF prediction sample range reduction) [Y.-W. Chen (Kwai)]

[JVET-P0742](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8545) Crosscheck of JVET-P0254 (Issue of simplified luma mapping of LMCS) [T. Chujoh (Sharp)]

[JVET-P0155](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7944) CE4-related: An encoder switch for forcing temporal MV to zero in SbTMVP [Y.-L. Hsiao, C.-C. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0859](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8674) Crosscheck report of JVET-P0155 (CE4-related: An encoder switch for forcing temporal MV to zero in SbTMVP) [X. Xu (Tencent)]

[JVET-P0172](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7961) AHG16/Non-CE4: Prediction sample value clipping for PROF [J. Li, C. S. Lim (Panasonic)]

[JVET-P0933](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8748) Crosscheck of JVET-P0172 (AHG16/Non-CE4: Prediction sample value clipping for PROF) [W. Chen (InterDigital)]

[JVET-P0174](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7963) Non-CE4: Modifications of TPM and GEO [J. Li, C. S. Lim (Panasonic)]

Not reviewed in BoG.

[JVET-P0925](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8740) Crosscheck of JVET-P0174: Non-CE4: Modifications of TPM and GEO [H. Gao (Huawei)]

[JVET-P0191](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7980) Enabling BDOF and DMVR according to reference picture types [N. Zhang, H. Liu, L. Zhang, K. Zhang, Y. Wang (Bytedance)]

[JVET-P0200](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7989) Non-CE4: Modifications on BDOF intermediate parameter derivation [D. Liu, R.Yu (Ericsson)]

[JVET-P0678](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8477) Crosscheck of JVET-P0200 (Non-CE4: Modifications on BDOF intermediate parameter derivation-Test 1) [F. Chen (Hikvision)]

[JVET-P0201](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7990) Non-CE4: Simplification on BDOF offset calculation [D. Liu, R. Yu (Ericsson)]

[JVET-P0734](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8536) Crosscheck of JVET-P0201 on simplification on BDOF offset calculation [X. Xiu (Kwai Inc.)]

[JVET-P0209](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7998) Non-CE4: On the affine AMVR [H. Huang, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-P0698](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8497) Cross-check of JVET-P0209: Non-CE4: On the affine AMVR [H. Sun, J. Li (Panasonic)]

[JVET-P0214](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8003) CE4-related: Simplification of the CIIP chroma Intra Prediction Mode [J. Park, B. Jeon (SKKU)]

[JVET-P0234](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8023) AHG-2/Non-CE4: On clarification of weightedPredFlag [T. Chujoh, T. Ikai (Sharp)]

[JVET-P0236](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8025) Non-CE4: On a simplification for triangle merge mode [T. Chujoh, E. Sasaki, T. Ikai (Sharp)]

[JVET-P0690](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8489) Crosscheck of JVET-P0236 (Non-CE4: On a simplification for triangle merge mode) [P. Bordes (InterDigital)]

[JVET-P0811](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8626) Crosscheck of JVET-P0236 (Non-CE4: On a simplification for triangle merge mode) [K. Abe (Panasonic)]

[JVET-P0237](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8026) Non-CE4: On conditions for PROF [T. Chujoh, E. Sasaki, T. Ikai (Sharp)]

[JVET-P0833](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8648) Crosscheck of JVET-P0237 (Non-CE4: On conditions for PROF) [H. Liu (Bytedance)]

[JVET-P0238](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8027) Non-CE4: On definition of motion vector range for PROF and BDOF [T. Chujoh, E. Sasaki, T. Ikai (Sharp)]

[JVET-P0248](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8037) CE4-related: Modification of GEO mode [L. Xu, X. Cao, Y. Sun, F. Chen, L. Wang (Hikvision)]

Not reviewed in BoG.

[JVET-P0729](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8531) Crosscheck of JVET-P0248 (CE4-related: On Modifications of GEO) [R.-L. Liao (Alibaba)]

[JVET-P0249](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8038) CE4-related: On simplification for CIIP with triangular partitions [Y. Sun, F. Chen, L. Wang (Hikvision)]

Not reviewed in BoG. This is related to a subjective test in the CE.

[JVET-P0789](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8604) Crosscheck of JVET-P0249 (CE4-related: On simplification for CIIP with triangular partitions) [S. Blasi, (BBC)]

[JVET-P0250](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8039) CE4-related: On simplification for GEO weight derivation [Y. Sun, F. Chen, L. Wang (Hikvision)]

Not reviewed in BoG.

[JVET-P0926](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8741) Crosscheck of JVET-P250: CE4-related: On simplification for GEO weight derivation [H. Gao (Huawei)]

[JVET-P0253](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8042) Non-CE4: Simplify the division process of DMVR [K. Abe, Y. Kato, T. Toma (Panasonic)]

[JVET-P0741](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8544) Crosscheck of JVET-P0253 (Non-CE4: Simplify the division process of DMVR) [H. Tsurusaki, K. Unno (KDDI)]

[JVET-P0260](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8049) CE4-related: On inheritance of half-pel interpolation filter in merge mode [S. H. Wang (PKU)]

[JVET-P0695](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8494) Cross-check of JVET-P0260: CE4-related: On inheritance of half-pel interpolation filter in merge mode [H. Sun, J. Li (Panasonic)]

[JVET-P0261](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8050) Non-CE4: On Affine Motion Vector Restriction [X. W. Meng (PKU)]

[JVET-P0860](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8675) Crosscheck report of JVET-P0261 (Non-CE4: On Affine Motion Vector Restriction) [X. Xu (Tencent)]

[JVET-P0263](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8052) Non-CE4: On PROF conditions [X. W. Meng (PKU)]

[JVET-P0679](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8478) Crosscheck of JVET-P0263 (Non-CE4: On PROF conditions) [F. Chen (Hikvision)]

[JVET-P0264](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8053) CE4-related: Simplification of GEO using angles with power-of-two tangents [K. Reuzé, C.-C Chen, H. Huang, W.-J Chien, V. Seregin, M. Karczewicz (Qualcomm)]

Not reviewed in BoG.

[JVET-P0722](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8523) Crosscheck of JVET-P0264 (CE4-related: Simplification of GEO using angles with power-of-two tangents) [H.-J. Jhu (Kwai Inc.)]

[JVET-P0278](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8067) Non-CE4: HMVP buffer update for TPM block [N. Park, J. Nam, H. Jang, J. Lim, S. Kim (LGE)]

[JVET-P0660](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8458) Crosscheck of JVET-P0278 (Non-CE4: HMVP buffer update for TPM block) [N. Zhang (Bytedance)]

[JVET-P0275](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8064) Non-CE4/AHG17: On slice-level syntax for TPM and GEO [A. Filippov, V. Rufitskiy (Huawei)]

Move to non-CE4.

[JVET-P0829](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8644) Cross-check result of JVET-P0275 (Non-CE4/AHG17: On slice-level syntax for TPM and GEO) [K. Kawamura, S. Naito (KDDI)]

[JVET-P0320](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8109) Non-CE4/AHG17: On slice-level syntax for BDOF and DMVR [A. Filippov, V. Rufitskiy (Huawei)]

Move to non-CE4.

[JVET-P0830](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8645) Cross-check result of JVET-P0320 (Non-CE4/AHG17: On slice-level syntax for BDOF and DMVR) [K. Kawamura, S. Naito (KDDI)]

[JVET-P0279](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8068) Non-CE4: Interaction between PROF and other tools [N. Park, J. Nam, H. Jang, J. Lim, S. Kim (LGE)]

[JVET-P0869](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8684) Crosscheck of JVET-P0279 (Non-CE4: Interaction between PROF and other tools) [T. Chujoh (Sharp)]

[JVET-P0280](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8069) Non-CE4: Fix the behavior between BCW and WP [N. Park, J. Nam, H. Jang, J. Lim, S. Kim (LGE)]

[JVET-P0994](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8809) Crosscheck of JVET-P0280 (Non-CE4: Fix the behavior between BCW and WP) [C.-C. Chen, W.-J. Chien (Qualcomm)]

[JVET-P0281](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8070) Non-CE4: Corrections on parameter calculation for PROF and BDOF [N. Park, J. Nam, H. Jang, J. Lim, S. Kim (LGE)]

[JVET-P0934](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8749) Crosscheck of JVET-P0281 (Non-CE4: Corrections on parameter calculation for PROF and BDOF) [W. Chen (InterDigital)]

[JVET-P0282](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8071) Non-CE4: Block size alignment between PROF and BDOF [N. Park, J. Nam, H. Jang, J. Lim, S. Kim (LGE)]

[JVET-P0870](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8685) Crosscheck of JVET-P0282 (Non-CE4: Block size alignment between PROF and BDOF) [T. Chujoh (Sharp)]

[JVET-P0285](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8074) Non-CE4: Intra prediction mode of CIIP selection using left adjacent coded block [D. Jiang, J. Lin, F. Zeng, C. Fang (Dahua)]

[JVET-P0286](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8075) Non-CE4: Intra prediction mode of CIIP selection using left and above adjacent coded block [D. Jiang, J. Lin, F. Zeng, C. Fang (Dahua)]

[JVET-P0287](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8076) Non-CE4: Modified MVD derivation method for bidirectional MMVD using the magnitude of MV [D. Jiang, J. Lin, F. Zeng, C. Fang (Dahua)]

[JVET-P0288](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8077) Non-CE4: Modified MVD derivation method for bidirectional MMVD using the magnitude of MV and POC distance [D. Jiang, J. Lin, F. Zeng, C. Fang (Dahua)]

[JVET-P0291](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8080) AHG17: MMVD and CIIP parameters in PPS or slice header [Y. Yasugi, E. Sasaki, T. Ikai (Sharp)] [late]

This proposes moving some control from the SPS to lower levels.

[JVET-P0304](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8093) CE4-related: Simplification of blending weights and motion field storage in geometric merge mode [R.-L. Liao, J. Chen, Y. Ye, J. Luo (Alibaba)]

Not reviewed in BoG.

[JVET-P0305](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8094) CE4-related: Unification of triangle partition mode and geometric merge mode [R.-L. Liao, J. Chen, Y. Ye, J. Luo (Alibaba)]

Not reviewed in BoG.

[JVET-P0309](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8098) Non-CE4: Improved signaling method for merge modes [F. Chen, L. Wang (Hikvision)]

[JVET-P0880](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8695) Crosscheck of JVET-P0309: Non-CE4: Improved signaling method for merge modes [X. W. Meng (PKU)]

[JVET-P0310](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8099) Non-CE4: On simplification of PROF and BDOF [F. Chen, L. Wang (Hikvision)

[JVET-P0945](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8760) Crosscheck of JVET-P0310 (Non-CE4: On Simplification of PROF and BDOF) [K. Unno (KDDI)]

[JVET-P0311](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8100) Non-CE4: On enabling condition of BDOF and DMVR [F. Chen, L. Wang (Hikvision)]

[JVET-P0750](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8554) Crosscheck of JVET-P0311 (Non-CE4: On Enabling Condition of BDOF and DMVR) [D. Liu, R. Yu (Ericsson)]

[JVET-P0312](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8101) Non-CE4: On condition of SMVD [F. Chen, L. Wang (Hikvision)]

[JVET-P0752](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8556) Crosscheck of JVET-P0312 (Non-CE4: On Condition of SMVD) [D. Liu, R. Yu (Ericsson)]

[JVET-P0314](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8103) Non-CE4: Harmonization of PROF, BDOF and DMVR syntax [X.W. Meng (PKU), X. Zheng (DJI), S.S. Wang, S.W. Ma (PKU)]

[JVET-P0317](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8106) Non-CE4: BCW clean-up for weight signaling [D. Park, Y.-U. Yoon, [J. Do](mailto:jhdo@kau.kr), J.-G. Kim (KAU), J. Lee, J. Kang (ETRI)]

[JVET-P0675](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8474) Crosscheck of JVET-P0317 (Non-CE4: BCW cleanup for weight signalling) [Y.-L. Hsiao (MediaTek)]

[JVET-P0322](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8111) Non-CE4: CIIP size restriction [G. Ko, D. Kim, J. Jung, J. Son, J. Kwak (WILUS)]

[JVET-P0972](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8787) Crosscheck of JVET-P0322 (Non-CE4: CIIP size restriction) [M. Koo (LGE)]

[JVET-P0325](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8114) Non-CE4: Construction of spatial merge candidates [Z. Wang, Y. Yan, J. Luo (Alibaba)]

[JVET-P0954](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8769) Crosscheck of JVET-P0325 (Non-CE4: Construction of spatial merge candidates) [H. Liu (Bytedance)]

[JVET-P0340](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8129) Non-CE4: Unification of merge interpolation filter (triangle and pairwise-average) [P. Bordes, A. Robert, F. Le Léannec, F. Galpin (InterDigital)]

[JVET-P0658](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8456) Crosscheck of JVET-P0340 (Non-CE4: Unification of merge interpolation filter (triangle and pairwise-average)) [Y. Wang (Bytedance)]

[JVET-P0341](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8130) Non-CE4: Coding of interpolation filter index in non-merge inter mode [P. Bordes, F. Galpin, F. Le Léannec, E. François (InterDigital)]

[JVET-P0744](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8547) Crosscheck of JVET-P0341 (Non-CE4: Coding of interpolation filter index in non-merge inter mode) [T. Chujoh (Sharp)]

[JVET-P0384](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8173) Non-CE4: Flexible MMVD candidates [F. Galpin, F. Le Léannec, A. Robert (InterDigital)] [late]

[JVET-P0857](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8672) Crosscheck of JVET-P0384 (non-CE4 flexible MMVD candidates) [L. Pham Van, G. Van der Auwera (Qualcomm)]

[JVET-P0385](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8174) Non-CE4: MV rounding in sbTMVP [K. Zhang, L. Zhang, H. Liu, Z. Deng, N. Zhang, Y. Wang (Bytedance)]

[JVET-P0874](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8689) Crosscheck of JVET-P0385 "Non-CE4: MV rounding in sbTMVP" [G. Li (Tencent)]

[JVET-P0387](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8176) Non-CE4: Flexible CIIP mode [F. Galpin, F. Le Léannec, A. Robert, K. Naser (InterDigital)] [late]

[JVET-P0408](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8197) CE4-related: On PROF on/off control [J. Chen, R.-L. Liao, J. Luo, Y. Ye (Alibaba)]

[JVET-P0413](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8202) CE4-related: Clipping for PROF [W. Chen, Y. He (InterDigital)]

[JVET-P0697](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8496) Cross-check of JVET-P0413: CE4-related: Clipping for PROF [H. Sun, J. Li (Panasonic)]

[JVET-P0414](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8203) Non-CE4: Simplification of SIF [W. Chen, Y. He (InterDigital)]

[JVET-P0871](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8686) Crosscheck of JVET-P0414 (Non-CE4: Simplification of SIF) [H. Chen (Huawei)]

[JVET-P0415](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8204) Non-CE4: Unification of DMVR and BDOF enabling conditions [W. Chen, Y. He (InterDigital)]

[JVET-P0817](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8632) Crosscheck of JVET-P0415 (Non-CE4: Unification of DMVR and BDOF enabling conditions) [N. Park (LGE)]

[JVET-P0416](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8205) Non-CE4: Using integer MV in CIIP [W. Chen, Y. He (InterDigital)]

[JVET-P0755](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8559) Crosscheck of JVET-P0416 on using integer MV in CIIP [X. Xiu (Kwai Inc.)]

[JVET-P0434](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8223) Non-CE4: Enabling conditions of PROF [Z. Deng, L. Zhang, K. Zhang, H. Liu, N. Zhang, K. Fan (Bytedance)]

[JVET-P0439](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8228) Non-CE4: Motion pruning with alternative half-pel interpolation filter flag [G. Li, X. Li, X. Xu, S. Liu (Tencent)]

[JVET-P0828](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8643) Crosscheck of JVET-P0439 (Non-CE4 Motion pruning with alternative half-pel interpolation filter flag) [A. Robert (InterDigital)]

[JVET-P0440](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8229) Non-CE4: On inheritance of alternative half-pel interpolation filter flag in MMVD [G. Li, X. Li, X. Xu, S. Liu (Tencent)]

[JVET-P0646](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8444) Cross-check of JVET-P0440 (Non-CE4: On inheritance of alternative half-pel interpolation filter flag in MMVD) [K. Zhang (Bytedance)]

[JVET-P0442](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8231) Non-CE4: Unified AMVR signalling [G. Li, X. Li, X. Xu, S. Liu (Tencent)]

[JVET-P0910](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8725) Cross-check of JVET-P0442 (Non-CE4: Unified AMVR signaling) [J. Nam (LGE)]

[JVET-P0443](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8232) Non-CE4: On DMVR early termination [G. Li, X. Li, X. Xu, S. Liu (Tencent)]

[JVET-P0735](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8537) Crosscheck of JVET-P0443 on DMVR early termination [X. Xiu (Kwai Inc.)]

[JVET-P0444](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8233) Non-CE4: On DMVR without padding [G. Li, X. Li, X. Xu, S. Liu (Tencent)]

[JVET-P0736](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8538) Crosscheck of JVET-P0444 on DMVR without padding [X. Xiu (Kwai Inc.)]

[JVET-P0445](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8234) Non-CE4: Encoder optimization for subblock-based merge candidate search [G. Li, X. Li, X. Xu, S. Liu (Tencent)]

[JVET-P0714](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8515) Cross-check of JVET-P0445: Non-CE4: Encoder optimization for subblock-based merge candidate search [J. Zhao (LGE)]

[JVET-P0449](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8238) CE4-related: Thin Partition Mode [K. Panusopone, S. Hong, L. Wang (Nokia)]

[JVET-P0779](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8594) Cross-check of JVET-P0449 (CE-4 related: Thin Partition Mode) [M. Zhou (Broadcom)]

[JVET-P0461](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8250) Non-CE4: Usage of half-pel switchable interpolation filter for pairwise candidate [N. Zhang, H. Liu, L. Zhang, K. Zhang, Y. Wang (Bytedance)]

[JVET-P0490](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8279) Non-CE4: Cleanup of half-pel switchable interpolation filter [H. Liu, N. Zhang, L. Zhang, K. Zhang, Z. Deng, J. Xu (Bytedance)]

[JVET-P0867](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8682) Crosscheck of JVET-P0490 (Non-CE4: Cleanup of half-pel switchable interpolation filter) [N. Hu (Qualcomm)]

[JVET-P0491](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8280) CE4-related: On MVD derivation in PROF [H. Liu, L. Zhang, K. Zhang, Y. Wang, J. Xu, Y. Wang (Bytedance)]

[JVET-P0745](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8548) Crosscheck of JVET-P0491 (CE4-related: On MVD derivation in PROF) [T. Chujoh (Sharp)]

[JVET-P0496](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8285) Non-CE4: Switchable interpolation filter in TPM [Y. Wang, L. Zhang, H. Liu, K. Zhang, N. Zhang, Y. Wang (Bytedance)]

[JVET-P0689](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8488) Crosscheck of JVET-P0496 (Non-CE4: Switchable interpolation filter for TPM) [P. Bordes (InterDigital)] [miss\_end\_meeting]

[JVET-P0498](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8288) Non-CE4: On weight derivation process in CIIP [N. Zhang, H. Liu, L. Zhang, [K. Zhang](mailto:zhangkai.video@bytedance.com), Y. Wang (Bytedance)

[JVET-P0818](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8633) Crosscheck of JVET-P0498 (Non-CE4: On weight derivation process in CIIP) [N. Park (LGE)]

[JVET-P0499](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8289) Non-CE4: Removal of MVD scaling process in MMVD [N. Zhang, H. Liu, L. Zhang, K. Zhang, Y. Wang (Bytedance)]

[JVET-P0645](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8442) Cross-check of JVET-P0499: Non-CE4: Removal of MVD scaling process in MMVD [J. Zhao (LGE)]

[JVET-P0512](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8302) Non-CE4: SIMD support for motion compensated prediction at high internal bit-depth [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-P0940](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8755) Crosscheck of JVET-P0512 on SIMD support for motion compensated prediction at high internal bit-depth [?? (??)]

[JVET-P0513](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8303) Non-CE4: Extending switchable interpolation filter to affine mode [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-P0875](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8690) Crosscheck of JVET-P0513 "Non-CE4: Extending switchable interpolation filter to affine mode" [G. Li (Tencent)]

[JVET-P0518](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8308) AHG16/Non-CE4: Addressing 16-bit multiplication overflow issue of the PROF [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-P0935](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8750) Crosscheck of JVET-P0518 (AHG16/Non-CE4: Addressing 16-bit multiplication overflow issue of the PROF) [W. Chen (InterDigital)]

[JVET-P0519](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8309) Non-CE4: On SAD threshold for BDOF early termination [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-P0524](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8314) On high-level control flags of BDOF and PROF [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-P0530](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8320) Non-CE4: Alignment of luma and chroma weight calculation for TPM blending [Z. Deng, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)]

[JVET-P0936](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8751) Crosscheck of JVET-P0530 (Non-CE4: Alignment of luma and chroma weight calculation for TPM blending) [W. Chen (InterDigital)]

[JVET-P0532](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8322) CE4-related: Modified hpelIfIdx derivation for half-pel interpolation filter [Y. Kidani, K. Kawamura, K. Unno, S. Naito (KDDI)]

[JVET-P0911](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8726) Cross-check of JVET-P0532 (CE4-related: Modified hpelIfIdx derivation for half-pel interpolation filter) [J. Nam (LGE)]

[JVET-P0533](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8323) CE4-related: Motion vector rounding in enabled hpelIfIdx [Y. Kidani, K. Kawamura, K. Unno, S. Naito (KDDI)]

[JVET-P0912](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8727) Cross-check of JVET-P0533 (CE4-related: Motion vector rounding in enabled hpelIfIdx) [J. Nam (LGE)]

[JVET-P0541](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8331) Non-CE4: Context modeling for inter prediction mode [J. Nam, H. Jang, N. Park, J. Lim, S. Kim (LGE)]

[JVET-P0876](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8691) Crosscheck of JVET-P0541 "Non-CE4: Context modeling for inter prediction mode" [G. Li (Tencent)]

[JVET-P0542](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8332) Non-CE4: Cleanup on alternative half-pel interpolation filter [J. Nam, H. Jang, N. Park, J. Lim, S. Kim (LGE)]

[JVET-P0947](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8762) Crosscheck of JVET-P0542 (Non-CE4: Cleanup on alternative half-pel interpolation filter) [Y. Kidani, K. Unno, (KDDI)]

[JVET-P0544](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8334) Non-CE4: A slice header flag disabling PROF [K. Unno, K. Kawamura, S. Naito (KDDI)]

[JVET-P0546](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8336) Non-CE4: An applying condition of BDOF [K. Unno, K. Kawamura, S. Naito (KDDI)]

[JVET-P0810](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8625) Crosscheck of JVET-P0546 (Non-CE4: An applying condition of BDOF) [K. Abe (Panasonic)]

[JVET-P0572](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8362) AHG17/Non-CE4: Restrict integer-pel fetch for BDOF and RPOF for subpicture [H. Jang, J. Nam, N. Park, S. Paluri, S. Kim, J. Lim (LGE)]

[JVET-P0583](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8374) CE4-related: On the SBT in CE4-1.1 [H. Huang, T. Hsieh, V. Seregin, K. Reuze, C.-C. Chen, H.E. Egilmez, W.-J. Chien, M. Karczewicz (Qualcomm)]

Not reviewed in BoG.

[JVET-P0595](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8387) Non-CE4: Neighboring locations for CIIP [G. Ko, D. Kim, J. Jung, J. Son, J. Kwak (WILUS)]

[JVET-P0598](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8390) CE4-related: Harmonized CU-level Condition Check in BDOF and DMVR [C.-C. Chen, H. Huang, K. Reuzé, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-P1005](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8820) Crosscheck of JVET-P0598 (CE4-related: Harmonized CU-level Condition Check in BDOF and DMVR) [J. R. Arumugam (Ittiam)]

[JVET-P0600](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8392) CE4-related: Support large rotation and flipping in affine and PROF [A. Aminlou (Nokia)]

[JVET-P0664](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8462) Cross-check of JVET-P0600: CE4-related: Support large rotation and flipping in affine and PROF [Y. He (InterDigital)]

[JVET-P0601](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8393) CE4-related: Support slice level disabling for PROF [K. Kondo, M. Ikeda (Sony)] [late]

[JVET-P0604](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8397) Non-CE4: Motion field storage optimization for the line buffer [T. Solovyev, S. Ikonin, A. Karabutov, R. Chernyak (Huawei)]

[JVET-P0605](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8398) Non-CE4: On triangular merge list size signalling [T. Solovyev, S. Ikonin, A. Karabutov, R. Chernyak (Huawei)]

Discussed Thursday 1700 Track B (GJS). This proposed action is already incorporated in P0113, which was agreed.

[JVET-P0617](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8411) Non-CE4: On TPM merge mode in the presence of weighted prediction [A. Filippov, V. Rufitskiy (Huawei)] [late] [miss]

[JVET-P0989](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8804) Crosscheck of JVET-P0617 (Non-CE4 On TPM merge mode in the presence of WP) [P. Bordes (InterDigital)]

[JVET-P0620](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8414) Non-CE4: Flexible SBT mode [F. Galpin, F. Le Léannec, A. Robert, K. Naser, E. François (InterDigital)] [late]

Initial version rejected as “placeholder”

[JVET-P0993](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8808) Crosscheck of JVET-P0620 (non-CE4: flexible sbt mode) [L. Pham Van, G. Van der Auwera (Qualcomm)]

[JVET-P0621](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8415) Non-CE4: On motion information comparison [A. Robert, F. Le Léannec, F. Galpin, T. Poirier (InterDigital)] [late]

[JVET-P0879](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8694) Crosscheck of JVET-P0621 "Non-CE4: On motion information comparison" [G. Li (Tencent)]

[JVET-P0629](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8426) CE4-related: CIIP Simplification [J. Y. Lee (Sejong Univ.), W. Lim, G. Bang (ETRI)] [late]

[JVET-P0821](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8636) Cross-check of JVET-P0629 (CE4-related: CIIP Simplification) [K. Choi (Samsung)]

[JVET-P0653](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8451) Non-CE4: On BDOF and PROF parameter derivation [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai)] [late]

[JVET-P0937](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8752) Crosscheck of JVET-P0653 (Non-CE4: On BDOF and PROF parameter derivation) [W. Chen (InterDigital)]

[JVET-P0654](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8452) Non-CE4: Unified BDOF and DMVR early termination threshold [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai)] [late]

[JVET-P0964](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8779) Crosscheck of JVET-P0654: Non-CE4: Unified BDOF and DMVR early termination threshold [H. Gao (Huawei)]

[JVET-P0663](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8461) CE4-1.14 related: Block size limitation of enabling TPM and GEO [Z. Deng, L. Zhang, H. Liu, K. Zhang, Y. Wang (Bytedance)] [late]

[JVET-P0785](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8600) Crosscheck of JVET-P0663 (CE4-1.14 related: Block size limitation of enabling TPM and GEO) [T.-H. Li, C.-Y. Teng (Foxconn)]

[JVET-P0746](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8549) CE4-related: Combination of JVET-P0264 and JVET-P0304 on GEO simplification [K. Reuzé, C.-C. Chen, H. Huang, W.-J. Chien, V. Seregin, M. Karczewicz (Qualcomm), R.-L. Liao, J. Chen, Y. Ye, J. Luo (Alibaba)] [late]

[JVET-P0856](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8671) Non-CE4: On switchable interpolation filter and bi-prediction weight indices cleanup [T. Solovyev, S. Ikonin, A. Karabutov, R. Chernyak (Huawei)] [late] [miss]

[JVET-P1023](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8838) Joint solution for the reference picture conditions in DMVR and BDOF (JVET-P0089, JVET-P0191, JVET-P0311, JVET-P0415, JVET-P0546, JVET-P0598) [?? (??)]

[JVET-P0884](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8699) Simplified GEO without multiplication and minimum blending mask storage (harmonization of JVET-P0107, JVET-P0264 and JVET-P0304) [H. Gao, S. Esenlik, E. Alshina, A. M. Kotra, B. Wang (Huawei), M. Bläser, J. Sauer (RWTH Aachen)] [late]

Not reviewed in BoG. This and P0885 are combination proposals that were not reviewed in the BoG.

Discussed Thurs 10 Oct 1315 (GJS)

In this contribution the CE test CE4-1.14 is used as a basis GEO implementation and 2 simplifications are included according to JVET-P0107, JVET-P0264 and JVET-P0304.

* First modification: Quantize GEO angles to replace per-sample multiplications with shift. Same in JVET-P0107, JVET-P0264.
* Second modification: enable storing precalculated blending masks with minimum total storage requirement. As in JVET-P0304.

The number of partition modes supported are 80, with 12 possible PU sizes (19 if counting transpositions separately). The simulations results show 0.32% and 0.65% BD-rate reduction in RA and LDB configurations, with ~2% encoder runtime increase. This contribution is identical to JVET-P0885.

This proposes a multiplication-free scheme that is asserted to have the same complexity as TPM.

A stored mask approach is asserted to use 204 bytes. Smaller block masks are cropped from larger block masks.

An equation is given to calculate distance from line, said to be similar to TPM. A pre-calculated weight is used (described in P0304).

MV storage is based on the CE4-1.14 (separate from TPM).

TPM is done separately, not unified with this approach.

All proponents of GEO support this approach.

The CE had some things tested on top of GEO, and these would also be compatible with the modified GEO.

The specification text was said to be well aligned with TPM; it is functionally a generalization of TPM.

It was suggested to just remove TPM and just have this instead (with the TPM angles included; currently these are excluded from the proposal). That would provide some gain over the current design of about 0.2% in RA and ~0.6% in LB.

It was noted that TPM operates with small and narrow blocks, while this does not.

It was suggested to focus on the core engine first. It was agreed that we don't want a non-unified design with TPM and this as separately designed modes.

It was suggested to replace TPM with a unified GEO scheme that removes the smallest block sizes of TPM. P0305 had proposed such a unification.

It was requested to have text and software with complete angle coverage and no 4xN, Nx4 blocks.

Some examples were shown by the proponent which appeared to indicate a good correspondence between object edges and segmentation boundaries.

This was further discussed in the Friday 11 October closing plenary 1015 (GJS).

A revision was provided with text; software (based on the CE software) was circulated to software coordinators. The text had been reviewed by some key participants. It was confirmed that there were 82 cases in the text and software and that the text had a well-integrated approach. The software impact was substantial. Some issues with the software were noted, but not especially serious.

Partial cross-check results were available in an update of P0895.

It was agreed to put this in a CE and to use it as one of two anchors in the CE.

[JVET-P0895](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8710) Crosscheck of JVET-P0884 (Simplified GEO without multiplication and minimum blending mask storage (harmonization of JVET-P0107, JVET-P0264 and JVET-P0304)) [Y.-L. Hsiao (MediaTek)]

[JVET-P0885](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8700) Simplified GEO without multiplication and minimum blending mask storage (harmonization of JVET-P0107, JVET-P0264 and JVET-P0304) [K. Reuzé, C.-C Chen, H. Huang, W.-J Chien, V. Seregin, M. Karczewicz (Qualcomm), R.-L Liao, J. Chen, Y. Ye, J. Luo (Alibaba), M. Bläser, J. Sauer (RWTH Aachen Uni.)] [late]

Not reviewed in BoG. This is identical to P0884. See notes for that contribution.

## CE5 related – Loop filtering (72)

Contributions in this category were reviewed in BoG JVET-P1033 (A. Norkin, C.-Y. Chen) except noted otherwise.

[JVET-P0043](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7832) AHG16/Non-CE5: A cleanup for de-blocking in the affine and TPM mode [[B. Heng](mailto:brian.heng@broadcom.com), M. Zhou (Broadcom)]

[JVET-P0656](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8454) Crosscheck of JVET-P0043 (AHG16/Non-CE5: A cleanup for de-blocking in the affine and TPM mode) [J. Xu (Bytedance)]

[JVET-P0053](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7842) AHG16/Non-CE5: A cleanup for the ALF sample padding [M. Zhou (Broadcom)]

[JVET-P0086](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7875) AHG16/Non-CE5: Deblocking boundary strength fix for Affine and TPM [A. M. Kotra, S. Esenlik, H. Gao, B. Wang, E. Alshina (Huawei)]

[JVET-P0844](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8659) Crosscheck of JVET-P0086 (AHG16/Non-CE5: Deblocking boundary strength fix for Affine and TPM) [C.-M. Tsai (MediaTek)]

[JVET-P0087](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7876) Non-CE5: Deblocking boundary strength modification for triangle and affine mode [K. Misra, F. Bossen, A. Segall (Sharp Labs of America)]

[JVET-P0845](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8660) Crosscheck of JVET-P0087 (Non-CE5: Deblocking boundary strength modification for triangle and affine mode) [C.-M. Tsai (MediaTek)]

[JVET-P0105](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7894) Non-CE5: Modified Chroma QP derivation for deblocking filter [A. M. Kotra, S. Esenlik, B. Wang, H. Gao, E. Alshina (Huawei)]

[JVET-P0846](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8661) Crosscheck of JVET-P0105 (Non-CE5: Modified Chroma QP derivation for deblocking filter) [C.-M. Tsai (MediaTek)]

[JVET-P0106](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7895) AHG16/CE5-Related: Simplifications for Cross Component Adaptive Loop Filter [A. M. Kotra, S. Esenlik, B. Wang, H. Gao, E. Alshina (Huawei)]

[JVET-P0847](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8662) Crosscheck of JVET-P0106 (AHG16/CE5-related: Simplifications for cross component adaptive loop filter) [C.-M. Tsai (MediaTek)]

[JVET-P0109](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7898) AHG18/Non-CE5: Boundary strength fix for coding units using BCW [A. M. Kotra, S. Esenlik, B. Wang, H. Gao, E. Alshina (Huawei)]

[JVET-P0848](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8663) Crosscheck of JVET-P0109 (AHG18/Non-CE5: Boundary strength fix for coding units using BCW) [C.-M. Tsai (MediaTek)]

[JVET-P0121](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7910) On adaptive loop filter [J. Chen, Hendry (Futurewei)]

[JVET-P0156](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7945) CE5-related: ALF padding process when raster scan slices are used [C.-Y. Lai, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek), A. M. Kotra, S. Esenlik, H. Gao, B. Wang, E. Alshina (Huawei)]

[JVET-P0157](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7946) CE5-related: Align ALF padding processes at picture and subpicture boundaries [C.-Y. Lai, O. Chubach, L. Chen, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0158](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7947) CE5-related: Align ALF virtual boundary processes in the bottom CTU rows of one picture and one subpicture [C.-Y. Lai, O. Chubach, L. Chen, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0159](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7948) CE5-related: DMVR deblocking by inheriting neighbouring boundary strength values [C.-M. Tsai, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0948](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8763) Crosscheck of JVET-P0159 (CE5-related: DMVR deblocking by inheriting neighbouring boundary strength values) [A. M. Kotra (Huawei)] [miss\_end\_meeting]

[JVET-P0160](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7949) CE5-related: Unification of deblocking processes for transform block and prediction block boundaries [C.-M. Tsai, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0792](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8607) Crosscheck of JVET-P0160 (CE5-related: Unification of deblocking processes for transform block and prediction block boundaries) [Y. Han, N. Hu (Qualcomm) ]

[JVET-P0161](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7950) CE5-related: Deblocking considering prediction weights in BCW and TPM [C.-M. Tsai, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0927](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8742) Crosscheck report of JVET-P0161 [K. Misra (Sharp Labs of America)]

[JVET-P0162](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7951) CE5-related: Simplified ALF syntax with removal of alf\_ctb\_use\_first\_aps\_flag [Y.-L. Hsiao, C.-C. Chen, O. Chubach, C.-W. Hsu, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0748](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8552) Cross-check of JVET-P0162 (CE5-related: Simplified ALF syntax with removal of alf\_ctb\_use\_first\_aps\_flag) [K. Andersson (Ericsson)]

[JVET-P0163](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7952) CE5-related: SAO encoder-only improvements [C.-Y. Lai, C.-Y. Chen, T.-D. Chuang, O. Chubach, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0820](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8635) Cross-check of JVET-P0163 (CE5-related: SAO encoder-only improvements) [K. Choi, W. Choi, K. P. Choi (Samsung)]

[JVET-P0164](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7953) CE5-related: Simplified ALF syntax regarding to alf\_luma\_coeff\_signalled\_flag and alf\_luma\_coeff\_flag [C.-Y. Lai, C.-Y. Chen, T.-D. Chuang, O. Chubach, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0946](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8761) Crosscheck of JVET-P0164 (CE5-related: Simplified ALF syntax regarding to alf\_luma\_coeff\_signalled\_flag and alf\_luma\_coeff\_flag) [A. M. Kotra (Huawei)]

[JVET-P0165](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7954) CE5-related: Simplified CCALF [O. Chubach, C.-Y. Lai, C.-Y. Chen, T.-D. Chuang, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0923](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8738) Crosscheck report of JVET-P0165 [K. Misra (Sharp Labs of America)]

[JVET-P0173](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7962) AHG16/Non-CE5: Cross component ALF simplification [J. Li, C. S. Lim (Panasonic)]

[JVET-P0852](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8667) Crosscheck of JVET-P0173 (AHG16/Non-CE5: Cross component ALF simplification) [K. Fan (??)]

[JVET-P0178](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7967) CE5-related: Unification of CCALF and ALF [C.-W. Kuo, J. Li, C.S. Lim (Panasonic)]

[JVET-P0717](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8518) Crosscheck of JVET-P0178 (CE5-related: Unification of CCALF and ALF) [H.-J. Jhu (Kwai Inc.)]

[JVET-P0179](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7968) Non-CE5: ALF as a post-filter [H.-B. Teo, H.-W. Sun, C.-S. Lim (Panasonic)]

[JVET-P0180](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7969) Non-CE5: Cleanup of ALF syntax elements [H. Liu, L. Zhang, K. Zhang, N. Zhang, Y. Wang, Y. Wang (Bytedance)]

[JVET-P0672](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8471) Crosscheck of JVET-P0180 (Non-CE5: Cleanup of ALF syntax elements) [C.-Y. Lai (MediaTek)]

[JVET-P0192](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7981) CE5-related: Reducing the number of luma filters in ALF [O. Chubach, C.-Y. Chen, T.-D. Chuang, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0767](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8582) Crosscheck of JVET-P0192 (CE5-related: Reducing the number of luma filters in ALF) [Y.-W. Chen (Kwai)]

[JVET-P0195](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7984) Non-CE5: Unified strong deblocking filter for luma and chroma [Y. Ahn, D. Sim (Digital Insights)]

[JVET-P0760](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8575) Cross-check of JVET-P0195 (Non-CE5: Unified strong deblocking filter for luma and chroma) [S.-C. Lim, H. Lee, J. Lee, J. Kang (ETRI)]

[JVET-P0246](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8035) AHG17/Non-CE5: on loop filter processing for subpicture treated as a picture

See 6.19.1.1 for the disposition of the HLS aspects of this contribution.

TBP for the low-level signal processing aspects.

[JVET-P0251](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8040) CE5-related: Simplified CCALF [Y. Zhao, H. Yang (Huawei)]

[JVET-P0849](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8664) Crosscheck of JVET-P0251 (CE5-related: Simplified CCALF with 6 filter coefficients) [C.-M. Tsai (MediaTek)]

[JVET-P0892](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8707) Cross-check of JVET-P0251 (Simplified CCALF with 6 filter coefficients) [P. Onno (Canon)]

[JVET-P0255](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8044) CE5-related: Bilateral filter with SAO band offset [K. Abe, T. Toma (Panasonic)]

[JVET-P0868](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8683) Crosscheck of JVET-P0255: CE5-related: Bilateral filter with SAO band offset [J. Ström (Ericsson)]

[JVET-P0262](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8051) AHG16/Non-CE5: Deblocking boundary design cleanup for affine and TPM mode [X. W. Meng (PKU)]

[JVET-P0950](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8765) Crosscheck of JVET-P0262 (AHG16/Non-CE5: Deblocking boundary design cleanup for affine and TPM mode) [H. Liu (Bytedance)]

[JVET-P0269](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8058) AHG18 / non-CE5: Deblocking for TPM and BCW

[JVET-P0290](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8079) CE5-related: Clipping of intermediate value in CC-ALF [Y. Yasugi, T. Ikai (Sharp)]

[JVET-P0668](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8466) Crosscheck of JVET-P0290 (CE5-related: Clipping of intermediate value in CC-ALF) [A. Nalci (Qualcomm)]

[JVET-P0299](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8088) CE5-related: Interaction between Bilateral Filter and Cross-Component Adaptive Loop Filter [C. Hollmann, J. Ström (Ericsson)]

[JVET-P0710](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8511) Cross check report of JVET-P0299 [K. Misra (Sharp Labs of America)]

[JVET-P0306](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8095) Non CE5: DMVR internal edge deblocking without using refined MVs [J. R. Arumugam, S. Kotecha, S. Ramamurthy (Ittiam)]

[JVET-P0743](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8546) Crosscheck of JVET-P0306 (Non CE5: DMVR internal edge deblocking without using refined MVs) [T. Chujoh (Sharp)]

[JVET-P0330](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8119) Non-CE5: CC-ALF filtering simplification [J. Taquet, P. Onno, C. Gisquet, G. Laroche (Canon)]

[JVET-P0962](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8777) Crosscheck report of JVET-P0330 [K. Misra (Sharp Labs of America)]

[JVET-P0331](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8120) Non-CE5: CC-ALF design simplification [J. Taquet, P. Onno, C. Gisquet, G. Laroche (Canon)]

[JVET-P0963](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8778) Crosscheck report of JVET-P0331 [K. Misra (Sharp Labs of America)]

[JVET-P0332](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8121) AHG17/Non-CE5: On parsability of alternative ALF Chroma filter signaling [J. Taquet, P. Onno, C. Gisquet, G. Laroche (Canon)]

[JVET-P0801](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8616) Crosscheck of JVET-P0332: AHG17/Non-CE5: On parsability of alternative ALF Chroma filter signaling [S. Esenlik (Huawei)]

[JVET-P0333](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8122) On SAO performance [P. Onno, G. Laroche (Canon)]

[JVET-P0372](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8161) CE5-related: Joint chroma cross-component adaptive loop filtering [H. Yang, Y. He, H. Li (InterDigital)]

[JVET-P0704](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8505) Crosscheck of JVET-P0372 on joint chroma cross-component adaptive loop filtering [X. Li (Tencent)] [miss\_end\_meeting]

[JVET-P0386](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8175) Non-CE8/Non-CE5: Deblocking for IBC blocks [H. Gao, S. Esenlik, E. Alshina, A. M. Kotra, B. Wang (Huawei)]

[JVET-P0864](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8679) Crosscheck report of JVET-P0386 (Non-CE8/Non-CE5: Deblocking for IBC blocks) [X. Xu (Tencent)]

[JVET-P0411](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8200) Non-CE5: Fixes for long luma deblocking filter decision [K. Andersson, J. Enhorn (Ericsson)]

[JVET-P0412](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8201) CE5-related: On further modification of Hadamard filter from CE5-3.2 [S. Ikonin, V. Stepin, A. Karabutov, S. Nikolaeva (Huawei)]

[JVET-P1007](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8822) Crosscheck of JVET-P0412: CE5-related: On further modification of Hadamard filter from CE5-3.2 [J. Ström (Ericsson)]

[JVET-P0423](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8212) Non-CE5: Modified boundary strength derivation [W. Zhu, L. Zhang, J. Xu (Bytedance)]

[JVET-P0635](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8432) Crosscheck of JVET-P0423 (Non-CE5: Modified boundary strength derivation) [T.-H. Li, C.-Y. Teng (Foxconn)]

[JVET-P0441](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8230) Non-CE5: On deblocking on affine internal prediction sub-block edges [G. Li, X. Li, X. Xu, S. Liu (Tencent)]

[JVET-P0944](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8759) Crosscheck of JVET-P0441 (Non-CE5: On deblocking on affine internal prediction sub-block edges) [K. Unno (KDDI)]

[JVET-P0452](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8241) Non-CE5/AHG17: Low-delay ALF syntax [K. Sühring, R. Skupin, Y. Sanchez, T. Schierl (HHI)]

[JVET-P0468](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8257) CE5-Related: Reducing multiplier count in CC-ALF [K. Misra, F. Bossen, A. Segall (Sharp Labs of America)]

[JVET-P1009](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8824) Crosscheck of JVET-P0468 (CE5-Related: Reducing multiplier count in CC-ALF) [W.-Q. Lim (HHI)]

[JVET-P0470](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8259) Non-CE5: Simplification of Cross Component Adaptive Loop Filter [[X. Li](mailto:xlxiangli@tencent.com), X. Zhao, L. Zhao, Y. Du, S. Liu (Tencent)]

[JVET-P0738](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8540) Crosscheck report of JVET-P0470 [K. Misra (Sharp Labs of America)]

[JVET-P0492](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8281) Non-CE5: Fixes of ALF sample padding [H. Liu, L. Zhang, K. Zhang, Y. Wang, J. Xu, Y. Wang (Bytedance)]

[JVET-P0504](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8294) CE5-related: Harmonization of Hadamard filter, SAO and ALF [V. Stepin, S. Ikonin, A. Karabutov (Huawei)]

[JVET-P1011](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8826) Crosscheck of CE5-related: Harmonization of Hadamard filter, SAO and ALF [J. Ström (Ericsson)]

[JVET-P0505](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8295) Non-CE5: On non-linear ALF clipping values [Y. Du, X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-P0708](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8509) Crosscheck of JVET-P0505 (Non-CE5: On non-linear ALF clipping values) [H. Yang (InterDigital)]

[JVET-P0534](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8324) AhG16/Non-CE5: On deblocking at ALF virtual boundaries [Z. Deng, L. Zhang, K. Zhang, H. Liu, H.-C. Chuang (Bytedance)]

[JVET-P0727](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8528) Crosscheck of JVET-P0534 (AhG16/Non-CE5: On deblocking at ALF virtual boundaries) [Y.-W. Chen (Kwai Inc.)]

[JVET-P0539](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8329) Non-CE5: A chroma deblocking clean-up [J. Xu, L. Zhang, W. Zhu, K. Zhang, H. Liu (Bytedance)]

[JVET-P0543](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8333) CE5-related: Cleanup on cross-component adaptive loop filter [J. Nam, J. Choi, J. Lim, S. Kim (LGE)]

[JVET-P0893](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8708) Cross-check of JVET-P0543 (Cleanup on cross-component adaptive loop filter) [P. Onno (Canon)]

[JVET-P0547](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8337) Non-CE5: Deblocking filter at PROF sub-block boundary [K. Unno, K. Kawamura, S. Naito (KDDI)]

[JVET-P0877](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8692) Crosscheck of JVET-P0547 "Non-CE5: Deblocking filter at PROF sub-block boundary" [G. Li (Tencent)]

[JVET-P0551](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8341) AHG16/Non-CE5: On ALF boundary padding [N. Hu, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-P0552](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8342) AHG12/Non-CE5: Extending slice boundary processing for adaptive loop filter for raster scanned slices [N. Hu, V. Seregin, M. Coban, A. K. Ramasubramonian, M. Karczewicz (Qualcomm)]

[JVET-P0553](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8343) Non-CE5: Using truncated binary codes for ALF filter indices [N. Hu, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-P0953](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8768) Crosscheck of JVET-P0553 (Non-CE5: Using truncated binary codes for ALF filter indices) [H. Liu (Bytedance)]

[JVET-P0554](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8344) Non-CE5: Clean up of coefficient coding of adaptive loop filter [N. Hu, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-P0555](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8345) CE5-related: Dynamic range reduction for coefficients of cross component adaptive loop filter [N. Hu, J. Dong, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-P0850](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8665) Crosscheck of JVET-P0555 (CE5-related: Dynamic range reduction for coefficients of cross component adaptive loop filter) [C.-M. Tsai (MediaTek)]

[JVET-P0556](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8346) CE5-related: Temporal buffer removal for cross component adaptive loop filter [N. Hu, J. Dong, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-P0941](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8756) Cross-check of JVET-P0556 (CE5-related: Temporal buffer removal for cross component adaptive loop filter) [S.-C. Lim, H. Lee, J. Lee, J. Kang (ETRI) ]

[JVET-P0557](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8347) CE5-related: Multiplication removal for cross component adaptive loop filter [N. Hu, J. Dong, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-P0703](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8504) Crosscheck of JVET-P0557 on Multiplication removal for cross component adaptive loop filter [X. Li (Tencent)]

[JVET-P0967](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8782) Crosscheck report of JVET-P0557 Method 2 [K. Misra (Sharp Labs of America)]

[JVET-P0558](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8348) CE5-related: Reduced filter shape for cross component adaptive loop filter [N. Hu, J. Dong, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-P0674](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8473) Crosscheck of JVET-P0558 (CE5-related: Reduced filter shape for cross component adaptive loop filter) [C.-Y. Lai (MediaTek)]

[JVET-P0570](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8360) AHG10/Non-CE5: Performance of encoder-side deblocking optimization in VTM-6.0 [N. Hu, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-P0571](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8361) CE5/CE8: Deblocking Filter for BDPCM coded block [H. Jang, J. Nam, S. Kim, J. Lim (LGE)]

[JVET-P0851](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8666) Crosscheck of JVET-P0571 (CE5/CE8: Deblocking filter for BDPCM coded block) [C.-M. Tsai (MediaTek)]

[JVET-P0851](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8666) Crosscheck of JVET-P0571 (CE5/CE8: Deblocking filter for BDPCM coded block) [C.-M. Tsai (MediaTek)]

[JVET-P0586](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8378) [AHG18][Non-CE5] Proposed cleanup of deblocking filter process [S. Iwamura, S. Nemoto, A. Ichigaya (NHK), K. Andersson, R. Yu, J. Enhorn (Ericsson)]

[JVET-P0700](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8499) Crosscheck of JVET-P0586 Aspect #1 ([AHG18][Non-CE5] Proposed cleanup of deblocking filter process) [Z. Deng (Bytedance)]

[JVET-P0783](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8598) Crosscheck of JVET-P0586 (Aspect 3 of [AHG18][Non-CE5] Proposed cleanup of deblocking filter process) [K. Kondo, M. Ikeda (Sony)]

[JVET-P0815](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8630) Crosscheck of JVET-P0586 (Non-CE5: Proposed cleanup of deblocking filter process) [K. Kazui (Fujitsu)]

[JVET-P0602](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8394) [AHG18][non-CE5] Boundary strength derivation for CUs with TPM [S. Iwamura, S. Nemoto, A. Ichigaya (NHK)]

[JVET-P0611](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8405) Non-CE5/AHG-11: Boundary strength harmonization for BDPCM, TS, Palette and IBC [B. Ray, G. Van der Auwera, M. Karczewicz (Qualcomm)]

[JVET-P0981](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8796) Cross-check of JVET-P0611 (Non-CE5/AHG-11: Boundary strength harmonization for BDPCM, TS, Palette and IBC) [K. Andersson (Ericsson)]

[JVET-P0613](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8407) Non-CE5: On the average calculation for luma adaptive deblocking filter [B. Ray, D. Rusanovskyy, G. Van der Auwera, M. Karczewicz (Qualcomm)]

[JVET-P0863](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8678) Crosscheck of JVET-P0613: Non-CE5: On the average calculation for luma adaptive deblocking filter [K. Naser (InterDigital)] [miss\_end\_meeting]

[JVET-P0614](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8408) Non-CE5: On the gridsize for virtual boundaries [B. Ray, G. Van der Auwera, M. Karczewicz (Qualcomm)]

[JVET-P0665](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8463) Non-CE5: Spec fix for ALF filter and transpose index calculation [N. Hu, V. Seregin, M. Karczewicz (Qualcomm)] [late]

[JVET-P0666](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8464) Non-CE5: Combination of JVET-P0470 and JVET-P0557 on simplification of CC-ALF [X. Li., X. Zhao, L. Zhao, X. Du, S. Liu (Tencent), N. Hu, J. Dong, V. Seregin, M. Karczewicz (Qualcomm)] [late]

[JVET-P0709](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8510) Crosscheck of JVET-P0666 (Non-CE5: Combination of JVET-P0470 and JVET-P0557 on simplification of CC-ALF) [H. Yang (InterDigital)]

[JVET-P0688](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8487) Non-CE5: Intra deblocking coefficients for weak filters [L. Xu, J. Zhu, K. Kazui (Fujitsu)] [late]

[JVET-P0837](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8652) Crosscheck of JVET-0688 on Intra deblocking coefficients for weak filters [S. Iwamura (NHK)]

[JVET-P0739](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8541) CE5-related: Combination of CCALF methods in JVET-P0165, JVET-P0556, and JVET-P0557 [O. Chubach, C.-Y. Lai, C.-Y. Chen, T.-D. Chuang, Y.-W. Huang, S.-M. Lei (MediaTek), N. Hu, J. Dong, V. Seregin, M. Karczewicz (Qualcomm)] [late] [miss]

[JVET-P0949](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8764) Crosscheck of JVET-P0739 (CE5-related: Combination of CCALF methods in JVET-P0165, JVET-P0556, and JVET-P0557) [H. Liu (Bytedance)]

[JVET-P0740](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8542) CE5-related: Combination of JVET-P0086 and JVET-P0161 for TPM deblocking [C.-M. Tsai, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek), A. M. Kotra, S. Esenlik, H. Gao, B. Wang, E. Alshina (Huawei)] [late] [miss]

[JVET-P0918](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8733) Crosscheck of JVET-P0740 (CE5-related: Combination of JVET-P0086 and JVET-P0161 on deblocking boundary strength fix for TPM and affine mode) [H. Jang (LGE)]

[JVET-P1017](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8832) Crosscheck of JVET-P0740 (CE5-related: Combination of JVET-P0086 and JVET-P0161 on deblocking boundary strength fix for TPM and affine mode-method2) [F. Urban (InterDigital)]

[JVET-P1001](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8816) Non-CE5: Chroma QP derivation fix for deblocking filter (Combination of JVET-P0105 and JVET-P0539) [A. M. Kotra, S. Esenlik, B. Wang, H. Gao, E. Alshina (Huawei)] [late]

[JVET-P1002](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8817) Non-CE5: Chroma QP derivation fix for deblocking filter (Combination of JVET-P0105 and JVET-P0539) [J. Xu, L. Zhang, W. Zhu, K. Zhang, H. Liu (Bytedance Inc.)] [late]

[JVET-P1008](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8823) CE5-related: On the design of CC-ALF [K. Misra, F. Bossen, A. Segall (Sharp Labs of America), N. Hu, J. Dong, V. Seregin, M. Karczewicz (Qualcomm), P. Onno, C. Gisquet, G. Laroche (Canon), J. Li, C.S. Lim, C.-W. Kuo (Panasonic), J. Nam, J. Choi, J. Lim, S. Kim (LGE)] [late]

[JVET-P1010](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8825) Crosscheck report of JVET-P1008 (CE5-related: On the design of CC-ALF) [E. François (InterDigital)]

[JVET-P1029](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8844) Cross-check of JVET-P1008 (CE5-related: On the design of CC-ALF) [T.-C. Ma (Kwai Inc.)]

[JVET-P1038](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8853) Non-CE5: Suggested text changes for ALF padding process [H. Liu, L. Zhang, K. Zhang, J. Xu, Y. Wang (Bytedance), N. Hu, V. Seregin, M. Coban, A. K. Ramasubramonian, M. Karczewicz (Qualcomm), C. Lai, O. Chubach, L. Chen, C. Che, T. Chuang, C. Hsu, Y. Huang, S. Lei (MediaTek), M. Zhou (Broadcom)] [late]

The following aspects regarding ALF padding are proposed in this contribution which also cover the Method 2 in JVET-P0551, method 4 in JVET-P0157, the first aspect of JVET-P0053, the determination of unavailable samples in JVET-P0492 and JVET-P0492, the first aspect in JVET-P0158.

1. Apply repetitive padding for all boundaries excluding virtual boundaries for ALF line buffer reduction as per method 2 in JVET-P0551, method 4 in JVET-P0157, and the first aspect of JVET-P0053.
2. applying ALF VB to all CTU in a picture, including the bottom CTU row as per JVET-P0158
3. Use horizontal repetitive padding for filling unavailable samples
4. For cases of filtering with repetitive padding, the classification padding should be the same as currently in the cases of repetitive padding (e.g. as at the picture boundary). ALF virtual boundary classification should not be changed.

Decision: adopt JVET-P1038 (decided in closing plenary Friday Oct. 11)

## CE6 related – Transforms and transform signalling (40)

Contributions in this category were discussed Friday 4 Oct. 1400–2245 and Sat. 5 Oct. 0900-1130 in Track A (chaired by JRO).

[JVET-P0166](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7955) CE6-related: Transform selection with intra prediction mode for implicit MTS [M.-S. Chiang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

This contribution proposes that for an intra luma coding block, the intra prediction mode is used to select the primary transform when explicit multi-transform set (MTS) is disabled and implicit MTS is enabled. The current design is to use the transform block width and height to decide the transform types for implicit MTS. Two variations are proposed. Compared to VTM6.0 with explicit MTS disabled and implicit MTS enabled, the results are summarized as follows.

Variation 1: intra prediction mode with an even number uses DST-VII

AI: BD-rates = -0.06% (Y), -0.13% (Cb), -0.11% (Cr); EncT=99%; DecT=100%

RA: BD-rates = -0.05% (Y), -0.14% (Cb), -0.03% (Cr); EncT=100%; DecT=101%

LB: BD-rates = -0.05% (Y), -0.19% (Cb), -0.02% (Cr); EncT=99%; DecT=101%

Variation 2: intra prediction mode under specified conditions uses DST-VII

AI: BD-rates = -0.04% (Y), 0.11% (Cb), 0.13% (Cr)

RA: BD-rates = 0.00% (Y), 0.02% (Cb), 0.06% (Cr)

LB: BD-rates = 0.0X% (Y), 0.0X% (Cb), 0.0X% (Cr)

The main aspect of the proposal is to replace explicit MTS with implicit MTS in CTC, plus a modification of implicit MTS that gives the coding gain above versus the current implicit method.

Compared to CTC (explicit MTS), loss of 0.02%/0.03% for RA/AI

No obvious benefit.

[JVET-P0928](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8743) Crosscheck of JVET-P0166 (CE6-related: Transform selection with intra prediction mode for implicit MTS) [S. Blasi (BBC)]

[JVET-P0929](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8744) Crosscheck of JVET-P0166 (CE6-related: Transform selection with intra prediction mode for implicit MTS) [C.-C Lin (ITRI)]

[JVET-P0196](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7985) CE6-related: Latency reduction for LFNST signalling [J. Lainema (Nokia)]

In VTM-6, LFNST is signalled at the end of the CU and signalling depends on transform block level data from all components present in a CU. This is reportedly causing latency in both encoder and decoder as, for example, knowing if LFNST is available for the luma component depends on chroma transform coefficients.

It is proposed to remove this “backwards” dependency by signalling LFNST indexes in the TU level. In the proposed approach, LFNST indexes for luma and LFNST indexes for TUs in single-tree coding mode are signalled in the luma TB. In the case of separate chroma tree mode, the chroma LFNST index is signalled in the first coded chroma TB in a TU. LFNST indexes are signalled after the last coefficient position syntax, which allows the last coefficient position based LFNST availability rule of VTM-6 to be applied using the last coefficient position of the current TB. In addition, signalling of the MTS index is proposed to be moved after LFNST index to handle all transform type signalling in a single place.

The proposed change is reported to have BD-rate impacts of -0.11 % and -0.07 % in AI and RA configurations, respectively. Encoder and decoder runtimes are reportedly not affected with respect to those of VTM-6.

Currently, signalling of LFNST depends on last coeff. Positions, including chroma. It was expressed in the discussion that the proposal has interesting aspects, but it includes various changes, and the benefit is not obvious if all these are needed. More information is requested on the particular benefit e.g. of making changes of MTS signalling. It is asserted that the benefit in compresson mainly comes due to making MTS signalling dependent on LFNST.

It is also asked if there is a significant latency issue. It was expressed that for certain implementations it would be desirable to decouple the LFNST from the chroma information.

LGE is currently cross-checking. One expert points out that there may be misalignment between spec and software – cross-checkers should investigate this.

Several experts expressed support that this proposal has beneficial aspects.

Further study in CE.

[JVET-P0971](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8786) Crosscheck of JVET-P0196 (CE6-related: Latency reduction for LFNST signalling) [M. Koo (LGE)]

[JVET-P0197](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7986) CE6-related: LFNST transform mapping [J. Lainema (Nokia) , M.-S. Chiang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

This document proposes to change the mapping of LFNST indexes to transform matrices. Two methods are tested. Method 1 is described as follows. For LFNST index 1, the proposed approach selects transform index 1 for even and 2 for odd numbered intra prediction modes. For LFNST index 2 the selection is inverted and thus transform index 1 is selected for odd and 2 for even intra prediction modes. In addition, context coding for the second bin of the lfnstIdx syntax element is re-introduced. Method 2 is similar to method 1 but uses different mapping methods for the intra prediction modes <= 34 and intra prediction modes > 34.

It is asserted that for CTC conditions the coding efficiency is practically unaffected, but a low complexity encoder can operate at 90 % encoder runtime with +0.13%~+0.14 % bitrate impact under AI conditions and at 97 % encoder runtime with +0.11 % bitrate impact under RA conditions. This is reported to be a significantly lower BD-rate penalty than what was achieved with the comparable encoder approaches in CE6-1, where the best performing encoder side approach had +0.46 %~+0.48% impact on BD-rate for AI and +0.27 % for RA.The proposal allows still selecting the two NST types, but depending on intra mode parity the signalling is toggled. Furthermore, a context coded bin is added. A fast encoder could always select the same type and would go to the solution of CE6-1. The benefit in encoding runtime versus compression loss is still the same (slightly worse) as for CE6-1. The signalling becomes more complicated.

No action.

Similar approaches: P0215, P0349/P0350, P0568.

[JVET-P0215](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8004) CE6 related: Harmonization of CE6-1.1 and two-mode LFNST [X. Zhao, X. Li, S. Liu (Tencent)]

Identical to JVET-P0197 – no action.

[JVET-P0216](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8005) Non-CE6: Simplified SBT mode coding [J. Park, B. Jeon (SKKU)]

This contribution proposes context simplification for cu\_sbt\_pos\_flag in VVC 6.0. Since its probability being 0 or 1 is expected to be similar to each other, it is proposed to encode cu\_sbt\_pos\_flag in the bypass-mode. This simplification shows an average of Y(-0.01%), U(0.07%) and V(0.00%) BDBR for RA; and an average of Y(0.01%), U(0.05%) and V(0.08%) BDBR for LD.

This is not critical, and no support expressed by experts.

[JVET-P0806](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8621) Crosscheck of JVET-P0216 (Non-CE6: Simplified SBT mode coding) [L. Pham Van, G. Van der Auwera (Qualcomm)]

[JVET-P0259](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8048) Non-CE6: On LFNST reduced kernels [J. Gan, C. Rosewarne (Canon)]

In the current design, the Low-frequency Non-separable Transform (LFNST) requires 8KB of memory to store the transform matrices. This contribution proposes to reduce the LFNST 16x48 matrices to 16x36 by removing primary transform coefficients that correspond to columns of low magnitude weights in the 16x48 matrices. It is reported that the proposed method achieves 18.75% table size reduction with 0.04% loss in All Intra configuration in CTC.

The powerpoint deck has some additional information.

It is asserted that the occupation of the LFNST matrices with low-weight matrices is due to the mode sets with directional orientation.

Interesting information about properties of LFNST.

As saving of ROM memory is not highly relevant. No reason to change the existing design.

[JVET-P0886](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8701) Crosscheck of JVET-P0259 (Non-CE6: On LFNST reduced kernels) [H. E. Egilmez (Qualcomm)]

[JVET-P0266](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8055) Non-CE6: LFNST signalling [C. Rosewarne, J. Gan (Canon)]

VVC uses a CU-level signalling of LFNST, sent after the residual when last positions of the TBs indicate all significant coefficients are subject to secondary transformation. When chroma separate tree (CST) is disabled in I slices, and in P or B slices, this results in the signalling applying both to luma and chroma TBs of a CU. This contribution proposes separate luma and chroma control of LFNST when CST is not in use. Coding performance results of this are AI: x.xx%, x.xx%, x.xx%, in Y, Cb, and Cr components, respectively.

Separate signalling for luma and chroma. No obvious benefit from the results, very slow encoder.

No need for action.

[JVET-P0271](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8060) Non-CE6: Context modelling for LFNST index coding [T. Tsukuba, M. Ikeda, Y. Yagasaki, T. Suzuki (Sony)]

In this document a bugfix for the configuration parameter MTSIntraMaxCand is proposed, which by itself is claimed to have no impact on the CTC. Furthermore, it is proposed to set the CTC value of the parameter for AI and RA to from currently 3 to 1, avoiding testing transform combinations which are reportedly rarely used. A minor BD-rate impact on the CTC results is reported, namely 0.00% (Y), 0.00% (U), 0.01% (V) for AI and 0.01% (Y), 0.01% (U), -0.01% (V) for RA.

The mismatch between SW and text is already resolved (ticket issued). Proposal to reduce the number of context variables of bin 0 from 2 to 1, removes dependency on tree type.

Very small loss (0.01% in RA) unless retraining matrices, and the complexity advantage appears negligible. No action.

[JVET-P0771](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8586) Crosscheck of JVETP0271 (Non-CE6: Context modeling for LFNST index coding) [Y.-W. Chen (Kwai)]

[JVET-P0273](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8062) Non-CE6: On MTSIntraMaxCand [C. Hollmann, D. Saffar, J. Ström (Ericsson)]

In this document a bugfix for the configuration parameter MTSIntraMaxCand is proposed, which by itself is claimed to have no impact on the CTC. Furthermore, it is proposed to set the CTC value of the parameter for AI and RA to from currently 3 to 1, avoiding testing transform combinations which are reportedly rarely used. A minor BD-rate impact on the CTC results is reported, namely 0.00% (Y), 0.00% (U), 0.01% (V) for AI and 0.01% (Y), 0.01% (U), -0.01% (V) for RA.

“Bugfix” is the current disabling of MTSIntraMaxCandidate when LFNST is enabled.

This only applies to software and configuration files.

If LFNST is used, currently the software overwrites this parameter by a value of 4. Would be better to hve it configurable.

Decision (SW/CTC): It is agreed to apply the suggested bugfix (make the number of candidates configurable), but set the value to 4 in CTC (i.e. keeping CTC unchanged).

[JVET-P0930](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8745) Crosscheck of JVET-P0273 (Non-CE6: On MTSIntraMaxCand) [Y. Wang (Bytedance)]

[JVET-P0276](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8065) Non-CE6: On Supporting 64x64 Chroma Transform Unit with Composite VPDU [W. Cai, J. Zhu, J. Yao, K. Kazui (Fujitsu)]

This contribution proposes to support the maximum transform unit size of chroma components in 4:2:0 format up to 64x64 by introducing composite VPDU concept. For CTUs coded in dual tree in I slices, a flag is used to indicate whether a 64x64 chroma block is split into 4 32x32 blocks or not. If a 64x64 chroma block is not split, i.e. chroma CU size is 64x64, its TU size is also 64x64. CCLM is disabled for 64x64 chroma CU. For inter CU, when inter CU size in luma samples is larger than 64x64 (i.e. 128x128, 128x64 or 64x128), the size of transform unit of chroma components is up to 64x64. Otherwise, the maximum transform unit size of chroma is 32x32. By sharing transform core and internal buffer between luma TU and chroma TU, there is no extra hardware cost on decoder pipeline except scheduling mechanic (controller) of pipeline. The simulation results show -0.01%(Y), -0.20%(Cb), and -0.29%(Cr)BD-rates for AI configuration and -0.00%(Y), -0.17%(Cb), and -0.22%(Cr)BD-rates for RA configuration respectively on top of VTM-6.0.

The benefit in compression is low, and the proposal makes the VPDU concept more complicated. Also unclear how it would work with IBC, DMVR, etc.

No action.

[JVET-P0786](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8601) Crosscheck of JVET-P0276 (Non-CE6:On Supporting 64x64 Chroma Transform Unit with Composite VPDU) [F. Urban (InterDigital)]

[JVET-P0301](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8090) Non-CE6: Decoding process of implicit TU partitioning [G. Ko, D. Kim, J. Jung, J. Son, J. Kwak (WILUS)]

This contribution proposes to change the decoding process related to the implicit TU partitioning. The configurable maximum transform size has been adopted and the transform tree syntax related to the implicit TU partitioning has changed accordingly. Meanwhile, the corresponding decoding process has remained unchanged. Therefore, there exists a case that the processing order of partitioned transform blocks is different in the syntax and the decoding process. It is proposed to make a change on the decoding process of the implicit TU partitioning to follow the syntax. The proposed change has no impact on VTM.

It is reported that the sequence of block processing for case of implicit partuitioning is different in the syntax and decoding process description of the spec text. Decoder software implements the sequence as in the syntax part of the spec.

Decision (BF/text/ed.): Editors to check and align as necessary.

[JVET-P0313](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8102) Non-CE6: Simplification of LFNST LUT [S. Shrestha, A. Kumar, B. Lee (Chosun Univ.), Y. Lee, J. Park (Humax)]

In VTM-6.0, four LFNST transform kernel sets with kernel sizes and are defined. One of the LFNST transform kernel set (lfnstTrSetIdx) among four transform sets is selected based on predModeIntra. In this contribution, a LFNST LUT is newly defined to save the total memory size of LFNST LUT by removing the LUT for WAIP. In our proposed method, lfnstTrSetIdx for MIP and WAIP is decided to 0 and 1, respectively and lfnstTrSetIdx for predModeIntra from 67 to 94 is removed in the proposed LFNST LUT. The proposed LFNST LUT can save 28 bytes out of 96 bytes of memory size of LFNST LUT. The experimental results show Y: 0.00%, U: 0.00%, V: 0.00%, EncT: 99, DecT: 106% for AI and Y: 0.00%, U: 0.00%, V: 0.00%, EncT: 100%, DecT: 100% for RA.

The saving of memory is not significant, and instead two conditional checks are introduced.

Benefit not obvious – no action.

[JVET-P0951](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8766) Crosscheck of JVET-P0313 (Non-CE6: Simplification of LFNST LUT) [J. Heo (LGE)]

[JVET-P0342](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8131) CE6-related: LFNST applied to ISP mode [F. Le Léannec, K. Naser, F. Galpin (InterDigital)]

Intra sub-partition (ISP) is the only intra coding mode where LFNST is not applied in VTM-6. This contribution proposes to unify the VVC design by allowing LFNST in coding units coded in ISP mode. As for MIP, LFNST is allowed for CU size greater or equal to 16 in width and height. The proposed extended used of LFNST brings coding gain in every class of the JVET RA CTC. It reportedly brings -0.02% average gain in RA, with unchanged coding and decoding time. No change in AI performance is observed. A second tested method allows the LFNST/ISP combination if the CU size is such that the ISP splitting leads to TU size at least equal to 4x4. It is shown that it improves the BD-rate performances of the first method.

From the results given (0.02% gain in RA for 2% enc time increase) no need for action.

Similar contribution: JVET-P0392

[JVET-P0906](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8721) Cross-check of JVET-P0342 (CE6-related: LFNST applied to ISP mode) [S. De-Luxán-Hernández (HHI)]

[JVET-P0346](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8135) Non-CE6: SPS Clean-up of SBT [K. Naser, T. Poirier, F. Le Léannec, F. Galpin (InterDigital)]

Sub-Block Transform (SBT) is controlled by an SPS parameter (sps\_sbt\_enabled\_flag) to activate/deactivate it. If activated, another SPS parameter (sps\_sbt\_max\_size\_64\_flag) is coded to indicate if max SBT size is 64 or 32. However, due to the adoption of JVET-O0545, max SBT size is restricted to the maximum allowable transform size. Therefore, if the maximum transform size is set to 32, maximum SBT size is restricted to 32 regardless of the SPS parameter sps\_sbt\_max\_size\_64\_flag. This contribution proposes to code sps\_sbt\_max\_size\_64\_flag only if the maximum transform size is 64, otherwise max SBT size is inferred to be zero.

P0405 aspect 2 proposes the same.

P0391 aspect 1 proposes the same.

See further notes under JVET-P0391

[JVET-P0349](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8138) CE6 Related: MIP Adaptation On Top of CE6-1.1d [K. Naser, F. Galpin, T. Poirier, Y. Chen (InterDigital)]

Makes an additional dependency on selecting transform type when MIP is used (based on even/odd MIP mode). Additional benefit is average 0.01%, more (0.04%) for class A1.

No action.

[JVET-P0350](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8139) CE6 Related: Modified LFNST Index Coding For Fast Encoder Implementation [K. Naser, F. Galpin, T. Poirier, Y. Chen (InterDigital)]

Identical to JVET-P0197 in one version, and the second version makes an additional dependency on selecting transform type when MIP is used. The latter gives on average 0.01% compression benefit – no action.

Proponents announce that they are currently running simulations by changing the LFNST type flag to context coded (it had been also context coded in an earlier version), and having a fast encoder select always one type, such that the flag would cost almost nothing. Further review performed Thursday 9 Oct. after results were available.

These additional results indicate that by just changing the second bin to context coded, the loss for a fast encoder (still saving 10% run time) would be 0.25% in AI, whereas in CTC no change would be observed.

Otherwise (bypass coding of that bin), a fast encoder would have around 0.5% loss

With modifying the semantics of that bin, the loss of a fast encoder would be 0.11% in AI

The change of semantics would be to make the interpretation of the LFNST index dependent in even/odd intra prediction mode (as had been studied CE6.1.1)

Introducing this additional dependency would be undesirable just for a small benefit of a fast encoder. No action on the proposal

Decision: Introduce context coding (single context model) for the second LFNST bin (as it had been some time before) – proponents of JVET-P0350 will provide text and software (to be uploaded in a new version of doc).

[JVET-P0882](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8697) Crosscheck of JVET-P0350 (CE6-related: Modified LFNST Index Coding For Fast Encoder Implementation) [J. Lainema (Nokia)]

[JVET-P1013](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8828) Crosscheck of JVET-P0350 (CE6 Related: Modified LFNST Index Coding For Fast Encoder Implementation) [H. E. Egilmez (Qualcomm)] [late]

[JVET-P0354](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8143) Non-CE6: LFNST Up to 64x64 CU’s [K. Naser, T. Poirier, F. Le Léannec, F. Galpin (InterDigital)]

During the last JVET meeting, LFNST was restricted to CU’s not larger than the maximum TU size in order to solve the VPDU issue. However, due to the adoption of JVET-O0545, the maximum transform size changes between 64x64 and 32x32 depending on the SPS flag sps\_max\_luma\_transform\_size\_64\_flagsps\_sbt\_max\_size\_64\_flag. Despite no VPDU issue, LFNST is restricted to 32x32 when sps\_max\_luma\_transform\_size\_64\_flagsps\_sbt\_max\_size\_64\_flag is set to zero according to the current specification. This contribution proposes to remove this restriction and allow LFNST up to 64x64 regardless sps\_max\_luma\_transform\_size\_64\_flagsps\_sbt\_max\_size\_64\_flag, where TU tiling is performed when CU size is larger than TU. It is reported that the -0.04% AI luma gain is achieved.

This only applies to non-CTC case when max TU size is set to 32. Conceptually similar to the combination of ISP and LFNST, where LFNST is signalled at CU level but applied to several TUs in that CU.

The gain is small, and would require additional checks in the syntax. No need for action.

[JVET-P0872](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8687) Crosscheck of JVET-P0354: Non-CE6: LFNST Up to 64x64 CU’s [J. Jung, D. Kim, G. Ko, J. Son, J. Kwak (WILUS)]

[JVET-P0376](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8165) Non-CE6: Refined LFNST restriction with MIP [H. Yang, Y. He (InterDigital)]

In VTM-6.0, LFNST (low-frequency non-separable transform) is allowed to be used together with MIP (Matrix weighted intra prediction) for large coding blocks (i.e. min(width, height) ≥ 16). In this proposal, we propose to always disallow LFNST with MIP for inter slices. Simulation result shows +0.02% Y BD-rate change of RA, with similar encoding and decoding time.

Several experts expressed that there is no issue in terms of complexity. No reason imposing specific restrictions.

[JVET-P0682](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8481) Crosscheck of JVET-P0376: Refined LFNST restriction with MIP [X. Zhao (Tencent)]

[JVET-P0379](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8168) Non-CE6: Unified zero-out range for 4x4 LFNST [K. Fan, L. Zhang, K. Zhang, Y. Wang (Bytedance)]

The current LFNST design defines the zero-out range according to transform block sizes. In this contribution, a unification of the zero-out ranges for 4×4 LFNST is proposed. With the proposed method, it is asserted that the computational complexity of LFNST could be saved by 50% for 4×N and N×4 blocks. Meanwhile, the on-chip memory size required by 4×4 LFNST is reported to be reduced by 50%. Experimental results reportedly show that the BD-rate changes are negligible, i.e., 0.03%, 0.01% for AI and RA configurations, respectively. For the low QP settings according to CE6 test conditions, the coding loss is reported to be 0.03% for AI configuration.

Does not change the worst case of complexity (which is for 4x4 blocks).

The memory saving for storing matrices is not a big deal (ROM), see notes under CE6-2.

The benefit in terms of hardware implementation appears minor, better keep design unmodified.

[JVET-P0696](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8495) Cross-check of JVET-P0379: Non-CE6: A unified zero-out range for 4x4 LFNST [H. Sun, J. Li (Panasonic)]

[JVET-P0391](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8180) Non-CE6: A clean-up of SPS maximum SBT size signalling [M. G. Sarwer, R. L. Liao, J. Luo, Y. Ye (Alibaba)]

In VVC6, when sps\_sbt\_enabled\_flag = 1, sps\_sbt\_max\_size\_64\_flag is signalled regardless of the value of maximum transform block size specified by sps\_max\_luma\_transform\_size\_64\_flag. This contribution proposes to signal sps\_sbt\_max\_size\_64\_flag only if the maximum transform block size is 64. If the maximum transform block size is 32, sps\_sbt\_max\_size\_64\_flag is inferred to be 0. As an alternative approach, this contribution also proposes to remove the maximum SBT size signaling and maximum SBT size is inferred to be equal to maximum transform block size.

First aspect: Same as P0346

Second aspect: In CTC, currently the SBT flag is set to maximum 32 for classes C and D. This is mainly for encoder complexity, as larger SBT would hardly be used. As the purpose is different from the max transform size, better keep both.

From the discussion: The name of the SBT transform size flag may be misleading. Its purpose is rather restricting usage of SBT for CU >32

In a follow-up discussion (in context of defining a similar flag for ISP as per JVET-P0699) it was suggested to better remove the sps\_sbt\_max\_size\_64\_flag, as the encoder benefit can also be achieved in a non-normative way. Somebody should generate results for classes C and D to investigate the benefit of that flag. see under JVET-P0983

[JVET-P0392](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8181) Non-CE6: Combination of ISP and LFNST [S. De-Luxán-Hernández, V. George, G. Venugopal, J. Brandenburg, B. Bross, H. Schwarz, D. Marpe, T. Wiegand (HHI), M. Koo, M. Salehifar, J. Lim, S. Kim (LGE)]

In VTM-6.0 LFNST and ISP are mutually exclusive. This contribution proposes to remove this restriction. In case of ISP, the LFNST index is also signalled at the CU-Level and applied to all ISP TUs. The results of two different encoder configurations, Test 1 and 2, are presented. Test 1 obtains a gain of 0.19% and 111% and 100% encoder and decoder run-times respectively for AI. In the case of RA, the gain is 0.12% and 102% and 101% encoder and decoder run-times respectively. Test 2, which applies a fast encoder search, obtains a a gain of 0.10% and 101% and 99% encoder and decoder run-times respectively for AI. In the case of RA, the gain is 0.10% and 101% and 101% encoder and decoder run-times respectively.

It is further reported that the gain of ISP (based on tool-off test) increases when combined with LFNST. This seems to indicate that the two tools have a positive synergy.

LFNST is not changed.

The modifications are straightforward in terms of checking for ISP block sizes instead of cu sizes.

Signalled at CU level, coding and syntax not changed.

Question is raised how it would combine with JVET-P0196, which is studied in CE.

It was suggested to study in CE along with JVET-P0196.

Later, a joint proposal JVET-P1026 was made.

[JVET-P0854](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8669) Cross-check of JVET-P0392 (Non-CE6: Combination of ISP and LFNST) [F. Le Leannec (InterDigital)]

[JVET-P0405](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8194) Non-CE6: Cleanups of maximum transform size related syntax elements [Z. Deng, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)]

In current VVC, the maximum transform size is signalled regardless the size of maximum CTU size. In addition, the maximum SBT size is signalled regardless the size of maximum transform sizes. This contribution proposes to conditionally signal the maximum transform size and maximum SBT size. More specifically, two aspects are proposed as follows:

Aspect #1: **sps\_max\_luma\_transform\_size\_64\_flag** is signalled only when the CTU size is larger than or equal to 64.

Aspect #2: **sps\_sbt\_max\_size\_64\_flag** is signalled only when the maximum transform size is equal to 64.

Aspect 2: Same as P0346. It also simplifies the spec, as currenly it is necessary to enforce the SBT transform to size 32 when the flag is signalling 64

Aspect1: Saving 1 bit in SPS for very specific cases is irrelevant, and it would require another parsing condition. No obvious benefit.

[JVET-P0430](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8219) AHG17: High level syntax cleanup on the syntax elements of transform skip [Y.-J. Chang, V. Seregin, M. Coban, M. Karczewicz (Qualcomm)]

The proposal is summarized as follows:

1. Replace ue(v) with u(2) for the binarization of the syntax element log2\_transform\_skip\_max\_size\_minus2

2. Infer sps\_transform\_skip\_enabled\_flag to be 0 when MinCbLog2SizeY is larger than 5. Add a requirement of conformance that log2\_transform\_skip\_max\_size\_minus2 shall be larger than or equal to log2\_min\_luma\_coding\_block\_size\_minus2.

The ue(v) signalling was inherited from RExt syntax. There is no obvious benefit replacing it with fixed length code.The issues mentioned under 2 are not critical, as there will be no problem in block-level decoding, since a TS flag would never appear (unless it would an illegal bitstream).

The aspect of moving the signalling from PPS to SPS needs further study anyway (see notes under JVET-P0486)

[JVET-P0493](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8282) CE6-related: Further simplification with new LFNST transform basis [?? (??)] [late]

(include abstract)

It is asserted that saving of memory for LFNST matrices is not a real problem (ROM, fixed table). No reason to change the existing design.

[JVET-P0887](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8702) Crosscheck of JVET-P0493 (CE6-related: Further simplification with new LFNST transform basis) [H. E. Egilmez (Qualcomm)]

[JVET-P0495](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8284) Non-CE6: On implicit MTS [Y. Wang, H. Liu, L. Zhang, K. Zhang, Z. Deng, Y. Wang (Bytedance)]

In the current design of VVC, implicit MTS may be applied on ISP-coded blocks, SBT-coded blocks and normal-intra coded blocks with different rules. Implicit MTS is controlled together for all the three cases. When sps\_mts\_enabled\_flag is equal to 0, only DCT2 can be used in all the three cases, which is inflexible and deteriorates the coding performance of ISP and SBT. In this contribution, two aspects are proposed to control implicit MTS in three cases separately. Two flags are signalled in SPS to indicate whether non-DCT2 transform kernels are allowed for ISP and SBT, respectively. Simulation results reportedly show BD-rate changes of -0.37%/-0.35%/-0.34% in AI/RA/LB configurations on average, compared to VTM-6.0 with MTS disabled.

It is mentioned that JVET-P0569 method 3 is a superset.

Comparison is not CTC

More clarity needed what is desirable:

* Encoders might want only using DCT2 -> MTS enabled flag manages that
* If MTS enabled:
  + Using implicit MTS only for SBT and ISP, without using for anything else
  + Select separately for inter and intra
    - Not using MTS
    - Using implicit for all blocks (in case of inter only for SBT)
    - Using explicit for blocks that are not SBT or ISP

The solution of P0501 plus an additional “DCT only” flag of P0569 could achieve this:

“If !DCTonly {syntax of 501}”

Proponents of 495, 501, 569 should provide a table that indicates to what extent the different possible syntax states provide which level of flexibility – see JVET-P1031

JVET-P1021 is also related.

[JVET-P0691](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8490) Crosscheck of JVET-P0495: Non-CE6: On implicit MTS [C. Hollmann (Ericsson)]

[JVET-P0501](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8291) Non-CE6: Cleanup on MTS related HLS [X. Zhao, X. Li, S. Liu (Tencent)]

In VVC Draft 6, there are three MTS related coding tools, including intra implicit MTS, intra explicit MTS and inter explicit MTS, and the enabling/disabling of these three tools are controlled by SPS flags. According to VVC Draft 6, in order to enable inter explicit MTS for inter prediction residuals, either implicit or explicit MTS must be enabled for intra prediction residuals, which is not necessary. In this contribution, it is proposed to decouple the HLS controlling of intra (either implicit or explicit) MTS and inter explicit MTS, such that intra MTS and inter explicit MTS can be enabled/disabled individually.

It is agreed that this is a useful change, allowing configuring MTS more independently for intra and inter cases. Proposals JVET-P0569 and JVET-P0495 target similar issues.

[JVET-P0527](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8317) Non-CE6: On context model for coding last NZ position [T.-C. Ma, Y.-W. Chen, X. Xiu, H.-J. Jhu, X. Wang (Kwai Inc.)]

This contribution is proposed to align the context model selection of last non-zero coefficient position coding with the size of zero-out TUs. The proposed modification reduces 10 context models.

The result of test shows that the coding loss is 0.02%, 0.03%, 0.02XXX% for All Intra, RA, and LDB, respectively.

The further reduction of context models does not appear important.

[JVET-P0758](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8562) Crosscheck of JVET-P0527 (Non-CE6: On context model for coding last NZ position) [T. Tsukuba (Sony)]

[JVET-P0538](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8328) Non-CE6: Transform skip with fixed transform shift [J. Xu, L. Zhang, W. Zhu, K. Zhang, H. Liu, Z. Deng (Bytedance)]

In the current VVC design, a transform shift is applied to simulate transform process for all blocks even for a transform skip coded block. In this contribution, two methods are proposed. Method 1 is to have a fixed shifting to fit the 16-bit range. Method 2 is to remove such a transform simulation for transform skip blocks. It is asserted that computational complexity reduction is achieved. No BD-rate changes under the CTC are observed. For low QPs (2, 7, 12, 17), some minor BD-rate changes are reported.

The deviation is due to the fact that the current method of VVC invokes a right shift (block size dependent) in dequantization which introduces a kind of rounding error that cannot be compensated by the subsequent left shift. This effect becomes noticeable only at very low QPs.

The proposed methods solve this issue and by tendency have (marginally) better performance, in most cases bit-wise equal. Method 2 which is basically performing “transquant-bypass with quantization/scaling”

JVET-P0272 and JVET-P0515 are targeting the same issue

JVET-P0272 and JVET-P0515 are identical to method 2 at decoder, but have a modified encoder in terms of RD optimization. The additional gain is not high (0.1% in TGM and class F in AI for JVET-P0515)

Proponents of the three contributions to come together, and provide text, software and a recommendation of possible changes to the encoder. See JVET-P1000

[JVET-P1000](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8815) Proposed text and encoder for transform shift removal in transform skip mode (harmonization of JVET-P0272, JVET-P0515 and JVET-P0538) [J. Xu, L. Zhang, W. Zhu, K. Zhang, H. Liu, Z. Deng (Bytedance Inc.), T. Tsukuba, M. Ikeda, Y. Yagasaki, T. Suzuki (Sony Corporation), H.-J. Jhu, X. Xiu, Y.-W. Chen, T.-C. Ma, X. Wang (Kwai Inc.)] [late]

Discussed Thu. 9 Oct. in Track A.

It is proposed to remove transform shift in transform skip mode in JVET-P0272, JVET-P0515 and JVET-P0538. This contribution presents suggested text changes and an encoder for consideration.

Decision: Adopt JVET-P1000 (text+software)

[JVET-P0759](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8563) Crosscheck of JVET-P0538 (Non-CE6: Transform skip with fixed transform shift) [T. Tsukuba (Sony)]

[JVET-P0540](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8330) Non-CE6: Disabling MTS for 64xN and Nx64 CUs [J. Jung, D. Kim, G. Ko, J. Son, J. Kwak (WILUS)]

In this contribution, the block size condition for applying MTS (Multiple Transform Selection) is proposed when the maximum transform size is equal to 32. In VVC Draft 6, the maximum transform size is signalled in the SPS (Sequence Parameter Set) and it can be configured to either 32 or 64. When the maximum transform size is equal to 32, 64xN and Nx64 (N>=4) CUs are partitioned into 32xMin(32, N) and Min(32, N)x32 TUs, respectively. For the partitioned TUs, MTS is allowed and MTS index (tu\_mts\_index) is coded. However, when the maximum transform size is equal to 64, MTS is not allowed to 64xN and Nx64 (N>=4) CUs. This contribution proposes to disallow MTS for 64xN and Nx64 (N>=4) CUs when the maximum transform size is equal to 32. In the proposed method, only DCT-II and transform skip mode are allowed and MTS index is not coded for 64xN and Nx64 (N>=4) CUs. This would harmonize the maximum CU block size that can utilize MTS as 32x32 irrespective of the signaled maximum transform size. It is reportedly shown that the proposed method achieves -0.02% (AI), -0.02% (RA) and -0.05% (LDB) BD-rates with same encoding and decoding times when the maximum transform size is configured to 32 in VTM-6.0. Additionally, when inter MTS is enabled (--MTS=3), the proposed method achieves 0.03% (RA) and -0.09% (LDB) BD-rates with 93% and 92% encoding times.

This has small benefit under non-CTC, and the encoder runtime reduction could also be achieved in a non-normative way by signalling MTS off in the 64xN and Nx64 TU with very small overhead.

[JVET-P0680](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8479) Crosscheck of JVET-P0540: Disabling MTS for 64xN and Nx64 CUs [X. Zhao (Tencent)]

[JVET-P0545](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8335) CE6-2.3-related: further reduced 8x8 LFNST matrices [K. Fan, L. Zhang, K. Zhang, Y. Wang (Bytedance)]

The current LFNST design defines eight 16×16 matrices and eight 16×48 matrices. In this contribution, 16×48 matrices are proposed to be further reduced to 16×36 matrices and only one coefficient pattern is utilized. With the proposed method, it is asserted that the required on-chip memory size of transform matrices is reduced by 1.5 KB and the computational complexity for 8×8 LFNST are reduced by 25%.0.04%, 0.02% for AI and RA configurations, respectively. For the low QP settings according to CE6 test conditions, the BD-rate change is reported to be 0.00% for AI configuration.

No presenter available Sat 5 Oct. morning. This seems to fall into the category of ROM storage reduction which is asserted to be not highly relevant (see noted under CE6-2.3).

[JVET-P0898](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8713) Crosscheck of JVET-P0545: CE6-2.3-related: Reduced 8×8 matrices for LFNST [T. Zhou (Sharp)]

[JVET-P0566](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8356) CE6-related: On LFNST Support Patterns [H. E. Egilmez, A. Said, V. Seregin, M. Karczewicz (Qualcomm)]

This document proposes two alternative designs for LFNST. The first design aims to simplify the existing 8x8 LFNST design by replacing the L-shaped, 48-sample support pattern with the 6x6-square pattern. It is experimentally shown that the proposed simplification with optimized transform matrices provides -0.01%AI and 0.00% RA over VTM-6.0. The second design aims to provide additional coding gains by introducing a circular 48-sample support pattern for 8x8 LFNST. The experimental results show that -0.09% AI and -0.04% RA BD-rates are achieved over VTM-6.0.

Not changing worst case of number of mult. , and ROM storage reduction is asserted to be not highly relevant (see noted under CE6-2.3).

[JVET-P0931](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8746) Crosscheck of JVET-P0566 (CE6-related: On LFNST Support Patterns) [J. Gan (Canon)]

[JVET-P0567](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8357) CE6-related: Optimized LFNST matrices for CE6-2.1 [H. E. Egilmez, A. Said, V. Seregin, M. Karczewicz (Qualcomm)]

This document proposes a complete set of LFNST matrices (kernels) optimized for the simplification method studied in CE6-2.1. The experimental results show that the proposed set of matrices recovers the coding loss introduced in CE6-2.1. Over VTM-6.0, -0.02% AI and -0.02% RA BD-rates are achieved.

As the CE6-2.1 was not adopted, no need to consider.

[JVET-P0897](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8712) Crosscheck of JVET-P0567: CE6-related: Optimized LFNST matrices for CE6-2.1 [T. Zhou (Sharp)]

[JVET-P0568](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8358) CE6-related: An LFNST Index Signaling with Bin Prediction [H. E. Egilmez, V. Seregin, A. Nalci, A. Said, M. Karczewicz (Qualcomm)]

Identical to JVET-P0197, with a different signalling method – no action.

[JVET-P0883](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8698) Crosscheck of JVET-P0568 (CE6-related: An LFNST Index Signaling with Bin Prediction) [J. Lainema (Nokia)]

[JVET-P0569](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8359) AHG17/Non-CE6: High-level syntax for MTS and Implicit Transform Derivations [H. E. Egilmez, V. Seregin, M. Karczewicz (Qualcomm)]

This document proposes modifications for SPS-level signaling of MTS-related flags in order to remove unnecessary dependencies between explicitly signalled and implicitly defined transform selection.

The current design has following issues:

1) Explicit MTS flags **sps\_explicit\_mts\_intra\_enabled\_flag** and **sps\_explicit\_mts\_inter\_enabled\_flag** can enable implicit MTS derivation even though it is set to be disabled (i.e., VTM-6.0 configuration is set to MTSImplicit = 0). For example, when only inter MTS is enabled and implicit MTS is disabled (i.e., when VTM-6.0 configurations are MTS=2 and MTSImplicit = 0), VTM-6.0 enables implicit transform for intra blocks. In other words, the implicit MTS derivation for intra can depend on inter MTS flag.

2) Flags **sps\_explicit\_mts\_intra\_enabled\_flag**, **sps\_explicit\_mts\_inter\_enabled\_flag** and **sps\_mts\_enabled\_flag** can modify the transform derivation for SBT and ISP, which is counter-intuitive. If all these three flags are disabled, only DCT-2 transform can be used in all TUs. On top of this, if only inter MTS flag is enabled, then ISP uses a combination of DCT-2 and DST-7. In other words, transform derivation on ISP (which is an intra coding tool) can depend on inter MTS flag. Similarly, transform derivation for SBT (which is an inter coding tool) can depend on Intra MTS flag.

[JVET-P0634](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8431) Non-CE6: Removal of LFNST for 4x4, 4xN and Nx4 blocks [H. E. Egilmez, T. Hsieh, V. Seregin, M. Karczewicz (Qualcomm)] [late]

This document proposes to disable LFNST for 4x4, 4xN and Nx4 blocks and reduce latency, which is critical for small blocks, and it reduces 2KB of memory. The experimental results show that the proposed simplification leads to 0.16% AI and 0.10% RA luma BD-rate losses over VTM-6.0, and the encoder runtime is reduced about 10% for AI coding.

Latency is not critical at decoder, as the residual can be reconstructed separately from the prediction. An encoder that has latency problems might better disable LFNST. The loss is too large to justify the change.

[JVET-P0987](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8802) Cross-check of JVET-P0634 (Non-CE6: Removal of LFNST for 4x4, 4xN and Nx4 blocks) [S. De-Luxán-Hernández (HHI)]

[JVET-P0637](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8434) CE6-related: On measuring reconstruction error of LFNST matrices [X. Zhao (Tencent)] [late]

In this contribution, different methods for analyzing the “orthogonality” of LFNST kernels are studied together with their connections to coding performance.

For information.

[JVET-P0640](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8437) Non-CE6: High Level Syntax Flag for SBT Transform Selection [K. Naser, F. Le Léannec, M. Kerdranvat, T. Poirier (InterDigital)] [late]

In JVET-O0538, SPS control was provided to enable DCT2 transform implementation of ISP and SBT, where non-DCT2 transforms are enabled for ISP and SBT if they are also enabled for other blocks. Specifically, it is controlled by the SPS flag sps\_mts\_enabled\_flag. The motivation was to decouple the two tools from the transfom design such that a low-memory encoder that is not equipped with DST7 and DCT8 can still use ISP and SBT. However, in the case of implicit MTS, the encoder requires DCT2 and DST7 for ISP and normal blocks and DCT8 for SBT. That is, unless DCT8 is supported, SBT need to be off. This contribution proposes removing this limitation and allow SBT to use DCT2 if DCT8 is not supported by the encoder.

The benefit is in the range of 0.1%. It is not obvious why an encoder would be able to implement DST7, but not able to implement DCT8 (both require full matrix multiplications).

This would introduce another special setting without obvious benefit. No action.

[JVET-P1027](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8842)Crosscheck of JVET-P0640 (Non-CE6: High Level Syntax Flag for SBT Transform Selection) [J. Gan (Canon)]

[JVET-P0699](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8498) Non-CE6 / Non-CE3: On ISP and Maximum Transform Size [K. Naser, T. Poirier, T. Urban, G. Rath (InterDigital)] [late]

Due to the adoption of JVET- O0545, the maximum transform size changes between 64x64 and 32x32 depending on the SPS flag sps\_max\_luma\_transform\_size\_64\_flag. This change impacted the use of ISP, since ISP is allowed up to the maximum transform size. That is, when sps\_max\_luma\_transform\_size\_64\_flag is zero, ISP is allowed up to CU sizes 32x32. Experimental results show 0.00% and, 0.01% and -0.03% AI and, RA and LDB luma loss when ISP maximum size is 32x32 under CTC. It is argued that in general there is no need for ISP beyond 32x32 CU’s, and therefore it is proposed to either limit the maximum size to 32x32, independently from sps\_max\_luma\_transform\_size\_64\_flag, or to add an SPS flag to enable ISP up to 64x64. The second option is inline with the design of the SBT, whose maximum size is controlled by sps\_sbt\_max\_size\_64\_flag.

There is no reason of a complexity problem to disable ISP for large blocks. Main benefit would be to speed up encoder search. This could also be achieved in a non-normative way. It is undesirable to introduce too many specific settings and additional SPS flags for fast encoder benefits.

Method 4 would become obsolete when the sbt related flag would be removed (see under P0391).

No need for action, as JVET-P0983 was adopted.

[JVET-P0983](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8798) Test results on removing sps\_sbt\_max\_size\_64\_flag [Y. Zhao (Huawei)] [late] [miss]

The sps\_sbt\_max\_size\_64\_flag was designed to provide functionality similar to log2\_transform\_skip\_max\_size\_minus2 for configuring encoder complexity. This contribution reports coding results of two tests of removing sps\_sbt\_max\_size\_64\_flag with MaxSbtSize always being set equal to 64 in CTC. In test 1, an encoder only method is used to disallow SBT for CUs with one side greater than 32 for class C, D. and E, which tests the coding loss from encoder only method that achieves the functionality of sps\_sbt\_max\_size\_64\_flag = 0. In test 2, the encoder only method is not used, which shows the increase of encoding time as well as the coding gain if always trying SBT for CUs with one side of 64 pixels. Test 2 is also the cross-check of JVET-P0391 table 4 (the code was kindly provided by the proponent of JVET-P0391), and the simulation results match with that in JVET-P0391.

Test 1 results in 0.01% and -0.02% PSNR-Y-BD-rates in RA configuration for class C and D, respectively, and 0.01%, 0.02% and 0.13% PSNR-Y-BD-rates in LDB configuration for class C, D and E, respectively. The maximum loss is 0.29% for KristenAndSara sequence in LDB.

Test 2 results in -0.04% and -0.08% PSNR-Y-BD-rates in RA configuration for class C and D, respectively, and -0.03%, -0.01%, -0.11% PSNR-Y-BD-rates in LDB configuration for class C, D and E, respectively. The encoding time increase is around 2% and 3% for RA and LDB.

Both tests remove the sps\_sbt\_max\_size\_64\_flag.

Test 1 is encoder only method, small loss in LB, but only for few sequences in class E

Test 2 sets the max size to 64, which does not have a loss, but increases the encoder run time for sequences with sizes smaller than HD.

There is no reason having a specific flag which helps an encoder for only few sequences. As test 2 would increase the encoder run time, and test 1 only affects 3 sequences, the test 1 method is preferable

Decision: Adopt JVET-P0983 (removal of sps\_sbt\_max\_size\_64\_flag)

Decision (CTC): Use test1 method, encoder enforces not using sbt for sequences below HD resolution.

[JVET-P0991](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8806) Crosscheck of JVET-P0983 (Test results on removing sps\_sbt\_max\_size\_64\_flag) [M. Sarwer (Alibaba)]

[JVET-P0702](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8502) Non-CE6 / Non-CE3: Combined Test of JVET-P0352 and JVET-P0354 [K. Naser, T. Poirier, F. Le Léannec, F. Galpin (InterDigital)] [late]

This contribution provides the results of combining JVET-P0352 and JVET-P0352. When the maximum transform size is set to 32 (sps\_max\_luma\_transform\_size\_64\_flag is zero), JVET-P0352 proposes to allow MIP for CU’s up to 64x64 by TU tiling and then performing MIP. Similarly, JVET-P0352 proposes allowing LFNST for CU’s up to 64x64 by TU tiling and performing LFNST on each of the tile. The combination of the two tools is reported to provide 0.06% luma gain in AI condition when sps\_max\_luma\_transform\_size\_64\_flag is zero in both test and anchor. It is also reported that the coding gain in luma of class A1 is 0.20% and 0.42% in AI and RA conditions.

The reported gain is under non-CTC condition, restricting max transform size to 32

Was discussed in context of CE6, where it was identified that JVET-P0352 may have some interesting aspects that would better be discussed in context of other MIP in CE3. The point is that unlike normal intra prediction, in case of switching max transform size to 32, MIP would be disallowed for a 64x64 CU, whereas other intra modes would be applied on 32x32 transform blocks. It is suggested in P0352 that MIP should also be applied per 32x32 transform block in such case.

[JVET-P0747](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8550) Crosscheck of JVET-P0702 (Non-CE6 / Non-CE3: Combined Test of JVET-P0352 and JVET-P0354) [T. Biatek (Qualcomm)]

[JVET-P0814](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8629) Non-CE6: On LFNST kernels [M. Koo, M. Salehifar, J. Lim, S. Kim (LGE)] [late]

In the 14th JVET meeting, Low Frequency Non-Separable Transform (LFNST) was adopted. LFNST provides coding performance by considering the predictable distribution of primary transform coefficients after intra prediction (i.e., directional prediction). After the adoption of LFNST, several coding tools and new restrictions on LFNST have been added. In this contribution, it is investigated that how much coding performance can be obtained from newly trained LFNST kernel. It was reportedly observed that BD-rate reductions from the new kernel are around 0.07% and 0.04% for AI and RA, respectively. Also 3 sets version of the transforms (instead of the current 4 sets) reportedly provides 0.03% and 0.03% BD-rate reduction for AI and RA respectively, where the mapping to the 3 sets is the same as that of CE6-2.1.

As a result, newly trained kernel does not provide significant coding performance improvement, but it gives a small improvement in coding performance for current CTC condition.

For information. The training was performed with non-CTC sequences.

The recommendation of the contribution is to freeze the matrices as they are currently, as they seem to be sufficiently stable.

The proponents are asked to provide a list of the sequences used for training to the reflector.

[JVET-P0965](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8780) Crosscheck of JVET-P0814 (Non-CE6: On LFNST kernels) [G. Ko, D. Kim, J. Jung, J. Son, J. Kwak (WILUS)]

Only cross-check of the bitstreams

[JVET-P0878](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8693) CE6-related: Optimized LFNST matrices for VTM-6.0 [H. E. Egilmez, A. Said, V. Seregin, M. Karczewicz (Qualcomm)] [late]

This document proposes a complete set of LFNST matrices (kernels) optimized on top of VTM-6.0. The experimental results show that the proposed set of matrices provide -0.08% AI and -0.04% RA BD-rates over VTM-6.0.

The matrices were trained on CTC sequences. Compared to using non-CTC sequences as in JVET-P0814 this gives almost identical gain (+0.01% in AI).

It is reported that by visual inspection the two sets of matrices (of 814 and 878) look structurally very similar. P0259 also included the two sets in their investigation.

The results of both contributions indicate that the additional gain by re-training matrices with the current statistics of the primary transform is low (regardless if they are trained with CTC or non-CTC conditions), such that it can be concluded that the current matrices are stable enough and shall be frozen in the interest of a stability of the standard development.

No action.

[JVET-P0988](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8803) Cross-check of JVET-P0878 (CE6-related: Optimized LFNST matrices for VTM-6.0) [S. De-Luxán-Hernández (HHI)] [miss\_end\_meeting]

[JVET-P0210](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7999) Non-CE8: Transform skip for chroma block in the single tree [J. Park, B. Jeon (SKKU)]

This contribution proposes to allow the transform skip for a chroma block coded as the DM mode in a single tree according to the transform skip signal of its corresponding luma block. Two test are conducted: one (test 1) is to use the transform skip signal of the corresponding luma block for a chroma block in the DM mode. The other test (test 2) is to use the transform skip signal of the corresponding luma block only for a chroma block of size 4x4 in the DM mode. Simulation results show for the test 1 (second number is for the class F), an average of Y(0.00%, 0.03%), U(-0.01%, -0.01%) and V(0.02%, -0.04%) BDBR for AI; an average of Y(0.00%, 0.01%), U(-0.01%, -0.11%) and V(0.03%, -0.15%) BDBR for RA; and an average of Y(-0.03%, -0.04%), U(0.05%,-0.33%), and V(-0.10%, -0.67%) BDBR for LD. For the test 2, an average of Y(0.00%, 0.00%), U(-0.01%, -0.05%) and V(0.00%, -0.07%) BDBR for AI; an average of Y (-0.01%, -0.04%), U (0.05%, -0.08%) and V (0.03%, -0.15%) BDBR for RA; and an average of Y (-0.03%, -0.16%), U(-0.21%, -0.23%), and V(-0.22%, 0.13%) BDBR for LD.

It is generally agreed that TS for chroma is desirable in the context of the overall design also for the 4:2:0 case. It is expected to be beneficial in particular for screen content and in the low QP range, and also needed for lossless coding. However, the specific concept of the current proposal may not be generic enough: TS for chroma should also be applied for dual tree; allowing TS only in DM mode is too restrictive. In HEVC, separate flags are used for luma and each of the two chroma components at the block level. Investigate in CE, also include JVET-P0058.

[JVET-P0681](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8480) Crosscheck of JVET-P0210: Transform skip for chroma block in the single tree [X. Zhao (Tencent)]

[JVET-P1021](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8836) Non-CE6: Review of SPS control of Transform Selection Proposal [K. Naser, F. Le Léannec (InterDigital)] [late]

This contribution examines the different configurations of high-level syntax flags related to MTS and transform selection of ISP and SBT. Specifically, it provides a visualization of all possible configuration obtained with the contributions of JVET-P0569, JVET-P0501, JVET-P0495 and JVET-P0640 in comparison to the current VTM design.

Discussed Thursday 9 Oct in track A

The analysis shows that the current syntax would not allow the case where intra blocks including ISP use only DCT2, but inter uses MTS. It is asked what would be the benefit of this case. This is not too obvious.

JVET-P1031 would allow 9 different configurations (see powerpoint deck attached to that contribution) instead of currently 5. The motivation of this is claimed to be a cleanup decoupling inter and intra decision, but it would introduce 4 additional configurations that may not necessarily be needed.

It is concluded that the current design is sufficient. No action.

[JVET-P1026](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8841) Non-CE6: Combination of JVET-P0196 and JVET-P0392 on applying LFNST for ISP Blocks and simplifying the transform signalling [S. De-Luxán-Hernández, V. George, G. Venugopal, J. Brandenburg, B. Bross, H. Schwarz, D. Marpe, T. Wiegand (HHI), M. Koo, M. Salehifar, J. Lim, S. Kim (LGE), J. Lainema (Nokia)] [late]

This document combines proposals JVET-P0196 and JVET-P0392. The following results are reported: 0.19% gain, 101% EncT and 100% DecT for AI and 0.18% gain, 101%, 100% DecT in the RA case.

This proposal combines two aspects present in JVET-P0196 and JVET-P0392:

1) MTS signalling is moved from the transform unit syntax to after LFNST signalling.

2) The restriction that disallows the usage of LFNST if the CU is using ISP is removed.

In the proposed syntax, both LFNST and MTS are signalled in the same place (at the end of the CU) and both are signalled conditionally to the last significant position syntax element. This aspect is compatible with the removal of the ISP-LFNST restriction, so that now the LFNST can be applied to all intra-predicted blocks with the appropriate size.

More details of these aspects can be found in JVET-P0196 and JVET-P0392.

Already in VTM6, the LFNST flag depends on last position. In the proposal, this now also applies to MST flag (same rule is kept as currently for LFNST).

Further, LFNST is also applied to ISP.

Cross check confirms results, text/software is also confirmed

Straightforward change, results show that the gain of the two proposals is additive.

No CE.

Decision: Adopt JVET-P1026.

[JVET-P1030](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8845) Cross check of JVET-P1026: "Non-CE6: Combination of JVET-P0196 and JVET-P0392 on applying LFNST for ISP Blocks and simplifying the transform signalling" [F. Le Léannec (InterDigital)]

[JVET-P1031](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8846) Proposed text for MTS related HLS (harmonization of JVET-P0495, JVET-P0501 and JVET-P0569) [X. S. Liu (Tencent), H. E. Egilmez, V. Seregin, M. Karczewicz (Qualcomm), Y. Wang, H. Liu, L. Zhang, K. Zhang, Z. Deng, Y. Wang (Bytedance)] [late]

This contribution proposes the spec text for MTS related HLS based on a harmonized solution of the methods proposed in JVET-P0495, JVET-P0501 and JVET-P0569.

JVET-P1021 is also related – see further notes there

## CE7 related – Quantization and coefficient coding (24)

Contributions in this category were discussed Saturday 5 Oct. 1145–1315 and 1445-1845 in Track A (chaired by JRO).

[JVET-P0042](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7831) Non-CE7: A cleanup for inter\_pred\_idc coding [B. Heng, M. Zhou (Broadcom)]

It is asserted that the current design of inter\_pred\_idc coding is inconsistent, because the same context model is shared by the coding of the bi\_pred\_flag for 8x8 CUs and the list0/list1 flag of uni-pred CUs of all sizes, two basically unrelated elements. It is proposed to add one context model so that the different context models can be assigned to coding of those two elements. The experimental results revealed that the proposed change led to an average BD-rate difference of -0.01% in RA and -0.02% in LD\_B, respectively, when compared to the VTM6.0 anchor.

Though this rather relates CE4 (MV coding), it was presented in CE7.

Decision (cleanup): Adopt JVET-P0042

JVET-P0541 touches a similar issue

[JVET-P0713](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8514) Crosscheck of JVET-P0042 (Non-CE7: A cleanup for inter\_pred\_idc coding) [K. Panusopone (Nokia)]

(move 541 and cross-check here)

In VVC, inter\_pred\_idc syntax which specifies inter prediction mode uses five context models. Especially, the 5th context model is being shared by the 4x16, 8x8, or 16x4 bi-predicted CUs and uni-predicted CUs. This contribution proposes two alternative methods to prevent from the 5th context model being shared between bi-prediction and uni-prediction cases. From experiment results, luma BD-rate changes of method 1 is reported as -0.01% and -0.02% for RA and LDB. luma BD-rate changes of method 2 is reported as -0.02% and -0.03% for RA and LDB.

The solution of JVET-P0042 is simpler and more straightforward to understand for implementers.

[JVET-P0050](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7839) AHG16/Non-CE7: A study of bin to bit ratio for VTM6.0 [M. Zhou (Broadcom)]

This contribution reports the bin to bit ratio of the VTM6.0 for both the CTC and low QP setting (QP =2, 7, 12, 17). The summary results are as follows:

1. On average for CTC AI/RA/LD\_B configurations,
   1. the weighted bin to bit ratio in the VTM6.0 is 19.89%/21.70% /17.14% higher than the HM16.19, up from 19.71%/20.88% /16.99% in the VTM5.0, respectively.
   2. the unweighted bin to bit ratio in the VTM6.0 is 12.91%/14.36%/11.57% higher than the HM16.19, down from 14.21%/15.25%/12.88% in the VTM5.0, respectively.
2. On average for low-QP AI/RA/LD\_B configurations,
   1. the weighted bin to bit ratio in the VTM6.0 is 17.71%/15.15%/17.73% higher than the HM16.19, down from 20.24%/19.00%/19.67% in the VTM5.0, respectively.
   2. the unweighted bin to bit ratio in the VTM5.0 is 9.85%/6.87%/8.98% higher than the HM16.19, down from 11.40%/8.39%/10.28% in the VTM5.0, respectively.

As far as low-QP AI configuration is concerned, the weighted and un-weighted bin to bit ratio of the VTM6.0 is roughly 18% and 10% higher than that of VTM16.19, respectively.

In the weighted bin to bit ratio, a bypass bin is counted at 0.25 context coded bins; in the unweight bin to bit ratio, a bypass bin and a context coded bin carry an equal weight (1:1). All the percentage numbers are measured against the HM16.19.

The contribution indicates that the situation in terms of bin to bit ratio has decreased in VTM6.

[JVET-P0169](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7958) CE7-related: Further context reduction for sig\_coeff\_flag [S.-T. Hsiang, T.-D. Chuang, Y.-W. Huang, S.-M. Lei (MediaTek)]

This contribution proposes two modified methods for entropy coding the syntax element sig\_coeff\_flag. In the proposed methods, the context reduction scheme in CE7-3.1 is applied to more subsets for further reducing the number of context variables. The proposed Method 1 reportedly provides 0.03%, 0.01%, and -0.02% luma BD-rates for AI, RA, and LB, respectively, versus the VTM6.0 anchor under the common test conditions (CTCs) while achieving reduction of context variables by 20. The proposed Method 2 reportedly provides -0.01%, 0.00%, and 0.00% luma BD-rates for AI, RA, and LB, respectively, versus the VTM6.0 anchor under the CTCs while achieving reduction of context variables by 24.

The equation (and additional computation) is simplified compared to CE7-3.1.

Compared to the current design, still an additional operation is necessary to identify the region in which the coefficient is.

Number of context models is not a critical issue – no need for action.

[JVET-P0942](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8757) Crosscheck of JVET-P0169: CE7-related: Further context reduction for sig\_coeff\_flag [C. Auyeung, X. Li (Tencent)]

[JVET-P0170](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7959) CE7-related: Simplification of coding transform coefficient levels [S.-T. Hsiang, T.-D. Chuang, Y.-W. Huang, S.-M. Lei (MediaTek)]

This contribution proposes a simplied method for deriving the variable ZeroPos[ n ] associated with the reconstruction of the coefficient level value from the decoded syntax element dec\_abs\_level. The proposed method reportedly provides 0.01%, 0.00%, and 0.00% luma BD-rates for the AI, RA, and LB settings, respectively, versus the VTM-6.0 anchor under the common test condition (CTC) QPs, and provides 0.00%, -0.04%, and -0.04% luma BD-rates for the AI, RA, and LB settings, respectively, versus the VTM6.0 anchor under the low QPs.

Several experts expressed support for this simplification. A simple computation replaces a lookup table which also simplifies the spec text.

Decision: Adopt JVET-P0170

Alignment of text and SW confirmed by crosschecker.

[JVET-P0966](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8781) Crosscheck of JVET-P0170: CE7-related: on Simplification of coding transform coefficient level [M. Sosulnikov, M. Sychev (Huawei)]

[JVET-P0270](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8059) Non-CE7: Modified signalling method of cu\_cbf and tu\_cbf\_luma [D. -J. Won, J. -M. Ha, J. -H. Moon (Sejong university)]

This contribution proposes a modified signaling method for cu\_cbf and tu\_cbf\_luma syntax when the current tree type is equal to dual tree and the current coding unit is coded by MODE\_IBC. In MODE\_IBC of the current VVC draft 6, the cbf information for luma is signaled by cu\_cbf in the dual tree. while in the other coding modes, the cbf information for luma is signaled by tu\_cbf\_luma in Transform unit syntax. It is inconsistent in terms of the semantics of encoding the syntax. This contribution presents a signaling method in which cu\_cbf is signaled only when the current tree type is single tree and the cbf information for luma of the current block coded by MODE\_IBC in dual tree is informed by tu\_cbf\_luma. And an additional context for tu\_cbf\_luma is added to minimize a coding loss.

In Test 1, only syntax changes on cu\_cbf and tu\_cbf\_luma are applied. In Test 2, additional context is added for tu\_cbf\_luma based on Test 1. Under the AI CTC configurations with IBC being on, the average (Y, U, V) BD rate performances of the proposed are reported with negligible encoding and decoding time change as follows:

Test 1 - VTM6.0-AI: {(Y, U, V)-BD-rate = (0.XX %, 0.XX %,0.XX%), EncT = YYY %, DecT = YYY %}

Test 2 - VTM6.0-AI: {(Y, U, V)-BD-rate = (0.XX %, 0.XX %,0.XX %), EncT = YYY %, DecT = YYY%}

Not obvious that there is a problem. The purpose of cu\_cbf is sufficiently understandable in the spec.

[JVET-P0762](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8577) Cross-check of JVET-P0270 (Non-CE7: Modified signaling method of cu\_cbf and tu\_cbf\_luma) [S.-C. Lim, H. Lee, J. Lee, J. Kang (ETRI)]

[JVET-P0272](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8061) On Scaling of Transform Skip [T. Tsukuba, M. Ikeda, Y. Yagasaki, T. Suzuki (Sony)]

VVC has two scaling processes in inverse transform skip as “tsShift” and “bdShift”, which are jointly conducted as “iTransformShift (= bdShift – tsShift = maxLog2DynamicRange – bitDepth – (log2(nTbW) + log2(nTbH))/2)” in SW. However, considering concept of transform skip, there should be no scaling process in transform skip. This contribution proposes to remove scaling process in transform skip by combining scaling (tsShift, bdShift in 8.7.2) for transform skip into scaling (bdShift in 8.7.3) in inverse quantization process.

It is reported that:

For ClassA1/A2/B/C/D/E sequences, average BD-rate differences are 0.00%, 0.00% and 0.00% for AI, RA and LB, respectively.

For ClassF sequences, average BD-rate differences are 0.00%, 0.00% and 0.00% for AI, RA and LB, respectively.

For SCC sequences, average BD-rate differences are 0.00%, 0.00% and -0.04% for AI, RA and LB, respectively.

No separate presentation – see notes JVET-P0538.

[JVET-P0809](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8624) Crosscheck of JVET-P0272 (On Scaling for Transform Skip) [J. Xu (Bytedance)]

[JVET-P0298](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8087) CE7-related: Unification of CCB check method and bypass coding between two residual coding modes [Y. Kato, K. Abe, T. Toma (Panasonic)]

In this contribution, it is proposed to simplify the CCB (Context Coded bins) check method and unify the syntax design after CCB count exceeds the maximum number between transform residual and transform skip (TS) residual. Two items are proposed. In Item1, the CCB check method is changed from per coefficient flag to per coefficient of each pass in VTM6.0. This CCB check method is same as that of CE7-1.3b [2]. In Item2, level mapping is disabled after CCB count on top of CE7-1.3b-alternative method [2]. This Item2 is also same concept of JVET-O0406 [3]. As a modified Item2, bypass sign flag is excluded from the pass of bypass-coded coefficients on Item2. In this item, syntaxes of transform residual and TS residual after CCB count exceeds the maximum number are exactly the same.

Simulation results reportedly are shown as follows:

Item1:

ClassF: 0.02% AI, 0.02% RA, -0.01% LB ClassTGM: 0.04% AI, 0.00% RA, -0.01%LB

Item1 (Low QP):

ClassF: 0.08%AI, -0.01%RA, 0.03%LB ClassTGM: 0.10%AI, 0.06%RA, 0.00%LB

Item2

ClassF: 0.01% AI, 0.02% RA, 0.00% LB ClassTGM: 0.05% AI, 0.04% RA, -0.06%LB

Item2 (Low QP):

ClassF: -1.21%AI, -1.55%RA, -0.44%LB ClassTGM: -1.36%AI, -2.01%RA, -0.91%LB

The “level mapping” performs prediction of the abs value. The results show this is not necessary in the remaining coefficient coding after the ctx bin budget is exceeded..

After inspection of the draft text, the additional change on top of CE7-1.3b\* is straightforward and simple. Decision: Adopt JVET-P0298 second aspect.

[JVET-P0705](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8506) Crosscheck of JVET-P0298 (CE7-related: Unification of CCB check method and bypass coding between two residual coding modes) [H. Yang (InterDigital)]

[JVET-P0319](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8108) CE7-related: Re-position GT3 flag into the first coding pass in TS residual coding [Y. Chen, F. Le Léannec, T. Poirier, F. Galpin (InterDigital)]

In order to unify the residual coding structure between transform residual and transform skip residual coding, this contribution proposes re-positioning *abs\_level\_gtx\_flag[1]* (gt3\_flag) into the first coding pass for residual coding of the transform skip (TS) residual block. The proposed method reportedly provides ClassF: 0.03% AI, 0.01% RA, -0.05% LDB luma BD-rates, and ClassTGM: 0.06% AI, 0.04% RA, -0.15% LDB luma BD-rates, respectively, versus the VTM6.0.

In principle, this could also be combined with the method 7-1.3b\*. However, the benefit is not obvious. No need for action.

[JVET-P0631](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8428) Crosscheck of JVET-P0319: Re-position GT3 flag into the first coding pass in TS residual coding [Y.-H. Chao (Qualcomm)]

[JVET-P0360](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8149) On chroma CBFs and transform units [A. K. Ramasubramonian, G. Van der Auwera, V. Seregin, M. Karczewicz (Qualcomm)]

Several modifications to the transform unit syntax structure are proposed in this document. These changes are associated with the signalling of chroma CBF flags and the definition of a transform unit in VVC. It is asserted that most of these changes are proposed to clarify the specification text. In particular, three aspects are proposed:

1. Definition of transform unit: it is proposed to clarify the definition of a transform unit under the dual tree scenario where the splitting architecture of both the luma and chroma may be independent.
2. An asserted bug fix for parsing of chroma residual syntax elements in the transform unit syntax structure.
3. Proposal to de-couple delta QP signalling from chroma CBF flags.

Decision (ed./cleanup): Adopt JVET-P0360 items 1. and 2. It is furthermore noted that the condition for dual tree luma is correct in the spec., however it may be difficult to read since it is only specified in semantics that cbf for chroma is inferred as zero in the dual tree case. This could be an item for editorial improvement left to discretion of editors. -> it is noted that JVET-P0436 also resolves this issue.

The proponents originally suggest to enable signalling of delta QP only conditioned on luma cbf (for single tree and for dual tree luma). This is not appropriate for the single tree case, as it would prohibit flexible control of chroma quantization at block level (chroma qp offset is not flexible enough).

Furthermore, there is no option for signalling the delta QP for chroma in dual tree case separately, which was done by intention, as it is inferred from collocated luma, with some additional flexibility by chroma QP offset.

No action on item 3.

[JVET-P0370](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8159) Non-CE7: Signaling of coded\_sub\_block\_flag [M. G. Sarwer, R. L. Liao, J. Luo, Y. Ye (Alibaba)]

In VVC 6, coded\_sub\_block\_flag is always context coded even after the number of context coded bins reached to the maximum limit. Since coded\_sub\_block\_flag is always context coded, it is possible that even after reaching the limit of number of the context coded bins in a TU, CABAC module still has to switch between by-pass and context coding within the TU. This contribution proposes two methods to avoid context/by-pass switching after reaching the maximum number of context coded bins. Method 1 applies bypass coding to this flag when maximum number of context coded bins is reached in a TU, and method 2 re-positions the coded\_sub\_block\_flag of the CGs towards the beginning of the TU. Following results are reported.

* Test 1.1: bypass coding of coded\_sub\_block\_flag after reaching context coded bin limit. The maximum number of context coded bins are same as VVC 6.
  + 0.00% (AI), 0.00% (RA), 0.02% (LB) luma BD-rate
* Test 1.2: bypass coding of coded\_sub\_block\_flag after reaching context coded bin limit. The maximum number of context coded bins are adjusted (VVC6 context coded bins + number of sub-blocks)
  + 0.00% (AI), -0.01% (RA), -0.02% (LB) luma BD-rate
* Test 2: Reposition the coded\_sub\_block\_flag. The maximum number of context coded bins are same as VVC 6.
  + 0.00% (AI), 0.00% (RA), 0.00% (LB) luma BD-rate

No need for action – unlike transform coefficients, the coded SB flag has a hard limit which is already in cluded in considerations about hypothetical maximum number of CC bins per pixel.

[JVET-P0853](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8668) Cross-check of JVET-P0370 (Non-CE7: Signaling of coded\_sub\_block\_flag) [F. Le Leannec (InterDigital)]

[JVET-P0373](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8162) CE7-related: Decouple level mapping from transform skip residual coding [M. G. Sarwer, R. L. Liao, J. Luo, Y. Ye (Alibaba)]

The newly adopted level mapping process in transform skip (TS) residual coding requires inverse mapping to be performed during parsing, because the Rice parameter derivation depends on the inverse mapped level value. It is asserted that this could affect the CABAC throughput. In order to improve CABAC throughput, this contribution proposes to derive the Rice parameter from the mapped value so that the inverse mapping process can be untied from the parsing process. The proposed method also unifies the processing flow of the transform-skip mode and BDPCM mode. It is reported that the BD-rate impact of the proposed method is 0.00% (AI), 0.05% (RA), 0.01% (LB) for the SCC sequences under CTC test conditions, which is negligible.

The loss under low QP for class TGM is 0.12/0.19/0.19 for AI in AI/RA/LB. As the level mapping when originally proposed provided 1.5% gain for this specific content (and approximately no gain for other content), such loss should be acceptable.

From the viewpoint of hardware implementation, the method would be beneficial for CABAC throughput, but also would require additional buffering of values before the mapping. Proponents and hardware experts had been asked to analyse the necessary amount of buffer. No further information was brought – no action.

Further, upon adoption of JVET-P0562 this would no longer be required.

[JVET-P0756](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8560) Crosscheck of JVET-P0373 (CE7-related: Decouple level mapping from transform skip residual coding) [T. Tsukuba (Sony)]

[JVET-P0397](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8186) CE7-related: Simplified two-pass transform-skip residual coding [M. G. Sarwer, R. L. Liao, J. Luo, Y. Ye (Alibaba)]

This contribution proposes a two-pass transform skip (TS) residual coding method. The proposed method reduces the worst case number of checking of whether to perform bypass or context coding from 8 per coefficient position to 1 per coefficient position. Similar to VVC6 transform residual coding, after reaching to the maximum limit of the context coded bin, the proposed method switches to the Rice-Golomb coding. Following results are reported.

 CTC QP:

o Overall: 0.00% (AI), 0.01% (RA), -0.05% (LB) luma BD-rate

o Class SCC: 0.25% (AI), 0.17% (RA), -0.03% (LB) luma BD-rate

 Low QP:

o Class SCC: -0.69% (AI), -1.46% (RA), -0.46% (LB) luma BD-rate

No need for presentation after CE7-1.3b\* adoption.

[JVET-P0692](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8491) Crosscheck of JVET-P0397 (CE7-related: Simplified two-pass transform-skip residual coding) [S.-T. Hsiang (MediaTek)]

[JVET-P0402](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8191) CE7-related: Unification of CCB count method between transform residual and transform skip residual coding [Y. Chen, F. Le Léannec, T. Poirier, K. Naser (InterDigital)]

In order to unify the context-coded bins (CCB) count method between transform residual and transform skip (TS) residual coding, this contribution proposes: 1) align the number of CCB per coefficient for transform residual coding and TS residual coding by assigning 1.75 bin/coefficient at TB-level, and exclude coeff\_sign\_flag from CCB count in TS residual coding; 2) on top of Test 1, assign another CCB\_SIGN (0.5 bin/coefficient at TB-level) to restrict the maximum number of context coded bins for coeff\_sign\_flag. The proposed Test 1 and Test2 reportedly provides the following luma BD-rates results, respectively, versus the VTM6.0:

• Test 1: Align CCB to 1.75 + exclude coeff\_sign\_flag from CCB count in TS residual coding

o CLF: -0.06% AI, -0.10% RA, -0.05% LDB

o TGM: -0.11% AI, -0.09% RA, -0.02% LDB

• Test 2: Test 1 + CCB\_SIGN to 0.5 for coeff\_sign\_flag

o CLF: -0.05% AI, -0.06% RA, 0.05% LDB

o TGM: -0.09% AI, -0.07% RA, -0.09% LDB

No need for consideration after CE7-1.3b\* adoption.

[JVET-P0632](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8429) Crosscheck of JVET-P0402: Unification of CCB count method between transform residual and transform skip residual coding [Y.-H. Chao (Qualcomm)]

[JVET-P0422](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8211) Non-CE7: Unified neighbouring block selection in context and MV/mode derivation [W. Zhu, L. Zhang, J. Xu (Bytedance)]

The MV predictor and most probable modes list construction processes access different above and left neighbouring blocks from those used in the context derivation process. This document proposes to unify the positions of neighbouring blocks for different cases, to reduce the number of access of neighbouring information and number of cases for the conformance test. Simulation results reported show that the BD-rate changes are 0.00%, -0.02% and -0.06% for AI, RA and LDB, respectively.

Upload presentation deck.

There is no obvious benefit for software and hardware implementation, as e.g. the derivation aof MV, MPM etc. is done by separate modules. Also in the spec, there is no direct relation between neighbor definitions for ctx coding and parameter derivation.

The small compression benefit does not justify the change.

[JVET-P0648](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8446) Crosscheck of JVET-P0422 (Non-CE7: Unified neighbouring block selection in context and MV/mode derivation) [H. Dou, L. Xu (Intel)]

[JVET-P0435](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8224) CE7-related: Modifications to transform skip significant flag coding [C. Auyeung, X. Li, X. Zhao, S. Liu (Tencent)]

In VVC Draft 6, six contexts are used to encode coefficient sign flag in transform skip mode. This contribution proposes to use 10 contexts to improve coding efficiency.

Compared to VTM-6.0 at standard QPs with QP in [22, 27, 32, 37], experimental results show ‑0.02% AI, ‑0.01% RA, ‑0.02% LB luma BD-rate for Class F, and ‑0.03% AI, ‑0.01% RA, ‑0.04% LB luma BD-rate for Class TGM.

Compared to VTM-6.0 at low QPs with QP in [2, 7, 12, 17], experimental results show ‑0.05% AI, ‑0.11% RA, ‑0.03% LB luma BD-rate for Class F, and ‑0.06% AI, ‑0.03% RA, ‑0.12% LB luma BD-rate for Class TGM.

Compared to VTM-6.0 at standard QPs with QP in [22, 27, 32, 37] with the proposed at 1.75 bins/coefficient, experimental results show 0.10% AI, 0.10% RA, 0.11% LB luma BD-rate for Class F, and 0.24% AI, 0.19% RA, 0.08% LB luma BD-rate for Class TGM. In contrast to VTM-6.0 with 1.75 bins/coefficient, experimental results show 0.11% AI, 0.07% RA, 0.05% LB luma BD-rate for Class F, and 0.26% AI, 0.20% RA, ‑0.02% LB luma BD-rate for Class TGM.

Compared to VTM-6.0 at low QPs with QP in [2, 7, 12, 17] with the proposed at 1.75 bins/coefficient, experimental results show 0.28% AI, 0.27% RA, 0.09% LB luma BD-rate for Class F, and 0.47% AI, 0.45% RA, 0.46% LB luma BD-rate for Class TGM. In contrast to VTM-6.0 with 1.75 bins/coefficient, experimental results show 0.30% AI, 0.38% RA, 0.03% LB luma BD-rate for Class F, and 0.46% AI, 0.49% RA, 0.41% LB luma BD-rate for Class TGM.

[JVET-P0437](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8226) CE7-related: Modifications to transform skip coefficient sign flag coding [C. Auyeung, X. Li, X. Zhao, S. Liu (Tencent)]

In VVC Draft 6, three contexts are used to encode significant coefficient flag in transform skip mode. This contribution proposes to use four contexts to improve coding efficiency.

Compared to VTM-6.0 at standard QPs with QP in [22, 27, 32, 37], experimental results show 0.17% AI, 0.19% RA, 0.25% LB luma BD-rate for Class F, and 0.34% AI, 0.28% RA, 0.29% LB luma BD-rate for Class TGM.

Compared to VTM-6.0 at low QPs with QP in [2, 7, 12, 17], experimental results show 0.08% AI, 0.20% RA, 0.17% LB luma BD-rate for Class F, and 0.21% AI, 0.24% RA, 0.24% LB luma BD-rate for Class TGM.

Compared to VTM-6.0 at standard QPs with QP in [22, 27, 32, 37] with the proposed at 1.75 bins/coefficient, experimental results show 0.07% AI, 0.03% RA, 0.22% LB luma BD-rate for Class F, and 0.06% AI, 0.10% RA, 0.25% LB luma BD-rate for Class TGM.

Compared to VTM-6.0 at low QPs with QP in [2, 7, 12, 17] with the proposed at 1.75 bins/coefficient, experimental results show 0.24% AI, 0.27% RA, 0.19% LB luma BD-rate for Class F, and 0.24% AI, 0.31% RA, 0.09% LB luma BD-rate for Class TGM.

[JVET-P0447](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8236) CE7-related: Rice parameter range extension in residual coding with transform skip [C. Auyeung, X. Li, X. Zhao, S. Liu (Tencent)]

When VTM-6.0 is encoded at low QPs with QP in [22, 27, 32, 37], experimental results show 0.30% AI, 0.38% RA, 0.03% LB luma BD-rate for Class F, and 0.46% AI, 0.49% RA, 0.41% LB luma BD-rate for Class TGM. This contribution reports the results of extending the range of Rice parameter for residual coding in transform skip mode to improve the coding efficiency at low QP values and at 1.75 bins per coefficient.

Compared to VTM-6.0 at standard QPs with QP in [22, 27, 32, 37], experimental results show 0.00% AI, ‑0.01% RA, 0.01% LB luma BD-rate for Class F, and 0.00% AI, ‑0.01% RA, ‑0.02% LB luma BD-rate for Class TGM.

Compared to VTM-6.0 at low QPs with QP in [2, 7, 12, 17], experimental results show ‑0.14% AI, ‑0.12% RA, ‑0.15% LB luma BD-rate for Class F, and ‑0.43% AI, ‑0.72% RA, ‑0.30% LB luma BD-rate for Class TGM. Coding gain is observed at low QPs.

Compared to VTM-6.0 at standard QPs with QP in [22, 27, 32, 37] with the proposed at 1.75 bins/coefficient, experimental results show 0.10% AI, 0.07% RA, 0.13% LB luma BD-rate for Class F, and 0.26% AI, 0.21% RA, ‑0.05% LB luma BD-rate for Class TGM. The coding loss is similar to VTM-6.0 with 1.75 bins/coefficient. In VTM-6.0 with 1.75 bins/coefficient, experimental results show 0.11% AI, 0.07% RA, 0.05% LB luma BD-rate for Class F, and 0.26% AI, 0.20% RA, ‑0.02% LB luma BD-rate for Class TGM.

Compared to VTM-6.0 at low QPs with QP in [2, 7, 12, 17] with the proposed at 1.75 bins/coefficient, experimental results show 0.17% AI, 0.16% RA, ‑0.01% LB luma BD-rate for Class F, and 0.03% AI, ‑0.11% RA, 0.19% LB luma BD-rate for Class TGM. The coding loss is reduced from VTM-6.0 with 1.75 bins/coefficient. In VTM-6.0 with 1.75 bins/coefficient, experimental results show 0.30% AI, 0.38% RA, 0.03% LB luma BD-rate for Class F, and 0.46% AI, 0.49% RA, 0.41% LB luma BD-rate for Class TGM.

[JVET-P0451](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8240) CE7-related: Combination of JVET-P0435, JVET-P0437, and JVET-P0447 for residual coding at 1.75 bins/coefficient [C. Auyeung, X. Li, X. Zhao, S. Liu (Tencent)]

This contribution reports results of combination tests of JVET-P0435, JVET-P0437, and JVET-P0447 for residual coding at 1.75 bins/coefficient.

When VTM-6.0 with 1.75 bins/coefficient and standard QPs with QP in [22, 27, 32, 37] is compared with VTM-6.0 with 2 bins/coefficient, experimental results show 0.11% AI, 0.07% RA, 0.05% LB luma BD-rate for Class F, and 0.26% AI, 0.20% RA, ‑0.02% LB luma BD-rate for Class TGM.

Using VTM-6.0 (i.e. with 2 bins/coefficient in transform skip mode) and standard QPs as anchor, the experimental results of combined JVET-P0435, JVET-P0437 and JVET-P0447 at 1.75 bins/coefficient and standard QPs show ‑0.11% AI, ‑0.06% RA, ‑0.24% LB luma BD-rate for Class F, and ‑0.09% AI, ‑0.14% RA, ‑0.35% LB luma BD-rate for Class TGM.

When VTM-6.0 with 1.75 bins/coefficient and low QPs with QP in [2, 7, 12, 17] is compared with VTM-6.0 with 2 bins/coefficient, experimental results show 0.30% AI, 0.38% RA, 0.03% LB luma BD-rate for Class F, and 0.46% AI, 0.49% RA, 0.41% LB luma BD-rate for Class TGM.

Using VTM-6.0 (i.e. with 2 bins/coefficient in transform skip mode) and low QPs as anchor, the experimental results of combined JVET-P0435, JVET-P0437 and JVET-P0447 at 1.75 bins/coefficient and low QPs, show 0.02% AI, 0.00% RA, ‑0.23% LB luma BD-rate for Class F, and ‑0.18% AI, ‑0.45% RA, ‑0.37% LB luma BD-rate for Class TGM.The benefit in terms of compression performance only for SC classes is too small to take an action.

[JVET-P0823](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8638) Crosscheck of JVET-P0451, JVET-P0435, JVET-P0437, and JVET-P0447: Modifications to the context modelling for residual coding [T. Nguyen (HHI)]

[JVET-P0465](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8254) Non-CE7: Rice parameter derivation for coefficient level coding [J. Choi, J. Heo, S. Yoo, J. Choi, J. Lim, S. Kim (LGE)]

In VVC, Rice parameter derivation for coefficient level coding is determined based on the sum of absolute levels of five neighboring coefficients. However, it is not always five neighboring coefficients available. Therefore, in this contribution, Rice parameter derivation method based on the number of available neighboring coefficients is investigated. It is reported from experimental results that the proposed Rice parameter derivation provides better coding performance.

For QP = 2, 7, 12, 17 (Luma BD-rates for overall, Class F, TGM)

* Overall: -0.02% (AI), 0.0% (RA), 0.0% (LD)
* Class F: -0.03% (AI), -0.13% (RA), -0.12% (LD)
* TGM: -0.14% (AI), -0.05% (RA), -0.11% (LD)

The benefit in terms of compression performance only for SC classes is too small to take an action.

[JVET-P0960](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8775) Cross-check of JVET-P0465 (Non-CE7: Rice parameter derivation for coefficient level coding) [Y. Chen (InterDigital)]

[JVET-P0488](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8277) Non-CE7: On updating a variable for context model selection [S. Yoo, J. Choi, J. Lim, S. Kim (LGE)]

In the residual coding part in VVC, a syntax element indicating absolute level in the first pass (i.e., AbsLevelPass1) is referenced when deriving the context model index of sig\_coeff\_flag, par\_flag, and gtx\_flag. This contribution points out a mismatch between spec text and software regarding AbsLevelPass1 update process, and introduces two alternative methods to fix the issue as follows:

- Method 1: Change spec text to align with software.

- Method 2: Remove updates process of AbsLevelPass1

For Method 2, the existing update of AbsLevelPass1 is suggested to be removed because the update process is not essentially required. The experiment shows that the BD-rate impact of the Method 2 is 0.00% (AI) / 0.00% (RA) / 0.01% (LDB) for CTC QPs, and 0.00% (AI) / X.XX% (RA) / 0.00% (LDB), for the low QPs, respectively.

Decision (ed./cleanup): It is agreed that the sentence (7-176) can be removed from the text. It is not needed any more after some change adopted in last meeting.

The processing applied to AbsLevelPass1 is otherwise as described as described in the syntax part of the spec – there is no need to change the software.

[JVET-P0907](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8722) Cross-check of JVET-P0488 (Non-CE7: On updating a variable for context model selection) [F. Le Léannec (InterDigital)]

[JVET-P0508](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8298) CE7-related: unification for joint chroma residue coding modes [L. Zhao, X. Li, X. Zhao, S. Liu (Tencent)]

In VVC Draft 6, there are three different joint chroma residual coding (JCCR) modes, wherein JCCR mode 2 is applied to both intra and inter coded CUs, but mode 1 and mode 3 are only applied to intra coded CU. It is reported that this is not a consistent design. In this contribution, the restrictions for JCCR mode 1 and mode 3 are removed so that these three JCCR modes can be consistently applied to both intra and inter coded CUs. To compensate the performance loss, for JCCR mode 1 and 3, the context for signaling tu\_joint\_cbcr\_residual\_flag is shared and dependent on intra/inter mode flag of current block, and context number is kept unchanged. It is reported that the proposed method achieves 0.01%, 0.00%, and -0.03% luma BD-rate changes for AI, RA, and LDB configurations, respectively.

There is no real need for the unification, because characteristics of intra and inter residuals could be different in a way that they are higher correlated where modes 1 and 3 would show good performance. The proponents claim that modes 1 and 3 might also be beneficial for HDR/WCG content, where however there is no evidence for that.

No need for action.

[JVET-P0881](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8696) Crosscheck of JVET-P0508 (CE7-related: unification for joint chroma residue coding modes) [J. Lainema (Nokia)]

[JVET-P0562](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8352) Non-CE8: Transform skip residual coding simplification [Y.-W. Chen, X. Xiu, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

In residual coding of a transform skip block, for each sample, the remaining absolute levels are adaptively binarized using the Rice parameters derived depending on the levels of the left and above residual samples. In this contribution, a fix codeword (rice parameter =K) is used to replace this per-sample adaptive codeword derivation.

The results of using fixed rice parameter=1 on TGM sequences compared to VTM6.0 are shown below:

Standard QP (22, 27, 32, 37): 0.02% AI, -0.02% RA, -0.06% LB

Low QP (2, 7, 12, 17): -0.37% AI, 0.08% RA, -0.19% LB

The results of using fixed rice parameter=2 on TGM sequences compared to VTM6.0 are shown below:

Standard QP (22, 27, 32, 37): 0.25% AI, 0.11% RA, 0.03% LB

Low QP (2, 7, 12, 17): -2.15% AI, -1.81% RA, -1.35% LB

Moreover, it is observed that larger Rice parameters are preferred under lower QPs because the codewords of larger Rice parameters better fit the distributions of the residual value under lower QPs. It is proposed to use adaptive binary codewords for the syntax element abs\_remainder according to the CU quantization parameter (QP).

The results of QP-dependent Rice parameter determination on TGM sequences compared to VTM6.0:

Standard QP (22, 27, 32, 37): 0.25% AI, 0.11% RA, 0.03% LB

Low QP (2, 7, 12, 17): -3.55% AI, -2.97% RA, -2.08% LB

It is generally agreed that a method with fixed Rice parameter for TS entropy coding is a relevant simplification and would also resolve the problem raised in JVET-P0373. From the results, the best tradeoff would be with K=1. Candidate for adoption.

Further discussed Thu. 9 Oct. in Track A. Results in JVET-P0562r4, tables 9 and 10 show that combining the fixed Rice parameter (k=1) with the CE7-1.3b\* method (limit 1.75) comes with almost no loss both for normal QP and low QP for natural sequences; for screen content, some loss is observed in normal QP range, but some gain in low QP. Results were crosschecked.

It is asked if this reasonable simplification would still be applicable in case of lossless coding. No results are available on that. However, as anyway th CE on lossless performs further investigation on improving the TS residual coding, taking CE7-1.3b\* plus the fixed Rice parameter as anchor.

Decision: Adopt JVET-P0562.

[JVET-P0642](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8439) Crosscheck of JVET-P0562 (Non-CE8: Transform skip residual coding simplification) [L. Zhao (Tencent)]

[JVET-P1003](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8818) Cross-check of combined results of JVET-P0562, CE7-1.3.b-alt and JVET-P0606 [M. G. Sarwer (Alibaba)]

[JVET-P0585](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8377) CE7-related: Alignment of number of context coded bins per coefficients for TS residual coding and transform coefficient coding [M. Coban, M. Karczewicz (Qualcomm)]

This contribution proposes to align the number of context coded bins per coefficient for transform skip residual coding and transform coefficient coding by assigning 1.75 bin/coefficient at TB-level. The simulations results show Class F:0.11% AI, 0.07% RA, 0.05% LB BD-Rate, and Class TGM: 0.26% AI, -0.20% RA, -0.02% LB BD-Rate, versus VTM-6.0 anchor under common test conditions.

No need for presentation, “1.75 problem” was resolved.

[JVET-P0587](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8379) CE7-related: Simplifying the derivation process of ctxInc for residual coding [S.-T. Hsiang, T.-D. Chuang, Y.-W. Huang, S.-M. Lei (MediaTek)]

This contribution proposes a modified derivation process of ctxInc for residual coding by re-organizing the indexing of the context variables associated the syntax elements par\_level\_flag and abs\_level\_gtx\_flag. In the proposed method, the three context variables for entropy coding the values of abs\_level\_gtx\_flag[n][0], par\_level\_flag[n], and abs\_level\_gtx\_flag[n][1] for a current coefficient at the scanning position n can be grouped into a subset and accessed jointly. The proposed method reportedly does not have any impact on BD bitrate performance.

This is interesting for implementation, but does not make the spec better readable. Does not change anything normatively. No need for action.

[JVET-P0619](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8413) Non-CE7: State-dependent Binarization for Transform Coefficient Levels [H. Schwarz, A. Henkel, D. Marpe, T. Wiegand] [late]

This contribution proposes to select the binarization of transform coefficient levels depending on the quantization state. It only affects transform coefficient coding for dependent quantization; it does not modify the transform coefficient coding for conventional quantization. It is asserted that the proposed change reduces the bin-to-bit ratio by about 5%, which has the effect that the bin-to-bit ratio for dependent quantization becomes very similar to the bin-to-bit ratio for conventional quantization. In addition to the VTM-6 binarization, a second binarization is used, in which the first bin indicates whether the absolute value is equal to 1. Two variants are presented. In variant A, the binarization is only dependent on the quantization state. In variant B, it depends on the state and on whether the sum of absolute levels inside the template is equal or unequal to zero. It is asserted that variant B achieves a slightly larger reduction of the bin-to-bit ratio. For the common test conditions, the following results are reported:

Variant A:  
 AI: -0.03%, -0.07%, -0.16% (Y,Cb,Cr); max/avg. bin-to-bit ratio of -4.84% / -4.73%  
 RA: 0.05%, -0.07%, -0.13% (Y,Cb,Cr); max/avg. bin-to-bit ratio of -5.40% / -4.78%  
 LB: 0.07%, 0.02%, 0.15% (Y,Cb,Cr); max/avg. bin-to-bit ratio of -5.09% / -5.65%

Variant B:  
 AI: -0.04%, -0.22%, -0.27% (Y,Cb,Cr); max/avg. bin-to-bit ratio of -5.28% / -5.12%  
 RA: 0.03%, -0.01%, -0.16% (Y,Cb,Cr); max/avg. bin-to-bit ratio of -5.62% / -5.03%  
 LB: 0.04%, -0.04%, -0.16% (Y,Cb,Cr); max/avg. bin-to-bit ratio of -5.84% / -6.32%

It is asserted that both proposed variants prevent the insertion of cabac\_zero\_word’s in the bitstreams generated according to the common test conditions and the low QP configuration.

From the discussion, it is agreed that with the current design of VVC in terms of the number of context coded bins and in terms of bin to bit ratio is acceptable. No need for action. It is also noted that the approach of JVET-P0619 makes the entropy coding less regular which may be undesirable.

There are other contributions on similar aspects in section 6.10.

[JVET-P0901](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8716) Crosscheck of JVET-P0619 (Non-CE7: State-dependent Binarization for Transform Coefficient Levels) [M. Coban (Qualcomm)]

## CE8 related – Screen content coding tools (36)

Contributions in this category were discussed Saturday 5 Oct. 1845–2000 and Sunday 0900-1130 in Track A (chaired by JRO).

Problem with palette mode memory footprint – Y.-H. Chao volunteered fixing that issue.

BoG (X. Xu) to review the remaining contributions related to palette mode (from JVET-P0460 onwards) was established.

[JVET-P0230](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8019) CE8-1.2-related: Compound palette mode with signalled merge index [W. Zhu, J. Xu, L. Zhang (Bytedance)]

Reviewed in Track A

This document presents a method of compound palette mode with signalled merge index. Different from the compound palette mode (CPM) in CE8-1.2, a merge index is signalled for each coding unit coded with CPM. The proposed method is implemented and evaluated with VTM6. The simulations are conducted with the CE8 test conditions. Simulation results are summarized as below:

CTC QP = {22, 27, 32, 37}:

Dual tree on:

TGM1080p: AI: -0.32%, 103%, 99%; RA: -0.41%, 104%, 99%; LDB: -0.27%, 104%, 99%

Dual tree off:

TGM1080p: AI: -1.31%, 103%, 100%; RA: -0.84%, 102%, 99%; LDB: -0.21%, 103%, 100%

Low QP = {2, 7, 12, 17}:

Dual tree on:

TGM1080p: AI: -0.72%, 102%, 99%; RA: -0.71%, 102%, 98%; LDB: -0.66%, 104%, 99%

Dual tree off:

TGM1080p: AI: -3.01%, 104%, 100%; RA: -1.95%, 102%, 100%; LDB: -1.58%, 102%, 100%

Variant of CE8-1.2 with similar coding gain. As CE8-1.2 was not taken into consideration, no need for further action.

[JVET-P0889](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8704) Cross-check of JVET-P0230 (CE8-1.2-related: Compound palette mode with signalled merge index) [Y.-C. Sun (Alibaba)]

[JVET-P0283](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8072) Non-CE8: Modified DM mode selection under IBC mode using left block [D. Jiang, J. Lin, F. Zeng, C. Fang (Dahua)] [late]

Initial version rejected: requested authors not referring to CTC as other test set is used.

No presenter available Sun 6 Oct. morning. Was asked several times, no contributor showed up.

[JVET-P0284](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8073) Non-CE8: Modified DM mode selection under IBC mode using left and above block [D. Jiang, J. Lin, F. Zeng, C. Fang (Dahua)] [late]

Initial version rejected: requested authors not referring to CTC as other test set is used.

No presenter available Sun 6 Oct. morning. Was asked several times, no contributor showed up.

[JVET-P0375](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8164) Non-CE8: Palette mode CU size restriction [H. Yang, Y. He (InterDigital)]

Reviewed in Track A

Palette mode is included in VTM-6.0 for 4:4:4 screen content coding. However, due to the coding overhead cost of a palette table, it may not be efficient for small block sizes, especially for inter slices with much less frequent use of palette mode than that in I-slices. This contribution proposes to disable palette mode for inter slice CUs with sizes less than or equal to 32 samples. In simulation, CU size limit of 16, 32, 64 samples was tested. For the best performed 32 samples of the CU size limit, 4:4:4 CTC result shows that: compared with VTM-6.1 with palette mode, for dual-tree ON, −0.13%/−0.12% (RA/LDB) Y BD-rate gain is achieved, while for dual-tree OFF, −0.13%/+0.01% (RA/LDB) Y BD-rate change is achieved, all with similar encoding and decoding times.

No obvious benefit.

[JVET-P0797](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8612) Crosscheck of JVET-P0375: Non-CE8: Palette mode CU size restriction [W. Zhu (Bytedance)]

[JVET-P0399](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8188) Non-CE8: On escape sample coding [W. Zhu, J. Xu, L. Zhang (Bytedance)]

Reviewed in Track A

This document proposes to signal escape samples using QP dependent fixed-length binarization method. Three aspects are modified: 1) limit the lowest QP for escape samples; 2) fixed-length coding is applied; 3) reconstruction by left shift only. Accordingly, the dequantization process for escape samples is also modified which only has a QP dependent shifting operation. The proposed method is implemented and evaluate with VTM-6.0 following the CE8 test conditions. Results are summarized as below.

CTC QPs = {22, 27, 32, 37}

Dual tree on:

TGM1080P: AI: -0.07%, 102%, 101%; RA: - 0.14%, 102%, 102%; LDB: -0.08%, 101%, 100%

Dual tree off:

TGM1080P: AI: -0.22%, 100%, 102%; RA: 0.30%, 100%, 101%; LDB: -0.10%, 100%, 100%.

Low QPs = {2, 7, 12, 17}

Dual tree on:

TGM1080P: AI: -2.04%, 102%, 101%; RA: -1.62%, 102%, 98%; LDB: -1.27%, 103%, 102%

Dual tree off:

TGM1080P: AI: -3.33%, 101%, 99%; RA-2.89%, 100%, 100%; LDB: -1.79%, 101%, 101%.

The simplification is not large, but there is some advantage. Additionally, provides some coding gain. Study in CE.

[JVET-P0706](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8507) Crosscheck of JVET-P0399 (Non-CE8: On escape sample coding) [H. Yang (InterDigital)]

[JVET-P0400](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8189) AhG16/Non-CE8: Removal of shared merge list [Y. Wang, L. Zhang, H. Liu, K. Zhang, J. Xu, Y. Wang (Bytedance)]

This contribution proposes to increase the MV throughput of small blocks with IBC enabled. In the proposed method, the shared merge list is removed, and the derivation of spatial merge candidates for 4×4 blocks is skipped. Therefore, the pruning operations among BV candidates are totally removed. Additionally, updating of HMVP tables for certain block sizes (no greater than 16) is skipped as well. It is asserted that the proposed method could further reduce the complexity and increase the MV throughput. Simulation results reportedly show that BD-rate changes are {0.01%, -0.01%, -0.03%} and {0.06%, 0.02%, -0.11%} in {AI, RA, LDB} configurations for class F and class TGM, respectively.

HMVP table is never updated for case of 4x4 blocks. In the hypothetical case of only 4x4 blocks, the HMVP table would never be filled. This is no problem at the decoder; an encoder typically would not choose such a case.

The proposal simplifies the specification by removing the processes related to shared merge list. It is however introducing another condition of checking for larger block size in various steps of the merge list construction. It is argued that this would enforce duplicating the entire merge list construction logic, where the argument behind that is not fully clear.

It is agreed that this is a clear simplification which does not have significant impact on performance.

Confirmed by cros-checkers

Decision: Adopt JVET-P0400

[JVET-P0662](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8460) Crosscheck of JVET-P0400 (AhG16/Non-CE8: Removal of shared merge list) [J. Chen (Alibaba)]

[JVET-P0175](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7964) AHG16/Non-CE4: A clean-up to merge list generation by removing shared merge list [J. Li, C. S. Lim (Panasonic)]

Was moved to Non-CE8 as it is not related to inter coding.

This contribution proposes to clean up merge list generation by removing shared merge list. The proposed method is to skip pruning process when current block is 4x4 IBC block. It noted that additional benefit is that hardware cost si reduced by avoiding deplicate memory and logic. Text is also simplified.

Coding impact of test a and b are as below (with VTM6.0 + IBC on as anchor):

CTC Intra: -0.62%, -0.61%, -0.64%

RA: 0.02%, -0.03%, -0.09%

LDB: 0.02%, 0.20%, 0.15%

ClassF Intra: 0.02%, -0.09%, 0.01%

RA: 0.05%, 0.04%, 0.01%

LDB: 0.11%, 0.04%, 0.60%

TGM Intra: 0.14%, 0.13%, 0.10%

RA: 0.10%, 0.06%, 0.03%

LDB: 0.01%, 0.17%, 0.12%

The analysis in the proposal shows that removing the shared merge list.

The proposal is simplifying by removing shared merge list, but P0400 is even simpler.

[JVET-P0921](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8736) Crosscheck of JVET-P0175 on AHG16/Non-CE4: A clean-up to merge list generation by removing shared merge list [S.H. Wang (PKU), Y. Wang, X. Zheng (DJI)]

[JVET-P0421](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8210) Non-CE8: Palette mode with 8-bit entries [W. Zhu, J. Xu, L. Zhang, H.-C. Chuang (Bytedance)]

Reviewed in Track A

In the current palette design, the bit depth of palette entries is equal to the internal bit depth. This document proposes to set the bit depth of palette entries to 8. With the proposed method, it is claimed that the on-chip memory cost could be saved by up to 50%. The proposed method is implemented and compared with VTM-6.0. Simulation results are summarized as below.

Dual tree on: AI: 0.05%, 100%, 99%; RA: 0.14%, 99%, 100%; LDB: 0.05%, 101%, 99%

Dual tree off: AI: 0.42%, 100%, 99%; RA: 0.20%, 99%, 99%; LDB: 0.23%, 98%, 100%.

It is observed that the loss is significantly higher in the Glass Half sequence which is the only 10 bit sequence in the set. It is asserted that reducing the palette to 8 bit is not appropriate for up to date screen materials. No action.

[JVET-P0644](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8441) Cross-check of JVET-P0421: Non-CE8: Palette mode with 8-bit entries [J. Zhao (LGE)]

[JVET-P0424](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8213) Non-CE8: Resetting predictor palette at CTU row [W. Zhu, L. Zhang, J. Xu (Bytedance)]

Reviewed in Track A

In the palette mode, a palette predictor is used for predicting the current palette. This palette predictor is reset at the beginning of each slice/tile/brick, and it is also reset at the beginning of each CTU row only when WPP is enabled. It is proposed to always reset the palette predictor at the beginning of each CTU row regardless if WPP is enabled. The proposed method is implemented and compared with VTM-6.0 following the CE8 test conditions. Results are summarized as below.

Dual tree on: AI: 0.07%, 99%, 100%; RA: 0.04%, 99%, 100%; LDB: -0.14%, 99%, 100%

Dual tree off: AI: 0.28%, 100%, 98%; RA: -0.13%, 99%, 99%; LDB: -0.38%, 99%, 101%.

Further study (CE): In particular, investigate the behaviour with smaller tiles/bricks wich have low number of CTUs per row, where the compression performance might suffer, and the reset is not necessary at each CTU row.

[JVET-P0425](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8214) CE8-related: On index adjustment in palette mode [W. Zhu, J. Xu, L. Zhang (Bytedance)]

In the palette mode, a palette index adjustment process is utilized to derive the palette index to be used. However, the parsing process of escape pixels depends on the derived palette index, which means that parsing shall wait for the index derivation process. This contribution proposes to remove such a palette index adjustment process when escape pixels are involved. Thus, parsing can be performed without waiting for the index derivation. The proposed method is implemented and evaluated with VTM6 following the CE8 common test condition. Results are summarized as follows.

Dual tree on: AI: 0.04%, 100%, 100%; RA: 0.06%, 99%, 101%; LDB: 0.10%, 99%, 100%

Dual tree off: AI: 0.12%, 99%, 99%; RA: 0.04%, 99%, 100%; LDB: 0.05%, 99%, 99%.

Several experts expressed their opinion that there is no problem with the current spec, as the dependency that is mentioned here would never occur. Further study is needed, if there is a problem, it is likely not severe in particular because the new group coding method is simpler in resolving dependencies.

[JVET-P0732](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8534) Crosscheck of JVET-P0425 on index adjustment in palette mode [X. Xiu (Kwai Inc.)]

[JVET-P0454](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8243) Non-CE8: Constraints on IBC reference block locations [X. Xu, X. Li, S. Liu (Tencent)]

In this contribution, a constraint is imposed on the reference block location for IBC, such that all samples of the reference block should be in the same 64x64 grid aligned region in the current picture.

It is reported that the proposed modification avoids an encoder to generate some of the bitstreams that contain samples from disconnected areas in the decoded part of current picture, therefore reduce the efforts for conformance testing.

Simulation results reportedly show that the BD rate changes are as follows:

For method 1:

* For class F, 0.43%/0.35%/0.41% for AI/RA/LB configurations.
* For class TGM, 1.22%/0.86%/0.70% AI/RA/LB configurations.

For method 2:

* For class F, 0.17%/0.10%/0.18% for AI/RA/LB configurations.
* For class TGM, 0.42%/0.31%/0.16% AI/RA/LB configurations.

The argument of the proposal is that the current spec. enforces decoders to implement the storage following the VPDU concept, otherwise they would need to implement additional steps for the wraparound.

It is agreed that method 2 (imposing additional checks in the decoder) should not be used.

It is suggested by several experts that the bitstream constraint would simplify decoders that would not implement following precisely the VPDU concept. It is however not clear if the proposed text covers all corner cases. There is some concern that it might destabilize the specification, where it took several meeting cycles to get to a solution that guarantees operation of IBC with limited local memory.

It is also asked if the wraparound and the VPDU concept would be needed any more.

It is also mentioned that the loss might be larger with other CTU sizes.

See further notes under JVET-P1018.

[JVET-P0733](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8535) Crosscheck of JVET-P0454 on constraints on IBC reference block locations [X. Xiu (Kwai Inc.)]

[JVET-P0455](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8244) Non-CE8: IBC slice level on/off [X. Xu, X. Li, S. Liu (Tencent)]

In this contribution, it is proposed to control the usage of IBC at slice level, in addition to the current IBC SPS flag. That means, when IBC SPS flag is true, for each slice, an encoder can choose to turn on or off the usage of IBC. The indication of whether IBC is used for a slice is through the value of a slice level variable MaxNumIbcMergeCand. When this variable is set equal to 0, IBC is turned off for the slice. On top of this change, an encoder algorithm is provided to switch IBC on/off using the same logic as disabling MMVD fractional-pel offset, which already exists in the VTM. The intend of the suggested algorithm is that IBC mode is turned off for slices where IBC may not contribute much to the BD rate reduction while IBC mode is turned on for screen content materials. Simulation results report that:

* The BD rate/runtime changes for CTC (class A to E) average are -0.02%/0.02%/0.03% and 103%/100%/100% for AI/RA/LB, separately, when compared to VTM-6.0+IBC=0 anchor;
* The BD rate/runtime changes for Class F average are 0.00%/0.00%/0.00% and 98%/99%/99% for AI/RA/LB, separately, when compared to VTM-6.0+IBC=1 anchor
* The BD rate/runtime changes for Class TGM 1080p average are 0.00%/0.00%/0.00% and 98%/99%/99% for AI/RA/LB, separately, when compared to VTM-6.0+IBC=1 anchor

The control via the MaxNumIbcMergeCand is undesirable. It would be better to have a flag at picture level, if at all. There would be not much harm for an encoder that wants to use IBC only for some pictures, just not using it for the other ones. The penalty for IBC flag if not used should be rather small (proponents mentioned 0.4% for some sequences).

Not evident that this is needed.

In terms of HLS, the MaxNumIbcMergeCand syntax element should be handled like the same element for inter merge an affine merge.

[JVET-P0913](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8728) Crosscheck of JVET-P0455 (Non-CE8: IBC slice level on/off) [H. Jang (LGE)]

[JVET-P0456](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8245) Non-CE8: IBC chroma mode with dual-tree [X. Xu, X. Li, S. Liu (Tencent)]

In this contribution, IBC chroma mode is enabled for the dual-tree case. The proposed chroma IBC mode is a block level mode where samples of the entire chroma CU share the same BV, which is derived from the collocated luma area. This is guaranteed as a bitstream conformance condition. Simulation results report that:

* The BD rate changes for Class F average are 0.00%/-0.06%/0.00% for AI/RA/LB, separately, when compared to VTM-6.0 anchor.
* The BD rate for Class TGM average are -1.21%/-0.53%/0.00% for AI/RA/LB, separately, when compared to VTM-6.0 anchor.

Not worthwhile to consider, additional complexity too large for small coding gain.

[JVET-P0838](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8653) Cross-check of JVET-P0456 (Non-CE8: IBC chroma mode with dual-tree) [M. G. Sarwer (Alibaba)]

[JVET-P0457](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8246) Non-CE8: On IBC merge list size signaling [X. Xu, X. Li, S. Liu (Tencent)]

In this contribution, a spec/software mismatch has been identified with the current spec. Currently, IBC and inter mode have independent merge size signaling at slice level. The merge\_idx signaling at block level is shared by both inter merge and IBC merge modes. However, the range of merge index is decided by the value of MaxNumMergeCand while the actual maximum values for the two modes can be different. Undefined behaviour can happen if MaxNumIbcMergeCand is greater than MaxNumMergeCand. Accordingly, three solutions have been proposed as suggested potential fixes.

* In solution 1: the merge size of IBC is limited to be no greater than the merge size of inter.
* In solution 2: the merge\_idx range is set to be the larger of the two sizes.
* In solution 3: the merge idx range is switched at block level, depending on the current block’s prediction mode.

Decision (BF/align text with SW): Adopt JVET-P0457 solution 3

[JVET-P0676](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8475) Crosscheck of JVET-P0457 (Non-CE8: On IBC merge list size signalling) [Y.-L. Hsiao (MediaTek)]

[JVET-P0460](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8249) Non-CE8: Minimum QP for Palette Escape Coding [J. Zhao, S. Paluri, S. Kim (LGE)]

BoG

[JVET-P0798](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8613) Crosscheck of JVET-P0460: Non-CE8: Minimum QP for Palette Escape Coding [W. Zhu (Bytedance)]

[JVET-P0472](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8261) Non-CE8: Palette Coding Encoder Improvement [J. Zhao, S. Yoo, S. Kim (LGE)]

BoG

[JVET-P0719](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8520) Crosscheck of JVET-P0472 (Non-CE8: Palette Coding Encoder Improvement) [H.-J. Jhu (Kwai Inc.)]

[JVET-P0473](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8262) Non-CE8: Implicit block partitioning in palette mode [Y.-H. Chao, T. Hsieh, V. Seregin, M. Karczewicz (Qualcomm)]

BoG

[JVET-P0724](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8525) Crosscheck of JVET-P0473 (Non-CE8: Implicit block partitioning in palette mode) [Y.-W. Chen (Kwai Inc.)]

[JVET-P0474](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8263) Non-CE8: Minimum QP for escape mode in palette [Y.-H. Chao, H. Wang, V. Seregin, M. Karczewicz (Qualcomm)]

BoG

[JVET-P0795](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8610) Cross-check of JVET-P0474: Non-CE8: Minimum QP for escape mode in palette [J. Zhao (LGE)]

[JVET-P0475](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8264) Non-CE8: Simplification of palette predictor update for small CUs [Y.-H. Chao, T. Hsieh, V. Seregin, M. Karczewicz (Qualcomm)]

BoG

[JVET-P0707](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8508) Crosscheck of JVET-P0475 (Non-CE8: Simplification of palette predictor update for small CUs) [H. Yang (InterDigital)]

[JVET-P0476](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8265) Non-CE8: Palette mode and prediction mode signaling [Y.-H. Chao, C.-H. Hung, W.-J Chien, M. Karczewicz (Qualcomm)]

BoG

[JVET-P0843](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8658) Crosscheck of JVET-P0476 (Non-CE8: Palette mode and prediction mode signalling) [Y.-W. Chen (Kwai Inc.)]

[JVET-P0998](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8813) Crosscheck of JVET-P0476 (Non-CE8: Palette mode and prediction mode signaling) [H. Yang (InterDigital)]

[JVET-P0479](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8268) CE8-related: Restriction on context coded bins in palette [C.-H. Hung, Y.-H. Chao, M. Karczewicz (Qualcomm)]

BoG

[JVET-P0799](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8614) Crosscheck of JVET-P0479: CE8-related: Restriction on context coded bins in palette [W. Zhu (Bytedance)]

[JVET-P0483](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8272) Non-CE8: Quantization in palette escape mode [M. Karczewicz, H. Wang, Y.-H. Chao, M. Coban (Qualcomm)]

BoG

[JVET-P0720](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8521) Crosscheck of JVET-P0483 (Non-CE8: Quantization in palette escape mode) [H.-J. Jhu (Kwai Inc.)]

[JVET-P0486](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8275) CE8-related: Alignment of maximum transform-skip size with maximum transform block size [M. G. Sarwer, R. L. Liao, J. Luo, Y. Ye (Alibaba)]

Discussed in context of CE6 (Fri 4 Oct. 1930hrs)

Regarding the signalling of the maximum transform skip size, it is asserted that the current signalling in VVC draft 6 allows too much flexibility, which is not only unnecessary but also burdens hardware verification and conformance testing. Therefore, this contribution proposes to either remove it and set it to the same value as the maximum TB size, or to move it from PPS to SPS and to signal just as an SPS flag indicating either 32 or 64 in the same way as the maximum TB size signalling.

In VVC draft 6, the maximum transform skip (TS) block size and maximum BDPCM block size are 32x32, whereas the maximum transform block (TB) size is 64x64. This contribution proposes to align the maximum TS and BDPCM block size with maximum TB size. In the proposed method, the maximum TS block size can be up to 64x64. For larger TS and BDPCM blocks (i.e. size > 32), it is proposed to split them into 32x32 residual unit (RU). This way, the existing VVC6 TS residual coefficient scanning method can be reused, and a decoder never has to scan residual blocks larger than 32x32. It is reported that the BD-rate impact of the proposed method is -0.02% (AI), -0.13% (RA), -0.20% (LB) for the SCC sequences under CTC test conditions.

In terms of compression, no significant benefit.

As transform skip is targeting other content than regular transform, it is desirable to configure it separately. Encoders might also want to restrict its usage to small blocks only for lower complexity.

It is asserted that the current flexibility of TS is desirable.

Would be too early to decide at this meeting, needs further study. It is pointed out that TS is also studied in the context of the lossless CE, which will anyway include some study of signalling.

[JVET-P0866](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8681) Crosscheck report of JVET-P0486 (CE8-related: Alignment of maximum transform-skip size with maximum transform block size) [X. Xu (Tencent)]

[JVET-P0487](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8276) Non-CE8: Binarization of palette escape value [S. Yoo, J. Zhao, J. Nam, J. Choi, S. Kim, J. Lim (LGE)] [late]

Initial version rejected as “placeholder”.

BoG

[JVET-P0943](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8758) Crosscheck of JVET-P0487 (CE8-related: Binarization of palette escape value) [K. Unno, K. Kawamura (KDDI)]

[JVET-P0515](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8305) Non-CE8: Quantization unification for palette escape and transform skip [H.-J. Jhu, X. Xiu, Y.-W. Chen, T.-C. Ma, X. Wang (Kwai Inc.)]

BoG

[JVET-P0715](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8516) Crosscheck of JVET-P0515: Non-CE8: Quantization unification for palette escape and transform skip [Y.-H. Chao (Qualcomm)]

[JVET-P0516](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8306) Non-CE8: On palette mode signaling binarization [Y.-W. Chen, X. Xiu, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

BoG

[JVET-P0990](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8805) Crossscheck of JVET-P0516 Non-CE8: On palette mode signaling binarization [G. Li (Tencent)] [miss\_end\_meeting]

[JVET-P0630](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8427) Crosscheck of JVET-P0516: On palette mode signalling binarization [Y.-H. Chao (Qualcomm)]

[JVET-P0522](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8312) Non-CE8: On palette mode syntax [Y.-W. Chen, X. Xiu, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

BoG

[JVET-P0650](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8448) Crosscheck of JVET-P0522 (Non-CE8: On palette mode syntax) [T.-S. Chang (Alibaba)]

[JVET-P0523](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8313) Non-CE8: Context coded bin constraint for palette mode signaling [Y.-W. Chen, X. Xiu, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

BoG

[JVET-P0651](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8449) Crosscheck of JVET-P0523 (Non-CE8: Context coded bin constraint for palette mode signaling) [T.-S. Chang (Alibaba)]

[JVET-P0526](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8316) Non-CE8: Palette encoder improvements [H.-J. Jhu, Y.-W. Chen, X. Xiu, T.-C. Ma, X. Wang (Kwai Inc.)]

BoG

[JVET-P0796](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8611) Cross-check of JVET-P0526: Non-CE8: Palette encoder improvements [J. Zhao (LGE)]

[JVET-P0529](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8319) Non-CE8: QP dependent binarization for palette escape [H.-J. Jhu, Y.-W. Chen, X. Xiu, T.-C. Ma, X. Wang (Kwai Inc.)]

BoG

[JVET-P0652](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8450) Crosscheck of JVET-P0529 (Non-CE8: QP dependent binarization for palette escape) [T.-S. Chang (Alibaba)]

[JVET-P0565](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8355) CE8-related: Cross-component residual prediction for 4:4:4 format [K. Kawamura, S. Naito (KDDI)]

Residual modification process for transform blocks using cross-component prediction was adopted in the HEVC range extensions. This tool modifies the chrome residual signals by adding the scaled luma residual signals. In this contribution, a similar approach is proposed to improve the coding efficiency for 4:4:4 sequences. In VVC, luma and chroma coding trees is different in intra slice when chroma separate tree is enabled. An enabled condition of the modification is proposed to conform the VVC coding tree structure. Simulation results for 4:4:4 sequences show that -0.88% / -1.03% / -0.93% for AI/RA/LDB in single tree case and -0.51% / -0.74% for RA/LDB in chroma separate tree case.

For dual tree case, it is applied only in intra pictures

Gain is low for camera captured content compared to what it was in HEVC.

The benefit of the tool might be lower due to the fact that VVC has CCLM and JCC, which could be targeting the same properties.

For TGM1080, the gain is 2% for RA, 1.7% for AI, less for other SC classes.

Not worthwhile to include a new tool for SC for such small gain.

It is also noted that the VTM software still has some traces of this HEVC tool. Should be removed in a cleanup at some stage.

[JVET-P0957](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8772) Crosscheck of JVET-P0565 : CE8-related: Cross-component residual prediction for 4:4:4 format [S. Yoo, J. Lim (LGE)]

[JVET-P0573](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8363) AHG17/Non-CE8: Support parallel decoding based on initialization for palette predictor at CTU row [H. Jang, N. Park, J. Nam, S. Kim, J. Lim (LGE)]

BoG

[JVET-P0643](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8440) Crosscheck of JVET-P0573: AHG17/NonCE8: Support parallel decoding based on initialization for palette predictor at CTU row [W. Zhu (Bytedance)]

[JVET-P0577](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8367) AHG17/Non-CE8: APS support for palette predictor entry initialization [H. Jang, S. Paluri, S. Yoo, J. Nam, S. Kim, J. Lim (LGE)]

BoG

[JVET-P0670](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8468) Non-CE8: On num\_palette\_indices\_minus1 [W. Zhu, L. Zhang, J. Xu (Bytedance)] [late]

BoG

[JVET-P0731](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8533) Crosscheck of JVET-P0670 (Non-CE8: On num\_palette\_indices\_minus1) [H. Yang (InterDigital)]

[JVET-P0900](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8715) Non-CE8: Simplification of chroma BDPCM Syntax for single-tree [C.-C Kuo, [C.-C Lin](mailto:JackLin@itri.com), C.-L Lin (ITRI)] [late]

Chroma BDPCM can provide benefit on coding efficiency especially for low QP and lossless test conditions. This contribution proposed two modified syntax designs for chroma BDPCM when single-tree partition is used. In the first method, the signalling of chroma BDPCM depends on the luma BDPCM flag. In addition, the chroma BDPCM prediction direction is the same as luma BDPCM. For the second method, chroma BDPCM fully reuses the mode and prediction direction form luma BDPCM.

Both methods were implemented on top of CE8-4.1 source code and compared over the results of CE8-4.1. For common QP condition, average BD-rate (Y, U, V) for the first method are (-0.40%, -0.12%, -0.09%) and (-0.23%, 0.06 %, 0.03%) with 6% and 3% encoding time reduction for AI and RA respectively. For the second method, average BD-rate are (-0.33%, 0.37%, 0.24%) and (-0.11%, 0.29%, 0.10%) with 9% and 4% encoding time reduction. When test under low QP condition (QP=2, 7, 12, 17), average BD-rate for the first method are (-0.10%, 0.17%, 0.02%) and (-0.25%, 0.84 %, 0.96%) with 5% and 4% encoding time reduction and (0.30%, 0.72%, 0.58%) and (0.35%, 1.12%, 1.20%) average BD-rate for the second method with 11% and 6% encoding runt time reduction.

Powerpoint deck to be provided.

Compared to CE8-4.1 (which was adopted), the additional compression benefit is 0.2%-0.3%. The encoder runtime of method 2 is reduced by approx. <10% in AI, <5% in RA.

The method2 would give up the flexibility of independently controlling the BDPCM for luma and chroma.

No action.

[JVET-P0995](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8810) Crosscheck of JVET-P0900: Non-CE8: Simplification of chroma BDPCM Syntax for single-tree [Y.-H. Chao (Qualcomm)]

[JVET-P1018](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8833) Non-CE8: An alternative IBC virtual buffer setting to avoid reference sample wrapping around [J. Xu, L. Zhang, W. Zhu, K. Zhang, H. Liu (Bytedance Inc), X. Xu, X. Li, S. Liu (Tencent)] [late]

This proposal presents an IBC virtual buffer setting to avoid sample-wise IBC reference wrapping around. It is asserted that there is no performance change compared to VTM-6.0 encoder.

Unlike the original proposal JVET-P0454, this solution does not have an impact on performance. By re-defining the virtual buffer as 2 CTU (but requiring only 1 CTU physical memory) and just disabling the case of “physical wraparound” (whereas wraparound within the virtual buffer is still possible), the problem is solved.

It is also pointed out that this matches with the BV restrictions of the VTM5 encoder (which explains that there is no performance change).

Decision: Adopt JVET-P1018. Requires also software change of decoder, whereas encoder does not need a change.

It is also noted that in terms of conformance testing, a different encoder would be needed that all possible BV range of the virtual buffer restriction.

[JVET-P1022](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8837) Crosscheck of JVET-P1018: Non-CE8: An alternative IBC virtual buffer setting to avoid reference sample wrapping around [J. Li (Panasonic)]

## Quantization control (23)

Contributions in this category were discussed Monday 7 Oct. 2000–2300, Tuesday 8 Oct. 1400-1800, and Wednesday 9 Oct. 1130-1415 in Track A (chaired by JRO).

[JVET-P0093](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7882) Fix on value ranges of cu\_qp\_delta\_subdiv and cu\_chroma\_qp\_offset\_subdiv [E. Sasaki, T. Chujoh, T. Ikai (Sharp)]

This contribution proposes a fix on the value range of PPS syntax, cu\_qp\_delta\_subdiv and cu\_chroma\_qp\_offset\_subdiv in order not to refer slice level syntaxes. It is proposed to use variables, CtbLog2SizeY and MinCbLog2SizeY specified in SPS level to specify the value range of cu\_qp\_delta\_subdiv and cu\_chroma\_qp\_offset\_subdiv.

Related: JVEP-P0267, JVET-P0407

The primary issue is solving the dependency problem. It was argued that it might be desirable to use a narrower range for individual slices, as proposed in JVET-P0267 and JVET-P0407, which obtain the desirable flexibility by moving the signalling to the slice.

[JVET-P0110](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7899) AHG15: Quantization matrices with single identifier and enhanced prediction [P. de Lagrange, F. Le Léannec, E. François, K. Naser (InterDigital)]

This contribution is based on JVET-O0223, which proposed to change quantization matrix (QM) signaling and prediction, and allow prediction across all QMs regardless of block size, by identifying a QM with a single index, transmitting QMs in decreasing block size order, and specifying prediction as either a copy or decimation process. This contribution adds a scale factor to QM prediction, and refinement with a variable-length residual than can be used for full specification, adjustment of low-frequency coefficients, or QM offset.

The amount of the text needed to support QMs is reported to be reduced by half compared to VVC draft 6, and the proposed technique is said to save more than half of the bits needed to signal example QMs from a provided test package. (note: This may not refer the newest version of text – text editor to clarify)

The proposed features: scaled prediction across all QMs and variable-size refinement, are said to enable cost-efficient adaptation of QMs at picture level.

The bit rate saving on the “test set” of matrices is reported as 54%.

Main elements:

* New method of prediction in terms of ordering the matrices of different sizes, and interleaving between inter and intra – different from the current method, the prediction starts with largest matrix.
* Residual coding on top of prediction with diagonal scan that can stop at certain frequency
* Scaling prediction between inter and intra
* Removing prediction flag (i.e. always enabling prediction

The proposal shows that with the more sophisticated coding it is possible to save approx. 4% rate when quant matrices would be sent by picture, and approx. <0.1% when changed once per I refresh period.

It is however not obvious that change per picture may not be too relevant.

Question: Do we have enough evidence about relevant usage of quant. matrices to judge the benefit and usefulness of compressing matrices?

[JVET-P0754](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8558) Crosscheck of JVET-P0110 (AHG15: Quantization matrices with single identifier and enhanced prediction) [J. Le Tanou (MediaKind)]

[JVET-P0167](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7956) CE7-related: Improved coding of user defined quantization matrices [O. Chubach, C.-Y. Lai, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

In this contribution, an improved predictive coding of user defined quantization matrices (QMs) is proposed. The current design in VVC Draft 6 allows either referencing one of the previously coded QMs having the same sizeId as the current QM or DPCM coding of elements within the current QM. This contribution suggests simple changes on top of the current design to improve coding efficiency as follows.

1. **[Inter QM extended copy mode]**  
   Allow referencing a previously coded QM with the same base size as the current QM, where the reference QM sizeId can be the same as or smaller than the current QM sizeId.
2. **[Inter QM prediction mode]**Allow coding element-to-element differences between the current QM and the reference QM.
3. **[Intra QM prediction mode]**  
   When the previous two modes are impossible or inefficient, the original DPCM coding of elements within the current QM can still be applied.

The number of bits required for each of the three methods is computed, and the method requiring minimum number of bits will be chosen for coding of the current QM. The proposed method was implemented on top of VTM6.1 and tested on multiple scaling list sets, and the results are provided in the last section of this document. On average 43% bits for QMs are saved.

Note: The same test set of matrices was used as in JVET-P0110.

Prediction can refer previously decoded matrices with same base size ID, whereas P0110 can also refer matrices with larger base size (some kind of downsampling needs to be specified).

Both proposals reuse the current coding of values to encode prediction residual, however P0110 has no means of direct coding of values (or has to predict from the default matrix)

P0110 uses a different sequence of coding to allow prediction from larger base size ID.

Design a scheme that supports

* Referencing of previous decoded matrix or the default
* Retain the current sequence of coding
* Encode the difference relative to the prediction, using the current scheme for coding
* APS must be self contained

Proponents of the two proposals were suggested to discuss offline and try joining the common elements. New joint proposal JVET-P1034.

[JVET-P1034](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8849) CE7-related: Improved coding of user defined quantization matrices [O. Chubach, C.-Y. Lai, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek), P. d. Lagrange, F. L. Léannec, E. François, K. Naser (InterDigital)]

In this contribution, an improved predictive coding of user defined quantization matrices (QMs) is proposed. The current design in VVC Draft 6 allows either referencing one of the previously coded QMs having the same sizeId as the current QM or DPCM coding of elements within the current QM. This contribution suggests simple changes on top of the current design to improve coding efficiency as follows.

1. Allow referencing a previously coded QM with the same base size as the current QM.
2. Allow coding element-to-element differences between the current QM and the reference QM.
3. Keep the original DPCM coding of elements within the current QM.
4. Use a single matrix identifier scalingListId which combines matrixId and sizeId.

The number of bits required for each of the three methods is computed, and the method requiring minimum number of bits will be chosen for coding of the current QM. The proposed method was implemented on top of VTM6.1.

This also includes the expected text simplifications and the editorial cleanup.

Decision: Adopt JVET-P1034 (text and software)

[JVET-P0813](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8628) Crosscheck of JVET-P0167 (CE7-related: Improved coding of user defined quantization matrices) [T. Toma, K. Abe (Panasonic)]

[JVET-P0168](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7957) CE7-related: Removing 2x2 chroma quantization matrices [O. Chubach, C.-Y. Lai, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek), H. Jang, J. Nam, S. Paluri, S. Kim, J. Lim (LGE)]

In the current version of VVC, 2x2, 2x4, and 4x2 chroma intra coding blocks (CBs) do not exist, and the smallest intra block size is equal to 2x8 and 8x2, as well as the smallest chroma intra block copy (IBC) block size. Furthermore, in the current VVC version inter-prediction is disabled for 4x4 luma CBs. Therefore, small 2x2 chroma blocks can be created only by applying a subblock transform (SBT). Considering these essences, two methods are proposed: 1) remove 2x2 intra chroma quantization matrices (QMs) from the default QM list, and not code user-defined intra QMs for this size; 2) always apply default 2x2 chroma QMs (flat, with all values equal to 16), which is equivalent to disabling QMs for small 2x2 chroma blocks. The proposed methods are implemented on top of VTM6.1.

Method 1 is a reasonable cleanup after removal of small chroma blocks decided in last meeting. Decision (cleanup): Adopt JVET-P0168 method 1 (removal of 2x2 quant matrices)

[JVET-P0256](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8045) AHG15: 16x16 base scaling matrix for 64x64 TU [T. Toma, K. Abe (Panasonic)]

This contribution proposes to use 16x16 base scaling matrix instead of 8x8 for 64xN and Nx64 TU. 8x8 base scaling matrix is used up to 32xN and Nx32 TU and 16x16 matrix is used for 64xN and Nx64 so that maximum up-sampling ratio for the base scaling matrix is 4 times. This method is implemented in VTM 6.0.

The matrix is only for luma (inter and intra).

It is pointed out that in case of 64x64 transform, zero-out is applied.

This would increase the memory for storing the matrices (factor approx. 1.3).

It is not demonstrated that more precise matrices are needed for the large blocks, which typically don’t have large amount of detail.

No need for action.

[JVET-P0909](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8724) Crosscheck of JVET-P0256 (AHG15: 16x16 base scaling matrix for 64x64 TU) [O. Chubach (MediaTek)]

[JVET-P0257](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8046) AHG15: VTM decoder speed-up for handling scaling matrices [T. Toma, K. Abe (Panasonic)]

This contribution proposes to speed-up VTM 6.0 implementation of initialization process for scaling matrices. Initialization process at slice level that calculates the scaling matrices for all block size / shape is modified to be done only if an active SPS or PPS for a slice is changed. When the scaling matrices are enabled, decoding time compared to VTM 6.0 is 96%, 91%, and 85% in AI, RA, and LDB, respectively.

It is reported that the initialization of the matrices causes a significant increase in decoding time.

It is pointed out that the matrices are signalled via APS, which would now be referred by the picture header.

The change is beneficial for cases where somebody performs experiments with scaling matrices and would be surprised about an unexpected decoder runtime increase.

Decision (SW/non-CTC): Adopt JVET-P0257, with modification as necessary due to referencing the associated APS in picture header.

[JVET-P0761](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8576) Cross-check of JVET-P0257 (AHG15: VTM decoder speed-up for handling scaling matrices) [S.-C. Lim, H. Lee, J. Lee, J. Kang (ETRI)]

[JVET-P0267](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8056) Quantization group subdivision level signalling [C. Rosewarne, J. Gan (Canon)]

The VVC WD6 text includes quantization group subdivision level signalling in the PPS, with a range dependent on partition constraints, which may be overridden in the slice header (see JVET-L0678). To provide more flexibility for encoders to adapt to the scene characteristics and to encoding time limitations, and consistency with the partition constraint override signalling, this contribution proposes adding quantization group subdivision level signalling to the slice header when partition constraints are overridden in the slice header.

Similar to JVET-P0407 in signalling at slice level, but keeps the PPS level signalling and does not solve the dependency problem raised in JVET-P0093.

[JVET-P0292](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8081) AHG15: Scaling process for LFNST case [T. Hashimoto, E. Sasaki, T. Ikai (Sharp)]

This contribution is a follow-up proposal of JVET-O0383. In the VVC specification, scaling matrices (i.e. spatial frequency weighting) are applied even in the case of LFNST coefficients, which does not correspond to conventional transform coefficients. This contribution proposes a fix for this problem by applying scaling matrices in the coefficients of LFNST output as a second scaling process. The proposed scheme provides transform coefficients’ control capability in LFNST transform cases as well as conventional case.

The method applies the scaling matrices between LFNST and primary transform (at the decoder), i.e. an additional scaling step.The experiments use the default scaling matrices of HEVC, which loses some BD performance.

Current VTM applies scaling matrices regardless which transform it is. Additional results show that the gain of LFNST stays more or less the same with the fix, regardless if scaling matrices are used or not.

A visual example is shown that indicates a quality problem with using LFNST and scaling without the proposed change, which is however not very clearly visible.

More evidence would be required showing that introduction of specific matrices for LFNST is really necessary.

[JVET-P0657](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8455) Crosscheck of JVET-P0292 (AHG15: Scaling process for LFNST case) [Y. Wang (Bytedance)]

[JVET-P0293](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8082) AHG15: Signalling scaling matrix for LFNST case [T. Hashimoto, E. Sasaki, T. Ikai (Sharp)]

In VVC-6, scaling matrices (i.e. spatial frequency weighting) are applied even in the case of LFNST coefficients, which does not correspond to conventional transform coefficients. This contribution proposes a fix for this problem by introducing LFNST specific scaling matrices, which are signalled in APS. The proposed method provides transform coefficient control capability in the LFNST transform case as well as the conventional case.

In addition, this contribution shows the method of signaling scaling matrices on top of JVET-P0110, which proposes a new syntax to transmit scaling matrices.

The proposal introduces 6 additional scaling matrices (different for the small and large blocks, for the three components YCbCr)

One example of visual artifact is shown, which looks somewhat different for the cases without and with the change, where however also the block shapes are different.

More evidence would be required showing that introduction of specific matrices for LFNST is really necessary.

[JVET-P1015](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8830) Crosscheck of JVET-P0293 (AHG15: Signaling scaling matrix for LFNST case) [R. Hashimoto (Renesas Electronics)]

[JVET-P0321](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8110) AHG15: Signalling of chroma QP mapping table [Z. Wang, Y. Ye, J. Luo (Alibaba)]

At the 15th JVET meeting, a new signalling mechanism for the luma-to-chroma QP mapping table proposed in JVET-0186 was adopted into the VVC draft 6. VVC draft 6 supports signalling of only one luma-to-chroma QP mapping table used for Cb, Cr and joint CbCr coding simultaneously, or three tables for Cb, Cr and joint CbCr separately. This contribution proposes two changes to the signalling of luma-to-chroma QP mapping table. Firstly, it is proposed to support a default table without explicit signalling, such that for most use cases an encoder is not required to put the same luma-to-chroma QP table repeatedly in the bitstreams. Secondly, it is proposed to condition the signalling and derivation of the joint CbCr table based on whether the joint CbCr residual coding tool is enabled or not.

VVC6 allows signalling one joint table, or 3 tables (Cb,Cr,JCbCr). The proposal also would allow additionally signalling no table, or 2 tables (inherit JCbCr). During the discussion, it was considered that such an amount of flexibility might not be needed, as saving some bits at high level is not too relevant, and it would make the spec more complicated. One reasonable aspect of the proposal is that it is unnecessary to send a table for JCbCr when that mode is disabled. This latter aspect is also proposed in JVET-P0426 (part of aspect 1 of that document) and JVET-P0667.

The partial aspect “not signaling QP offset table for JCbCr in SPS if that mode is not enabled” is adopted, but better draft text found in JVET-P0667.

[JVET-P0324](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8113) AHG15: Quantization matrix selection based on block area [P. de Lagrange, P. Bordes, K. Naser, E. François (InterDigital)]

This contribution proposes to change quantization matrix selection for rectangular transform blocks, so that it is based on block area instead of block maximal dimension. This is said to be consistent with other parts of VVC like quantization groups, DMVR, BCW, and expected to derive QMs of rectangular blocks more likely from square-sized QMs.

Currently, the spec determines the matrix for non-square blocks from the maximum dimension. The proposal is to use the log-average of the two sizes. It is not proven that this would have benefit.

The simplifications of the spec text are purely editorial.

[JVET-P0335](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8124) AHG15: Chroma QP mapping table for HDR [T. Lu, F. Pu, P. Yin, S. McCarthy, W. Husak, T. Chen (Dolby)]

This contribution proposes to update the non-normative chroma QP mapping tables for HDR to improve the luma and chroma balance in VTM 6.0 for HDR common test conditions (CTC). It is proposed that:

* For class H1 (PQ content), use separate tables for Cb/Cr and joint CbCr. The tables are derived by absorbing the WCGPPSoffsets for P3 content into the mapping. More than 30% BDrate gain in wPSNRY can be achieved compared with HM16.18 anchor. Subjective evaluation has been performed on PQ reference display (Pulsar) and it is verified chroma coding performance is similar to the current VTM 6.0 anchor.
* For class H2 (HLG content), two candidate tables are provided for selection.

It is agreed that the current CTC setting of the mapping table is not appropriate.

It is asked how “absorbing WCGPPSoffsets” could work as it is currently sequence dependent? It is at least removed in the results.

After the viewing session, it was confirmed that the usage of three separate tables for Cb, Cr, and JCbCr provides similar visual quality as the configuration of the VTM6 anchor. Viewing was only performed for PQ content

Decision (CTC): Adopt the aspect from JVET-P0335 to change the chroma QP mapping table for class H1, and change WCGPPSoffsets to 0.

No change for class H2, further study on this aspect.

Informal viewing to be performed at EBU. Results and findings are reported in JVET-P1037.

[JVET-P1037](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8852) Report on HDR Viewing [A. Segall, K. Andersson]

This report summarizes the HDR viewing that was performed at the 16th meeting. Preparations for the viewing occurred on October 7th and 8th, and the informal viewing occurred on October 9th. Informal viewing was performed at the EBU on October 9th from 3-4PM. The following comments were made by the participants:

1. VTM6 LMCS on versus VTM6.0 anchor

2. VTM6 Anchor versus VTM5 anchor (in terms of chroma quality)

3. VTM6 Anchor versus HM16.18

4. JVET-P0335: Proposed versus VTM6

First session JVET-P0335 versus VTM6 anchor:

Comments: Some differences but overall very similar.

Second session VTM6 with LMCS on versus VTM6 with LMCS off:

Comments: Some differences but overall very similar. One participant noted improvements of rope at QP 32 for Balloon for LMCS.

Third session VTM6 vs VTM5:

Comments: Some differences but overall very similar. One participant noted improvements of rope at QP 32 for Balloon for VTM5.

Additionally, an informal viewing of VTM6 versus HM 16.18 was performed. In this viewing, the bit-streams were created using the same QP parameter. This resulted in bit-streams of different bit-rates and of similar (but not the same) objective quality.

Demo session of HEVC vs VVC on request by viewers:

Comments: Significant improvement.

Report was given verbally Thursday 10 Oct. afternoon.

The viewing also included testing VTM5 vs. VTM6 (the latter both with LMCS off and on). It is concluded that LMCS on for PQ does not incur subjective problems. As it provides objective benefit, it should be turned on.

It is further reported that with same QP, VTM looked visually better than HM, even though rate was lower. Independent experts of EBU pointed out that chroma looked significantly better for VTM, but they also pointed to some overfiltering issue in one sequence.

Decision (CTC): Enable LMCS for class H1.

[JVET-P0623](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8418) Crosscheck report of JVET-P0335 on Chroma QP mapping table for HDR [E. François (InterDigital)]

[JVET-P0339](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8128) AHG15: Signalling of CU level chroma QP offset [Z. Wang, Y. Ye, J. Luo (Alibaba)

At the 15th JVET meeting, CU level chroma QP control proposed in JVET-O1168 was adopted into the VVC draft 6. In VVC draft 6, CU level chroma QP offsets are signalled in PPS by cb\_qp\_offset\_list, cr\_qp\_offset\_list and joint\_cbcr\_qp\_offset\_list for Cb, Cr and joint CbCr respectively. This contribution proposes to signal the joint\_cbcr\_qp\_offset\_list only when the joint CbCr residual coding tool is enabled. Two methods are proposed in this contribution. In the first method, it is proposed to move the signaling of CU level chroma QP offsets to the slice header. In the second method, it is proposed to signal the CU level chroma QP offsets in the APS by adding a new APS type.

New APS would be undesirable for such a small item.

Picture header would mean it has to be resent even if not changed.

Not sending the QP offset list if JCbCr is off could be resolved by duplicating the JCbCr enabling flag in PPS to avoid the parsing dependency. Exactly that is agreed by adoption of JVET-P0667.

[JVET-P0361](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8150) On chroma quantization groups [A. K. Ramasubramonian, G. Van der Auwera, W.-J. Chien, H. Huang, Y. Han, B. Ray, M. Karczewicz (Qualcomm)]

This document proposes to modify the derivation of chroma QP by specifying a chroma quantization group and aligning the definition of the chroma quantization group with that of the luma quantization group. It is asserted that the current chroma QP derivation may not be consistent for the dual tree architecture, where the luma and chroma splits are independent. It is asserted that the proposed method of aligning the definition of chroma and luma quantization groups results in simpler and cleaner QP derivation process.

The quantization adaptation group in chroma is larger than luma. The proposal is that the same Luma QP value is applied to the whole chroma quant adaptation group, on which the offset is applied.

It is argued that this simplifies the processing at encoder and decoder. However, several experts mention that also encoders would not use sophisticated local chroma offset adaptation mechanisms (i.e. select a very large chroma quantization group area). In such a case, the proposed scheme would not be appropriate.

No action on this.

[JVET-P0365](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8154) AHG15: Scaling matrices for LFNST-coded blocks [A. K. Ramasubramonian, G. Van der Auwera, V. Seregin, H. E. Egilmez, M. Karczewicz (Qualcomm)]

This document proposes a modified method of applying scaling matrices for LFNST-coded blocks. It is asserted that the current VVC design of applying the scaling matrices has some shortcomings. For all LFNST-coded blocks, it is observed that the LFNST coefficients are restricted to be contained in a 4x4 region of the transform block. It is proposed that when scaling matrices are applied to an LFNST-coded block, the scaling matrix corresponding to the 4x4 transform block size be applied to the LFNST coefficients. For applications that use quantization matrices for rate control, this method is asserted to be sufficient. For use of scaling matrices for perceptual quantization, it is not evident that the scaling matrices that are specified for the primary matrices may be useful for LFNST coefficients. Until such evidence is available, it is proposed that flexibility be provided to disable the scaling matrices for LFNST coefficients.

There is no evidence that the usage of 4x4 scaling matrices for all block sizes of LFNST is beneficial. Actually, the properties of LFNST coefficients may be closer to the primary transform.

It is agreed that the aspect of just disabling the scaling by an APS flag is straightforward and allows an encoder to just ignore LFNST in the design of scaling, or by purpose disabling the scaling in case of LFNST if it would produce artifacts.

Decision: Adopt JVET-P0365 (only the aspect of scaling\_matrix\_for\_lfnst\_disabling\_flag in APS for scaling matrices)

[JVET-P0371](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8160) AHG7/AHG15: signalling of corrective values for chroma residual scaling [E. François, F. Galpin, K. Naser, P. de Lagrange (InterDigital)]

This contribution relates to LMCS. It proposes to enable signalling in the APS corrective values for the chroma residual scaling. In current VTM, chroma residual scaling values are inferred as the inverse values of the luma mapping slopes. The table of luma mapping slopes is signalled in the APS. In order to provide higher encoder control flexibility, it is proposed to add in the APS a corrective chroma residual scaling parameters table. The corrective parameters are determined at the encoder and signalled in the APS as additive values to the luma mapping slopes. The final chroma residual scaling values are obtained by inverting the corrected luma mapping slope values.

It is reported that the proposed chroma residual scaling control allows much finer tuning of the luma/chroma bitrate balance than using the delta QP control. As an example, results of the tool-off test of LMCS in SDR, RA configuration, with VTM6.0, and with the proposal, are reported.

* VTM6.0 LMCS off: PSNR-Y, -U, -V 1.63%, -1.30%, -1.42%
* Proposal LMCS off: PSNR-Y, -U, -V 1.53%, -0.22%, -0.39%

Other test results for SDR and HDR PQ are also reported. Encoding and decoding runtime impact is said to be negligible.

The additional offset allows additional control of the relative benefit of LMCS on luma and chroma. Currently LM has more benefit on luma than CS has on chroma.

It is generally agreed that this is beneficial in terms of better controlling the effect of LMCS on luma and chroma separately.

There are two versions proposed, one with a table, and one with one single offset that would be applied to all current CS table entries. The latter is preferable.

In this, the offset is currently signalled by a fixed length code with max. amplitude of 63, which would be equivalent to changing the chroma QP by 8. It seems that a range which would correspond to a QP change of 2 would be sufficient.

Decision: Adopt JVET-P0371 (version with one offset value, restricted to a range which would correspond to a QP change of 2)

Decision (CTC): Enable JVET-P0371 in CTC. Values for HDR and SDR still to be determined by proponents, such that the gain/loss would be homogeneous for luma and chroma in tool on / tool off testing. Should be done based on VTM7 release 1.

[JVET-P0711](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8512) Crosscheck of JVET-P0371 (AHG7/AHG15: signalling of corrective values for chroma residual scaling) [T. Lu (Dolby)]

[JVET-P0407](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8196) AHG15: cu\_qp\_delta\_subdiv and cu\_chroma\_qp\_offset\_subdiv syntax dependency removal [J. Chen, R.-L. Liao, J. Luo, Y. Ye (Alibaba)]

In VVC draft 6, cu\_qp\_delta\_subdiv and cu\_chroma\_qp\_offset\_subdiv are signaled in PPS, while the range of these two syntax elements depends both on SPS and slice level information, which causes a syntax dependency issue. This contribution proposes to remove the syntax dependency by moving cu\_qp\_delta\_subdiv and cu\_chroma\_qp\_offset\_subdiv to slice header.

It is asserted that keeping the syntax at PPS is not really necessary. In case when locally adaptive QP is used, the necessary overhead at block level would be much larger than the signalling of few parameters for each slice.

For the case of a picture containing both intra and inter slices, it would be desirable controlling the parameters independently. On the other hand, if there are multiple slices per picture, the overhead might again grow large.

With the new design of the picture header, it is suggested to better put the parameters there. Two independent sets of parameters should be defined for inter and intra slices, which would then be used for each slice of the respective type in the given picture. The dependency on mtt depth would also be resolved, as it is reported that this has already been decided to be moved from slice to picture header.

Decision: Adopt JVET-P0407, but as a subsequent action related to HLS design moving the parameters from slice header to picture header as stated above.

[JVET-P0410](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8199) AHG15: chroma QP mapping table syntax variant with less bits [P. de Lagrange, P. Bordes, K. Naser, E. François (InterDigital)]

This contribution proposes changes in the luma to chroma QP mapping table syntax adopted in VVC draft 6, which consists in sending pivot points of a piecewise linear function. The proposed modifications are: making the first point relative to QP 26 instead of -QpBdOffsetC, transmitting luma to chroma QP differences instead of chroma QPs, and inferring the first difference to be zero. This is said to reduce the number of bits needed in the SPS and to make the syntax independent from bit depth.

Generally, saving few bits in SPS is not really relevant.

JVET-P0469 is related to the aspect of transmitting difference rather than direct values, leaves the current syntax elements unchanged, and generates the values by a simple XOR.

Making the first value dependent on QP26 has the advantage that it becomes independent on bit depth, but requires signed syntax element – agreed.

Difference coding – straightforward, but the solution of JVET-P0469 is more elegant – agreed.

Inferring first difference to zero also simplifies the text – agreed.

Decision: Adopt JVET-P0410 (aspects of making first value dependent on QP26, and inferring first difference to zero).

[JVET-P0426](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8215) AHG17/AHG15: On quantization control parameters signalling [R. Chernyak (Huawei)]

This contribution proposes a modification of VVC 6 specification aimed to remove an inconsistency in high level quantization control parameters signalling. The contribution consists of two aspects. The first aspect proposes to align signalling of all syntax elements related to joint chrominance component residual (JCCR) coding with each other’s and make it depending of JCCR control flag. The second aspect proposes to simplify specification text in part of quantization control parameters signalling at slice header level.

The proposal has some inconsistent syntax dependencies which are corrected.

The PPS change does not make much sense, as the JCbCr enabling flag would need to be sent again just to not sent the QP offset flag.

The partial aspect “not signaling QP offset table for JCbCr in SPS if that mode is not enabled” is adopted, but better draft text found in JVET-P0667.

“Aspect 2” (removing signalling of pps\_slice\_chroma\_qp\_offset\_present\_flag”) is not useful.

[JVET-P0667](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8465) AHG17/AHG15: Comments on aspect 1 of JVET-P0426 [B. Ray, A. K. Ramasubramonian, G. Van der Auwera, M. Karczewicz (Qualcomm)] [late]

This contribution proposes some comments on the solution to aspect 1 of JVET-P0426 which aligns various QP control parameters related to joint Cb-Cr residual (JCCR) coding and provides an alternative that assertedly does not contain any parsing dependency issues.

The first aspect (not signalling QP offset table for JCbCr in SPS if that mode is not enabled) is agreed as a cleanup

In a follow-up discussion related to JVET-P0339, it was agreed that also the second aspect (including the JCbCr enabling flag in SPS, and using it as a gating flag for joint\_cbcr\_qp\_offset\_present\_flag, and joint\_cb\_cr\_qpoffset list) should be included to avoid presence of unused syntax elements.

Decision (cleanup): Adopt JVET-P0667.

[JVET-P0436](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8225) AHG15: On CU Adaptive Chroma QP Offset Signalling [J. Zhao, S. Paluri, S. Kim (LGE)]

In VVC, there are two issues in terms of CU chroma QP offset signalling. Firstly, chroma QP offset signaling is unnecessary for DUAL\_TREE\_LUMA case. Secondly, chroma QP offset signalling is inconsistent with the principle of VPDU QP availability as in luma delta QP signalling. Therefore, this document proposes two modifications to the conditions of signalling CU chroma QP offset.

* Modification 1 removes the unnecessary signalling of CU chroma QP offset in the case of DUAL\_TREE\_LUMA in transform\_unit
* Modification 2 makes CU chroma QP offset signalling consistent with the VPDU CU QP delta availability, and for CU larger than 64x64, send the chroma QP offset with the first transform unit regardless of whether it has non-zero CBF or not.

Decision (ed./cleanup): Adopt JVET-P0436 Modification 1 (relation to JVET-P0360 – editor to decide the solution that is best consistent – syntax part should avoid the make existence of syntax elemets dependent on semantics)

It is agreed that modification 2 resolves a problem with VPDU, as the chroma QP offset would currently only be sent with a later TU in a large CU, even though needed earlier.

Decision: Adopt JVET-P0436 Modification 2.

[JVET-P0608](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8401) [AHG15] On scaling list for JCCR [S. Iwamura, S. Nemoto, A. Ichigaya (NHK), P. de Lagrange, F. Le Leannec, E. François (InterDigital)]

In the scaling process for transform coefficients in the current VVC draft specification, chroma QP offset Qp′CbCr is introduced to apply to the TU coded with JCCR. It is because the residual energy distribution of the transform block with JCCR might be different from that without JCCR. Nevertheless, the current draft specification does not support scaling list for the transform block coded with JCCR. This contribution proposes scaling list for transform blocks with joint coding of chroma residual (JCCR). When a given transform block is coded with JCCR and both tu\_cbf\_cb and tu\_cbf\_cr are equal to 1, scaling list for JCCR are used for the scaling process. An alternate solution is also proposed to avoid signalling of additional scaling lists. The solution consists in deriving the scaling factors in case of JCCR by averaging the scaling factors applying to the Cb and Cr components.

Not evident that there is really need to have a separate scaling list for mode 2 of JCbCr. For mode 2, there is some indication that both components are similar anyway.

This would require additional generating and storing the average of the two scaling lists which every decoder would need to implement, whereas only few encoders might use scaling lists and optimize wrt. JCbCr.

No action.

[JVET-P0974](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8789) Crosscheck of JVET-P0608 ([AHG15] On scaling list for JCCR) [T. Hashimoto (Sharp)]

[JVET-P0469](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8258) AHG15: efficient coding of qp\_out\_val [F. Bossen, A. Segall (Sharp)]

The current VVC draft includes the ability to encode custom chroma QP mapping tables using a set of qpY and qpC pairs. Such pairs are delta coded as syntax elements delta\_qp\_in\_val\_minus1 and delta\_qp\_out\_val. Two modified encodings of delta\_qp\_out\_val are proposed. It is asserted that these modifications reduce the number of bits required to encode the mapping table by about 25-30% on average, while preserving a built-in constraint that restricts qpC to monotonically increase with qpY.

See further notes under JVET-P0410

Decision: Adopt JVET-P0469.

[JVET-P0730](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8532) AHG15: default quantization matrix [P. de Lagrange, E. François (InterDigital)] [late]

It is proposed to replace the all-16 default quantization matrix with an 8..64 linear ramp along the diagonal. Combined with JVET-P0110, this is said to reduce the coding cost of custom QM by allowing first-order approximation through scale and offset, and provide a reasonable default as-is.

Not evident that default matrices are needed, as it is unknown and highly application dependent what would be the best default. From this point of view, it might even be dangerous to define a default, as it might be misleading.

Saving the bits in APS might not be a big advantage.

No action.

[JVET-P0393](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8182) On BD rate computation for tools affecting quantization [S. Keating, K. Sharman, A. Browne (Sony)]

Presented Thursday 9 Oct. Track A

In JVET-N0031 it was proposed to increase the number of points used in rate-distortion curves to improve the accuracy of BD rate computation. This paper studies LMCS, which modifies the effective quantization, as an example of a tool where the BD rate computation is affected. The use of a combined YUV metric, as proposed in JVET-N0341, is also studied for the same example.

It is pointed out that for cases where different interpolation methods in BD rate computation show different results, this might be an indicator that the interpolation is misleading. This was verified by comparing against a step-1 (every QP) RD curve, which was then even more different.

An extreme case was slide editing, where the interpolation seems to show benefit, which was almost gone withstep-1 computation.

The effect seems also to be related to cases where the rate gap between two measured QP points is large (mostly between QP22 and QP27)

It is also pointed out that for low QP (where only first 100 frames are tested) the results could be quite different from those for the whole sequence, if characteristics are changing (such as Food Market, Ritual Dance).

Very interesting results which indicate that BD rate might be misleading in certain cases.

However, at this late stage of VVC development, established metrics might better be kept.

## Entropy coding (4)

Contributions in this category were discussed Wednesday 8 Oct. 1515–1715 in Track A (chaired by JRO).

[JVET-P0300](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8089) High throughput CABAC mode for VVC [H. Kirchhoffer, D. Marpe, B. Bross, T. Nguyen, C. Rudat, H. Schwarz, T. Wiegand (HHI)]

A high throughput mode for VVC is proposed where the context model update is disabled for all context models on a stream level and the arithmetic coding engine uses the generalized bypass mode as proposed in JVET-O0554. The high throughput mode can be implemented with only a few minor changes to the current design of VVC. For three generalized bypass probability values (1/4, 1/8, and 1/16) and QPs 22-37, the BD-rates are 3.68% for AI, 4.49% for RA, 3.09% for LB, and 3.15% for LP. For QPs 2-17, the BD rates are 3.89% for AI, x.xx % for RA, 4.09% for LB, and 4.23% for LP.

For RA with 17 frames, results at low QP are 4.94% in RA (for the case of parameter numGB=3).

The “generalized bypass” uses a simplified arithmetic coding without multiplication and without probability update. Init values were retrained such that it fits both normal CABAC and the fixed engine.

Results without retraining (using the init values retrained for CABAC) are 2-3% worse for parameter numGB=3 and low QP range. Retraining was done with low QP and normal QP, whereas the normal retraining for CABAC is done in normal QP range, and it is shown that in the latter case the loss is smaller.

There is also a “variant 1” which is slightly less complex, but has higher loss.

It is pointed out that retraining with CTC sequences may somehow overfit. For the case of fixed probability, another option could be to signal the probability values.

It is also pointed out that the whole process of context derivation is still necessary, which also causes a throughput issue due to recursive block dependencies.

The approach of totally bypassing (which would be equivalent to numGB=0) would definitely solve major throughput issues, but also has major loss around 20% (see results under JVET-P0939).

There could also be other throughput issues even with bypass coding, e.g. to determine Rice parameters.

It is pointed out that this might be interesting for a high throughput profile (e.g., supporting extreme high resolutions). Not something for main.

Further clarification is needed on requirements. By which factor would the throughput need to be increased and how to measure it?

Further study needed and recommended. Should become part of AHG mandates (16 or 18).

[JVET-P0996](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8811) Crosscheck of JVET-P0300 (High throughput CABAC mode for VVC) [J. Dong (Qualcomm)]

[JVET-P1020](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8835) Crosscheck of JVET-P0300 (High throughput CABAC mode for VVC) [F. Bossen (Sharp)] [miss\_end\_meeting]

[JVET-P0395](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8184) CABAC zero word thresholds [A. Browne, S. Keating, K. Sharman (Sony)]

This document describes a modified coding method for padding with cabac\_zero\_word. The current specification uses a single constraint for the number of bins allowed in a picture based on the picture size and the size of the encoded stream. Following a suggestion from the 15th JVET meeting in Gothenburg, an empirical study has been completed which compares the effect of the cabac\_zero\_word constraint on HM and VTM. In addition, three further configurations of VTM were studied – one with dependent/trellis quantization disabled, one with certain coefficient coding thresholds disabled, and one with both dependent quantization and coefficient coding thresholds disabled.

It is proposed that the cabac\_zero\_word constraint is modified due to the integration of the dependent quantization tool. If, later, when profiles are defined, some profiles do not permit dependent quantization, the current lower levels could be used in order to simplify decoder design.

This contribution also demonstrates the effect of the coefficient coding threshold constraints (JVET-N0280 & JVET-O0052) on the bin-to-bit ratios.

CABAC zero words are inserted at the end of a slice when the bin to bit ratio increases over the defined limit.analysis shows that the occurrence of CABAC zero words is 0.7% (in case of one slice per frame) and 3.7%) (in case of one CTU per slice) in low QP range, but it also occurs in normal QP range at the lower end (22). The effect on bit rate increase is marginal.

Dependent quantization does seem to increase the cases where zero words are inserted only rarely.

The proposal suggests new limits (slope/intercept of boundary) that would basically bring the occurrence to zero. It is suggested defining it different for the cases with and without dependent quantization. This is however agreed not to be consistent, better only have one limit.

Options on the table:

* Just keep the limit as is, as it does not cost much in compression (0.03% gain when no limit would be imposed)
* Change the limit, but if yes, to which value?

Further evidence would be needed on implications of modified limits to hardware implementation.

Further study would be beneficial also with other cases than CTC, e.g. white noise.

No action at this moment, but should be considered in context of profile/level definition if a change of limits is useful relative to HEVC.

[JVET-P0396](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8185) Switching between CABAC context coded bins and bypass coded bins [A. Browne, S. Keating, K. Sharman (Sony)]

This contribution describes a modified coding method for entropy coding, proposing to remove the need to use cabac\_zero\_word padding and to simplify coefficient coding. The modification works by switching between CABAC and bypass coding at discrete points. An implementation is described which uses 5 of these points. Results are given which show gains in low QP conditions (-0.33% overall for RA), without harming performance in CTC. In addition, results are given for class TGM which show gains of -0.43% for AI in CTC, and -2.49% for RA in low QP.

It is pointed out that it would not be possible to replace the limit of context coded bins at TU level, as imposing such a limit at higher level might enable much more inhomogeneous distribution of context coded bins in the TUs all over the picture. This is the likely reason for high gain in TGM

The method, though simplified, still would be more complicated than the zero word insertion (which is well understood and does not have high impact on bit rate)

No action.

[JVET-P0603](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8395) CABAC zero word signalling [M. Coban, A. Ramasubramonian, V. Seregin, M. Karczewicz (Qualcomm)]

This contribution proposes to signal the number of stuffing bytes needed to satisfy picture level maximum bin to bit ratio constraint after coding a picture instead of appending cabac zero bytes.

It is pointed out that this would require parsing the bit stream for the given syntax element to identify presence of zero words.

Furthermore, as reported in JVET-P0395, the compression loss due to occurrence of zero words is almost negligible, as they occur only rarely.

No action.

[JVET-P0939](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8754) Report of CABAC skip mode results on VTM-6.0 [K. Abe, T. Toma (Panasonic)] [late]

This contribution is an information contribution which reports the coding results of CABAC skip mode on VTM-6.0. CABAC skip mode was proposed by JVET-M0089, JVET-N0207, and JVET-O0308. It directly outputs binarized bins as a bitstream without CABAC processing, and can avoid CABAC throughput issue without any additional building blocks. Simulation results reportedly show that the CABAC skip mode can guarantee the fixed processing delay with the cost of 15%, 18%, and 21% bits increasing for AI, RA, and LDB on VTM-6.0, and XX%, XX%, and XX% bits increasing for AI, RA, and LDB on VTM-6.0-lossless.

Document for information, implementing JVET-O0308 on top of VTM6. Penalty of bypassing CABAC is similar.

Initial results for lossless indicate that the bit rate increase is on average only 5% for class A, but higher for lower resolution classes (in RA).

Further study needed (see comments under JVET-P0300).

## Partitioning (21)

Contributions in this category were discussed XXday X Oct. XXXX–XXXX in Track X (chaired by XXX).

[JVET-P0406](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8195) Non-CE3: Generalization of SCIPU for different YUV formats [L. Pham Van, G. Van der Auwera, V. Seregin, H. Huang, A. K. Ramasubramonian, M. Karczewicz (Qualcomm)]

Discussed in Track B Saturday 1615 (GJS).

This document proposes to fix a bug of SCIPU (smallest chroma intra PU) regarding the different color formats.

Firstly, SCIPU is disabled for YUV 4:0:0 and 4:4:4.

Secondly, the block size of the chroma component is used to decide the SCIPU mode constraint.

* In YUV 4:2:2, remove SCIPU restriction in coding trees where there is no 2x2/2x4/4x2 blocks
  + Method 1: Using chroma scaling factors in SCIPU constraint derivation
  + Method 2: Use chroma block size in SCIPU constraint derivation

The proposed fix reportedly achieves an average (Y, U, V) BD-rate gain of (-0.21%, -0.47%, -0.40%) in the RA configuration for YUV 4:2:2 tested sequences with a negligible running time change, since .

It was commented that P0063, P0406, P0520, P0537, and P0575 are the same, although editorially different.

The text in P0537 was reviewed.

Decision: Adopt (editor may choose the phrasing of the text, likely based on P0537).

[JVET-P0701](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8500) Crosscheck of JVET-P0406 (Non-CE3: Generalization of SCIPU for different YUV formats) [Z. Deng (Bytedance)]

[JVET-P0520](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8310) Non-CE3: Spec fix for the smallest chroma intra prediction unit (SCIPU) [Y.-W. Chen, X. Xiu, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

See notes for P0406.

[JVET-P0537](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8327) Non-CE3: Cleanups on local dual tree for non-4:2:0 chroma formats [Z. Deng, J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)]

See notes for P0406.

[JVET-P0063](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7852) AHG16: Fix on local dual tree [Y. Zhao, H. Yang (Huawei), Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

Discussed in Track B Saturday 1630 (GJS).

This contribution proposes two fixes to the local dual tree technique of JVET-O0050. The first fix normatively disallows BT/TT split that creates 4x4 luma blocks in an inter coding region, which removes redundant CU-split-related flags (e.g., split\_cu\_flag) and has -0.01% luma BD-rate impact in RA.

For this aspect see also P0624.

The second fix harmonizes JVET-O0050 with other color formats beyond YUV4:2:0, i.e., monochrome, YUV4:2:2 and YUV4:4:4. For this aspect, see the notes for P0406.

In addition, the contribution informatively discusses a way of maintaining luma delta QP at the encoder to fit the local dual tree, which was not mentioned in the JVET-O0050.

Decision (Ed.): The contribution also proposes some editorial refinements that may be considered by the editor.

[JVET-P0766](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8581) Crosscheck of JVET-P0063 (AHG16: Fix on local dual tree) [C. Rosewarne (Canon)]

[JVET-P0575](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8365) Non-CE: to support SCIPU with local dual tree for various color format [H. Jang, J. Nam, S. Kim, J. Lim (LGE)]

See notes for P0406.

[JVET-P0908](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8723) Crosscheck of JVET-P0575 (NonCE: to support SCIPU with local dual tree for various color format) [T. Ikai (Sharp)]

[JVET-P0624](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8419) AHG16: Bugfix for local dual tree [L. Zhao, X. Li, X. Zhao, S. Liu (Tencent)] [late]

Discussed in Track B Saturday 1645 (GJS).

See notes for P0406 for one aspect.

In VVC Draft 6, a coding tree node in an inter coding region of local dual tree can split into 4x4 coding units (CU). However, in this case, neither Intra (including IBC) nor Inter coding mode is allowed for these coding tree, because 4x4 blocks are not allowed to use Inter mode and CUs in Inter coding region cannot use Intra mode. In this contribution, two alternative methods are proposed to fix this issue. In the first method, the tree depth within local dual tree region is restricted to be no larger than 1. In the second method, the tree depth for inter coding region in local dual tree is restricted to be no larger than 1. It is reported that the first method achieves 0.09%, 0.01%, and -0.02% luma BD-rate changes for AI, RA and LDB configurations, respectively, and the second method achieves 0.00% and -0.02% luma BD-rate changes for RA and LDB configurations, respectively.

Some participants remarked that the proposed solution was unnecessarily restrictive.

It was suggested to preserve flexibility by choosing P0063. The proponent of P0624 remarked that P0063 had losses on some test sequences. However, non-proponents emphasized just trying to fix the serious problem without making other changes.

Decision: Adopt the first aspect of P0063.

[JVET-P0737](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8539) Crosscheck of JVET-P0624 on Bugfix for local dual tree [X. Xiu (Kwai Inc.)]

[JVET-P0484](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8273) Non-CE3: Signalling unification of prediction mode and SCIPU mode [L. Pham Van, G. Van der Auwera, A. K. Ramasubramonian, H. Huang, V. Seregin, M. Karczewicz (Qualcomm)]

Discussed in Track B Saturday 1710 (GJS).

This contribution proposes a change of signalling for prediction mode and SCIPU mode. Particularly, it is proposed that the SCIPU mode is signalled using the prediction mode flag, which is asserted to reduce the number of contexts by two. It is reported that the proposed technique achieves an average (Y, U, V) BD-rate gain of (-0.01%, 0.07%, 0.01%) and (-0.05%, 0.04%, 0.13%) in the RA and LDB configurations, respectively, with a negligible runtime change.

It was commented that this seems to be more-or-less just tinkering without a clear problem to be solved. No action was taken.

[JVET-P0976](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8791) Crosscheck of JVET-P0484 (Non-CE3: Signalling unification of prediction mode and SCIPU mode) [F. Galpin (InterDigital)]

[JVET-P0531](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8321) Non-CE3: Removal of 2×N chroma intra blocks [Z. Deng, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)]

P0531, P0596 and P0641 are closely related; the proponent suggested to just present P0641.

[JVET-P0805](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8620) Crosscheck of JVET-P0531 (Non-CE3: Removal of 2×N chroma intra blocks) [L. Pham Van, G. Van der Auwera (Qualcomm)]

[JVET-P0596](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8388) Non-CE3: Removal of chroma 2xN blocks in CIIP mode [L. Pham Van, G. Van der Auwera, A. K. Ramasubramonian, T Hsieh, V. Seregin, M. Karczewicz (Qualcomm)] [late]

Initial version rejected as “placeholder”.

P0531, P0596 and P0641 are closely related; the proponent suggested to just present P0641.

[JVET-P0977](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8792) Crosscheck of JVET-P0596 (Non-CE3: Removal of chroma 2xN blocks in CIIP mode) [F. Galpin (InterDigital)]

[JVET-P0641](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8438) Non-CE3: Combination of JVET-P0596 and JVET-P0531 on removal of 2xN chroma intra blocks [L. Pham Van, G. Van der Auwera, T. Hsieh, A. K. Ramasubramonian, V. Seregin, M. Karczewicz (Qualcomm), Z. Deng, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)] [late]

Discussed in Track B Saturday 5 October 1720 (GJS)

P0531, P0596 and P0641 are closely related; the proponent suggested to just present P0641.

This document presents the result of a combination of JVET-P0596 Test 2 and JVET-P0531 Test 2. In the combination test, 2xN intra chroma blocks in dual tree are proposed to be removed by disabling binary and ternary splits for 4xN and 8xN chroma partitions, respectively. In the single tree case, the regular 2xN chroma intra blocks are removed by extending the local dual tree as proposed in JVET-P0531 Test 2. For 4xN CIIP blocks, the chroma block uses only inter prediction as proposed in JVET-P0596 Test 2. The average (Y, U, V) BD-rate change is reported as follows with a negligible runtime change:

* Dual tree off: AI: (-0.02%, -0.18%, -0.22%) with 3% encoding time reduction.
* Dual tree on: AI: (0.01%, 0.35%, 0.37%) and RA: (0.11%, 0.50%, 0.49%).

It was commented that very small blocks are a problem (and were already removed), but thin blocks are not especially a problem (although this may somewhat depend on architecture – two companies said 2xN intra is a problem although some others did not find it such a problem). There is some coding loss. Screen content testing was not reported.

There was then discussion of P0596, which is a subset of P0641 and just removes 2xN for CIIP and did not show loss. It was commented that it doesn't really save to remove this for CIIP if it still needs to be done for regular intra.

Low-delay test results were not initially provided. There was some loss in Class A. Later, some LB results where vebally reported to be about the same as for the RA case (about 0.1% for luma and 0.5% for chroma, not cross-checked).

The spec text and software impact was reportedly small (about 10 lines each).

Considering the degree of implementation concern expressed by some hardware implementers, it was agreed to act on this.

Decision: Adopt.

[JVET-P0778](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8593) Crosscheck of JVET-P0641 (Non-CE3: Combination of JVET-P0596 and JVET-P0531 on removal of 2xN chroma intra blocks) [[J. Choi (LGE)](mailto:jangwon84.choi@lge.com)]

[JVET-P0419](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8208) AHG16/AHG17: Simplification of CU Splitting Controls [T. Hellman, W. Wan, M. Zhou, B. Heng (Broadcom)]

The contribution says that VVC Draft 6 contains 14 syntax elements that control CU splitting possibilities, compared to five in the HEVC standard. This contribution contends that such a large number of controls adds unnecessary design complexity to VVC and introduces a significant burden to decoder testing and verification. It proposes to reduce the number of syntax elements to eight, and to remove them all from the slice header. The proposal claims that these reductions provide the same level of useful encoder flexibility while appreciably reducing the number of combinations to be implemented and tested.

The contribution says that the motivation for many of the limits established by syntax elements is to improve coding efficiency for encoders that are simplified to not check for splits under some circumstances – if these limits were not there, encoders could still choose not to split at these locations if they wish.

Specifically, the contribution focuses on:

* min\_luma\_coding\_block\_size: Smallest allowed CU size (width or height)
* max\_transform\_block\_size; Largest allowed TU size
* MaxMttDepth (Inter, IntraY, IntraC) (3 syntax elements): Max Bt/Tt split level
* MinQtSize (Inter, IntraY, IntraC) (3 syntax elements): Minimum size allowed for a Qt split
* MaxBtSize (Inter, IntraY, IntraC) (3 syntax elements): Maximum size allowed for a Bt split
* MaxTtSize (Inter, IntraY, IntraC) (3 syntax elements): Maximum size allowed for a Tt split

It was noted that the picture header concept had already been agreed at the meeting, so this aspect did not need discussion.

None of the proposed aspects affect the CTC.

Proposed aspects:

* Considering that "Min CU size" already exists, remove "MinQtSize" (3 syntax elements)
  + It was commented that this aspect has a coding efficiency benefit (note that a QT split can be emulated by two BT splits)
  + It was commented that we generally ought to test more non-CTC configurations to identify whether there is really compression gain available from the features that are there for that purpose.
* Merge the "Max Bt size" and "Max Tt size" (3 syntax elements).
  + It was commented that theseactually *are* used in the CTC. Fast encoders might want to not use Tt. A suggestion was to also provide a sequence-level disable flag for Tt.

Further study of these issues was encouraged.

[JVET-P0347](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8136) Comments on maximum MTT Depth and MinCbSize [T. Poirier, F. Le Léannec, F. Urban, F. Galpin (InterDigital)]

In VTM-6, the maximum multi-type tree (mtt) depth is signalled in the SPS and slice header as a fixed value, respectively for inter slice, intra luma slice and intra chroma slice (case of dual tree active for I slices). The value of the maximum MTT depth is in the range 0 to CtbSize – MinCbLog2SizeY. This range does not allow to reach the minimum Cb size using only MTT split in some configurations. This contribution proposes to increase the maximum range of max\_mtt\_hierarchy\_depth and to define a constraint on the range for log2\_min\_luma\_coding\_block\_size\_minus2 syntax element.

It is proposed that sps\_max\_mtt\_hierarchy\_depth\_intra\_slice\_luma and analogous syntax elements shall be in the range 0 to 2 \* ( CtbLog2SizeY − MinCbLog2SizeY). This is just a conformance issue, not a real restriction on what encoders can do.

Decision (BF): Adopt this aspect.

It also proposes to move sps\_max\_luma\_transform\_size\_64\_flag earlier in the syntax.

It is reported that log2\_min\_luma\_coding\_block\_size\_minus2 has no specified range, and proposed that the value of log2\_min\_luma\_coding\_block\_size\_minus2 shall be in the range of 0 to sps\_max\_luma\_transform\_size\_64\_flag ? 4 : 3, inclusive. (This is just to specify a range that makes sense, not to constrain usage.) A participant commented that an action taken in response to P0244 and P0429 may remove the need for this action, as reported in P0968.

This is just a conformance issue, not a signal processing issue. This was later said to be resolved by action taken on P0244.

[JVET-P0188](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7977) On constraining the maximum number of bits for a CU or CTU [T. Suzuki (Sony)]

Discussed Wed 9 Oct 1130 (GJS).

The main point of this one is not HLS.

This contribution proposes the maximum bits for CU/CTU and for picture. The proposed constraints are,

* Constraint on the maximum bits for CU/CTU
  + Constraint on the maximum bits for Min CU
  + Constraint on the maximum bits for CTU
* Constraint on the maximum bits for picture

In HEVC, the maximum bits for Min CU is constrained, and the information is signalled in VUI. The constraints are to reduce the worst case of bits at local area for cost feasible implementation. This contribution proposes to define a constrained on the maximum bits for MinCU for VVC and proposes related syntax elements in VUI.

This could also be constrained in profile/level definitions.

It was discussed whether to impose such a constraint at the CU level or CTU level or picture level.

A picture-level constraint roughly the same as in HEVC was also proposed.

A participant said the previous concern about wanting a local constraint is no longer really needed, and is a headache for encoders.

Decision: It was agreed to establish a picture-level constraint the same as in HEVC (using MinCR as a function of timing).

[JVET-P0582](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8373) AhG16: On dynamic internal bit depth [Y. Du, X. Zhao, X. Li, L. Zhao, S. Liu (Tencent)]

Discussed Wed 9 Oct 1145 (GJS).

In VTM-6.0, a fixed internal bit depth is implemented throughout all modules. When InternalBitDepth is greater than 8, 8-bit SIMD arithmetic instructions cannot be used. Since 8-bit SIMD instructions have higher throughput than 16-bit ones, this contribution proposes to use dynamic InternalBitDepth on certain modules which are not sensitive to bit depth. It is proposed to set InternalBitDepth to 8 in deblocking, intra planar mode, and intra angular mode, regardless of which InternalBitDepth is used globally.

It was asked whether this is just about coding 8 bit video or also for coding 10 bit video. It was also proposed even when processing 10 bit video.

It was commented that there could be subjective contouring effects. Also, this would be more critical at very low QP (obviously, especially with higher bit depth video).

It was also commented that we should not customize the design too much for particular implementations (e.g., 8-bit SIMD).

The proposal suggested to having different parts of the decoding process with different configurable bit depths.

No action was taken on this.

[JVET-P0865](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8680) Crosscheck of JVET-P0582: AhG16: On dynamic internal bit depth [K. Naser (InterDigital)] [miss\_end\_meeting]

[JVET-P0177](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7966) Non-CE3: On Constraint of CCLM and CST [C.-W. Kuo, J. Li, C.S. Lim (Panasonic)]

Discussed Wed 9 Oct 1200 (GJS).

To prevent the CCLM latency issue when CST is on, a CCLM enabling constraint (JVET-O1124) is applied in VVC Draft 6. However, it allows CCLM when luma VPDU is not split while chroma VPDU is split. It is proposed to disallow this case, to reduce hardware complexity for supporting luma subpart processing.

Simulation results were summarized as follows.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | **Random Access** | | | **Low Delay** | | |
| **Y** | **U** | **V** | **Y** | **U** | **V** | **Y** | **U** | **V** |
| Remove luma subpart processing | 0.00% | 0.12% | 0.07% | 0.01% | 0.08% | 0.07% | -0.02% | -0.05% | 0.16% |

The proposal suggested to change the constraint to disallow CCLM when 64x64 luma is not split but chroma is split.

It was commented that this case has no latency issue or clear implementation problem, so no strong need for action. The group was not convinced that there is a need to change this aspect.

[JVET-P0649](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8447) Crosscheck of JVET-P0177 (Non-CE3: On Constraint of CCLM and CST) [T.-S. Chang (Alibaba)]

[JVET-P0343](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8132) Flexible maximum MTT hierarchy depth [F. Le Léannec, F. Galpin, T. Poirier (InterDigital)]

HLS. [Ed. move the HLS-only contributions to a different section.]

[JVET-P0839](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8654) Cross-check of JVET-P0343 (AHG17: Flexible maximum MTT hierarchy depth) [M. G. Sarwer (Alibaba)]

[JVET-P0344](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8133) Overriding qtbtt\_dual\_tree\_flag [F. Le Léannec, K. Naser, F. Galpin, T. Poirier (InterDigital)]

HLS.

[JVET-P0348](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8137) On BT/TT flag signalling [T. Poirier, F. Le Léannec, F. Urban, F. Galpin (InterDigital)]

HLS.

[JVET-P0890](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8705) Crosscheck of JVET-P0348 (AhG17: On BT/TT flag signalling) [S.-T. Hsiang (MediaTek)]

[JVET-P0429](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8218) AHG17: On log2\_min\_luma\_coding\_block\_size\_minus2 [Y.-J. Chang, V. Seregin, M. Coban, A. Ramasubramonian, M. Karczewicz (Qualcomm)]

HLS.

[JVET-P0506](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8296) On max QT/BT/TT size signalling [Y. Du, X. Li, X. Zhao, B. Choi, S. Wenger, S. Liu (Tencent)]

HLS.

[JVET-P0764](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8579) Crosscheck of JVET-P0506: AHG17: On max QT/BT/TT size signaling [J. Jung, D. Kim, G. Ko, J. Son, J. Kwak (WILUS)]

[JVET-P0578](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8368) Interaction between dual tree and minimum CU size [T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

Presented in HLS BoG.

[JVET-P0580](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8371) On signalling CTU size in SPS [Y. Du, B. Choi, X. Li, X. Zhao, S. Wenger, S. Liu (Tencent)]

HLS.

## Chroma sampling and chroma formats (1)

Contributions in this category were discussed Wednesday 8 Oct. 1735–1750 in Track A (chaired by JRO).

[JVET-P0517](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8307) Support of adaptive color transform for 444 video coding in VVC [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

In this contribution, the adaptive color transform (ACT) tool in HEVC was implemented into the VVC framework, to efficiently reduce the redundancy between three color components of prediction errors in 444 videos. Same as in HEVC, color space conversion in the proposed implementation is carried out in residual domain. Additionally, to better suit the existing VVC tools, two additional changes are proposed: 1) move the ACT enabling/disabling flag from TU-level to CU-level; 2) disable the ACT when the separate-tree partition or intra sub-partition prediction (ISP) mode is applied.

Based on the same test sequences used for HEVC SCC, simulation results reportedly show that when the separate-tree partition is off the proposed ACT implementation provides average {G, B, R} BD-rate savings {9.4%, 3.6%, 4%}, {16.7%, 8.1%, 9.5%} and {23.4%, 10.6%, 12.3%} for AI, RA and LD configurations, respectively. When the separate-tree partition is on, the corresponding {G, B, R} BD-rate savings are {11%, 4.9%, 6.7%} and {20.7%, 9.2%, 11%} for RA and LD configurations.

LMCS is also enabled in both anchor and test, and performed after inverse ACT at decoder. It is reported that LMCS still provides some gain for G. Impact on results seems minor

Including ACT is straightforward, simple computation, and beneficial for case of 4:4:4 RGB coding. For YCbCr, no gain or minor loss is observed.

Decision: Adopt JVET-P0517. SPS flag is included in the spec text

Appropriateness of software and text was confirmed by crosscheckers.

[JVET-P0683](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8482) Crosscheck of JVET-P0517: Support of adaptive color transform for 444 video coding in VVC [X. Zhao (Tencent)]

## Lossless and near lossless coding (24)

Contributions in this category were discussed Sunday 6 Oct. 1145–1400 and Wednesday 8 1815-2145 in Track A (chaired by JRO).

[JVET-P0082](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7871) AHG18: BDPCM for Lossless [A. Nalci, H. Wang, H. E. Egilmez, M. Coban, M. Karczewicz (Qualcomm)]

In AHG18 VTM-6.0-lossless branch, transquant bypass (QB) mode provides a lossless alternative for VVC. This contribution proposes to enable block DPCM (BDPCM) coding when QB mode is used for lossless. Here, 5 different proposals are presented with varying bit-rate savings for lossless.

*For proposal #1*, we enable BDPCM for both transform skip (TS) residual coding and transform residual (TR) coding. The simulation results show overall bit-rate savings of -1.34% AI, and -0.30% RA with Class F: -3.80% AI, and -2.75% RA, and Class TGM: -3.54% AI, and -2.67 % RA.

*For proposal #2*, we enable BDPCM only for TR residual coding. The simulation results show overall bit-rate savings of -1.28% AI, and -0.26% RA, with Class F: -2.75% AI, and -1.14% RA, Class TGM: -1.58% AI, and -0.57% RA.

*For proposal #3*, we enable BDPCM only for TS residual coding. The simulation results show overall bit-rate savings of -0.46% AI, and -0.14% RA with Class F: -3.15% AI, and -2.52% RA, Class TGM: -3.16% AI, and -2.54% RA.

*For proposal #4*, we enable chroma BDPCM with TR residual coding on top of proposal #1. The simulation results show overall bit-rate savings of -2.21% AI, and -0.47% RA, with Class F: -5.37% AI, and -3.53% RA, Class TGM: -6.63% AI, and -3.63% RA.

*For proposal #5*, we enable chroma BDPCM both for TR and TS residual coding on top of proposal #2. The simulation results show overall bit-rate savings of -2.22% AI, and -0.48% RA, with Class F: -5.44% AI, and -3.67% RA, Class TGM: -7.64% AI, -4.12% RA.

It is basically shown that BDPCM has benefit for lossless coding, if enabled on top of the software used in the AHG study (which enabled the trans\_quant\_bypass (TQB) from HEVC, plus disabled the loop filters).

The proposal provides interesting information also in terms of the benefit of regular transform coding in combination with TQB and BDPCM (method 4). In that case, there is also benefit (1.7% AI) compared to HEVC.

It demonstrates that VVC could perform lossless encoding if such mechanisms were aailable, and invoking BDPCM is beneficial in such cases.

Study in CE

[JVET-P0807](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8622) Crosscheck of JVET-P0082 Proposal#4 and #5 (AHG18: BDPCM for Lossless) [T. Tsukuba (Sony)]

[JVET-P0896](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8711) Crosscheck of JVET-P0082 (AHG18: BDPCM for lossless) [Z.-Y. Lin (MediaTek)]

[JVET-P0147](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7936) AHG18: BDPCM in lossless coding [Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

This contribution is to improve the block-wise differential pulse code modulation (BDPCM) mode in lossless coding. In VTM6.0, the BDPCM processes are implemented in the quantization-related functions, which are skipped if a BDPCM block is coded with lossless mode. To fix this problem, it is proposed to move the forward BDPCM and backward BDPCM outside the quantization function and inverse quantization function, respectively, so the BDPCM processes will not be skipped in lossless mode coding. To further improve BDPCM in lossless coding, two methods are proposed. In Method 1, BDPCM is applied to both luma and chroma. In Method 2, unlike always applying transform skip (TS) coefficient coding to BDPCM blocks in VTM6.0, non-TS coefficient coding can be applied to BDPCM blocks. Three schemes are developed for Method 2. To indicate applying non-TS or TS coefficient coding to BDPCM blocks, Scheme 1 proposes a flag in the sequence parameter set (SPS), and Scheme 2 proposes a flag in the picture parameter set (PPS). Scheme 3 always applies non-TS coefficient coding to BDPCM blocks coded with lossless mode. The results of combining the bug fix, Method 1, and Method 2 with Scheme 3 reportedly show 2.23% and 0.57% bit savings under AI and RA, respectively, when compared to VTM6.0-lossless software.

About method 1:

* Already decided: BDPCM chroma for 4:4:4 from CE8, however no benefit was shown for low QP range (mostly motivated by design consistency for RGB)
* No results on BDPCM benefit for 4:2:0 case

Establish CE to investigate benefit of BDPCM for chroma in case of lossless coding

[JVET-P0775](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8590) Crosscheck of JVET-P0147, TEST1, TEST2 (AHG18: BDPCM in lossless coding) [Y.-W. Chen (Kwai)]

[JVET-P0148](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7937) AHG18: Disabling dependent quantization in lossless coding [Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek), T.-C. Ma, Y.-W. Chen, X. Xiu, H.-j. Jhu, X. Wang (Kwai), A. Nalci, H. E. Egilmez, M. Coban, M. Karczewicz (Qualcomm), M. G. Sarwer, R. Liao, J. Luo, Y. Ye (Alibaba)]

When enabling dependent quantization (DQ) at slice level, the conversion from coefficient levels to quantized coefficients and the quantization state (Q-state) dependent coefficient coding is performed in the coefficient parsing stage. The conversion from coefficient levels to quantized coefficients always changes the received residuals, which makes lossless coding impossible. The Q-state dependent coefficient coding was designed under lossy coding conditions and may not be beneficial for lossless coding. Therefore, Method 1 is proposed to achieve lossless coding by removing the conversion from coefficient levels to quantized coefficients, and has no impact on the VTM6.0-lossless software in BD-rate and runtime. Based on Method 1, Method 2 further disables the Q-state transition and fix the Q-state to state 0 during the coefficient coding. It reportedly shows 0.15% and 0.25% bit savings compared to the VTM6.0-lossless software under AI and RB, respectively, with negligible runtime changes. Based on Method 2, Method 3 further removes the signalling of the last significant coefficient position in lossless blocks. Results of Method 3 show 0.62 % and 0.67% bit savings compared to the VTM6.0-lossless software under AI and RA, respectively.

Study in CE -> using regular residual coding for lossless

[JVET-P0659](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8457) Crosscheck of JVET-P0148 (AHG18: Disabling dependent quantization in lossless coding) [N. Zhang (Bytedance)]

[JVET-P0149](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7938) AHG18: Disabling LMCS for lossless coding [Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

This contribution proposes two methods to achieve lossless coding when luma mapping with chroma residual scaling (LMCS) is enabled at sequence level and transquant bypass mode is enabled at picture level. In Method 1, if the transquant bypass mode is enabled at picture level, it is proposed to force disabling LMCS at slice level. In Method 2, it is proposed to force disabling LMCS for lossless coded blocks and to allow LMCS for lossy coded blocks. Both methods can support lossless coding for an entire picture and lossless coding for a partial picture.

Would only be relevant when lossless functionality was enabled via transquant bypass.

No need to study in CE

[JVET-P0176](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7965) AHG18: Lossless coding support related to cross-component ALF [J. Li, C. S. Lim (Panasonic)]

This contribution proposes to support CU level lossless coding related to cross-component ALF (CCALF) by disabling CCALF for samples wherein cu\_transquant\_bypass\_flag is true.

CCALF was not discussed yet. Beyond that, would only be relevant when lossless functionality was enabled via transquant bypass.

In any case, CCALF would be treated along with ALF.

[JVET-P0258](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8047) AHG18: Disabling Dependent Quantization for Lossless [A. Nalci, H. Wang, H. E. Egilmez, M. Coban, M. Karczewicz (Qualcomm)]

In VTM-6.0, trans quant bypass (QB) mode provides an early lossless alternative in VVC. Even though quantization and transform stages are bypassed in QB mode, residual coding still uses dependent quantization (DQ) and Q-state transitions in regular (non-TS) residual coding. We propose to disable DQ in QB mode such that Q-state is always 0 for lossless blocks.

Note that the changes are in residual coding, thus slice level DQ can still be 1 such that in a mixed lossy and lossless scenario, DQ will be used for blocks that are lossy coded, and DQ will not be used for lossless blocks.

Moreover, we present additional results for the proposals in JVET-P0082 after disabling DQ. These results are as follows:

* Variant #1: This proposal (JVET-P0258) combined with JVET-P0082 Proposal #1. In which BDPCM is enabled for both transform skip (TS) residual coding and regular transform (TR) coding for luma.
* Variant #2: This proposal combined with JVET-P0082 Proposal #3. In which BDPCM is enabled only for TS residual coding. TS and TR residual coding can still be used without BDPCM as in VTM-6.0.
* Variant #3: This proposal combined with JVET-P0082 Proposal #4. In this case BDPCM is enabled for both transform skip (TS) residual coding and regular transform (TR) residual coding for luma. Additionally, BDPCM is enabled for TR residual coding for chroma.
* Variant #4: This proposal combined with JVET-P0082 Proposal #5. In this case BDPCM is enabled for both transform skip (TS) residual coding and regular transform (TR) residual coding for luma. Additionally, BDPCM is enabled for **both** TR and TS residual coding for chroma.

Same as method 1 of JVET-P0148, plus combination with JVET-P0082.

Study in CE

[JVET-P0827](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8642) Crosscheck of JVET-P0258: AHG18: Disabling Dependent Quantization for Lossless [T.Poirier (Interdigital)]

[JVET-P0327](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8116) AHG18: Configurable Maximum Transform Size for Mixed Lossy and Lossless Coding [A. Nalci, H.E. Egilmez, H. Wang, Y.-H. Chao, M. Coban, M. Karczewicz (Qualcomm)]

This document proposes to enable configurable maximum transform size, which is normatively disabled by restricting the maximum transform size down to 32 in the latest version of the VTM-6.0 software provided by the AHG18 for lossless coding. In a mixed lossy and lossless coding setting, the proposed modifications allow transform sizes up to 64 (as in current CTC) for lossy coded blocks and keeps the current 32-size restriction for lossless coded blocks.

No evidence that this gives compression benefit, and it could be straightforward either leaving it to the encoder, or signal transquant bypass only for blocks <=32.

[JVET-P0816](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8631) Cross-check of JVET-P0327: AHG18: Configurable Maximum Transform Size for Mixed Lossy and Lossless Coding [H. Sun, J. Li (Panasonic)]

[JVET-P0463](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8252) AHG18: Residual coding method for lossless mode [M. G. Sarwer, R. L. Liao, J. Luo, Y. Ye (Alibaba)]

This contribution first reports and fixes a BDPCM-related software bug in the AHG18 lossless software. The bug fix achieves {-2.80%, -1.63%} rate reduction for {class F, TGM} in AI and {-1.18%, -0.55%} for {class F, TGM} in RA.

In VVC draft 6 and in the lossless software, when BDPCM mode is selected, transform-skip (TS) residual coding is used. This contribution allows BDPCM mode to select the residual coding method based on the value of cu\_transquant\_bypass\_flag. In the proposed method, if cu\_transquant\_bypass\_flag = 1, BDPCM mode selects transform residual coding, otherwise BDPCM mode selects TS residual coding. This contribution also proposes to remove signaling the position of last coefficient from the transform residual coding if cu\_transquant\_bypass\_flag = 1.

Following results are reported (Anchor is the VTM-6.0 lossless + Bug fix):

* Test 1: remove signaling the position of last significant coefficient
  + -0.51% (AI) and -0.44%(RA) BD-rate saving in CTC test conditions in lossless coding
* Test 2: select transform residual coding for BDPCM mode
  + -1.28% (AI) and -0.26%(RA) BD-rate saving in lossless coding
* Test 3: combine test 1 and test 2
  + –1.71% (AI) and -0.70%(RA) BD-rate saving in lossless coding

As an alternative, this contribution also proposes a SPS level flag to signal residual coding method of the BDPCM mode.

In version2 of the contribution, TS residual coding of VTM-6.0 lossless software is replaced by CE7-1.3.b alternative method proposed in JVET-P0072[2]. Following results are reported (Anchor is the VTM-6.0 lossless + Bug fix):

* Test 4: TS residual coding of VTM-6.0 is replaced by CE7-1.3.b-alt
  + -0.96% (AI) and -x.xx%(RA) BD-rate saving in lossless coding
* Test 5: Test 1 + test 4
  + -1.33% (AI) and -x.xx%(RA) BD-rate saving in lossless coding

One method identical as P0148, another method identical to P0258. See further notes there.

[JVET-P0914](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8729) Crosscheck of JVET-P0463 (AHG18: Residual coding method for lossless mode) [H. Jang (LGE)]

[JVET-P0466](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8255) AHG18: Residual coding for lossless video coding [J. Choi, H. Jang, J. Heo, S. Yoo, J. Lim, S. Kim (LGE)]

In this contribution, residual coding method for lossless coding is proposed. VVC includes two residual coding methods: transform skip (TS) residual coding and normal residual coding. AHG18 released initial lossless software where BDPCM blocks are coded by TS residual coding and other blocks are coded by normal residual coding. In this contribution, TS residual coding for (i) intra and IBC modes (ii) IBC mode (iii) entire modes are suggested in lossless coding. In addition, we tested VTM-6.0 TS residual coding, CE7-1.2d, and CE7-1.2d-alternative methods.

No detailed presentation needed, not relevant in context of the new TS residual coding method.

Provides benefit mostly for TGM, but requires additional conditions where regular and TS specific residual coding is used.

Study in CE

[JVET-P0824](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8639) Crosscheck of JVET-P0466: Test #3, #4, and #5 [T. Nguyen (HHI)]

[JVET-P0467](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8256) AHG18: Rice parameter extension [J. Choi, H. Jang, J. Heo, S. Yoo, J. Lim, S. Kim (LGE)]

This contribution introduces an extended Rice parameter based on lossless coding flag (i.e., cu\_transquant\_bypass\_flag). The proposed method is tested with the lossless residual coding in JVET-P0466, where transform skip residual coding methods in CE7-1.2d and CE7-1.2d-alternative are used for intra and IBC modes of lossless coding. Specifically, the proposed method extends maximum Rice parameter without additional look-up table or signaling.

No detailed presentation needed, not relevant in context of the new TS residual coding method.

[JVET-P0774](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8589) Crosscheck of JVET-P467, TEST2, TEST4 (AHG18: Rice parameter extension) [Y.-W. Chen (Kwai)]

[JVET-P0477](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8266) AHG18: On Last Position Signaling for Lossless [A. Nalci, H. E. Egilmez, M. Coban, M. Karczewicz (Qualcomm)]

In AHG18 VTM-6.0-lossless branch, transquant bypass (QB) mode provides a lossless alternative in VVC. This can be achieved by setting a CU-level cu\_transquant\_bypass\_flag=1. In the lossy version of VVC, last position of primary transform coefficients is explicitly signaled and used in various inference schemes for LFNST and signaling of significant flags/groups. In the lossless setting, last position signaling may carry signaling overhead. This is because transform coefficients are in the frequency domain and lossless residuals are in the spatial domain and lossless residuals are not necessarily clustered in the top-left corner of a transform block.

*In proposal #1*, we disable last position signaling for lossless. The simulation results show overall bit-rate savings of -0.59% AI, -0.47% RA, and -0.53% LDB.

*In proposal #2*, we disable last position signaling on top of JVET-P0082 Proposal #1. In this case BDPCM is enabled for lossless for both TS and transform residual coding. The simulation results show overall bit-rate savings of -1.83% AI, -0.76% RA, and -1.01% LDB.

*In proposal #3*, we disable last position signaling on top of JVET-P0082 Proposal #4. In this case BDPCM is enabled for lossless for both TS and transform residual coding, additionally chroma BDPCM is allowed. The simulation results show overall bit-rate savings of -2.68% AI, -0.92% RA, and -1.15% LDB.

*In proposal #4*, we disable last position signaling on top of JVET-P0258 Proposal #1. In this additional test we disable dependent quantization for lossless blocks.

Would only be relevant when lossless functionality was enabled via transquant bypass.

No action.

[JVET-P0826](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8641) Crosscheck of JVET-P0477: Last coding for lossless [T. Nguyen (HHI)]

[JVET-P0979](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8794) Cross-check of JVET-P0477: AHG18: On Last Position Signaling for Lossless Test4 [H. Sun, J. Li (??)]

[JVET-P1014](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8829) Crosscheck of proposal 2 and 3 of JVET-P0477 (AHG18: On Last Position Signaling for Lossless) [M. G. Sarwer (Alibaba)]

[JVET-P0485](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8274) AHG18: Performance of CE7-1.2d and CE7-2.2 on lossless coding [Y.-H. Chao, A. Nalci, H. Wang, M. Coban, M. Karczewicz (Qualcomm)]

This document reports the transform skip modification proposed in CE7-1.2d-alternative and the transform skip binarization proposed in CE7-2.2a-alternative for lossless coding. Two test scenarios are tested: In the first scenario, the anchor base uses only regular transform residaul coding (TR) for lossless coding with BDPCM support in luma and the test base uses only transform skip (TS) residual coding with BDPCM support in luma and chroma. In the 2nd scenario, the anchor base is AHG18 lossless branch and the test base is the method 1 in JVET-P0082, which enables transform (TR) residual coding, transform skip (TS) residual coding, and BDPCM for lossless coding. The results show:

* 1st test scenario (TR only v.s. TS only)
  + CE7-1.2d-alternative:

Overall: -1.64% AI, 0.40% RA, xxx% LB

Class F: -2.92% AI, -1.39% RA, -2.37% LB

Class TGM: -7.03% AI, -9.45% RA, xxx% LB

* 2nd test scenario (AHG18 v.s. TS + TR)
  + CE7-1.2d-alternative:

Overall: -2.72% AI, -1.28% RA, -1.51% LB

* + CE7-2.2a-alternative:

Overall: -3.30% AI, -1.69% RA, -1.92% LB

No detailed presentation needed, not relevant in context of the new TS residual coding method.

There is a new document JVET-P1028, which combines this with the new TS residual coding.

[JVET-P0956](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8771) Crosscheck of JVET-P0485 (AHG18: Performance of CE7-1.2d and CE7-2.2 on lossless coding) [J. Choi, J. Lim (LGE)]

[JVET-P0502](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8292) AHG18: Interaction between lossless coding and max transform size [X. Zhao, X. Li, S. Liu (Tencent)]

In AHG18, coding tools for lossless and near-lossless coding are being studied for VVC. The initial VTM-6 based SW supporting lossless coding mode has been released through JVET reflector, and the changes include a configuration on setting maximum transform size to be 32x32 because 64-length transform cannot guarantee lossless coding. In this contribution, it is proposed to avoid redundant signaling of lossless coding flag if transform size is greater than 32.

Not relevant as there will not be something as a “lossless coding flag”.

[JVET-P0514](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8304) AHG18: Enable lossless coding for VVC [T.-C. Ma, Y.-W. Chen, X. Xiu, H.-J. Jhu, X. Wang (Kwai Inc.)]

This contribution is proposed to enable the lossless coding mode for VVC. Several aspects are tested and integrated into a lossless package for VVC lossless.

The test result shows significant reduction on encoding time while similar coding performance between anchor [1] and proposed modification. The coding performance comparing to AHG18 reference software [1] is 0.00%, 0.10%, and -0.02% for All Intra, RA, and LDB, respectively. Meanwhile, the encoder runtime reduction is 42%, 23%, and 3% for All Intra, RA, and LDB, respectively.

Based on transquant bypass. No need for action.

[JVET-P0916](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8731) Crosscheck of JVET-P0514 (AHG18: Enable lossless coding for VVC) [H. Jang (LGE)]

[JVET-P0521](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8311) AHG18: Disabling DMVR and BDOF for lossless coding [T.-C. Ma, Y.-W. Chen, X. Xiu, H.-J. Jhu, X. Wang (Kwai Inc.)]

This contribution is proposed to disable the DMVR and BDOF under lossless coding. The result shows that the coding loss is 0.03%, 0.00% for RA, and LDB, respectively

Based on transquant bypass. No need for action.

[JVET-P0955](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8770) Cross-check of JVET-P0521 (AHG18: Disabling DMVR and BDOF for lossless coding) [J. Choi, J. Lim (LGE)]

[JVET-P0525](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8315) AHG18: Residual coding selection signaling for lossless VVC [T.-C. Ma, Y.-W. Chen, X. Xiu, H.-J. Jhu, X. Wang (Kwai Inc.), Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S. Lei (MediaTek)]

This contribution is proposed to signal 1 bit syntax to select residual or transform coefficient coding scheme for lossless. Four tests are provided in this contribution.

The test1 is signaling 1 bit syntax in cu level to select either residual coding or transform coefficient coding for current CU. The result of test1 is XXX %, XXX %, and XXX % in All Intra, RA, and LDB, respectively.

The test2 is based on JVET-P0058 [1] and signaling 1 bit syntax by reusing the **transform\_skip\_flag** to indicate the selection between residual coding and transform coefficient coding scheme for non-BDPCM modes. The result of test2 is XXX%, XXX%, XXX% in All Intra, RA, and LDB, respectively.

The test 3 is based on JVET-P0059 [2], enabling BDPCM and Transform-skip coding for chroma. The selection of coding scheme is signaled by **transform\_skip\_flag**. The result of test3 is XXX%, XXX%, XXX% in All Intra, RA, and LDB, respectively.

The test 4 is an alternative of test 1, same encoder but different decoder by signaling 1 bit syntax in tb level to indicate the selection of coding scheme for non-BDPCM modes. The result of test4 is XXX%, XXX%, XXX% in All Intra, RA, and LDB, respectively.

Study in CE, but also study if it is really necessary signalling at CU level.

[JVET-P0757](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8561) Crosscheck of JVET-P0525 Test2 (AHG18: Residual coding selection signaling for lossless VVC) [T. Tsukuba (Sony)]

[JVET-P0804](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8619) Crosscheck of JVET-P0525 (AHG18: Residual coding selection signaling for lossless VVC) [J. Heo (LGE)]

[JVET-P0858](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8673) Crosscheck of JVET-P0525 (AHG18: Residual coding selection signaling for lossless VVC) [L. Zhao (Tencent)]

[JVET-P0528](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8318) AHG18: On residual scanning order for lossless coding [T.-C. Ma, Y.-W. Chen, X. Xiu, H.-J. Jhu, X. Wang (Kwai Inc.)]

In this contribution it is proposed to rotate the residual blocks if transform coefficient coding is applied for lossless coding. The result shows that compared with AHG18 lossless coding anchor, the coding gain is -0.42%, -0.14%, -0.12% for All Intra, RA, and LDB, respectively.

Straightforward and simple.

Study in CE as improvement of regular residual coding

[JVET-P0671](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8470) Crosscheck of JVET-P0528 (AHG18: On residual scanning order for lossless coding) [Z.-Y. Lin (MediaTek)]

[JVET-P0559](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8349) AHG18: Rice parameter derivation for coefficient level coding in lossless [M. Karczewicz, H. Wang, Y.-H. Chao, M. Coban (Qualcomm)]

This document proposes new rice parameter derivation methods for coding abs\_remainder in transform (TR) residual coding and transform skip (TS) residual coding in lossless coding. In the first method, a new rice parameter derivation for transform (TR) residual coding is proposed. The method is implemented on top of method 1 in JVET-P0082 (JVET-P0082-m1), where transform (TR) residual coding, transform-skip (TS) residual coding, and BDPCM are used for lossless coding (transQuanBypass = 1). In the second method, besides the rice parameter derivation for TR as proposed in method 1, a new rice parameter derivation for TS is proposed. The method is implemented on top of method 1 in JVET-P0485 (JVET-P0082-m1 + CE7-1.2d-alternative TS coding) and JVET-P0082-m1.

Study in CE as improvement of regular residual coding, and potentially the 7-1.3b\* method

[JVET-P0825](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8640) Crosscheck of JVET-P0559: Rice parameter derivation for lossless [T. Nguyen (HHI)]

[JVET-P0574](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8364) AHG18: BDPCM residual coding for lossless coding [H. Jang, J. Choi, J. Nam, S. Kim, J. Lim (LGE)]

In VVC, the transform\_skip\_flag is inferred to be 1 when the current CU is BDPCM coded block, and transform skip residual coding is used. Since transform skip mode and the BDPCM mode are not supported for chroma block, regular residual coding is used for chroma block. This contribution proposes to use regular residual coding pass for BDPCM coded block when lossless mode is engaged so that unified residual pass is used for lossless coded block. The experimental result shows 0.05%, 0.05% for AI, 0.04%, -0.01% for RA and 0.070%, 0.03% for LDB Bd-rate change for SCC and TGM respectivly. Over anchor which is initial lossless software of AhG18 with bugfix for BDPCM lossless.

Seems to be similar as JVET-P0082, but gains are somewhat lower. Conceptionally, it is not desirable to make the selection depending in various other coding modes. Not obvious what the benefit is.

[JVET-P0841](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8656) Cross-check of JVET-P0574 (AHG18: BDPCM residual coding for lossless coding) [M. G. Sarwer (Alibaba)]

[JVET-P0576](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8366) AHG18: on low level coding for lossless [H. Jang, J. Choi, J. Nam, S. Kim, J. Lim (LGE)]

This contribution suggests to support lossless coding for VVC. In this proposal, in order to adaptively control whether lossless coding or lossy coding, a flag is transmitted to bypass transform and quantization in CU level as HEVC, and several low level coding tools are disabled for lossless block. The mandatory low level coding tool restriction is described as below:

1. Disabling transform related coding tools and syntax signaling; MTS, LFNST, SBT and transform skip for lossless coded block.
2. Disabling JointCbCr and the syntax signaling for lossless coded block
3. Disabling LMCS in slice level and the syntax signaling
4. Disabling sign data hiding for transform/quantization bypass block.

In order to support co-existence between the lossless coding and lossy coding at the CU-level, the following additional restrictions are suggested.

1. Bypass ALF processing for lossless coded block.
2. Support residual coding for Size MxN(M= 64 or N = 64) when MaxTbSize of 64 is signaled in SPS.
   1. Implicit TU tiling to 32 for lossless block
   2. Extend coefficient scanning

No need for action. Implicit TU tiling agreed by discussion in CE3 (JVET-P0352). It is further noted that lossless coding will be possible in VTM7, but existing high level flags together with appropriate signalling at block level are sufficient to disable tools that would be in conflict.

[JVET-P0776](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8591) Crosscheck of JVET-P0576 (AHG18: on low level coding for lossless) [Y.-W. Chen (Kwai)]

[JVET-P0834](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8649) Cross-check result of JVET-P0576: AHG18: on low level coding tool for lossless coding (mipTuTiling) [Z. Zhang (Ericsson)]

[JVET-P0584](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8375) AHG18: BDPCM for luma and chroma in lossless coding [T. Tsukuba, M. Ikeda, Y. Yagasaki, T. Suzuki (Sony)]

This contribution proposes to enable BDPCM for Luma and Chroma in lossless coding. TS residual coding is used for lossless coding when BDPCM is used while regular coding is used when BDPCM is not used. Proposed method has been integrated on top of CE8-4.1 source code. The coding performance comparing to AHG18 reference software is -0.79%, -0.17 % and z.zz% for AI, RA, and LB, respectively.

Note that simulations for classTGM for LB are not finished yet. It will be updated in the next revision.

Study in CE

[JVET-P0770](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8585) Crosscheck of JVET-P0584 (AHG18: BDPCM for luma and chroma in lossless coding) [Y.-W. Chen (Kwai)]

[JVET-P0606](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8399) AHG18: Enabling lossless coding with minimal impact on VVC design [[B. Bross](mailto:benjamin.bross@hhi.fraunhofer.de), T. Nguyen, H. Schwarz, D. Marpe, T. Wiegand (HHI), M. Karczewicz, Y.-H. Chao, H. Wang, M. Coban (Qualcomm)]

This contribution analyses the required changes to enable lossless coding in VVC. To facilitate lossless coding with minimal impact on current VVC syntax and decoding process, it is proposed to enable transform skip for chroma as tested in CE8-2.1 (JVET-P0058). In addition to that, in order to improve the coding efficiency with regard to an HM lossless anchor, the modified transform skip residual coding as tested in CE7-1.2d is proposed (JVET-P0079). The proposed design enables lossless coding with minimal impact on the syntax, i.e. without introducing an additional cu\_transquant\_bypass\_flag for lossless coding and condition other normative parts on that new syntax element. Compared to the HM lossless anchor, results show a bit-rate reduction of 5.27% for AI and 1.23% for RA and compared to the AHG18 VTM lossless anchor, results show a bit-rate reduction of 0.01% for AI and a bit-rate increase of 2.48% for RA.

The CU-level flag *cu\_transquant\_bypass\_flag* is introduced that controls the following:

* skips transform but compared to VTM transform skip:
  + skips transform\_skip\_flag syntax
  + skips transform also for chroma
  + skips transform for ISP
  + uses regular residual coding instead of transform skip residual coding
* disables scaling for luma and chroma, incl. dep. quantization (implicitly signalled)
* disables sign hiding (implicitly signalled)
* skips SBT syntax (implicitly signalled, syntax inferred as disabled)
* skips LFNST syntax (implicitly signalled, syntax inferred as disabled)
* disables deblocking (implicitly signalled)
* disables SAO (implicitly signalled)

In addition to that, the encoder needs to be configured as follows:

* Set maximum transform size to 32x32 (explicitly signalled)
* Disables Joint Cb Cr Residual (JCCR) coding on block level (explicitly signalled as 0)
* Disables BDPCM (not required and reported as a bug, signalled but never executed)
* Disables LMCS (explicitly signalled)
* Disables ALF (explicitly signalled)

It is noted that in case where only some regions of a picture are lossless coded, some of the above global disabling mechanisms might need to be put into the functionality of transquant bypass.

An alternative method to achieve lossless functionality would be invoking TS for chroma as well (adopted at this meeting for 4:4:4, but not 4:2:0), and use sufficiently low QP

The transquant bypass approach enables lossless functionality by imposing additional complexity to the decoder, whereas the method via TS and low QP would need more actions at the encoder, and likely have less compression performance for the case of local lossless coding.

There is also indication that with the newly adapted method of TS residual coding, the compression improves.

It is still open whether for lossless coding conventional residual coding or the new TS residual coding is better. The VTM6 TS residual coding was found to be worse.

* See further discussion in Sunday plenary.

From the discussion in track A, the method which puts the burden at the encoder is preferable. The only still necessary normative change is enabling TS for all chroma sampling schemes (see right column below).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **TOOL** | **AHG18 lossless anchor** | **Change** | **Proposed** | **Change** |
| SBT off | implicitly (transquant bypass) | yes | explicitly | no |
| LFNST off | implicitly (transquant bypass) | yes | explicitly | no |
| skip trafo Y | implicitly (transquant bypass) | yes | explicitly | no |
| skip trafo Cb | implicitly (transquant bypass) | yes | explicitly | yes |
| skip trafo Cr | implicitly (transquant bypass) | yes | explicitly | yes |
| skip trafo for ISP | implicitly (transquant bypass) | yes | no | no |
| BDPCM off | explicitly | no | explicitly | no |
| residual coding | regular | yes | transform skip (TSRC) | no |
| scaling off | implicitly (transquant bypass) | yes | implicitly (QP < 5) | no |
| JCCR off | explicitly | no | explicitly | no |
| SDH off | implicitly (transquant bypass) | yes | implicit (TSRC) | no |
| MaxTrafoSize=32x32 | explicitly | no | explicitly | no |
| LMCS off | explicitly | no | explicitly | no |
| DF off | implicitly (transquant bypass) | yes | explicitly | no |
| SAO off | implicitly (transquant bypass) | yes | explicitly | no |
| ALF off | explicitly | no | explicitly | no |

Further Information about results with 7-1.3b\* TS residual coding was reported Wednesday 8 Oct. See JVET-P1025

[JVET-P1025](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8840) Performance of CE7-1.3b\* in Lossless Mode [[T. Nguyen](mailto:tung.nguyen@hhi.fraunhofer.de), [B. Bross (HHI)](mailto:benjamin.bross@hhi.fraunhofer.de)] [late]

(include abstract)

Initial results were presented Wed. 8 (RA classes A1/A2 not available)

The results indicate that the method 7-1.3b\* performs significantly better than the previous TS residual coding also for the case of lossless. However, compared to the anchor used in AHG18, it still performs significantly worse for camera content, but better for screen content (where the latter fact might also be caused by using BDPCM).

Some more information is provided showing that by using some elements with modified GR table the gap towards the AHG18 anchor is smaller (the late contribution JVET-P1028 relates to that).

Notes regarding the CE on lossless coding

These results indicate that the version of lossless coding that would be available in VTM7 / draft 7 can further be optimized, and various aspects need to be better understood, including the questions

* Is the regular residual coding better than the TS residual coding in case of camera captured content?
* Would it be useful to have TS/BDPCM switchable between the two methods of residual coding? If yes, at which level should this be signalled?

Some proposals at this meeting (including the AHG18 software) seem to benefit from using the transquant bypass functionality for invoking the regular residual coding with TS. This might be better implemented at a higher level.

It is agreed that such a flag should not impose other decoder functionality such as not parsing various other tools flags, disabling loop filters, etc. as from the table in JVET-P0606.

These aspects should be investigated in a CE on lossless coding. The anchor of that CE should be the new TS residual coding, with QP4, BDPCM disabled. The CE should test BDPCM for both luma and chroma, also in 4:2:0 case.

The CE would only study the global lossless coding, not aspects of mixed lossy/lossless.

From the current evidence, it appears that the “TS residual coding”, if operated for lossless coding, only shows benefit for screen content (as is the case for lossy coding). There are however several proposals whih try to further improve it, e.g. by further modifications of Rice parameter mapping, making its usage dependent on more coding modes, etc. These aspects should be studied in a separate branch of the CE. The goal of this CE should be to improve the performance of TS residual coding, such that it becomes competitive (or better) for camera captured content for the lossless case. Proposals that only gain for screen content should not be considered.

The most desirable solution would be to have only one method of TS residual coding that is likewise performant for screen content and natural content when operated in lossless mode, and has good performance at least on screen content when operated in lossy mode.

[JVET-P0684](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8483) Crosscheck of JVET-P0606: Enabling lossless coding with minimal impact on VVC design [L. Zhao, X. Zhao (Tencent)]

[JVET-P0607](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8400) AHG18: Two Stage Residual Coding for Lossless [B. Bross, T. Nguyen, H. Schwarz, D. Marpe, T. Wiegand (HHI)] [late]

This contribution proposes two stage residual coding to improve the coding efficiency for the lossless coding use case. The proposed technique invokes the residual coding/decoding a second time to encode/decode the quantization error signal to allow for lossless coding. The proposed method provides 4.94% bit-rate reduction for AI compared to the AHG18 VTM lossless anchor and 9.95% bit-rate reduction compared to the HM lossless anchor.

Interesting gain, but the method doubles the possible maximum number of context coded bins. This is a kind of layered coding approach aka SNR scalability, where it is likely that the second layer has large number of context coded bins. Also requires two coding passes of each block, which would be too much additional complexity. It is unlikely that the gain would be kept when the number of context coded bins was reduced.

Further study recommended (not CE)

[JVET-P0721](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8522) Crosscheck of JVET-P0607: AHG18: Two Stage Residual Coding for Lossless [Y.-H. Chao (Qualcomm)]

[JVET-P0612](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8406) AHG18: Non-Lossless Coding Tools in VVC [T. Nguyen (HHI)] [late]

This document reports the results for a test configuration with several coding tools disabled that are not necessary for the lossless operation mode. Using a non-official lossless software package provided by the AHG18, the following coding tools are disabled by the encoder: ALF, DB, SAO, DepQuant, RDOQ, RDOQTS, MTS, LFNST, SBT, LMCS, and JointCbCr. The results show a slight improvement with the encoding time significantly decreases for AI and RA.

It is noted that this contribution could be valuable to define encoder settings in the VVC7 lossless anchor for the CE.

[JVET-P1028](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8843) AHG18: CE7.1.2d aligned with JVET-P0072 and JVET-P0298 methods for TS only based lossless coding JVET-P0606 [[H. Wang](mailto:hongtaow@qti.qualcomm.com), Y.-H. Chao,Coban, M. Karczewicz (Qualcomm)] [late]

This contribution combines CCB count check method of P0072, and level mapping removal in last coding pass of P0298 along with 1.75bin/coefficient CCB limit with CE7-1.2d alternative scheme and reports performance for TS based lossless coding.

Partial results show interesting gain (TS residual coding improves over AHG18 anchor).

Study in CE.

## Miscellaneous coding tools (6)

[JVET-P0394](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8183) AHG13: Luma clipping instead of LMCS [S. Keating, K. Sharman, A. Browne (Sony)]

Discussed Saturday 0915 in Track B (GJS).

This contribution compares the effect of clipping the reconstructed luma (clipping before in-loop filtering) with that obtained with LMCS, as commented during the 15th JVET meeting. An overall luma BD-rate gain of 0.08% for the CTC and in particular a gain of 1.58% on the TGM image class was reported over the LMCS tool-off anchor at AI. However, losses are reported against VTM6.1 (with LMCS enabled) of 1.01% and 1.64% for luma in AI and RA respectively (but similar gains for chroma).

Simple clipping of the reconstructed luma image thus gives only a small proportion of the gain of LMCS (even allowing for the limitations of a 4-point BD-rate calculation) but it does give significant gain for screen content.

So this basically confirms that LMCS has more value than simple clipping. There was no real interest in adding some other clipping as an additional feature.

[JVET-P0254](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8043) Issue of simplified luma mapping of LMCS [K. Abe, T. Toma (Panasonic)]

Discussed Saturday 0930 in Track B (GJS).

JVET-O0272 was adopted at the previous meeting as the encoder constraints for luma mapping of LMCS. But it reportedly has two problems; 1) Multiple pivots are assigned to one segment when the value of pivot is a multiple of 32, and 2) An unintended mapping table is generated when the input is other than 10 bit depth. This contribution proposes a modification for the constraints. The simulation results reportedly show that the proposed method has no BD-rate change on VTM-6.0 under the CTC.

No coding gain difference was reported.

Others commented that the intent of the design was different from what was described in regard to the first aspect.

There was agreement on the second aspect.

Decision (bug fix): Adopt the fix that results in always having 32 segments regardless of bit depth.

Comment: As a general comment, it was suggested for the software group or AHG13 to do some testing of 8 bit and 12 bit and RGB coding.

[JVET-P0383](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8172) Non-CE: JCCR and LMCS interaction [K. Fan, L. Zhang, K. Zhang, Y. Wang (Bytedance)]

Discussed Saturday 0945 in Track B (GJS).

In VVC draft 6, joint coding of chroma residuals (JCCR) and Luma Mapping with Chroma Scaling (LMCS) could be applied sequentially for the chroma residual coding. When JCCR is enabled, the two chroma residual blocks are derived first, followed by LMCS applied twice on each of the two chroma components separately. In this contribution, it is proposed LMCS to be applied once to the joint chroma residual, followed by JCCR to derive the residuals of the two chroma components. With the proposed method, it is asserted that the computational complexity of the per-sample chroma scaling and residual clipping of two chroma blocks could be saved by 50% when JCCR is enabled. Experimental results reportedly show that the BD-rate changes are negligible, i.e., 0.00%/0.02%/0.01%/, 0.00%/0.07%/-0.06%, -0.04%/0.17%/0.21% for Y/Cb/Cr under AI, RA, and LB configurations, respectively. The savings would be one clipping and one scaling per chroma sample.

It was commented that architecturally, if this change is adopted, there would need to be a different treatment to be able to invoke the process in two different places. One participant said that the current design provides more hardware implementation flexibility. This would require JCCR to be done in the prediction stage – changing the ordinary order – whereas otherwise there would be a choice available to put it in a different stage. At least for hardware, it was commented that there would be no benefit to the change. For software it would have some benefit but likely very small.

No action taken, as there is not a compelling benefit.

[JVET-P0712](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8513) Crosscheck of JVET-P0383 (Non-CE3: JCCR and LMCS interaction) [T. Lu (Dolby)]

[JVET-P0417](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8206) AHG13: Removal of ISP [T. Hellman, B. Heng, W. Wan (Broadcom)]

Discussed Saturday 1000 in Track B (GJS).

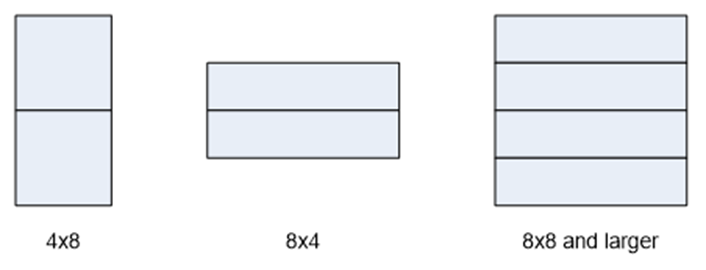
This contribution proposes a claimed simplification to VVC by the removal of the intra subblock partitioning (ISP) mode. It contends that ISP does not provide sufficient coding gain to justify its design complexity, especially at higher resolutions. It further claims that the unique transform and prediction sizes defined by ISP add an implementation and verification burden to decoders. The proposal recommends the complete removal of ISP mode from the text.

The tools with the lowest apparent gain in AHG13:

* SAO
* Multi-reference-line prediction
* Intra subblock partitioning
* Combined intra-inter prediction
* Symmetric motion vector difference

SAO has other justifications, such as use as an alternative to ALF and a subjective benefit argument, and was reported to have already been discussed; the others were suggested to be more in need of study.

The intra subblock partitioning (ISP) tool works by dividing an intra luma CU into 2 or 4 vertical or horizontal partitions. These partitions determine the transform unit (TU) size and, in most cases, the prediction unit (PU) size as well. The figure below provides some examples.



ISP substantially increases the number of 2D TU shapes. Others commented that most of the combinations are already in other parts of the design. Another participant commented that intra gain is especially difficult to obtain, and this is an intra feature (and this shows more gain in intra mode). Within RA and LB usage, intra frames cause bit rate fluctuation and have a delay effect. It was commented that it may have subjective effects as well.

[JVET-P0561](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8351) AHG16: Context restriction on CTU boundary for line buffer reduction [H.-J. Jhu, Y.-W. Chen, X. Xiu, T.-C. Ma, X. Wang (Kwai Inc.)]

Discussed Saturday 1045 in Track B (GJS).

This contribution proposes to reduces the line buffer of matrix intra prediction (MIP) and CU Depth information storage. For MIP mode flag storage, the context selection for the CABAC coding of MIP flag is not depending on the MIP flag of above CU when the above CU is not located in the same CTU as current CU. Compared to VTM6, the BD-rate results are 0.00%, 0.00%, and -0.04 % for AI, RA and LD, respectively, without increasing encoding and decoding time.

For intra mode flag storage, the context selection for the CABAC coding of prediction mode flag is not depending on the intra mode flag of above CU when the above CU is not located in the same CTU as current CU. Compared to VTM6, the BD-rate results are 0.01% and 0.00% for RA and LD, respectively, without increasing encoding and decoding time.

For depth information storage, the context selection for the CABAC coding of quadtree (or called QT) split flag is not depending on the depth information of above CU when the above CU is not located in the same CTU as current CU. Compared to VTM6, the BD-rate results are -0.01%, 0.01%, and 0.01% for AI, RA and LD, respectively, without increasing encoding and decoding time.

It was commented that similar proposals had been submitted before, but that the amount of line buffering currently does not seem like such a big issue. No strong need for action seemed evident.

[JVET-P0636](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8433) Crosscheck of JVET-P0561 (AHG16: Context restriction on CTU boundary for line buffer reduction) [T.-H. Li, C.-Y. Teng (Foxconn)]

[JVET-P0970](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=8785) AHG13: Additional ISP Tool-off tests [S. De-Luxán-Hernández, V. George, G. Venugopal, J. Brandenburg, B. Bross, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

The contributor indicated that this document did not need detailed presentation. It is available for study, and is summarized below.

This document provides additional tool-off tests of the ISP coding mode with the LFNST combination proposed in JVET-P0392, for higher QP ranges than for CTC and for lossless coding. The reported losses when turning ISP off are:

* AHG13: AI: 0.41% (Y), 86% (Enc), 97% (Dec) RA: 0.20% (Y), 98% (Enc), 100% (Dec)
* JVET-P0392 t2: AI: 0.52% (Y), 85% (Enc), 98% (Dec) RA: 0.30% (Y), 96% (Enc), 99% (Dec)
* QP 27,32,37,42: AI: 0.60% (Y), 87% (Enc), 98% (Dec) RA: 0.27% (Y), 98% (Enc), 99% (Dec)
* QP 32,37,42,47: AI: 0.84% (Y), 89% (Enc), 98% (Dec) RA: 0.35% (Y), 98% (Enc), 100% (Dec)
* AHG18 lossless: AI: 0.67%, 84% (Enc), 106% (Dec) RA: 0.12%, 98% (Enc), 100% (Dec)

## Neural networks (1)

Contributions in this category were discussed Wednesday 8 1750–1810 in Track A (chaired by JRO).

[JVET-P0489](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8278) AHG9: Multiple Convolution Neural Networks for Sequence-Independent Processing [H. Yin, R. Yang, X. Fang, Z. Gao, R. Yang (Intel)] [late]

In this proposal, Multiple Convolutional Neural Networks (MCNN) is proposed that extends the concept of multiple CNNLFs in ACNNLF to the sequence independent method. The multiple CNNs can be trained offline with external dataset without additional training pass in the encoding process. Both in-loop filter and post filter modes are implemented and compared, and we recommend the continue study of post filter mode in AHG that may be optional enabled in decoder side by using SEI message.

Compared with VTM-6.0-RA, the proposed MCNN (post filter mode) achieves –1.75%, -9.67 %, and – 9.43% BD-rates for Y, U, and V, respectively, for Class A1 video sequences; -2.00 %, -14.72 %, and – 12.41% BD-rates for Y, U, and V, respectively, for Class A2 video sequences; -1.16 %, -13.97 %, and – 11.01 % BD-rates for Y, U, and V, respectively, for Class B video sequences; and -1.24%, -4.80 %, and – 4.69 % BD-rates for Y, U, and V, respectively, for Class C video sequences.

Selection of CNN type is performed at CTU level

Training was performed with independent set (DIV2K 800 images)

Average decoder run time increase 150x on CPU. Encoder increase 1.3x

It is pointed out that the SEI message would need a description of the network types which could become very large

If in the future a majority of devices would be equipped by GPUs, such an approach might be more attractive in terms of decoder runtime

Currently, 3 types of networks plus the option using none is signalled per CTU.

Network has 9 layers, all convolutional with ReLU.

Further study recommended, nothing for immediate action.

## 360 degree video (2)

Contributions in this category were discussed XXday X Oct. XXXX–XXXX in Track X (chaired by XXX).

[JVET-P0315](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8104) Modified 360Lib for more flexible cube face arrangements [J. Sauer, M. Bläser (RWTH Aachen)

This contribution was discussed Thursday 10 October at 1845 in Track B (GJS).

This document describes a modification of the 360Lib software for more flexible packing of cube faces into a frame. The modified software removes restrictions on face size and positioning and adds at-runtime-configurable handling of padding of the different cube faces.

The modified 360Lib software was provided with the contribution. It was not suggested to be adopted into 360Lib, but was provided for study.

The 360Lib software contains many projection formats. Some of the cube based formats are quite similar. However some aspects of the configuration depend on the projection format or are not configurable at all.

* Padding
  + CMP: no
  + ACP: no
  + EAC: no
  + HEC: face row padding
* All cube formats only allow square face sizes
* All faces have the same size.

A modified 360Lib software was created, which only supports the formats ERP, CMP, EAC, HEC and Viewport, with following additional features:

* Arbitrary padding of faces (face row, every face, one-sided padding), configured with command line arguments
* Support for varying face sizes. Further faces do not have to be of square sizes.
* Unified handling of sample position adjustment (the conversion of CMP to EAC or alike)

Further, only E2E-PSNR and Viewport PSNR are currently supported. The modified 360Lib has been integrated into VTM-6.0 and can be found along with this document. A short Readme file with usage examples is provided as well.

0

4

3

5

1

2

no padding

0

4

3

5

1

2

face row padding

0

4

3

5

1

2

per face padding

double-L with padding

0

4

3

5

1

2

arbitrary face packing

0

4

3

5

1

2

2

3

4x3 with top/bottom face padding (one sided padding)

[JVET-P0669](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8467) AHG6: Wrap-around motion vector prediction at the picture boundary [M. Lee, J. Lee, J. Park, D. Sim, S.-J. Oh (KWU), W. Lim, G. Bang (ETRI)] [late]

This contribution was discussed Thursday 10 October at 1905 in Track B (GJS).

In this contribution, a wrap-around motion vector prediction at the picture boundary is proposed. The proposed method adds a wrap-around motion vector candidate with the above left or above right motion vector candidate at a picture boundary for coding efficiency. Simulation results reportedly show that the wrap-around motion vector prediction at the picture boundary yields -0.02%, -0.04%, and -0.12% BD-rate deltas in end-to-end WS-PSNR with no complexity burden for PERP with horizontal geometry padding of reference pictures.

It was commented that there would be an extra memory burden for this, since ordinarily some of the motion parameters that this uses could be discarded.

It was commented that this idea had been previously studied (along with wrap-around MV referencing and wrap-around intra prediction referencing) with only a very minor benefit shown. It was commented that the subjective and objective benefit of this, in comparison with the wrap-around effect of the MVs across the borders, seems very minor, especially when considering that an encoder can use special treatment for selection of appropriate MVs without affecting the decoding process if there are subjective effects to consider.

No action was taken on this.

[JVET-P1016](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8831) Crosscheck of JVET-P0669 (AHG6: Wrap-around motion vector prediction at the picture boundary) [W. Choi, K. Choi (Samsung)]

## High level tool control (0)

## AHG17: General high-level syntax (47)

### NAL unit header (2)

[JVET-P0362](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8151) AHG17: NAL unit header extension to extend the number of layers [R. Sjöberg, M. Pettersson, M. Damghanian (Ericsson)]

[JVET-P0363](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8152) AHG17: On NAL unit type table [M. Pettersson, R. Sjöberg, M. Damghanian (Ericsson)]

### PTL definition and signalling (2)

[JVET-P0217](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8006) On Profile, Tier, Level Syntax Structure [J. Samuelsson, S. Deshpande, A. Segall (Sharp)]

[JVET-P0478](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8267) AHG17: On (sub)profiles signalling in the DPS [R. Skupin, Y. Sanchez, K. Sühring, T. Schierl (HHI)] [late]

### Cross-RAP referencing and external reference pictures (2)

[JVET-P0114](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7903) AHG17: On external decoding refresh (EDR) [Y.-K. Wang, Hendry, J. Chen (Futurewei), H. Yu, L. Yu (ZJU)]

Discussed 0900 Wednesday (GJS & JRO)

This contribution proposes a design for support of random accessing a bitstream from inter-coded pictures without a recovery period. This technique is referred to as external decoding refresh (EDR) or cross RAP referencing (CRR). Using this technique, random access point (RAP) pictures can be coded as inter-predicted pictures typically using only one or two earlier pictures in the bitstream for inter prediction reference(s), thus reportedly achieving higher coding efficiency than coding of the RAP pictures as IRAP pictures.

When random accessing from such inter-coded RAP pictures, the reference pictures would not be available in the bitstream starting from the RAP, but need to be provided through an external means, e.g., in a separate file format track or a separate dynamic adaptive streaming over HTTP (DASH) representation. The externally-provided pictures are referred to as external pictures, and such RAP pictures are referred to as external decoding refresh (EDR) pictures.

The proposed design is summarized as follows:

1. A new NAL unit type (EDR\_NUT) is defined for EDR pictures.
2. An EDR picture may start a CVS (hence may also start a bitstream).
3. External pictures are provided in the form of coded pictures, and there is no change to the RPL syntax, semantics, and derivation process.
4. The general decoding process is updated to specify the decoding process of a bitstream starting from an EDR picture (i.e., when random accessing from an EDR picture) with externally-provided reference pictures.
5. Two alternative options regarding POC handling are proposed.
   1. In the first option, POC signalling and derivation are kept unchanged, while POC values are restricted as follows: For each EDR picture, let listOfPictures be the list of pictures that consists of all the pictures referred to by all entries in RefPicList[ 0 ] and all entries in RefPicList[ 1 ] of the EDR picture and the EDR picture itself, listed in increasing decoding order of these pictures. It is a requirement of bitstream conformance that the difference between the PicOrderCntVal values of any two of these pictures that are consecutive in the list shall be greater than −MaxPicOrderCntLsb / 2 and less than MaxPicOrderCntLsb / 2.
   2. In the second option, the POC MSB values of the external pictures except for the first external picture as well as the POC MSB value of the EDR picture itself are signalled in the slice headers, while the above constraint on POC values are not imposed.

The proposed detailed spec text changes are attached.

The "external" pictures are provided as *coded* pictures, and the decoder decodes them when performing random access.

It was asked why the decoder would need awareness of what happened. It was suggested that the system could handle the construction of a bitstream that appears to a decoder as an ordinary bitstream but was constructed by putting the coded AUs together in the right order before the inter-coded "RAP" AU. In this case, the encoder would need to be responsible for making sure that the POC MSBs have the necessary relationship to retain the MSBs tracking correctly and satisfy our constraint on the relationship of the POC of the current picture relative to its reference pictures. This seemed adequate without a need for special syntax or other handling in the decoding process spec. (We are not responsible for the format of the data within a server before the construction of the bitstream that is fed to a decoder.)

So no action seemed necessary.

[JVET-P0211](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8000) AHG17: On cross-RAP referencing [M. M. Hannuksela (Nokia)]

Discussed 0900 Wednesday (GJS & JRO)

JVET-P0212 proposes enabling the use of a single decoder instance and the single-layer VVC decoding process for decoding multiple independent layers. The decoding is performed as if all NAL units resided in a single layer only.

This contribution is asserted to achieve the functionality of cross-RAP referencing using the multiple independent layers functionality as proposed in the following ingredients of JVET-P0212:

1. A VPS flag to indicate that there is one and only one picture per each POC value among all independent layers and that the independent layers can be decoded as if there were in the same layer.
2. "Collective" HRD parameters can be signalled for the bitstream that contains multiple independent layers.
3. Possibility to control by external means that the entire bitstream is decoded as if it were a single-layer bitstream. Otherwise, the current layer-wise operation of VVC is carried out.

It is proposed to support the cross-RAP referencing functionality in VVC by adopting the above-listed aspects 1 to 3 of JVET-P0212.

The proponent indicated that this seems conceptually aligned with what had been agreed in discussion of P0114. As with P0114, POC relationships would need to be handled appropriately in the "encoder".

No further change seemed needed for the PTL signalling relative to the plan agreed earlier in the meeting (i.e., PTL indicates total capability needed for an operation point).

The remaining element of the proposal to consider was a high-level flag (associated with an OLS) that would indicate that every AU in the OLS contains only one picture.

A participant brought up the idea of combining this with multiple layers of a different type, e.g., having two spatial layers in which each spatial layer acts like the proposed scheme. The proponent suggested adjusting the semantics of the flag to indicate that every AU in the OLS contains only one *output* picture.

Another case brought up is multiview. In such a case, more than one view is output for an AU, but each view could be coded separately in the described manner.

Underlying the described case is the notion of using layers to deliver a functionality that can be provided with single-layer coding. The spirit of what is experienced by a decoder is basically single-layer operation.

Further study is encouraged to determine whether the single layer approach can be fully adequate for the envisioned functionality, or could be made adequate with some small adjustment, or if such a layering approach is needed instead.

[JVET-P0326](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8115) AHG17: External reference picture [P. Bordes, D. Doyen, F. Galpin, M. Kerdranvat (InterDigital)]

It is proposed to signal in the reference-picture-list-struct whether some reference pictures are provided by an external means not specified in the Specification. It is also proposed to signal in the reference-picture-list-struct whether the motion information associated with one reference picture is zero (default) or not.

Two distinctions between this proposal and P0114 are:

* The externally provide picture is provided in *decoded* form
* That picture may not come from a VVC bitstream, and thus may not have the syntax elements and motion data and other properties (e.g., a POC, a layer ID, a temporal ID, a NUT) that we ordinarily have available for a referenc picture.

The proposal includes proposal of a flag for whether motion data is available for the externally provided reference picture or not.

It was commented that SHVC conformance testing data was never provided for the similar functionality there.

If provided, such a capability would need to be optional in some way – e.g., made an optional feature of any profile or given a different profile.

A participant commented that this could provide an opportunity for externally specified operations (e.g., disparity compensation) to be applied to pictures that are then fed back into the ordinary VVC decoding process.

It was agreed that the functionality of feeding externally-generated pictures or externally modified pictures into the decoding process should be deferred for future study for consideration as part of some possible v2 (or v3) extension project (but not included in v1).

### Reference picture list signalling and constraints (9)

[JVET-P0123](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7912) AHG17: RPL constraints for RASL and RADL pictures [Hendry, Y.-K. Wang (Futurewei)]

[JVET-P0134](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7923) AHG17: On long-term reference picture signalling [X. Ma, H. Yang (Huawei)]

[JVET-P0135](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7924) AHG8/AHG17: On inter-layer reference picture signalling [X. Ma, H. Yang (Huawei)]

[JVET-P0182](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7971) AHG8/AHG17: On Reference Picture List and Inter-Layer Prediction [S. Deshpande (Sharp)]

[JVET-P0221](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8010) AHG8: On signaling interlayer reference picture list [B. Choi, S. Wenger, S. Liu (Tencent)]

[JVET-P0235](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8024) AHG17: A bugfix of SPS flags and reference picture list structure [T. Chujoh, E. Sasaki, T. Ikai (Sharp)]

Discussed Thursday 10 Oct (GJS) Track B

The text problem has already been fixed in P0113. Decision (SW): The software bug also needs fixing.

[JVET-P0356](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8145) AHG17: Bitstream constraints on RPL and GDR [R. Sjöberg, M. Pettersson, M. Damghanian (Ericsson)]

[JVET-P0589](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8381) AHG8: On inter-layer reference picture index range [V. Seregin, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-P0978](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8793) AHG17: Text for RPL restrictions [M. Pettersson, R. Sjöberg, M. Damghanian (Ericsson), Hendry, Y.-K. Wang (Futurewei)] [late]

### AUD, picture header, slice header parameters signalling (10)

[JVET-P0687](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8486) AHG17: A summary of HLS proposals on access unit delimiter, picture header, and slice header parameters signalling [Hendry (Futurewei)] [late]

Discussed Wednesday 2030 (GJS & JRO)

This contribution provides a summary of high-level syntax proposals submitted to this JVET meeting related to access unit delimiter, picture header, and slice header parameters signalling. A list of design questions is provided to help structure the review of the proposals.

The contributions in this category can be classified into two sub-categories:

* AUD and Picture Header
* Modifications to constant slice header paramater signalling (related to constant\_slice\_header\_params\_enabled\_flag)

**General questions:**

1. Do we want to avoid signalling syntax elements in slice header that are constrained to have same values for all slices of a picture?

If yes. Where to signal them? AUD? New NAL Picture Header? Use the constant slice header params signalling in PPS?

1. For constant slice header parameters, should some of the syntax elements be in PPS? or in AUD? or in Picture Header, if exists?

***On AUD and Picture Header.***

1. Do we want to have Picture Header?

Proposing yes. JVET-P0095, JVET-P0120, JVET-P0239

Why? JVET-P0092 & JVET-P0120: AUD is AU specific. An AU may contain multiple pictures.

JVET-P0120: Order of AUD is supposed to the first NAL unit in an AU. If AUD preceeds SPS & PPS, some picture-level syntax elements in SH cannot be moved to AUD. Having PH is asserted would solve this problem.

Decision: Yes, after considering the quantity of syntax elements that would go there, we should have a picture header.

1. If yes, what to signal in PH?
   1. Move some signalling from PPS to PH

JVET-P0095: Subpicture Id mapping, if it is not signalled in the SPS and not signaled in the PPS, to avoid needing to send a PPS for this

Decision: Allow the mapping in the PH when it is not in the SPS. If present, it overrides what is in the PPS. If not in the PPS and not in the SPS, then is shall be in the PH. As detailed below:

SPS syntax:

fancy\_weird\_stuff\_allowed\_flag

if( fancy\_weird\_stuff\_allowed\_flag ) {

sending\_details\_in\_sps\_flag /\* infer 0 if not present \*/

if ( sending\_details\_in\_sps\_flag )

Details

}

PPS syntax:

sending\_details\_in\_pps\_flag

if (sending\_details\_in\_pps\_flag)

Details

constraint: If fancy\_weird\_stuff\_allowed\_flag is 0 or sending\_details\_in\_sps\_flag is 1, sending\_details\_in\_pps\_flag shall be equal to 0.

PH syntax:

if ( fancy\_weird\_stuff\_allowed\_flag && !sending\_details\_in\_sps\_flag ) {

sending\_details\_in\_ph\_flag

if(sending\_details\_in\_ph\_flag)

Details

}

* 1. Signal syntax element both in PPS and PH. Present in PH if not present in PPS

JVET-P0095: Tile/Brick/Rect Slice signalling

Deferred to after considering GDR needs.

* 1. Move some signalling from SH to PH

Preliminary decision:

* + 1. JVET-P0095, P0120: no\_output\_of\_prior\_pics\_flag
    2. JVET-P0120, P0239: slice\_pic\_parameter\_set\_id, non\_reference\_picture\_flag, colour\_plane\_id, slice\_pic\_order\_cnt\_lsb, recovery\_poc\_cnt, pic\_output\_flag, slice\_temporal\_mvp\_enabled\_flag.

Comment: Think more about slice\_pic\_order\_cnt\_lsb as a loss detection mechanism

* + 1. JVET-P0239: slice\_lmcs\_aps\_id and slice\_scaling\_list\_aps\_id
    2. JVET-P0239 move some syntax elements that are currently not constrained to be the same for all slices of a picture, but asserted having no / minimal benefit and coding loss to transmitting them in every slice header as their anticipated usage would change at the picture level. 18 such syntax elements are identified in the contribution. (In the CTC, about half of these don't even change across different pictures.)

It was commented that this could affect the ability to merge slices from different encoders. However, others commented that encoding for such applications would already be customized to this use case (and possibly only coming from one common encoder or encoders from only one company).

* + - 1. six\_minus\_max\_num\_merge\_cand
      2. five\_minus\_max\_num\_subblock\_merge\_cand
      3. slice\_fpel\_mmvd\_enabled\_flag
      4. slice\_disable\_bdof\_dmvr\_flag
      5. max\_num\_merge\_cand\_minus\_max\_num\_triangle\_cand
      6. slice\_six\_minus\_max\_num\_ibc\_merge\_cand
      7. partition\_constraints\_override\_flag
      8. slice\_log2\_diff\_min\_qt\_min\_cb\_luma
      9. slice\_max\_mtt\_hierarchy\_depth\_luma
      10. slice\_log2\_diff\_max\_bt\_min\_qt\_luma
      11. slice\_log2\_diff\_max\_tt\_min\_qt\_luma
      12. slice\_log2\_diff\_min\_qt\_min\_cb\_chroma (only needed for I slices)
      13. slice\_max\_mtt\_hierarchy\_depth\_chroma (only needed for I slices)
      14. slice\_log2\_diff\_max\_bt\_min\_qt\_chroma (only needed for I slices)
      15. slice\_log2\_diff\_max\_tt\_min\_qt\_chroma (only needed for I slices)
      16. mvd\_l1\_zero\_flag (only needed for B slices)
      17. dep\_quant\_enabled\_flag
      18. sign\_data\_hiding\_enabled\_flag
  1. Signal some syntax element that are not constrained to be the same for all slices of a picture both in PH and SH. Present in SH if not present in PH
     1. JVET-P0120: RPL, joint cb/cr sign flag, SAO, ALF, LMCS, Scaling list

Preliminary decision:

joint cb/cr sign flag should be in the PH and never be in the SH

RPL, SAO, ALF, LMCS, deblocking (4 syntax elements in July output doc) should possible to put in SH (as override if also in higher layer), also possible in PH and in SPS (for each of these five categories, if it's in the PH, then it's not in the SH)

Scaling list control should never be in the SH

* 1. New syntax elements:
     1. JVET-P0095: A flag to specify whether associated picture contains mixed NAL unit types (i.e, mixed\_nalu\_types\_in\_pic\_flag). See JVET-P0124, JVET-P0146, and JVET-P0222.

See notes for HLS BoG.

* + 1. JVET-P0120: Picture type (whether picture is IDR, CRA, GDR, contains only I-slices, only P- and I- slices, any type of slices)

See notes for HLS BoG.

Discussion continued Track B Thursday 3 October 1115 (GJS).

1. If yes, what is property of PH?
   1. JVET-P0095, JVET-P0120, JVET-P0239: Mandating one PH one picture

Decision:

PH comes before the VCL NAL units for the picture; the SPS and PPS must precede it. APSs do not need to precede it but may. SEI messages for the picture follow it.

Do not allow PH to be "out of band" (and it should be in Type I category of HRD).

Allow repetitions; not more PHs than slices; not after the last VCL NAL unit.

* 1. JVET-P0120: Specifies layer Id, temporal Id, order of PH in access unit, etc.

Decision: Layer Id and temporal Id are those of the picture.

* 1. Is it VCL or non-VCL?

Decision: Non-VCL

* + 1. JVET-P0095, JVET-P0120: PH is a non-VCL NAL unit.
    2. JVET-P0239: PH is a VCL NAL unit.

1. Do we want to keep AUD?

Proposing no: JVET-P0095, JVET-P0120

Decision: Optional AUD (restore language of boundary detection). See also next item.

1. Do we want to keep mandating the presence of AUD?

Proposing no:

JVET-P0218. Signal single\_slice\_in\_pic\_flag in SPS. When single\_slice\_in\_pic\_flag is equal to 1, AUD is not mandated to be present. single\_slice\_in\_pic\_flag can be used to condition the presence of other syntax elements such as num\_bricks\_in\_slice\_minus1.

JVET-P0367: Signal a flag aud\_in\_next\_access\_unit\_present\_flag in AUD to specify whether the AUD is required to be present for next AU.

JVET-P0480: AUD is mandated only when there are more than 1 subpicture. Signal first\_slice\_in\_sub\_pic\_flag in SH. This flag can be used for detecting first slice of each picture when there is only one subpicture in a picture.

Conclusion: See above item 5 (AUD optional).

1. Do we want to signal more syntax elements in AUD?
   1. JVET-P0218: Optionally moves PPS Id, non\_reference\_picture\_flag, colour\_plane\_id, slice\_pic\_order\_cnt\_lsb, and pic\_output\_flag to AUD, if present. Create a syntax structure pic\_header(). NOTE: pic\_header is not in its own NAL unit.
   2. JVET-P0146: Signal syntax elements which specifies types of subpictures of a picture (non-IRAP, IDR, CRA). This would allow a picture to contain mixed subpicture types.
   3. JVET-P0222: Signal rap\_type and au\_order\_cnt. Syntax element rap\_type specifies which specifies whether the coded pictures in the access unit contain non-IRAP NAL unit only, IRAP NAL unit only, or both IRAP and non-IRAP.

Comments: JVET-P0146 and first aspect of JVET-P0222 suggest to allow mixed of IRAP and non-IRAP in a picture. They should be discussed together with JVET-P0095 and JVET-P0124.

No action.

1. AUD properties:

Decision: Adopt points a and c below.

* 1. JVET-P0218: The AUD shall have nuh\_layer\_id value equal to vps\_layer\_id[ 0 ].
  2. JVET-P0380: The AUD shall have nuh\_layer\_id value equal to 0.
  3. JVET-P0218: The AUD shall have TemporalId equal to the TemporalId of the access unit containing the NAL unit

***On signalling constant slice header params.***

1. Some bugs are asserted to be present in the signalling of syntax element when constant\_slice\_header\_params\_enabled\_flag? See notes for HLS BoG report.
   1. JVET-P0152:
      1. Update semantics of pps\_five-minus\_max\_mun\_subblock\_merge\_cand\_plus1 to incorporate the value of sps\_affine\_enabled\_flag.

Comment: The proposed changes seem to be more appropriate to be expressed as constraints.

* + 1. Update the inference of the value five\_minus\_max\_num\_subblock\_merge\_cand in SH when it is not present taking into account the proposed change above.
  1. JVET-P0427 proposal 1: Condition the signalling of pps\_max\_num\_merge\_cand\_minus\_max\_num\_triangle\_cand\_plus1 on the value of pps\_six\_minus\_max\_num\_merge\_cand\_plus1
  2. JVET-P0427 proposal 2: Update the range value of pps\_max\_num\_merge\_cand\_minus\_max\_triangle\_cand\_plus1 to not depend on the value of MaxNumMergeCand
  3. JVET-P0427 proposal 3: MaxNumTriangleMergeCand is inferred to be equal to 2 in slice header if MaxNumMergeCand is equal to 2 without signaling in either PPS or slice headers
  4. JVET-P0605: proposed to modify pps\_max\_num\_merge\_cand\_minus\_max\_num\_triangle\_cand\_minus1 to pps\_max\_num\_merge\_cand\_minus\_max\_num\_triangle\_cand\_plus1

This has been addressed by editor between last meeting and this meeting. The update is reflected in JVET-P0113

1. Adding more syntax element to be signalled in PPS when constant\_slice\_header\_params\_enabled\_flag is equal to 1:
   1. JVET-P0334 proposal / modification 1
   2. JVET-P0368
   3. JVET-P0428 proposal 1

Discussed Thursday Track B 1300 (GJS).

With us now having a PH, it was suggested for this to be a matter of indicating whether something is in the PPS or the PH. Whereas previously this mechanism would be saving one instance of each syntax element per slice, it would now be saving only one instance per picture header. This aspect was agreed in principle, with further discussion of the details.

See notes for HLS BoG report.

1. Improvement for signalling mechanism of constant slice header params:
   1. JVET-P0334 proposal 2 & 3:
      1. Instead of signalling 1 set of constant slice header params in PPS, allow signalling up to 7 sets of constant slice header params in PPS. In SH, signal index of the set to be used.
      2. When the number of constant slice header params set in PPS is equal to 0, signal the syntax elements in SH
   2. JVET-P0428 proposal 2: signal conformance\_constant\_params\_enabled\_flag in SH to specify if the slice uses the constant syntax elements signalled in PPS or not. This allow constant slice params to be present in the PPS but also present in SH (i.e., when the value of conformance\_constant\_params\_enabled\_flag is equal to 0)

[JVET-P0480](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8269) AHG17: On simplification of subpicture design [R. Skupin, Y. Sanchez, K. Sühring, T. Schierl (HHI)] [late]

The first\_slice\_in\_sub\_pic\_flag part of this contribution belongs to this category. For other aspects see section 6.19.1.1.

[JVET-P0095](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7884) AHG12/AHG17: On signalling of picture-specific syntax elements in access unit delimiter [M. M. Hannuksela (Nokia)]

[JVET-P0120](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7909) AHG17: On access unit delimiter [Hendry, Y.-K. Wang (Futurewei)]

[JVET-P0218](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8007) AHG8/AHG17: On Access Unit Delimiter and Picture Detection [J. Samuelsson, S. Deshpande, A. Segall (Sharp)]

[JVET-P0222](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8011) AHG17: On signaling parameters in AUD [B. Choi, S. Wenger, S. Liu (Tencent)]

[JVET-P0239](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8028) AHG17: HLS Cleanup [W. Wan, T. Hellman, B. Heng (Broadcom)]

[JVET-P0334](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8123) AHG17: On constant slice header parameter set in PPS [B. Wang, S. Esenlik, A. M. Kotra, H. Gao, E. Alshina (Huawei)]

[JVET-P0367](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8156) AHG17: On AUD signaling [M. Pettersson, R. Sjöberg, M. Damghanian (Ericsson)]

[JVET-P0368](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8157) AHG17: On selectively signal slice header parameters in PPS [M. Pettersson, R. Sjöberg, M. Damghanian (Ericsson)]

[JVET-P0427](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8216) AHG17: Bugfixes on constant slice header parameters [Y.-J. Chang, V. Seregin, M. Coban, A. Ramasubramonian, M. Karczewicz (Qualcomm)]

[JVET-P0428](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8217) AHG17: Improvement on signaling of constant slice header parameters [Y.-J. Chang, [V. Seregin](mailto:vseregin@qti.qualcomm.com), M. Coban, M. Karczewicz (Qualcomm)]

[JVET-P1006](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8821) AHG17: Text for picture header [W. Wan, T. Hellman, B. Heng (Broadcom), Hendry, Y.-K. Wang, J. Chen (Futurewei), M. M. Hannuksela (Nokia), J.-M. Thiesse (VITEC)] [late]

### Miscellaneous HLS topics (11)

[JVET-P0122](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7911) AHG17: On adaptation parameter set [Hendry, J. Chen, Y.-K. Wang (Futurewei)]

[JVET-P0359](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8148) AHG17: An STSA\_NUT restriction on PPS and APS availability [R. Sjöberg, M. Pettersson, M. Damghanian (Ericsson)]

[JVET-P0184](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7973) AHG8/AHG17: On Decoding Process for Unavailable Reference Pictures and Reference Picture List Construction [S. Deshpande (Sharp)]

[JVET-P0243](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8032) AHG17: HLS simplification W. Wan, T. Hellman, B. Heng (Broadcom)]

[JVET-P0244](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8033) AHG17: Miscellaneous HLS corrections [W. Wan, T. Hellman (Broadcom)]

[JVET-P0316](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8105) Coding of 360° video in non-compact cube layout using uncoded areas [J. Sauer, M. Bläser (RWTH Aachen)]

[JVET-P0366](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8155) AHG17: Signalling absence of NAL unit types in DPS [M. Pettersson, R. Sjöberg, M. Damghanian (Ericsson)]

[JVET-P0420](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8209) AHG8/AHG17: Reduction of overlapping between POC LSB and Temporal ID [M. Sychev (Huawei)]

[JVET-P0438](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8227) AHG17: On Constraints for ALF APS [J. Chen, Hendry (Futurewei)]

[JVET-P0497](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8286) AHG17: On LMCS Signalling [Y.-C. Yang, C.-Y. Teng, P.-H. Lin (Foxconn)]

[JVET-P0800](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8615) Crosscheck of JVET-P0497: AHG17: On LMCS Signalling [W. Zhu (Bytedance)]

[JVET-P0510](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8300) Non-CE3/AHG8: On picture size restriction [L. Zhao, X. Zhao, X. Li, S. Liu (Tencent)]

[note whether addressed]

[JVET-P0588](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8380) AHG17: APS for low latency ALF [V. Seregin, M. Coban, A. K. Ramasubramonian, N. Hu, M. Karczewicz (Qualcomm)]

[JVET-P0610](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8404) AHG8/AHG17: Sub-layer picture rates [M. Sychev (Huawei)]

[JVET-P0108](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7897) AHG17: On parsing dependency between slice data and APS [S. Esenlik, A. M. Kotra, B. Wang, H. Gao, E. Alshina (Huawei)]

[JVET-P0891](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8706) Cross-check of JVET-P0108 (On parsing dependency between slice data and APS) [P. Onno (Canon)]

### HRD (6)

[JVET-P0181](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7970) AHG17: On HRD Information Signalling [S. Deshpande (Sharp)]

[JVET-P0183](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7972) AHG17: On Picture Timing Information Signalling [S. Deshpande (Sharp)]

[JVET-P0189](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7978) AHG8/AHG17: On buffering period, picture timing, and decoding unit information SEI messages [Y.-K. Wang (Futurewei)]

[JVET-P0202](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7991) AHG17: Harmonized HRD parameters signalling for decoding units [V. Drugeon (Panasonic)]

[JVET-P0203](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7992) AHG17: Parsing HRD related SEI messages independently from the SPS [V. Drugeon (Panasonic), K. Sühring (HHI)]

[JVET-P0446](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8235) AHG17: On HRD for VVC: Splicing, Open GOP and DRAP support [Y. Sanchez, R. Skupin, K. Sühring, T. Schierl (HHI)]

### VUI and SEI (6)

[JVET-P0337](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8126) AHG17: On porting SEI messages specified in HEVC and AVC [S. McCarthy, T. Lu, F. Pu, P. Yin, W. Husak, T. Chen (Dolby)]

[JVET-P0338](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8127) AHG17: Shutter interval information SEI message [S. McCarthy, T. Lu, F. Pu, P. Yin, W. Husak, T. Chen (Dolby)]

[JVET-P0404](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8193) SEI message for MPEG-I Part 7 metadata [M. M. Hannuksela (Nokia)]

[JVET-P0459](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8248) AHG17: Mergeability identifier for subpictures [R. Skupin, K. Sühring, S. Sanchez, T. Schierl (HHI)]

[JVET-P0462](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8251) AHG6: 360-degree video related SEI messages [R. Skupin, Y. Sanchez, K. Sühring, T. Schierl (HHI)]

[JVET-P0597](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8389) AHG6/AHG17: Generalized cubemap projection syntax for 360-degree videos [Y.-H. Lee, J.-L. Lin, Y.-J. Chen, C.-C. Ju (MediaTek), J. Boyce, M. Dmitrichenko (Intel)]

## AHG12: high-level parallelism and coded picture regions (46)

### Subpictures (35)

#### General aspects (3)

[JVET-P0693](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8492) AHG12: Summary of HLS proposals on subpictures [M. M. Hannuksela (Nokia)] [late]

Discussed Tuesday 2140 (GJS)

This contribution provides a topic-wise summary of contributions related to:

* General aspects of subpictures
* Subpicture layout and ID signalling
* Subpicture boundary filtering

The purpose of the summary is to help structure and improve efficiency of the discussion of these contributions.

This version of the contribution does not cover contributions related to:

* subpicture-level random access and merging
* subpicture wraparound, padding, and cropping
* subpicture conformance definition and signalling

Discussed general aspects:

1. A subpicture consists of one or more complete rectangular slices within a picture. Subpictures cannot be used with raster-scan-order slices. (several contributions). Confirmed.
2. Tile rows and columns at the picture level apply across the entire picture. (P0245) Confirmed.
3. SPS/PPS parameters must be the same for all the subpictures in a picture. (P0245) Confirmed.
   * Supposedly this means that the same slice\_pic\_parameter\_set\_id value is referenced by all the VCL NAL units of the same picture Confirmed.
4. APS parameters must be the same for all the subpictures in a picture. (P0245). Not confirmed. Limits are established in the text.
5. All of the subpictures in the aggregate picture must use a common DPB with common DPB management (P0245) Confirmed. The DPB operates in units of pictures.
6. Properties shared across each subpicture (P0245):
   1. Same frame rate. Confirmed (i.e., each picture must be complete).
   2. Same reference picture lists. Not confirmed. Each slice has its own RPL, but has the same RPS.
   3. DPB can only be flushed at the same picture. Confirmed. The DPB operates in units of pictures.
   4. Same temporal sublayer. Confirmed (i.e., each picture must be complete and all VCL NAL units of the picture shall have the same TID).
   5. Same reference picture resampling (RPR) scale factor. Proposed to be violated by P0403.
   6. Same collocated reference picture. Confirmed (as a semantic constraint).
   7. Delta-POCs to all reference pictures must be the same. Confirmed. POC operates in units of pictures.
7. Can subpictures, if extractable, have a different random access properties from the whole picture? (P0139) Possibly, but not necessarily affecting the decoding process

Discussed Wednesday 1100 (GJS) & JRO)

***Container structure for signalling subpicture layout***

1. SPS
   * When signalled in the SPS, the signalling cannot use slices, tiles, or bricks for indicating subpicture boundaries
2. PPS
   * When signalled in the PPS, the signalling can use slices, tiles, or bricks for indicating subpicture boundaries
   * Note: There can be semantic constraints to keep the subpicture layout unchanged within a C(L)VS. This is discussed below.

Currently, we have the subpicture layout established at the SPS level. We have no proposals trying to change the subpicture layout within a CLVS.

It was agreed to keep the subpicture signalling in the SPS.

***Subpicture layout signalling in SPS***

1. Using a subpicture grid approach
   * Modifications of the subpicture grid design on VVC Draft 6
     + Indicating the grid in units of 8 luma samples (P0142)
     + Indicating the grid in units of CTBs (P0142, P0377, P0432)
     + replace max\_subpics\_minus1 with max\_subpics\_minus2 (P0129, P0432)
     + single\_subpic\_per\_grid\_flag to avoid signaling grid index for each subpicture when the grid is at the subpicture granularity (P0129)
     + Asserted bug fix: P0464 proposes modifications to the existing semantic derivations of the subpicture height and width dimensions i.e., SubPicHeight and SubPicWidth. In the current working draft (WD 6) of the Versatile Video Coding (VVC), the semantic derivations for SubPicHeight and SubPicWidth result in incorrect values when the subpicture grid index (subpic\_grid\_idx) present in the last row (i.e., subpic\_grid\_idx[row][col]) is different from the grid index present directly above (i.e., subpic\_grid\_idx[row-1][col]) it and alternatively, when the subpicture grid index present in the last column (i.e., subpic\_grid\_idx[row][col]) is different from the subpicture grid index present in front of it (i.e., subpic\_grid\_idx[row][col-1]).
   * Using the grid in units of CTBs with the signalling of the bottom-right delta grid index (P0139, P0143)
   * Having uniform and non-uniform subpicture grid signalling modes (similar to the signalling modes for tiles) (P0471)
2. Using units of CTBs, indicating top-left and bottom-right coordinates (P0171)

Decision: Units of CTBs, using top-left with width (minus1) and height (minus1). The proponent of P0171 agreed to provide text and to help develop software for this.

Constraints:

* + It is required that sub-pictures cannot be overlapped with each other, and all the sub-pictures must cover the whole picture. (P0377). This is already specified, and confirmed not to be changed.
  + Add a requirement of bitstream conformance that the following constraints apply: NumSubPicGridCols and NumSubPicGridRows cannot be concurrently equal to 1 if subpics\_present\_flag is equal to 1. NumSubPics shall be equal to 0 if subpics\_present\_flag is equal to 0. (P0432). This is not relevant to the approach taken.

***Subpicture layout signalling in PPS***

This section of the document is not relevant to the approach taken.

***Constraints on subpicture layout***

This section of the document is not relevant to the approach taken.

***single\_slice\_per\_subpic\_flag***

1. In SPS as an indication only (not affecting decoding) (P0579).
2. A constraint flag general\_constraint\_info( ) of the PTL structure: single\_slice\_subpic\_only\_constraint\_flag (P0579)
3. In PPS, used for inferring the derivation of subpicture\_id when they are not explicitly present (P0579)
4. In PPS, used for skipping subpicture boundary signalling (P0126, P0130) or slice boundary signalling (P0126)

As an initial assessment, it seems sensible to not need to signal slice layout in the PPS if this special case applies. However, other details should be considered for drafting the exact syntax and semantics before making a final conclusion on this. See notes for HLS BoG report.

***Subpicture ID in slice header***

1. Subpicture ID is included in the slice header (P0126, P0431, …)
   * Present, when:
     + subpics\_present\_flag equal to 1 (P0126, P0579, P0609)
     + subpics\_present\_flag equal to 1 and NumSubPics greater than 0 (P0431)
     + rect\_slice\_flag equal to 1 (P0480)
2. subpic ID is proposed in NAL unit header or slice header. First, a flag use\_nuh\_layer\_id\_as\_subpic\_id\_flagis signalled in SPS. When use\_nuh\_layer\_id\_as\_subpic\_id\_flag is equal to 1, subpicID is set equal to nuh\_layer\_id signaled in NAL unit header. When use\_nuh\_layer\_id\_as\_subpic\_id\_flag is equal to 0, subpicID is set equal to subpic\_id, which may be signalled in slice header (P0224)
3. Define a subpicture index for each slice. This could be a fixed length code (FLC) at the top of the slice header for easy bit stream manipulation. (P0242)
   * Details missing from the contribution.

Decision: When the subpics\_present\_flag is equal to 1 (in which case, raster scan slices are not supported), a subpic ID is sent in the SH, and the slice address is interpreted as an address within the subpicture.

P0224 proposes to have a mode in which the layer ID is instead a subpicture ID. This would have two advantages: 1) saving bits for subpicture ID, 2) exposing the subpicture ID at a more easily accessible location in the NAL unit. A participant commented that it seems undesirable to mix purposes for the layer ID, and that this would only be useful when the number of subpictures is less than 65. No action was taken on that aspect.

***Semantics of slice address (when subpictures are in use)***

1. Slice\_address is defined as the slice index within the subpicture. (P0126, P0609)
2. The slice address is the subPic brick ID (P0480).
   * subPic brick ID is the brick index within the subpicture, where bricks are indexed in their decoding order – to be confirmed with the proponent

Decision: When subpictures are used, the slice address is the slice index within the subpicture.

***Other syntax elements***

1. first\_slice\_in\_sub\_pic\_flag (P0480)

This could be used for detection of subpicture and AU boundaries.

For this aspect see 6.18.5

***Mapping of subpicture IDs to the subpicture layout – may subpicture IDs change within a CVS?***

1. Yes (e.g. P0139)
2. Yes, but it can be signalled if they stay unchanged (P0126)
   * It is indicated with a flag (in PPS) whether the mapping of subpicture IDs to subpicture indices remains unchanged within a CLVS or may change within a CLVS.
3. No (those contributions proposing to signal the mapping in SPS, e.g. P0579, P0609)

Viewport-dependent streaming is a use case where it is suggested for the IDs to be able to change.

Decision:

* flag for presence of the mapping at the PPS level
* flag for presence of the mapping at the SPS level
* the flags cannot both be equal to 1
* if both flags are equal to 0, the IDs are the same as the indexes
* The range of values used for the IDs can be bigger than for the indexes

***Container structure for the mapping of subpicture IDs***

1. A mapping indicated in the picture header NAL unit (P0095)

To be considered with picture header proposals.

1. A mapping of subpicture IDs to subpicture indices is signalled in the PPS

* Loop over the number of subpictures in a picture, each loop entry indicating the subpicture ID (P0126, P0141, P0431, P0579)
* Loop over slices, each loop entry listing the subpicture ID to which the slice belongs (P0144)

Decision: The first approach above is selected (regardless of whether it is as the PPS or SPS level) as a consequence of the conclusion in the previous category.

1. When subpicture IDs do not change in the CVS, a mapping of subpicture IDs to subpicture indices is signalled in the SPS (P0141, P0609)

See above conclusions.

1. A mapping of subpicture IDs to subpicture indices is signalled in the SPS, loop over subpictures, each loop entry indicating the subpicture ID (P0579)

See above conclusions.

***On explicitly signalled slice IDs***

1. The explicitly signalled slice IDs are removed from the PPS and the slice. (P0126, P0609)

This is confirmed as a consequence of the above conclusions.

It was commented that the subpicture concept has been designed to support some particular use cases in which there may be many subpictures in a picture (e.g., 96). The subpicture concept is not adequate without some special slice support (e.g., explicitly signalled slice IDs) if there is a limit on the number of allowed subpictures that is too restrictive.

1. **On flags controlling the behaviour of subpicture boundaries**
2. subpic\_treated\_as\_pic\_flag[ i ] and loop\_filter\_across\_subpic\_enabled\_flag[ i ] moved to PPS (P0126, P0480, …)

Conclusion: Keep these in the SPS level.

1. P0145 and P0246: Disallow loop\_filter\_across\_subpic\_enabled\_flag[ i ] equal to 1 when subpic\_treated\_as\_pic\_flag[ i ] is equal to 1, by either of the following:
   1. Make the presence loop\_filter\_across\_subpic\_enabled\_flag[ i ] conditional on subpic\_treated\_as\_pic\_flag[ i ] equal to 0. When not present, the value of loop\_filter\_across\_subpic\_enabled\_pic\_flag[ i ] is inferred to be equal to 0.

|  |  |
| --- | --- |
| if( !subpic\_treated\_as\_pic\_flag[ i ] ) |  |
| **loop\_filter\_across\_subpic\_enabled\_flag**[ i ] | u(1) |

* 1. Semantic constraint.

Conclusion: Keep these independently switchable, since they affect entirely different parts of the decoding process (and it seems plausible to want to switch them independently).

1. May the value of the flags change within a C(L)VS?
   1. For each subpicture index i, subpic\_treated\_as\_pic\_flag[ i ] and loop\_filter\_across\_subpic\_enabled\_flag[ i ] are required to be unchanged within a CLVS (P0126) / CVS (P0480).
   2. Related to subpicture-based adaptive resolution change: The constraints on having the same subpicture layout and the same values of subpic\_treated\_as\_pic\_flag[ i ] and loop\_filter\_across\_subpic\_enabled\_flag[ i ] throughout a CLVS are not imposed. Instead, when a reference picture is used for prediction, it is required that it has a subpicture with the same ID as the subpicture ID of the current slice.

Conclusion: No, these are in the SPS, so they can't change within the CLVS.

1. **Miscellaneous**
2. max\_subpics\_minus1 is changed to max\_subpics\_minus2 and added in the VPS. Adding num\_subpics\_minus2 in the SPS. (P0140)

Conclusion: No action, since the extraction and merging functionality requires the ability to have subpics\_present\_flag equal to 1 even when max\_subpics\_minus1 is equal to 0.

1. A bug fix (P0579): To change "<=" to "<" in the following.

Conclusion: Actually, this was just a bad variable name, not an error in the loop count. However, this part of the spec is being replaced anyway.

|  |  |
| --- | --- |
| for( i = 0; i <= NumSubPics; i++ ) { |  |
| **subpic\_treated\_as\_pic\_flag**[ i ] | u(1) |
| **loop\_filter\_across\_subpic\_enabled\_flag**[ i ] | u(1) |
| } |  |

[JVET-P0139](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7928) AHG17/AHG12: General questions on subpicture designs for discussion [L. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0242](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8031) AHG12/AHG16/AHG17: Subpicture Support [W. Wan, T. Hellman, M. Zhou, B. Heng, P. Chen (Broadcom)]

[JVET-P0245](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8034) AHG12/AHG17: Subpicture Properties [W. Wan, T. Hellman, B. Heng (Broadcom)]

#### Subpicture layout and ID signalling (18)

See 6.19.1.1 for the disposition of topics in this category.

[JVET-P0126](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7915) AHG12: Signalling of subpicture IDs and layout [M. M. Hannuksela (Nokia), Y.-K. Wang, Hendry (Futurewei)]

Some aspects of this are discussed in section 6.19.2.

[JVET-P0129](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7918) AHG12: On subpicture grid syntax [Y. He, A. Hamza (InterDigital)]

[JVET-P0130](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7919) AHG12: On subpicture ID [Y. He, A. Hamza (InterDigital)]

[JVET-P0140](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7929) AHG17/AHG12: Some comments on the VVC text [L. Chen, C.-W. Hsu, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

Aspects 1 and 2 of JVET-P0140 belong to this category.

[JVET-P0141](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7930) AHG17/AHG12: On signalling the subpicture IDs [L. Chen, C.-W. Hsu, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0142](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7931) AHG17/AHG12: Comments on the subpicture grid in the SPS [L. Chen, C.-W. Hsu, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0143](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7932) AHG17/AHG12: On signalling of subpicture structure in the SPS [L. Chen, C.-W. Hsu, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0144](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7933) AHG17/AHG12: On associating slices with a subpicture [L. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

For a bug fix aspect, see section 6.19.2.

[JVET-P0171](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7960) AHG12: Modification for subpicture [J. Li, K. Abe, V. Drugeon (Panasonic)]

[JVET-P0224](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8013) AHG12: On sub-picture layout and ID [B. Choi, S. Wenger, S. Liu (Tencent)] [late]

[JVET-P0377](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8166) AHG12: Cleanups on syntax design of sub-pictures [K. Zhang, L. Zhang, H. Liu, Z. Deng, J. Xu, N. Zhang (Bytedance)]

[JVET-P0431](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8220) AHG12: On subpicture ID [Y.-J. Chang, V. Seregin, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-P0432](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8221) AHG12: On signaling and grid size of subpictures [Y.-J. Chang, V. Seregin, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-P0464](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8253) AHG12: Comments on Subpicture Semantic Derivations [S. Paluri, J. Zhao, S. Kim (LGE)]

[JVET-P0471](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8260) AHG12 Explicit Signalling of Uniform and Non-Uniform Subpicture Grid in the SPS [S. Paluri, J. Zhao, S. Kim (LGE)

[JVET-P0480](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8269) AHG17: On simplification of subpicture design [R. Skupin, Y. Sanchez, K. Sühring, T. Schierl (HHI)] [late]

For the AU boundary detection aspect of this proposal, see section 6.18.5.

[JVET-P0579](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8370) AHG12: On Subpicture Information Signalling [S. Deshpande, J. Samuelsson (Sharp)]

[JVET-P0609](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8402) AHG12: On slice address signalling [R. Sjöberg, M. Damghanian, M. Pettersson (Ericsson)] [late]

[JVET-P1024](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8839) AHG12: single\_slice\_per\_subpic\_flag [M. M. Hannuksela (Nokia), Wang, Hendry (Futurewei)] [late]

#### Subpicture-level random access and merging (6)

[JVET-P0095](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7884) AHG12/AHG17: On signalling of picture-specific syntax elements in access unit delimiter [M. M. Hannuksela (Nokia)]

One aspect of JVET-P0095 belongs to here.

[JVET-P0124](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7913) AHG17: On mixed NAL unit types within a picture [Y.-K. Wang, Hendry (Futurewei)]

[JVET-P0146](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7935) AHG17/AHG12: On AUD as a picture header [L. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-P0458](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8247) AHG17: NAL unit type mapping [R. Skupin, K. Sühring, Y. Sanchez, T. Schierl (HHI)]

[JVET-P0351](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8140) [AHG12] On Subpictures merging [N. Ouedraogo, F. Denoual, F. Mazé (Canon)]

[JVET-P0378](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8167) AHG12: Removal of dependency between sub-pictures [K. Zhang, L. Zhang, H. Liu, Z. Deng, J. Xu, Y. Wang (Bytedance)]

#### Subpicture wraparound, padding, and cropping (4)

[JVET-P0127](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7916) AHG12: On subpicture wraparound motion compensation signalling [Y. He, Y. He, A. Hamza (InterDigital)]

[JVET-P0220](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8009) AHG12: On padding processing with sub-pictures [B. Choi, S. Wenger, S. Liu (Tencent)] [late]

[JVET-P0494](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8283) AHG12: Sub-picture signaling [B. Choi, S. Wenger, S. Liu (Tencent)] [late]

[JVET-P0581](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8372) AHG12: On Subpicture Cropping [S. Deshpande, J. Samuelsson, A. Segall (Sharp)]

#### Subpicture conformance definition and signalling (2)

[JVET-P0131](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7920) AHG12: On output sub\_picture sets [Y. He, A. Hamza (InterDigital)]

[JVET-P0448](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8237) AHG17: Sub-picture level info for extraction and merging [R. Skupin, Y. Sanchez, K. Sühring, T. Schierl (HHI)]

#### Subpicture boundary filtering (2)

[JVET-P0145](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7934) AHG17/AHG12: On the flags for processing with subpictures [L. Chen, C.-W. Hsu, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

See 6.19.1.1 for the disposition of this contribution.

[JVET-P0246](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8035) AHG17/Non-CE5: on loop filter processing for subpicture treated as a picture

See 6.19.1.1 for the disposition of the HLS aspects of this contribution.

The low-level signal processing aspect of this contribution, see section 6.5.

[JVET-P0984](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8799) AHG17: Subpicture level info for extraction and merging [R. Skupin, Y. Sanchez, K. Sühring (Fraunhofer HHI), J. Boyce, L. Xu (Intel)] [late]

TBP

### Slices, tiles, and bricks (12)

[JVET-P0144](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7933) AHG17/AHG12: On associating slices with a subpicture [L. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

For other aspects of this contribution, see section 6.19.1.1.

A bug fix: When single\_tile\_in\_pic\_flag is equal to 1, the value of num\_slices\_in\_pic\_minus1 is inferred to be equal to 0. (P0144). Decision: Adopt this aspect if still relevant and necessary after consideration of JVET-P0240.

[JVET-P0686](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8485) AHG12: A summary of HLS proposals on slices, tiles, and bricks [Y.-K. Wang (Futurewei)] [late]

Discussed Wednesday 1720 (GJS & JRO).

This contribution provides a summary of high-level syntax proposals submitted to this JVET meeting related to slices, tiles, and bricks. A list of design questions is provided to help structure the review of the proposals.

1. Have a single signalling mode instead of separate uniform and explicit tile/brick spacing modes (JVET-P0096)? Note that this proposal overlaps with a lot of aspects listed below. See notes below for JVET-P0096.
2. Change brick signalling as in JVET-P0233? Not relevant after other actions.
3. Remove brick signalling and signal rectanglar slices directly based on tiles? (JVET-P0240). See notes for that contribution.
4. Remove num\_tiles\_in\_pic\_minus1 from the brick syntax? (JVET-P0096, JVET-P0140, JVET-P0308, JVET-P0357, JVET-P0433) Not relevant after other actions.
5. Change " i <= num\_tiles\_in\_pic\_minus1 + 1" to "i < NumTilesInPic" in the loop for brick signalling? (JVET-P0096, JVET-P0140, JVET-P0186, JVET-P0308, JVET-P0357, JVET-P0433)? This is part of JVET-P0096, which was adopted.
6. Add CTU size in PPS? (JVET-P0096, JVET-P0308, JVET-P0357, JVET-P0433) This is part of JVET-P0096, which was adopted.
7. Add "i > 0" to the syntax condition for brick\_idx\_delta\_sign\_flag[ i ]? (JVET-P0126, JVET-P0140, JVET-P0232) Not relevant if action taken on JVET-P0240.
8. Add "isLastTileColumn[ BottomRightBrickIdx[ i − 1 ] ] = = 0" to the syntax condition for brick\_idx\_delta\_sign\_flag[ i ]? (JVET-P0232)? Not relevant if action taken on JVET-P0240.
9. Add the missing value range of brick\_row\_height\_minus1[ i ][ j ] to be 0..RowHeight[ i ] − 2? (JVET-P0186) Not relevant if action taken on JVET-P0240.
10. Allow a picture that contains only a single tile to be split into bricks/slices? (JVET-P0186) Decision (Ed.): Change the name of the flag and clarify the semantics to indicate that the flag disallows any partitioning of the picture into tiles/slices/brick/subpictures. Decision: Also allow there to be only one tile in the picture when the flag is 0 (which may or may not contain multiple slices).
11. Change/fix the equation for deriving slices based on bricks? (JVET-P0126, JVET-P0186) Not relevant if action taken on JVET-P0240.
12. Change the inferred value of brick\_height\_minus1[ i ] from RowHeight[ i ] − 1 to RowHeight[ i ] − 2? (JVET-P0231) Not relevant if action taken on JVET-P0240.
13. Add a constraint to explicitly express the requirement that when single\_tile\_in\_pic\_flag is equal to 1 there shall be no brick splitting? (JVET-P0231) See item 11 above.
14. Add loop\_filter\_across\_tiles\_enabled\_flag? (JVET-P0252) Decision: Adopt.
15. Split uniform\_tile\_spacing\_flag into uniform\_tile\_row\_spacing\_flag and uniform\_tile\_col\_spacing\_flag? (JVET-P0308) Resolved by action taken on JVET-P0096.
16. Replace tile\_row\_height\_minus1[ i ] and tile\_column\_width\_minus1[ i ] with tile\_row\_height\_delta[ i ] plus a sign flag and tile\_column\_width\_delta[ i ] plus a sign flag? (JVET-P0308) Resolved by action taken on JVET-P0096.
17. Allow signalling of multiple alternative tile configurations in the PPS and referring to one in the slice header? (JVET-P0364) It was commented that this may be related to how we support GDR. Offline study and consideration of GDR/CE2 contributions was then conducted. See notes for HLS BoG report.
18. Replace "if( RowHeight[ i ] > 1 )" and "if( RowHeight[ i ] > 2 )" in brick syntax with "if( TileHeight[ i ] > 1 )" and "if( TileHeight[ i ] > 2 )", respectively, and add that TileHeight[ i ] is derived to be equal to RowHeight[ i % ( num\_tile\_columns\_minus1 + 1 ) ]? (JVET-P0433) Not relevant if action taken on JVET-P0240.

[JVET-P0096](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7885) AHG12: On signalling of tile and brick partitioning [M. M. Hannuksela (Nokia)]

Discussed Wednesday 1820 (GJS & JRO).

This contribution proposes having a single signalling mode instead of separate uniform and explicit tile/brick spacing modes. The contribution is asserted to reduce:

* the number of syntax elements from 13 to 8,
* the number of syntax table rows from 28 to 17,
* the length of the semantics, and
* the length of the scanning process in clause 6.5.1.

The contribution is asserted to require a similar amount or fewer bits compared to VVC Draft 6 depending on the partitioning scheme.

Decision (Cleanup/simplification): Adopt.

[JVET-P0126](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7915) AHG12: Signalling of subpicture IDs and layout [M. M. Hannuksela (Nokia), Y.-K. Wang, Hendry (Futurewei)]

Some aspects in section 6.19.1.2.

Two aspects of JVET-P0126 (adding "i > 0" to the syntax condition for brick\_idx\_delta\_sign\_flag[ i ], and changing/fixing the equation for deriving slices based on bricks) belong to this category.

[JVET-P0140](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7929) AHG17/AHG12: Some comments on the VVC text [L. Chen, C.-W. Hsu, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

Aspects 3 and 4 of JVET-P0140 belong to this category.

[JVET-P0186](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7975) AHG12: On Tiles, Bricks, Slices [S. Deshpande (Sharp)]

[JVET-P0231](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8020) AHG12: On brick information signalling [B.-K. Lee (XRis), D. Jun (Kyungnam University)]

[JVET-P0232](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8021) AHG12: On rectangular slice addressing information [B.-K. Lee (XRis), D. Jun (Kyungnam University)]

[JVET-P0233](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8022) AHG12: Signaling of tile and brick information [B.-K. Lee (XRis), D. Jun (Kyungnam University)]

[JVET-P0240](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8029) AHG17: Slices [T. Hellman, W. Wan, M. Zhou, B. Heng, P. Chen (Broadcom)]

Discussed Wednesday 1740 (GJS & JRO).

This contribution proposes that the dimensions and locations of rectangular slices be signalled directly by using tile information rather than bricks. The proposal removes the need to predefine and store brick information at the PPS level in an effort to reduce the computation and storage required to determine rectangular slice dimensions and locations. It is asserted that there is no change to the slice and brick partitioning options available to the encoder, as the proposed changes only affect the signalling while keeping the underlying partitioning concepts intact.

The proposal was missing signalling for the number of entry points.

Brick boundaries would be established by a stop bit after each CTU row.

The proponent indicated that if the encoder does not want to use bricks, this could be indicated, e.g. at the picture or sequence level and the stop bit would not need to be sent.

It was noted that if the height is checked, the stop bit would not be needed after the last CTU row of the tile, which seems to be a sensible optimization.

The proponent indicated that the problem with the current syntax is that it requires storing information at the PPS level and using indirection to use this information which is needed only for determining brick sizes, whereas this could be signalled in the "old-fashioned" way of using a stop bit within the slice data.

It was commented that there is a bug in this approach, in that the entry points are useless because the vertical starting position of the brick would be unknown without parsing the slice data of the previous brick.

It was suggested that an alternative signalling that would achieve the same goal would be to signal in the slice header the number of bricks and the brick heights; this approach would preserve the usefulness of entry points and the ability to have multi-brick slices and would eliminate the need for the stop bits and might be more bit efficient.

It was questioned whether we really need multi-brick slices within tiles.

Additional discussion was held, considering the following questions:

* Do we need multi-brick slices within tiles?
* Text for the approach with brick heights in header.
* Text for the approach without multi-brick slices within tiles.

See notes for Bricksit (P1004).

[JVET-P0252](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8041) AHG12: Loop filter control flag for tile boundary [K. Abe, T. Toma, V. Drugeon (Panasonic)]

[JVET-P0308](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8097) AHG12: On signalling of tile partitioning [J. Do, D. Park, Y.-U. Yoon, J.-G. Kim (KAU)]

[JVET-P0357](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8146) AHG12: Signal the CTU size in both SPS and PPS [R. Sjöberg, M. Pettersson, M. Damghanian (Ericsson)]

[JVET-P0364](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8153) AHG12: Multiple tile partitions in PPS [M. Pettersson, R. Sjöberg, M. Damghanian (Ericsson)]

[JVET-P0433](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8222) AHG12: On brick signalling [Y.-J. Chang, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-P1004](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8819) AHG17: Removal of bricks [T. Hellman, W. Wan, M. Zhou, B. Heng, P. Chen (Broadcom)] [late] [miss]

[JVET-P1012](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8827) AHG17: An Informative for removal of bricks [W. Lim, G. Bang (ETRI)]

## AHG8: layered coding and resolution adaptivity (36)

### Scalability (27)

#### Output layer sets (3)

See also P0226 (open).

[JVET-P0115](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=7904) AHG8: Scalability - general and operation points [Y.-K. Wang (Futurewei)]

Discussed 1630 Tuesday (GJS).

It is asserted that the scalability design in VVC version 1 should be as simple as possible as long as main scalability use cases are addressed, while those fancy features that are not necessary for main scalability use cases, whenever they complicates the design and the specification, should not be included in VVC version 1.

This contribution proposes signalling of output layer sets.

It was asked whether we should define OLSs with inter-layer referencing. The current draft supports only identification of one operating point.

It was commented that this may partly be a matter of whether we consider the perspective of the server, which may have a more complete data set than what is served to a decoder. It was commented that conformance of an entire server-side bitstream may not need to be specified, versus only specifying what is sent to a decoder (which uses one operating point) and how to extract that.

At least as a starting point, the following was agreed:

A bitstream fed to a decoder would have only one specified conforming decoded output.

Metadata may be present in a bitstream to indicate how to convert the bitstream to a different bitstream with a different conforming decoded output.

There may be a larger set of data stored on a server for which there is no conformance point specified as the decoded output, without first applying a conversion/extraction/rewriting process to that set of data.

This is different from the current spec in regard to temporal sublayering , as the current draft has a concept of an indication to a decoder of the highest sublayer to decode. Similarly, the current spec has a concept of a decoder receiving an indication of a layer to decode within a bitstream that contains more than one layer (for independent simulcast layers). Decision: Agreed. This affects only subclause 8.1.1 of the draft text.

The extraction process is not conceptually part of the decoding process; it is something that happens before the creation of a bitstream to be consumed by a decoder. It becomes part of the specification of the semantics of the syntax used for the extraction.

It was noted that the current text does not even have level specifications yet (or even profile text).

[JVET-P0204](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7993) AHG8: Clarifications on output layers mode [V. Drugeon (Panasonic)]

[JVET-P0225](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8014) AHG8: On output layer set and PTL signalling [B. Choi, S. Wenger, S. Liu (Tencent)]

[JVET-P1019](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8834) AHG8: Signalling of output layer sets [Y.-K. Wang (Futurewei), B. Choi, S. Wenger, S. Liu (Tencent)]

#### Random access and POC (3)

Discussed Tuesday 1750 (GJS).

Both proposals suggest to allow IRAP and non-IRAP pictures in the same AU (not new; also supported in SHVC and SVC). For example, this would allow spatial scalability with more frequent IRAPs in the base layer than in the enhancement layer. Viewport-dependent ROI enhancement is another example, where there could be more frequent IRAPs in the enhancement layer than in the base layer.

Delay and coding efficiency were mentioned as issues involved in this. There was some questioning of whether this functionality is really needed.

It was mentioned that the point cloud coding activity in MPEG is using different IRAP periods in different layers. Another participant said that if the layers are independent, a system could use multiple bitstreams.

It was suggested that this functionality should not be difficult to support – mostly a matter of POC bookkeeping.

See notes for HLS BoG report.

[JVET-P0100](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7889) AHG8: Unaligned IRAP pictures across layers and layer-wise start-up [M. M. Hannuksela (Nokia)]

[JVET-P0101](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7890) AHG8: POC derivation for a multi-layer bitstream [M. M. Hannuksela (Nokia)]

JVET-P0116 AHG8: Scalability - random access [Y.-K. Wang (Futurewei)]

#### PTL, bitstream extraction, and conformance (6)

Discussed Tuesday 1830 (GJS).

SHVC supports PTL indication per layer in the context of each OLS.

It was discussed whether level should indicate the incremental resource needed to decode an individual layer or the total resource needed to decode an entire OLS. In SVC the latter approach was taken and in SHVC the former approach was taken. It was commented that the desire here is to use the same resource pool for scalable decoding as for single-layer decoding (e.g., with RPR being the same resource as spatial scalability upsampling and with a single DPB serving as a multilayer DPB), which would suggest the OLS approach. In SHVC the concept was more like using multiple single-layer decoders to implement a scalable decoder. Decision in principle: Level indicates total resource for an operating point (incl. CPB and DPB).

[An operation point is a temporal subset of an OLS.]

[JVET-P0117](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7906) AHG8: Scalability - PTL and decoder capability [Y.-K. Wang (Futurewei)]

[JVET-P0098](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7887) AHG8/AHG17: Handling of VPS and EOB NAL units in the sub-bitstream extraction process [M. M. Hannuksela (Nokia)]

[JVET-P0380](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8169) AHG8/AHG17: On the role of nuh\_layer\_id in the layer design [E. Thomas (TNO), M. Hannuksela (Nokia), L. Chen (MediaTek), Yong.He@InterDigital.com, S. Wenger, B. Choi (Tencent)]

[JVET-P0118](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7907) AHG8: Scalability - HRD [Y.-K. Wang (Futurewei)]

[JVET-P0125](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7914) AHG17: Miscellaneous HLS topics [Y.-K. Wang (Futurewei)]

[JVET-P0190](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7979) AHG8/AHG17: Scalable nesting SEI message [Y.-K. Wang (Futurewei)]

#### Region-wise scalability (1)

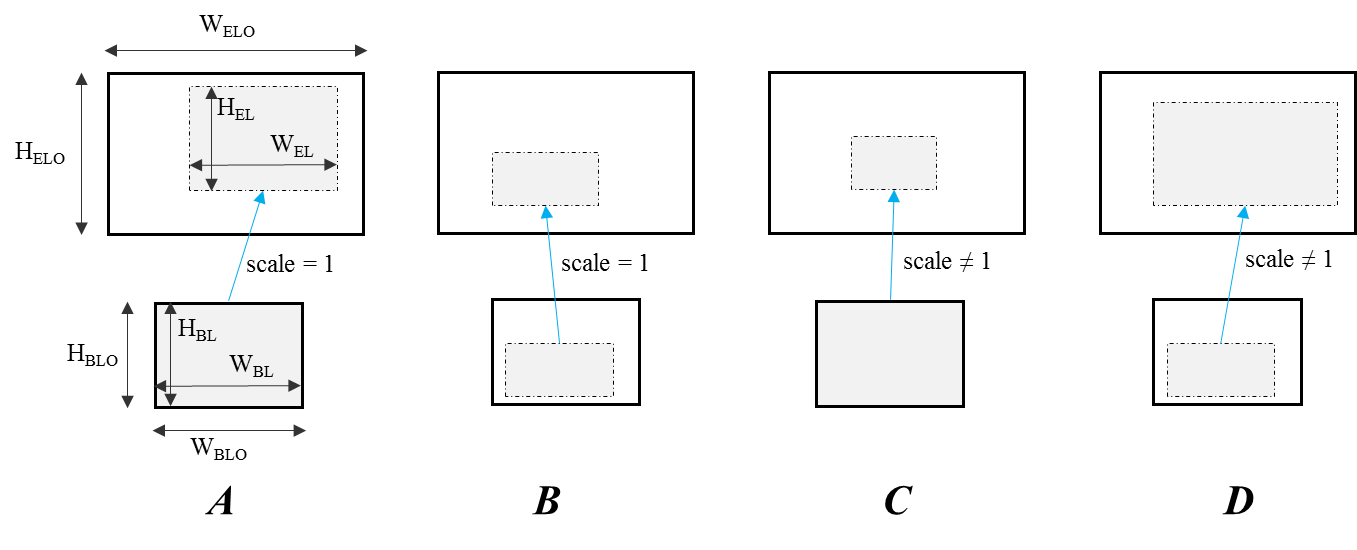
[JVET-P0336](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8125) AHG8: Support of ROI (Region-Of-Interest) scalability [T. Lu, F. Pu, P. Yin, S. McCarthy, W. Husak, T. Chen (Dolby)]

In SHVC we have the proposed functionality, illustrated below. A basic functionality is to have controllable spatial offsets and scaling between the reference layer and the enhancement layer. The proposal might also involve having some different treatment based on location within enhancement layer. It might also involve changing the bounding box of picture extrapolation for motion compensation.

It was commented that P0219 and P0482 for RPR are related.

Further clarity on the details of what is proposed and consideration of such details is needed.

See notes for HLS BoG report; this was planned for further study.



#### VPS and single-layer bitstreams/decoders (2)

Discussed Tuesday 1950 (GJS).

At the previous meeting, we had agreed in principle for VPS syntax to not be required to be present in a single-layer bitstream (and we actually had an ability to not have the VPS present, but did not properly specify what happened in that case).

[JVET-P0097](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7886) AHG8/AHG17: Removing dependencies on VPS from the decoding process of a non-scalable bitstream [M. M. Hannuksela (Nokia)]

This was said to be a bug fix for places in the spec text that are not aligned with the above-described decision.

[JVET-P0205](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7994) AHG17: Presence of Video Parameter Set in bitstreams [V. Drugeon (Panasonic)]

This was said to be a bug fix for places in the spec text that are not aligned with the above-described decision.

[JVET-P0185](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7974) AHG8/AHG17: On Video Parameter Set and Highest Temporal Sub-layer [S. Deshpande (Sharp)]

This has a bug fix for the above-described issue and has some additional aspects.

#### External independent layers (1)

Discussed Tuesday 2005 (GJS).

The basic question is whether to support external independent layers as was done in SHVC. This could be something for further study as an extension project, but does not seem like a priority to consider for v1.

[JVET-P0213](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8002) AHG8: External independent layers [M. M. Hannuksela (Nokia)]

#### Multi-layer based single-layer decoding and subpicture support (3)

[JVET-P0212](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8001) AHG8/AHG12: Decoding multiple independent layers with single-layer decoding process [M. M. Hannuksela (Nokia), S. Wenger, B. Choi (Tencent), E. Thomas (TNO), V. Seregin, M. Coban (Qualcomm), Y. He (InterDigital), L. Chen (MediaTek)]

Discussed Tuesday 2015 (GJS).

This proposes a method of using a single decoder instance and the single-layer VVC decoding process for decoding multiple independent layers. The decoding is performed as if all NAL units resided in a single layer only.

It is reported that the proposal can be used with any types of independent layers, such as "independent coded region" layers, and texture or depth layers, e.g. for 3DoF+. The type of a layer has no normative impact in the decoding process.

One use of this is to enable subpictures by decoding the rectangles separately and using a post-decoding compositor to assemble a combined picture. It was commented that this can enable non-CTU-aligned subpicture sizes. However, it was commented that the compositing step would be an additional processing compositing stage that would be needed and may or may not be outside the scope of the specified conforming decoding process.

In the contribution, the layout of the subpictures is signalled in an SEI message.

This was assuming aspects such as PTL per layer that are different from the design philosophy agreed to earlier in the meeting.

No action was taken on this.

[JVET-P0226](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8015) AHG8/AHG12: On output layer set with sub-pictures [B. Choi, S. Wenger, S. Liu (Tencent)] [late]

Discussed Tuesday 2035 (GJS).

Part of this relates to multi-layer-based subpicture support as with P0212; see notes for that contribution.

Another part proposes signalling of OLSs and should be considered with contributions in 6.20.1.1.

[JVET-P0481](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8270) AHG17: On output layers and output layer sets [Y. Sanchez, R. Skupin, K. Sühring, T. Schierl (HHI)] [late]

Discussed Tuesday 2050 (GJS).

Part of this relates to multi-layer-based subpicture support as with P0212 and P0226; see notes for that contribution.

In this proposal, the subpictures would be CTU aligned.

This aspect can provide a way to indicate conformance of a set of subpictures, since the subset an OLS. However, a participant commented that the same thing can be done for the illustrated use case using subpictures without using layers.

That subpicture aspect is only one functionality of the proposed approach.

Another is layer switching where the decoder is instructed to treat different layer IDs as the same for adaptive stream switching. However, it was commented that the server could use just one layer ID for both tracks and keep track for itself of which track to put into the bitstream that is given to the decoder and when to switch between the tracks; this sort of thing is sometimes done today (and DASH has some track switching metadata support).

There was no clear need for action on this, although it can be kept in mind if some further study indicates a way this can support necessary functionality that is not otherwise provided.

#### Miscellaneous scalability HLS topics (7)

[JVET-P0128](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7917) AHG8: Scalability - GDR [Y. He, A. Hamza (InterDigital)]

[JVET-P0132](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7921) AHG8: On inter-layer motion vector prediction [Y. He, Y. He, A. Hamza (InterDigital)]

[JVET-P0187](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7976) AHG8/AHG17: Comments on HLS of VVC [S. Deshpande (Sharp)]

[JVET-P0223](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8012) AHG8: Signalling representation format [B. Choi, S. Wenger, S. Liu (Tencent)] [late]

[JVET-P0228](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8017) AHG17: General comments on HLS of VVC [B. Choi, S. Wenger, S. Liu (Tencent)]

[JVET-P0453](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8242) AHG8: On diagonal referencing for layered VVC [Y. Sanchez, R. Skupin, K. Sühring, T. Schierl (HHI)]

Discussed Tuesday 2120 (GJS).

This contribution proposes to add support of diagonal referencing for layered VVC bitstream, i.e., inter-layer dependency for picture of different access units.

It was reported that SVC had a "medium granularity scalability" referencing of higher reference layers, but otherwise we have not supported diagonal referencing in prior scalability designs.

The proposal allows diagonal references to lower layers.

This would seem not especially difficult to support. However, no strong argument for supporting it was provided. Further study was encouraged to determine whether there is any significant advantage (e.g., in coding efficiency) for supporting this.

### Reference picture resampling (RPR) (6)

[JVET-P0206](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7995) AHG17: Clean-up on disabling temporal motion vector prediction in case of reference picture resampling [T. Nishi, V. Drugeon (Panasonic)]

[JVET-P0403](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8192) AHG8/AHG12: Subpicture-specific reference picture resampling [M. M. Hannuksela, A. Aminlou, K. Kammachi-Sreedhar (Nokia)]

[JVET-P0450](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8239) AHG17: On Sample Aspect Ratio for RPR [R. Skupin, Y. Sanchez, K. Sühring, T. Schierl (HHI)]

[JVET-P0482](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8271) AHG8: On reference picture resampling [Y. Sanchez, R. Skupin, K. Sühring, T. Schierl (HHI)] [late]

[JVET-P0591](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8383) AHG8: Resampled output picture [V. Seregin, A. K. Ramasubramonian, M. Coban, M. Karczewicz (Qualcomm)]

# Complexity analysis and reduction (2)

Contributions in this category were discussed XXday X Oct. XXXX–XXXX in Track X (chaired by XXX).

[JVET-P0084](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7873) Decoding Energy Assessment of VTM-6.0 [M. Kränzler, C. Herglotz, A. Kaup]

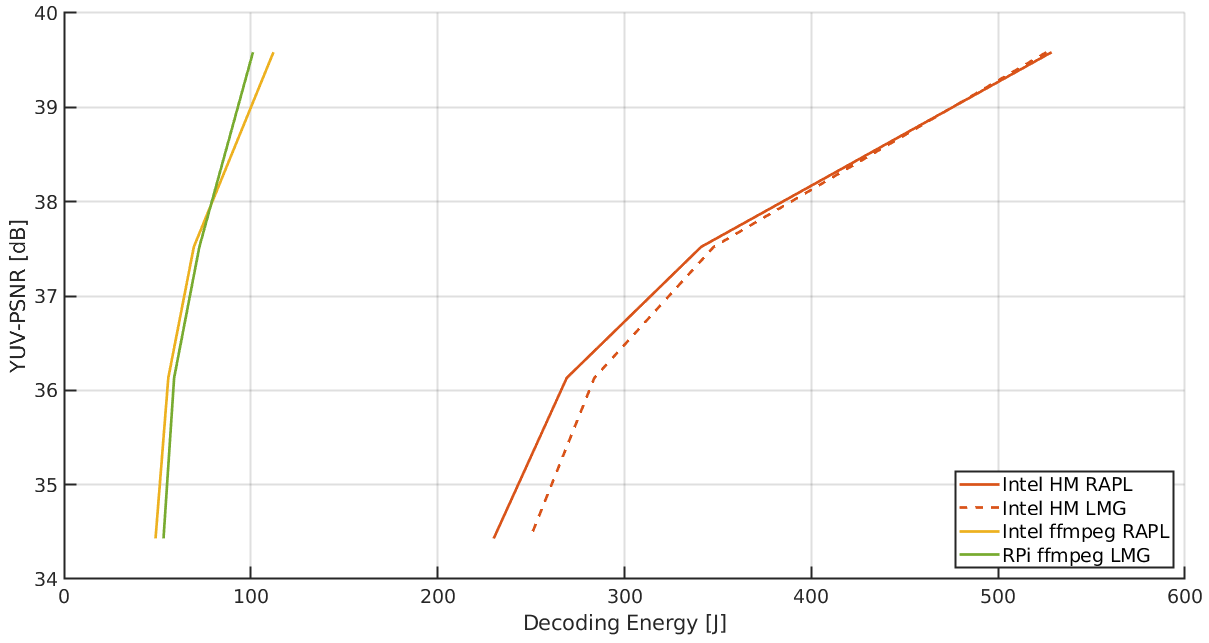
Discussed Wed 9 1750 October Track B (GJS)

This contribution describes the decoding energy assessment of the VTM-6.0 decoder. The contribution describes different possibilities to measure the energy of a video decoder on a desktop PC and a Raspberry Pi. The measurements are evaluated with the Bjøntegaard-Delta metric. It is reported that the evaluation of the decoding energy measurements indicate that the energy demand is increased by approximately 72% in comparison to bitstreams of the same sequence coded and decoded with HEVC at equal objective visual quality.

The Powerpoint deck was requested to be provided.

With the decoding energy measurements, it is reported that the VTM decoder has an increased energy demand for comparable bitstreams with equal objective visual quality as compared to HEVC. Furthermore, it could be determined that the measurement of the decoding energy has sufficient accuracy with RAPL. Additionally, the following findings were observed:

Figure 6: Evaluation of the decoding energy on different devices for the HEVC video codec for the sequences Campfire with the configuration randomaccess. The measurements on the desktop Pc are shown by the red and yellow curves and on the Raspberry Pi as green curve.



* Measurement methods for different hardware
* VTM currently needs 70% more decoding energy
* Energy increase is highest for intra, lowest for lowdelay
* A practical implementation (FFmpeg) saves 80% of energy for HEVC, for VTM, a similar amount is expected
* The expected decoding energy for Intel and ARM CPUs is almost the same
* Precise knowledge about VTM decoding energy could finally be used to optimize the VVC video bit stream using decoding-energy-rate-distortion optimization (DERDO).

In the discussion, intra was shown to have a substantial energy increase that seemed to distinguish this case from inter.

It was commented that the situation is quite different for custom hardware. Maybe

Is the video decoder more power consuming than the display?

It was commented that there is typically much less power consumption for video decoder than game playing or web browser.

The analysis can be done just based on the bitstream and decoder.

Studying individual coding tools was suggested.

It was commented that bandwidth is not the same thing as power consumption.

Transmisssion reception power consumption is reportedly much less in 5G than in previous systems.

It was commented that parallel processing measurement would be beneficial.

OpenHEVC was mentioned as a parallel implementation.

Further study was encouraged (e.g., in AHG13).

[JVET-P0085](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7874) Bit Stream Analyzer for Coding Tool Statistics [C. Herglotz, M. Kränzler, A. Kaup]

Discussed Wed 9 1820-1835 October Track B (GJS)

This contribution presents an analyzer add-on for the VTM decoder. It counts the use of certain coding tools used for reconstruction. The analyzer counts the occurrence of tools like intra prediction, transformations, residual coefficients, and in-loop filtering operations on slice level, block level, or pel level. The authors report that the tool is lightweight in terms of complexity and that the results of the analyzer can be used for further interpretation and assessment of coding tools.

The proposed tool is reported to be computationally lightweight in comparison with standard tracing and provides the following information:

* Occurrence of coding modes depending on block sizes
* Overall sequence-wise statistics

With the help of this information, the following benefits could be drawn:

* Information on the use of newly introduced coding modes.
* Information on the use of established coding modes, which might not or barely be used anymore.
* Investigation of the influence of external parameters (e.g., QP, encoder configuration) on the use of coding tools.
* Exploitation for energy modeling [3].
* Exploitation for decoding-energy optimal encoding [4].

The source code is provided at a URL given in the contribution, based on the VTM software, using the same copyright license.

It was suggested that this would be a good thing to have in our software. It does not affect runtime much.

It was commented that we could use this for things like looking at what is happening in a certain area of a picture where artefacts may be observed.

Further study of this software was encouraged.

# Encoder optimization (1)

[JVET-P0092](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7881) AHG13: Encoder speed up for SMVD [H. Chen, H. Yang (Huawei)]

This was discussed in the CE4 BoG; see notes on BoG report.

[JVET-P0903](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8718) Crosscheck of JVET-P0092 on encoder speed-up for SMVD [X. Xiu (Kwai Inc.)]

# Metrics and evaluation criteria (1)

Contributions in this category were discussed XXday X Oct. XXXX–XXXX in Track X (chaired by XXX).

# Withdrawn (24)

JVET-P0048 Withdrawn

JVET-P0102 Withdrawn

JVET-P0103 Withdrawn

JVET-P0104 Withdrawn

JVET-P0138 Withdrawn

JVET-P0227 Withdrawn

JVET-P0229 Withdrawn

JVET-P0247 Withdrawn

JVET-P0268 Withdrawn

JVET-P0296 Withdrawn

JVET-P0323 Withdrawn

JVET-P0564 Withdrawn

JVET-P0618 Withdrawn

JVET-P0627 Withdrawn

JVET-P0753 Withdrawn

JVET-P0765 Withdrawn

JVET-P0794 Withdrawn

JVET-P0802 Withdrawn

JVET-P0862 Withdrawn

JVET-P0920 Withdrawn

JVET-P0959 Withdrawn

JVET-P0975 Withdrawn

JVET-P0992 Withdrawn

JVET-P1035 Withdrawn

# Plenary meetings, joint meetings, BoG reports, and summary of actions taken

## High-level syntax / systems relation meeting

This planned session was cancelled due to a lack of identified need, as communicated by the relevant MPEG AHG chair.

## Plenary meeting Sunday 6 Oct. 1530-1800

Reports of the tracks were presented as follows:

The general status of track A was presented and discussed, which particularly included the following aspects (not every small decision is noted):

CE3: Intra prediction and mode coding

* Current MIP is performing the order of upsampling filters depending on the block shape (upsampling is applied for blocks >8x8 where the prediction is first generated in a downsampled version). The results of JVET-P0054 show that switching the order is not necessary, no compression loss. Also aligned with the order of filtering in motion comp.
* Non-CE3/related proposals in BoG

CE5: Loop filtering

* Not reviewed yet
* Subjective testing prepared for various filters

CE6: Transforms and transform signalling

* All on LFNST, no adoptions

CE7: Quantization and coefficient coding

* JVET-P0072, version 7-1.3b\* (aka 7-1.3alt): Simplified entropy coding for TS residual: Only 2 checks per context coded bin to determine switching to GR coding, limit 1.75 bin/coeff., same tabl as in transform residual for GR
* slight loss against the current method under CTC, but clear gain (1.75%) in low QP range

CE8: Screen content coding tools (6)

* Palette: CE8-1.3 (JVET-P0077) handling groups of 16 samples instead of whole CU (escape flags are coded after each group). Further replaces the run length coding by signalling the identity or non-identity with the previous sample. Worst case of context coded bins is not increased (2 per pixel, still less than for the case of transform coding)
* CE8-2.1 enables transform skip TS residual coding for the chroma components, shows gain for the screen content sequences. Enable in case of 4:4:4 coding for design consistency, in particular when RGB is encoded.
* CE8-4.1 additionally enables BDPCM along with TS, gives some additional gain for some classes of screen content - would be useful in particular when RGB is encoded.

CE6 related – Transforms and transform signalling

* Two contributions on re-training transforms indicate that additional gain is low (regardless if they are trained with CTC or non-CTC conditions). Concluded that the current matrices are stable enough and shall be frozen in the interest of a stability of the standard development.

CE7 related – Quantization and coefficient coding

* Some bug fixes and syntax cleanups
* Add-ons to new TS residual coding: omit prediction for GR coded amplitudes, use fixed Rice parameter

CE8 related – Screen content coding tools

* JVET-P0400: Removal of shared merge list in IBC (no loss)
* Remaining palette proposals to be reviewed in BoG tonight

Lossless and near lossless coding

* AHG18: transquant bypass approach enables lossless functionality by imposing additional elements to the decoder
* Alternative: Method via TS and low QP would need configuring action at the encoder, currently only TS for chroma is missing.
* There is also indication that with the newly adapted method of TS residual coding, the lossless compression improves.

Questions to plenary:

* Shall VVC include support for lossless?
* If yes, is it better by transquant bypass or TS / low QP?

Agreed in plenary, track A to decide upon availability of results with new TS entropy coding.

From the discussion in track A, the method which puts the burden at the encoder is preferable. The only still necessary normative change is enabling TS for all chroma sampling schemes (see right column below).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **TOOL** | **AHG18 lossless anchor** | **Change** | **Proposed** | **Change** |
| SBT off | implicitly (transquant bypass) | yes | explicitly | no |
| LFNST off | implicitly (transquant bypass) | yes | explicitly | no |
| skip trafo Y | implicitly (transquant bypass) | yes | explicitly | no |
| skip trafo Cb | implicitly (transquant bypass) | yes | explicitly | yes |
| skip trafo Cr | implicitly (transquant bypass) | yes | explicitly | yes |
| skip trafo for ISP | implicitly (transquant bypass) | yes | no | no |
| BDPCM off | explicitly | no | explicitly | no |
| residual coding | regular | yes | transform skip (TSRC) | no |
| scaling off | implicitly (transquant bypass) | yes | implicitly (QP < 5) | no |
| JCCR off | explicitly | no | explicitly | no |
| SDH off | implicitly (transquant bypass) | yes | implicit (TSRC) | no |
| MaxTrafoSize=32x32 | explicitly | no | explicitly | no |
| LMCS off | explicitly | no | explicitly | no |
| DF off | implicitly (transquant bypass) | yes | explicitly | no |
| SAO off | implicitly (transquant bypass) | yes | explicitly | no |
| ALF off | explicitly | no | explicitly | no |

The general status of track B was then presented and discussed, which particularly included the following aspects. Decisions recommended from track B were agreed and approved, unless otherwise noted:

* BoG on HLS ongoing
* CE 4 and BoG on CE4 inter prediction first pass finished, not yet reviewed – sections 5.4 and 6.4
  + CE4-2.1 P0057 BDOF and PROF refinement range, PROF precision 1/64 🡪 1/32
  + BoG and visual testing ongoing
* CE 1 related reference picture resampling (signal processing aspects) – section 5.1 and 6.1
  + CE1-1.3 filters for 1.5:1 case
  + P0353 filters for 2:1 case
  + Switching points are 1.25 and 1.75; bug fix for half-pel case
  + SPS enabling flag constraining picture size
  + P0590 separate windowing parameters
  + Prohibit PROF & RPR
  + Chroma alignment positioning flags
* CE 2 GDR – section 5.2
  + Boundary signalling in SPS or picture header
* Misc coding tools – section 6.14
  + Bug fix of LMCS signalling
* Partitioning – section 6.11
  + P0063, P0406, P0520, P0537 – fix for smallest chroma intra prediction unit (SCIPU) and fix for non-4:2:0 chroma formats
  + Additional item from P0063: normatively disallow BT/TT split that creates 4x4 luma blocks in an inter coding region, which removes redundant CU-split-related flags (e.g., split\_cu\_flag)
  + P0641 Removal of 2xN chroma intra blocks
  + P0347 Sensibility constraint on sps\_max\_mtt\_hierarchy\_depth\_intra\_slice\_luma and similar
  + 2 TBP, some considered HLS

Conformance testing was discussed (see section 4.6).

Profile, tier and level were discussed (see section 4.6).

## Plenary meeting xxday XXXX-XXXX

Need more consideration of potential removal of low-coding-gain stuff.

## Closing Plenary meeting Friday 11 Oct.

… .

## Joint meeting XXday XX March XXXX-

JVET with … .

## BoGs (X)

[JVET-P0968](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8783) Report of BoG on high-level syntax [Y.-K. Wang]

Reviewed in Track B Wed 9 Oct. 1900 (GJS)

The HLS BoG met on the following days and time slots:

1. 3 Oct. Thursday 14:00 to 21:40
2. 4 Oct. Friday 09:00 to 21:35
3. 5 Oct. Saturday 09:00 to 21:30
4. 7 Oct. Monday 14:00 to 21:20
5. 9 Oct. Wednesday 9:00 to 17:30

Altogether, 155 HLS proposals, in the following three areas, have been reviewed by the JVET plenary meeting on Tuesday 10/1 and Wednesday 10/2, JVET Track B Thursday 10/3 morning, and the above listed HLS BoG meetings:

1. 6.18 AHG17: General high-level syntax (65, excluding cross checks)
2. 6.19 AHG12: high-level parallelism and coded picture regions (57)
3. 6.20 AHG8: layered coding and resolution adaptivity (33)

In the list of recommendations below, the name in each instance of "SW/name" is suggested to be the person who would be responsible for coordinating the software implementation (if needed) of the recommendation if confirmed by the JVET. Currently, for each item (except one), the name is that of the first author of the first listed contribution.

Note that there is no need for identifying a person for spec text coordination for HLS adoptions.

Note that agreement (e.g., on subpicture topics) that were made earlier at JVET plenary or track meetings are not listed below.

Decision (Ed.): As noted in the HLS BoG meeting minutes. There were also some purely editorial suggestions that were noted in the HLS BoG meeting minutes to be delegated to the editors, and those are not listed here, either.

The BoG recommends the following adoptions:

1. Reserve nuh\_layer\_id values 56 to 63, inclusive, in VVCv1 [JVET-P0362][SW/R. Sjöberg] Decision (extensibility): Agreed.
2. Rearrange/cleanup the NAL unit types as follows [JVET-P0363][SW/M. Pettersson]:
   1. Switch position of RADL and RASL in the table to align with the order in HEVC. Decision (cleanup): Agreed.
   2. Add VPS\_NUT, which is missing, and order the parameter set NUTs in hierarchical order as in HEVC, in the order of DPS\_NUT, VPS\_NUT, SPS\_NUT, PPS\_NUT, APS\_NUT. Decision (BF/cleanup): Agreed.
   3. Group reserved non-IRAP VCL NUTs within one code range instead of two. Decision (BF/cleanup): Agreed.
   4. Allocate 5 codes instead of 6 for reserved non-IRAP VCL NUTs and 3 codes instead of 2 for reserved IRAP VCL NUTs. Decision (BF/cleanup): Agreed.
3. Change the PTL syntax and semantics as follows [JVET-P0217][SW/J. Samuelsson]:
   1. Move general constraints and general\_level\_idc before sub-profiles. Decision (BF/cleanup): Agreed, and also add reserved bytes preceded by an 8-bit length in bytes, with decoders required to allow and ignore the values of the reserved bytes and encoders required to set the length to 0.
   2. Allow signalling of zero or more sub-profiles. Decision (BF/cleanup): Agreed
   3. Add inference of sub-layer level based on the level of the next higher sublayer. Decision (cleanup): Agreed
4. Allow more than one PTL syntax structure in the DPS, with the following changes: reserve 5 bits instead of 1 bit, and use u(4) for the number of PTL syntax structures minus 1. [JVET-P0478, SW/R. Skupin] Decision (cleanup): Agreed
5. Add the following RPL-related constraints to ensure that the inter prediction relationship among IRAP, RASL, RADL, trailing, and GDR pictures etc. function as expected [JVET-P0978][SW/M. Pettersson]: Decision (expression of existing intent): Agreed (including the GDR note described below).

* When the current picture is a CRA picture, there shall be no entry in RefPicList[ 0 ] or RefPicList[ 1 ] that precedes, in output order or decoding order, any preceding IRAP picture in decoding order (when present).
* When the current picture is a trailing picture, there shall be no picture referred to by an active entry in RefPicList[ 0 ] or RefPicList[ 1 ] that was generated by the decoding process for generating unavailable reference pictures for the IRAP picture associated with the current picture.
* When the current picture is a trailing picture that follows in both decoding order and output order one or more leading pictures associated with the same IRAP picture, if any, there shall be no picture referred to by an entry in RefPicList[ 0 ] or RefPicList[ 1 ] that was generated by the decoding process for generating unavailable reference pictures for the IRAP picture associated with the current picture.
* When the current picture is a recovery point picture or a picture that follows the recovery point picture in output order, there shall be no entry in RefPicList[ 0 ] or RefPicList[ 1 ] that contains a picture that was generated by the decoding process for generating unavailable reference pictures for the GDR picture of the recovery point picture.
* When the current picture is a trailing picture, there shall be no picture referred to by an active entry in RefPicList[ 0 ] or RefPicList[ 1 ] that precedes the associated IRAP picture in output order or decoding order.
* When the current picture is a trailing picture that follows in both decoding order and output order one or more leading pictures associated with the same IRAP picture, if any, there shall be no picture referred to by an entry in RefPicList[ 0 ] or RefPicList[ 1 ] that precedes the associated IRAP picture in output order or decoding order
* When the current picture is a RADL picture, there shall be no active entry in RefPicList[ 0 ] or RefPicList[ 1 ] that is any of the following:
  + A RASL picture
  + A picture that was generated by the decoding process for generating unavailable reference pictures
  + A picture that precedes the associated IRAP picture in decoding order

And replace the requirement on exact match of GDR recovery point picture to a NOTE (exact wording delegated to editors).

1. Constrain that, when vps\_independent\_layer\_flag[ GeneralLayerIdx[ nuh\_layer\_id ] ] is equal to 1, the value of inter\_layer\_ref\_pics\_present\_flag shall be equal to 0. [JVET-P0182, JVET-P0221][SW/S. Deshpande] Decision (expression of existing intent): Agreed
2. Adopt the following improvement and bug fix: [JVET-P0221, JVET-P0589][SW/B. Choi] Decision (expression of existing intent): Agreed
   1. Update the value range of ilrp\_idc[ listIdx ][ rplsIdx ][ i ] to be in the range of 0 to the NumDependentLayers[ GeneralLayerIdx[ nuh\_layer\_id ] ] − 1, inclusive.
   2. Fix the equation for derivation of DirectDependentLayerIdx, by changing "i < " to "i <= ", and "j = i" to "j = i − 1".
3. Remove the following constraints: [JVET-P0122][SW/Hendry] Decision (cleanup unnecessary constraints): Agreed

* For intra slices and slices in an IRAP picture, slice\_alf\_aps\_id\_luma[ i ] shall not refer to an ALF APS associated with other pictures rather than the picture containing the intra slices or the IRAP picture.
* For intra slices and slices in an IRAP picture, slice\_alf\_aps\_id\_chroma shall not refer to an ALF APS associated with other pictures rather than the picture containing the intra slices or the IRAP picture.

1. Add an SEI message that contains only a flag self\_contained\_cvs\_flag in its syntax. The flag equal to 1 indicates that parameter sets are "self-contained" in a manner that enables random access from any CVSS picture without fetching parameter sets from AUs before the CVS (this piece is the same as in HEVC), and additionally, enables sub-layer up-switching at STSA pictures without fetching parameter sets from AUs before the switching point (this piece is not in HEVC). [JVET-P0359][SW/R. Sjöberg] Decision (cleanup): Agreed
2. Adopt the following clarifications: [JVET-P0184][SW/S. Deshpande] Decision (clarification): Agreed
   1. Clarify the process for generating unavailable reference pictures such that it is clear that the process only applies to intra-layer reference pictures.
   2. Fix the use of the sps\_max\_dec\_pic\_buffering\_minus1 syntax element without using an index now that it is an array/list.
3. Adopt the following clean-up changes: [JVET-P0243, JVET-P0244, JVET-P0429][SW/W. Wan] Decision (cleanup and expression of existing intent): Agreed, but just make chroma\_format\_idc a u(2).
   1. Signal a single bit depth to be used for both luma and chroma.
   2. Use u(4) for SPS IDs in the SPS syntax as well as in other places for referring to SPS.
   3. Code chroma\_format\_idc with u(3).
   4. Code log2\_max\_pic\_order\_cnt\_lsb\_minus4 with u(4).
   5. Specify the value range of min\_qp\_prime\_ts\_minus4 to be 0 to 48, inclusive.
   6. Specify the value range of log2\_min\_luma\_coding\_block\_size\_minus2 to be 0 to log2\_ctu\_size\_minus5 + 3, inclusive.
4. Add the following constraint flags into the general\_constraint\_info( ) syntax structure: [JVET-P0366][SW/M. Pettersson] Decision (cleanup): Agreed
   1. no\_trail\_constraint\_flag
   2. no\_stsa\_constraint\_flag
   3. no\_rasl\_constraint\_flag
   4. no\_radl\_constraint\_flag
   5. no\_idr\_constraint\_flag
   6. no\_cra\_constraint\_flag
   7. no\_gdr\_constraint\_flag
   8. no\_aps\_constraint\_flag
5. Add the following constraints to ensure that the referencing of ALF parameters from slice header to ALF APS works as expected: [JVET-P0438][SW/J. Chen] Decision (expression of existing intent): Agreed
   1. It is requirement of bitstream conformance that the values of alf\_luma\_filter\_signal\_flag and alf\_chroma\_filter\_signal\_flag shall not both be equal to 0.
   2. The value of alf\_luma\_filter\_signal\_flag of the APS NAL unit having aps\_params\_type equal to ALF\_APS and adaptation\_parameter\_set\_id equal to slice\_alf\_aps\_id\_luma[ i ] shall be equal to 1.
   3. The value of alf\_chroma\_filter\_signal\_flag of the APS NAL unit having aps\_params\_type equal to ALF\_APS and adaptation\_parameter\_set\_id equal to slice\_alf\_aps\_id\_chroma shall be equal to 1.
6. Allow an APS NAL unit to be after the last VCL NAL unit of the associated picture, by defining two NUTs for APSs, prefix APS NUT and suffix APS NUT. [JVET-P0588, JVET-P0452][SW/V. Seregin]. Decision (cleanup): Agreed. (This needs have the same content if it reuses an ID value that is referenced in the current picture, regardless of whether it is a prefix or suffix.) It was also suggested to consider adding some note to clarify that new APS content cannot be applied to VCL NAL units that are earlier in decoding order.
7. Adopt the following clean-up changes: [JVET-P0181, JVET-P0183][SW/S. Deshpande] Decision (cleanup and expression of existing intent): Agreed.
   1. Require that bp\_nal\_hrd\_parameters\_present\_flag and bp\_vcl\_hrd\_parameters\_present\_flag cannot be both equal to 0, and clean-up the syntax of the BP SEI message accordingly.
   2. Add inference rules for du\_cpb\_removal\_delay\_increment\_length\_minus1 and dpb\_output\_delay\_du\_length\_minus1 if needed.
   3. Add a flag to the BP SEI message syntax to specify whether the initial CPB buffering delay values are signalled for each temporal sub-layer or only for the highest temporal sub-layer.
   4. Conditionally signal cpb\_removal\_delay\_delta\_enabled\_flag[ i ] for i in the range of TemporalId to pt\_max\_sub\_layers\_minus1 − 1, inclusive, based on cpb\_removal\_delay\_deltas\_present\_flag.
   5. Specify the length of cpb\_removal\_delay\_delta\_idx[ i ] to be Ceil( Log2( num\_cpb\_removal\_delay\_deltas\_minus1+1) ) bits.
8. Adopt the following changes related to the BP, PT, and DUI SEI messages: [JVET-P0202, JVET-P0189, JVET-P0203][SW/ V. Drugeon] Decision (expression of existing intent): Agreed.
   1. Add a loop to the PT and the DUI SEI messages for signalling of CPB timing parameters for sub-layers in DU-based HRD operations, and remove pt\_max\_sub\_layers\_minus1 and dui\_max\_sub\_layers\_minus1 and use the corresponding syntax element in the BP SEI message.
   2. Repeat decoding\_unit\_hrd\_params\_present\_flag in the BP SEI message and move decoding\_unit\_cbp\_params\_in\_pic\_timing\_sei\_flag to the BP SEI message, and use these syntax elements in the BP SEI message in syntax conditions in the PT and DUI SEI messages as needed. [JVET-P0202, JVET-P0189][SW/ V. Drugeon]
9. Add the following HEVC and AVC SEI messages to ITU-T H.SEI | ISO/IEC 23002-7. [JVET-P0337][SW/S. McCarthy] Decision (cleanup/carry-over): Agreed, and also unregistered user data (using the HEVC version of these).
   1. User data registered by Recommendation ITU-T T.35 SEI message
   2. Film grain characteristics SEI message
   3. Frame packing arrangement SEI message
   4. Mastering display colour volume SEI message
   5. Content light level information SEI message
   6. Alternative transfer characteristics information SEI message
   7. Ambient viewing environment SEI message
   8. Content colour volume SEI message
10. Add the following HEVC and AVC SEI messages to ITU-T H.SEI | ISO/IEC 23002-7. [JVET-P0462][SW/R. Skupin] Decision (cleanup/carry-over): Agreed
    1. Equirectangular Projection SEI message
    2. Sphere rotation SEI message
    3. Region-wise packing SEI message
    4. Omnidirectional viewport SEI message
11. Adopt a new generalized cubemap projection SEI message, as proposed in JVET-P0597, but remove two lines of syntax for the byte alignment. into ITU-T H.SEI | ISO/IEC 23002-7. [JVET-P0597][SW/Y.-H. Lee]. HEVC had only a single layout without padding and did not support parameterized cubemaps and hemisphere cubemaps. Decision (enhanced vs. HEVC based on prior work in JVET): Agreed
12. Adopt a new SEI message that provides picture rate information, as proposed in JVET-P0610. Into ITU-T H.SEI | ISO/IEC 23002-7. [JVET-P0610][SW/M. Sychev].

This is deferred for first consideration in JCT-VC in the HEVC context, and can be considered later as a potential amendment for VVC.

1. Adopt a new SEI message that provides shutter interval information, as proposed in JVET-P0338, but add the number of sub-layers to avoid parsing dependency on SPS. Into ITU-T H.SEI | ISO/IEC 23002-7. [JVET-P0338][SW/S. McCarthy]

This is deferred for first consideration in JCT-VC in the HEVC context, and can be considered later as a potential amendment for VVC.

1. Adopt a new SEI message that indicates subpicture level information, with the syntax as proposed in JVET-P0984, with the following changes: [JVET-P0984][SW/R. Skupin]. It was agreed that there should be a constraint that the (rectangular) set of subpictures associated with the level shall have subpic\_treated\_as\_pic\_flag equal to 1. Decision (enabling extraction/merging functionality): Agreed.
   1. Change the reserved 4 bits to reserved 5 bits for byte alignment.
   2. Change "shall have" in NOTEs to "has".
   3. Add the SPS ID.
   4. Correct the wording of where the CPB size information is signalled.

Further work is needed to ensure that the conformance specification is complete.

1. Adopt a new SEI message that provides information on SAR dynamics, with the syntax as proposed in JVET-P0450 option 2, but drop the cancel flag and the persistence flag. The persistency scope is the set of AUs starting from the current until (exclusive) the next AU associated with the same SEI message. [JVET-P0450][SW/R. Skupin]

Decision (cleanup for RPR functionality): Adopt as proposed in regard to the cancel and persistence. This overrides the VUI for the relevant pictures when the SEI message is present.

Further study of persistence is encouraged.

Decision (Ed. clarification): It was noted that for separation of the SEI message specifications from the video coding spec, some aspects of how to use the SEI in the context of the video coding spec may need to be specified in the video coding spec for establishing precise conformance requirements. For example, the the SEI spec can't require a specific NAL unit type that is not defined in that spec. As an initial approach, the editors can establish such clarifying information in the VVC draft text where the SEI spec is referred to.

1. Fix a bug on dependency between subpictures, by fixing some equations in the clause of the derivation process for constructed affine control point motion vector merging candidates and in the clause of the luma integer sample fetching process. [JVET-P0378, JVET-P0572][SW/K. Zhang] Decision (BF): Agreed.
2. Adopt the following clean-up changes: [JVET-P0228][SW/B. Choi] Decision (cleanup): Agreed.
   1. Add "&& !vps\_all\_independent\_layers\_flag" to the syntax condition for vps\_output\_layers\_mode, and add the inference rule "When not present, the value of vps\_output\_layers\_mode is inferred to be equal to 1."
   2. Replace "pic\_output\_flag" in the following sentence with "PictureOutputFlag": vps\_output\_layer\_mode is equal to 0 and the current access unit contains a picture that has pic\_output\_flag equal to 1, has nuh\_layer\_id nuhLid greater than that of the current picture, and belongs to an output layer (i.e., OutputLayerFlag[ GeneralLayerIdx[ nuhLid ] ] is equal to 1)."
3. Remove pps\_temporal\_mvp\_enabled\_idc, and add a constraint in the spirit of the following: When no reference picture with the same resolution as the one of the current picture is available, it is a requirement of bitstream conformance that ph\_temporal\_mvp\_enabled\_flag shall be equal to 0. [JVET-P0206][SW/T. Nishi] Decision (BF): Agreed.
4. Reserve value 3 of log2\_ctu\_size\_minus5. [JVET-P0580][SW/Y. Du]. Decision (expression of existing intent): Agreed.
5. As a bug fix, disallow the min CU size to be greater than Min( 64, CTU size ). [JVET-P0578][SW/T.-D. Chuang] Decision (expression of existing intent): Agreed.
6. Adopt the clause 8.1.1 general decoding process text proposed in JVET-P0115-v2, and additionally specify the general decoding process as follows as a means for the decoder to know which OLS is being decoded (including which layers are being output) [JVET-P0115][SW/Y.-K. Wang]:

OlsIdx and HighestTid are given by external means, add a bitstream requirement that the bitstream does not contain any other layers than included in the OLS with OlsIdx and does not include any NAL unit with TemporalId greater than HighestTid.

Decision (consequence of agreement on OLS decoding concept): Agreed.

1. Adopt the PTL signalling mechanism in JVET-P0117-v3. PTL signalled for an OLS rather than a layer. [JVET-P0117][SW/Y.-K. Wang] Decision (consequence of agreement on OLS decoding concept): Agreed.
2. Adopt the HRD design in JVET-P0118-v5, as summarized and noted below: [JVET-P0118][SW/Y.-K. Wang] Decision (consequence of agreement on OLS decoding concept): Agreed.
   1. Add vps\_max\_sub\_layers\_minus1 (this piece is also in JVET-P0185) and vps\_all\_layers\_same\_num\_sub\_layers\_flag to the VPS.
   2. On signalling of sequence-level HRD parameters, the following applies:
      1. For each independent layer used as an OLS containing only the layer, the sequence-level HRD parameters are signalled in the SPS referred to by the layer. (not in JVET-P0118-v5, suggested and agreed by the HLS BoG).
      2. For other cases, sequence-level HRD parameters are signalled in the VPS.
   3. DPB parameters (size, reordering, latency) for independent layers when used as output layers are signalled in the SPS (for enabling single-layer bitstreams without referring to VPSs), and in the VPS for other cases. Different DPB sizes may be signalled for a layer that may be used both as an output layer (in some OLSs) and as a non-output layer (in some other OLSs).
   4. Sequence-level HRD parameters syntax elements general\_nal\_hrd\_params\_present\_flag, general\_vcl\_hrd\_params\_present\_flag, decoding\_unit\_hrd\_params\_present\_flag, tick\_divisor\_minus2, decoding\_unit\_cpb\_params\_in\_pic\_timing\_sei\_flag, bit\_rate\_scale, cpb\_size\_scale, cpb\_size\_du\_scale, sub\_layer\_cpb\_params\_present\_flag, num\_layer\_hrd\_params\_minus1, and bp\_cpb\_cnt\_minus1 are signalled at most once for each multi-layer bitstream.
   5. A list of OLS HRD parameter syntax structure is signalled, and an index to the list is signalled for each OLS as needed. Different OLS HRD parameter syntax strutures may include different numbers of sub-layer HRD parameter syntax structures.
   6. When sub\_layer\_cpb\_params\_present\_flag is equal to 0, the OLS HRD parameters for the lower sub-layer representations are inferred to be the same as the only set of OLS HRD parameters signalled in the OLS HRD parameters syntax structure for the highest sub-layer representation.
   7. The sub-bistream extraction process is no longer a part of the decoding process, thus moved from clause 10 to Annex C, and technically updated to output a sub-bitstream for a target OLS, and the extraction process removes SEI NAL units that contain buffering period, picture timing, or decoding unit information SEI messages that do not apply to the target OLS.
   8. Only one set of conformance tests, for testing the conformance of the OLSs specified by the VPS, is specified. Therefore, it is possible that there is no OLS specified by the VPS that included all layers of the entire bitstream, in which case the conformance of the entire bitstream is not specified.

Delegate the following to editors: Update the HRD text, particularly the part on describing the conformance tests, such that it does not appear that VPS would be needed even when the bitstream only has a single layer.

* 1. Similarly as in MVC, CPB operations are OLS-specific, i.e., there is only one CPB for the entire OLS bitstream. However, the DPB is specified to conceptually consist of a sub-DPB for each layer, and the DPB operates in a layer-specific manner.
  2. In the list of bitstream conformance constraints, added that the the DPB output times derived for all pictures in any particular access unit shall be the same.
  3. In the derivations of the value of the variable NoOutputOfPriorPicsFlag in the DPB operations texts, the syntax elements pic\_width\_in\_luma\_samples, pic\_height\_in\_luma\_samples are replaced by pic\_width\_max\_in\_luma\_samples and pic\_height\_max\_in\_luma\_samples.

1. Adopt the scalable nesting SEI message in JVET-P0190-v2. [JVET-P0190][SW/Y.-K. Wang] Decision (consequence of agreement on OLS decoding concept): Agreed.
2. Specify the following constraints and rules on values of TemporalId and nuh\_layer\_id of NAL units: [JVET-P0125][SW/Y.-K. Wang] Decision (expression of existing intent): Agreed.
   1. All pictures in an AU shall have the same value of TemporalId.
   2. The TemporalId of an SEI NAL unit shall be equal to the the TemporalId of the AU containing the NAL unit.
   3. An SPS NAL unit shall have nuh\_layer\_id equal to the lowest nuh\_layer\_id value of PPS NAL units that refer to it.
   4. A PPS NAL unit shall have nuh\_layer\_id equal to the lowest nuh\_layer\_id value of the coded slice NAL units that refer to it.
   5. Parameter sets of each type share the same parameter set ID value space, regardless of the nuh\_layer\_id values.
   6. The nuh\_layer\_id of an APS NAL unit shall be equal to the lowest nuh\_layer\_id value of the code slice NAL units that refer to it.
   7. The nuh\_layer\_id of an EOB NAL unit shall be equal to 0.
   8. The nuh\_layer\_id of a filler data NAL unit shall be equal to the nuh\_layer\_id of associated VCL NAL unit.
3. Add the set of general constraints and rules on SEI messages of the following categories in section 4 of JVET-P0125-v2: Decision (consequence of agreement on OLS decoding concept): Agreed.
   1. Two constraints on containing of SEI messages in SEI NAL units
   2. The specifiation of applicable layers of non-scalable-nested SEI messages
   3. Three constraints on the value of nuh\_layer\_id of SEI NAL units
4. Add the following constraints and inference rule: Decision (expression of existing intent): Agreed.
   1. When sps\_video\_parameter\_set\_id is equal to 0, it is a requirement for bitstream conformance that there shall be only a single layer in the bitstream. [JVET-P0097, JVET-P0205][SW/M. M. Hannuksela]
   2. Require that vps\_video\_parameter\_set\_id shall be greater than 0. [JVET-P0205][SW/V. Drugeon]
   3. Infer vps\_max\_layers\_minus1 to be equal to 0 when not present. [JVET-P0185][SW/ S. Deshpande]
5. As a bug fix, remove pps\_five\_minus\_max\_num\_subblock\_merge\_cand\_plus1, such that the syntax element five\_minus\_max\_num\_subblock\_merge\_cand does not use the "constant slice/picture header parameters in PPS" mechanism introduced by the adoption of JVET-O0238. [JVET-P0152][SW/O. Chubach] Decision (BF): Agreed.
6. Adopt the picture header design in JVET-P1006, but disallow PH repetition. [JVET-P1006][SW/W. Wan] Decision (cleanup): Agreed

The non-reference picture flag, when equal to 1, indicates that *no* pictures of *any* layers or sublayers reference the picture.

Further study is encouraged on avoiding signalling of irrelevant syntax elements (e.g., if all slices in the picture are intra slices)

1. Adopt the OLS signalling syntax (in the VPS) and semantics in JVET-P1019, with the addition of the following constraint: Each OLS shall have at least one output layer. [JVET-P1019][SW/B. Choi] Decision (consequence of agreement on OLS decoding concept): Agreed.
2. If it is not clearly specified, it needs to be clearly specified that, whenever a decoded picture is output, the conformance window applied shall be the conformance window that is associated with the picture. [SW/Hendry] – No need to say this, as it is already in the spec.
3. If JVET-P1004 is adopted, adopt the proposed syntax, semantics, and the derivation process for the single\_slice\_per\_subpic\_flag in JVET-P1024. Otherwise, adopt in principle to signal the indication of single slice per subpicture and use it to condition the syntax for signalling of rectangular slices when not needed. [JVET-P1024][SW/M. M. Hannuksela] Decision (cleanup): Adopt.
4. Adopt support of mixed IRAP and non-IRAP pictures within an AU, with the following POC design: Decision (layered coding support simpler than in SHVC): Agreed.
   1. For independent layers, use POC MSB cycle signalling. In the SPS, there is a flag to control whether picture header has ph\_poc\_msb\_cycle\_present\_flag, and a length in the SPS. When ph\_poc\_msb\_cycle\_present\_flag is equal to 1, the POC MSB cycle, u(v) coded, is signalled in the picture header. When POC MSB cycle is present, the POC MSB of the picture is set to poc\_msb\_cycle \* MaxPicOrderCntLsb. [JVET-P0116][SW/Y.-K. Wang]
   2. For dependent layers, if there is a picture picA in the same AU in a reference layer of the current layer, the POC is derived as equal to the POC of piA and POC LSB values are required to be cross-layer aligned. Otherwise, the current POC derivation process applies. [JVET-P0101][SW/M. M. Hannuksela]
5. Add a constraint to require that each IRAP AU is complete (i.e., there is a picture in each layer present in the CVS) and all pictures in an IRAP AU are IRAP pictures with the same NAL unit type. [JVET-P0116][SW/Y.-K. Wang] Decision (layered coding support simpler than in SHVC): Agreed.
6. Always keep VPS and EOB NAL units in the output sub-bitstream in the sub-bitsteam extraction process (unless there is a decision to handle layer ID 0 differently than other layer ID values, where layer ID 0 can only be used by NAL units that apply to all layers, e.g., as proposed in JVET-P0380). [JVET-P0098][SW/M. M. Hannuksela] Further discussed track B Thursday 1600 (GJS): Decision (existing design intent for extraction process): Agreed, and also keep DPS (no constraint on layer ID value for these).
7. Specify EOS NAL units to be layer specific, i.e., an EOS NAL unit applies only to the layer with the same nuh\_layer\_id as the EOS NAL unit (unless there is a decision to handle layer ID 0 differently than other layer ID values, where layer ID 0 can only be used by NAL units that apply to all layers, e.g., as proposed in JVET-P0380). [JVET-P0125][SW/Y.-K. Wang] Further discussed track B Thursday 1600 (GJS): Decision (existing design intent esp. for independent layers): Agreed.
8. Adopt a clarification to the bullet items in setting of PicOutputFlag in the decoding process of one coded picture involving variables derived from the VPS, by adding the condition "sps\_video\_parameter\_set\_id is greater than 0", which means that a VPS is referred to by the CLVS. [JVET-P0097][SW/M. M. Hannuksela] Decision (expression of existing intent): Agreed.
9. Add a constraint to require that when vps\_independent\_layer\_flag[ i ] is equal to 0 there shall be at least one value of j such that the value of vps\_direct\_dependency\_flag[ i ][ j ] is equal to 1. [JVET-P0135][SW/X. Ma] Decision (sensibility constraint): Agreed.

Track B stopped here at 1130 Wed 9 Oct. (GJS).

Track B resumed here at 1420 Thursday 10 Oct (GJS).

The BoG recommended confirming or further discussing the following items:

1. Support of mixed IRAP/non-IRAP slices within a picture, with two competing proposals on the table, one in JVET-P0124/ JVET-P0095/P0222, and the other in JVET-P0458

It was asked why we have special NUTs for IRAPs, especially if we might mix them with other NUTs in the same picture. It was commented that these are to enable quick and easy identification of IRAPs.

The desired functionality would be to be able to refresh one or some subpictures without refreshing all of them at once. Otherwise, rewriting of the NUT would be needed.

Low-latency operation and viewport-dependent streaming were suggested applications.

JVET-P0458 proposes to add a "mapped NUT" that would be interpreted together with the SPS to determine whether it is a trailing picture or an IDR picture. (This would not enable open-GOP mixing; more would be needed for open-GOP support.)

The other proposal is to have a flag in the PPS to indicate mixed or non-mixed picture.

PH instead of PPS was mentioned as a suggestion.

Systems, in practice, have timestamps and other support that do not require bitstream analysis to find picture boundaries.

Another potential discussed approach would be a NUT that indicates that the current subpicture is IDR but makes no assertion about whether all other subpictures of the picture are IDR.

Discussed possibility:

* constraint flag that indicates no LIDR\_NUTs in bitstream
* LIDR\_NUT indicates the current sp is refreshing, but maybe not the others
* flag in the sps that says whether all pics with LIDR\_NUT are IDR pictures

Versus

* constraint flag that indicate no mixtures in bitstream
* flag in pps that says whether the current picture is IRAP or not if the first VCL NUT is an IRAP NUT

Decision (extraction/merge functionality): Adopt second approach P0124 and P0095 and P0222.

1. JVET-P0404 on an SEI message for MPEG-I Part 7 metadata. This seems unquestionable in principle, but we can't act unless there is something to reference at the appropriate stage.
2. JVET-P0506 on max QT/BT/TT size signalling. No action seems needed.
3. Should EOS NAL units be layer specific (i.e., an EOS NAL unit applies only to the layer with the same nuh\_layer\_id as the EOS NAL unit?

JVET-P0380 is related. It uses nuh\_layer\_id equal to 0 as a special layer that does not contain VCL NAL units but contains non-VCL NAL units that apply across layers, regardless of which layers are present. It was unclear to some participants at the HLS BoG meeting on Monday 10/7 if the earlier JVET decision on not taking action on JVET-P0380 only applies to its AUD aspect or more generally.

Therefore the BoG requested the track/plenary to confirm the earlier JVET decision, and further discuss either only the aspect of whether EOS NAL units should be layer specific, or additionally JVET-P0380 excluding its AUD aspect.

No action on this aspect of P0380, as there doesn't seem to be a good reason not to allow VCL NAL units in layer 0.

1. Issues noted in the HLS BoG meeting minutes, agenda item 6.18.5 (AUD, picture header, slice header parameters signalling), under document JVET-P0687, section "On signalling constant slice header params", item categories 1 and 2, if not already resolved by non-HLS-BoG meeting sessions.

Some bugs were introduced by the previous meeting's adoption of O0238.

P0427 proposals 1 and 3 are withdrawn. Proposal 2 is to Update the range value of pps\_max\_num\_merge\_cand\_minus\_max\_triangle\_cand\_plus1 to not depend on the value of MaxNumMergeCand. This aspect is minor and can be resolved in further study.

P0334 proposes to add the following additional syntax elements to PPS and use the same mechanism provided by the constant\_slice\_header\_params\_enabled\_flag to either signal a parameter value in the PPS or in the slice headers:

* slice\_joint\_cbcr\_sign\_flag
* slice\_sao\_luma\_flag
* slice\_sao\_chroma\_flag
* slice\_alf\_enabled\_flag
* slice\_alf\_chroma\_idc
* slice\_lmcs\_enabled\_flag
* slice\_chroma\_residual\_scale\_flag
* cabac\_init\_flag
* sign\_data\_hiding\_enabled\_flag
* slice\_disable\_bdof\_dmvr\_flag

This was considered for further study as a deferred potential detail cleanup.

P0368 proposes to add the following additional syntax elements to PPS and use the same mechanism provided by the constant\_slice\_header\_params\_enabled\_flag to either signal a parameter value in the PPS or in the slice headers:

* pps\_num\_ref\_idx\_active\_override\_idc
* pps\_disable\_bdof\_dmvr\_idc
* pps\_lmcs\_aps\_id\_idc
* pps\_chroma\_residual\_scale\_idc
* pps\_collocated\_ref\_idx\_plus1
* pps\_log2\_diff\_min\_qt\_min\_cb\_luma\_plus1
* pps\_max\_mtt\_hierarchy\_depth\_luma\_plus1
* pps\_log2\_diff\_max\_bt\_min\_qt\_luma\_plus1
* pps\_log2\_diff\_max\_tt\_min\_qt\_luma\_plus1

This was considered for further study as a deferred potential detail cleanup.

1. Proposals 2 and 3 of JVET-P0132, if not already resolved by non-HLS-BoG meeting sessions. This is for further study.
2. JVET-P0446 on HRD bug fix and enhancements for slicing, open GOP and DRAP support.

In BP SEI message, sending maximum initial removal delay for which it would be guaranteed that "seamless splicing" would be possible to guarantee and signalling a flag per PT SEI message for whether it fulfils a condition. In a revision it is also proposed to send a presence flag so that not all encoders need to send this extra information.

Decision (BF & functionality): Adopted these aspects.

This also proposes a way to send HRD parameters for use with DRAP pictures with dropped intermediate picture, similar to the scheme used for dropped RASL pictures associated with a CRA picture.

We don't have DRAP pictures in the normative spec.

Decision (BF & functionality): Adopted.

1. JVET-P1004 on removal of bricks. Some bit count analysis was shown and is to be provided in a revision of P0240. It was reported that the bit counts would be reduced if there is a flag to indicate that slices are in raster order (i.e., among the empty areas at the highest position in the picture, start at the left-most position). It was commented that the primary consideration is having more NAL units rather than the amount of PPS overhead. Decision (design simplification): Adopt, also specify a raster order flag just before the loop syntax.

P1012 was a proposed refinement that avoids sending an unnecessary syntax element for the last slice under some circumstance. Decision (cleanup): Adopt.

1. JVET-P0336 on support of ROI (region-of-interest) scalability. Concern was expressed about whether this functionality would have a complexity problem. There is interest in this in concept, further study with provision of text and software was encouraged.

[JVET-P0969](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8784) Report of BoG on intra prediction and mode coding [G. Van der Auwera]

Presented Monday 7 Oct. 1400-1615 in Track A (chaired by JRO)

The BoG reviewed proposals related to the intra prediction and mode coding topics (CE3-related). This report includes the recommendations of the BoG for adopting or further studying of proposals. It is also suggested to further discuss two MIP-related items in track A.

The BoG met during the following times:

* Friday 4 Oct.: 9:00-11:00, 14:00-19:45
* Saturday 5 Oct.: 11:00-13:00, 19:00-20:00

Summary of BoG recommendations and open issues:

* MIP:
  + To be further discussed in track A:
    - P0199, P0289, P0303: Problem addressed is that given a 4 × 16 or 16 × 4 MIP coded block, a subset of the matrix multiplication output with odd row indices is used, while for other MIP coded blocks all matrix rows are used. It is proposed to align the MIP matrix multiplication process by defining MipSizeId to be equal to 1 for a 4 × 16 or 16 × 4 MIP coded block.  
      Agreed in Track A that this is useful.  
      Decision: Adopt
    - P0803 proposes combination of CE3-3.2, aspect of P0194, P0198, P0352, P0398, P0535 (see detailed notes in the report):
      * MIP upsampling order is fixed (adopted test CE3-3.2).
      * (a) MIP is allowed up to 64x64 regardless of the maximum transform size. (Motivation: handle sizes MIP as normal intra, gain 0.02% in AI and RA)  
        - agreed to adopt this aspect.
      * (b) The following three together give 0.06% AI and 0.04% RA, Matrices were retrained as the previous matrices would not fit:
        + Alignment that allows all MIP-modes to be transposed.
        + The number of MIP modes is 32 for sizeId=0, 16 for sizeId=1 and 12 for sizeId=2. (Motivation: Cleanup after removal of MPM)
        + Block aspect ratio restriction (<=4) is removed. (also allows long, narrow blocks)

During the discussion of track A, several experts expressed their opinion that this package is a reasonable cleanup, which removes several exception cases. Except for procedural concern (new proposal), no strong objection was raised, and additional information was provided as requested. Agreed to adopt this package of three items.

* + - * (c) Separate context for the first bin of the MTS-index depending on MIP. (gain: 0.04% AI, 0.02% RA) – it was agreed that this is not a cleanup, and the gain is so low it is not justified.

Decision: Adopt Items (a) and (b). JVET-P0803 without the context modification

The slide deck shown to be uploaded in a new version of JVET-P0803.

* + For further study (some potentially in core experiment, if established):
    - P0136: Reduces the MIP offset table (mode, sizeId). Can be studied in combination with CE3-2 test that simplifies the MIP right shifting operation. Suggested to start from floating point models to avoid double quantization.
    - P0625: Proposes to remove MIP offset table and replace offset multiplication with a shift operation. Suggested to start from floating point models to avoid double quantization.
    - P0509: Proposes to right shift the MIP input samples to 8-bit values before the matrix multiplication process so that MIP matrix multiplication process can be implemented with 8-bit SIMD multiplications. Suggested to further study of SIMD implementation and benefits. [From discussion in track A: Some concern is expressed that reducing the bit depth may have some impact on visual quality, and also may prohibit increased bit depth. Not so important to take action]
    - P0560: Proposes to reduce the number of contexts for MIP mode flag, which is claimed to save line buffer storage for MIP flag. Suggested to further study in the context of potential changes to MIP this meeting. [From discussion in track A: Advantage not substantial enough to take action]

The proponents of JVET-P0136, JVET-P0625 and CE3-2.1 are encouraged to perform further study on these proposals, based on the floating point models of the newly adopted matrices (to be obtained from J. Pfaff). The purpose of this study shall be removal of table lookups for better software implementation, in optimum case without changing the current behaviour in terms of bitstream output and performance. No CE on these aspects

* Intra mode coding:
  + For adoption:
    - P0615: Proposes to clean-up the sharing of context for cclm\_mode\_idx and intra\_chroma\_pred\_mode syntax elements. It is more logical for each syntax element to have its own context. Decision: Adopt.
  + For further study:
    - P0369, P0536: Extend MRL with non-MPM intra modes. Suggested to further study the encoder search for non-MPM MRL modes. [From track A discussion: Further study on this is discouraged, unless it is shown to provide >0.15% benefit in terms of compression without substantial run time increase.]
* Intra prediction – various topics:
  + For adoption:
    - P0111: Proposes cleanup to more accurately map angular modes from luma to chroma for 4:2:2 content (minor rounding changes to mode values in table). Agreed – Decision (BF): Adopt
    - P0329: The proposal suggests one editorial change that removes nW = Max(nTbW,2) from the spec, which is not needed because width 1 partitions were removed last meeting (ISP simplification). The second suggestion is a simplification to also remove the nH = Max(nTbH,2) from the spec, which has the effect that planar is applied only one-dimensionally in case the block height is one.  
      Agreed – Decision (BF): Adopt
    - P0418: Proposes to modify the definition of MRL to use the same 3 lines as CCLM. It is claimed that it aligns MRL with CCLM in terms of neighbouring pixel referencing and reduces the storage requirements for decoders. 0.04% AI loss is reported. Agreed – Decision: Adopt
    - P0599: Cleanup of interpolation filtering by replacing 4-tap “Gaussian” filter with the 4-tap smoothing filter obtained by convolving a linear filter with 3-tap FIR filter that has coefficients of [1, 2, 1]/4. The proposed filter coefficients are very similar to the current filter coefficients (fG in spec), but the observed frequency response issues with the current fG filter in VVC are fixed and some potential visual artifacts are claimed to be avoided. Agreed – Decision: Adopt
  + For further study (potentially in core experiment, if established):
    - P0500: It is proposed to extend CCLM with 4 additional modes (4 reference sample positions) in addition to LM, LM\_A, LM\_L (1.03%/1.06% U/V gains reported with negligible encoding/decoding time change). [The gain of around 1% only in chroma is fairly low and would not justify the additional modes (going from 3 to 7)]
  + Editorial: P0626 - Decision: to the discretion of editor to change that.

[JVET-P0986](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8801) BoG report on CE4 inter prediction related contributions [H. Yang, X. Xiu]

Discussed Wed 9 Oct 1215 (GJS)

Four BoG sessions have been organized for the BoG meeting, 104 contributions had been reviewed.

* Oct. 4, 1430 to 2130, on the category of affine motion compensation and merge mode modifications.
* Oct. 5, 1000 to 1230, on the category of decoder side motion vector derivation.
* Oct. 5, 1400 to 2200, on the remaining contributions in the category of decoder side motion vector derivation and on the category of switchable interpolation filter.
* Oct. 6, 0900 to 1300, on the category of weighted prediction and others.

Contributions on geometric partition and CIIP with triangle partition have not been reviewed.

Actions recommended by BoG:

* Normative changes
  + P0275: Conditional signalling of TPM syntax max\_num\_merge\_cand\_minus\_max\_num\_triangle\_cand in SH (not signalling it for B slices). This is a cleanup of unused syntax in B slice header. This is a minor HLS issue and was planned for further study.
  + P0530: Derive the TPM blending matrix for chroma component by subsampling the matrix for the luma component according to the chroma format. An identical weighting matrix can be derived for 4:4:4 content using the proposed method, which could remove potential visual artifact introduced by applying different weighting matrix for luma and chroma in the current TPM blending. Decision: Agreed.
  + P0325: Change the checking order of the first two spatial merge candidates, A1->B1 to B1->A1. Coding gain of 0.05% for RA and 0.21% for LD is achieved by the proposed change. This is a very small optimization, but was considered minor cleanup. It was commented that the previous order had been rather arbitrarily chosen and this is just coming "for free". The cross-checker said this made logical sense as a likely consequence of the way HMVP works, an aspect that was added later. Decision (minor borderline cleanup agreed as an exception): Agreed.
  + P0091: BDOF and PROF unification by moving 1-bit right-shift of calculating the BDOF sample offset to the derivation of motion refinement. It was commented that part of P0201 is also found in this method. The proposed method aligns the sample offset calculation of the BDOF and PROF while reducing the number of right-shifts by moving one bitwise right-shift to the 4x4 subblock level (removing a shift at the per-sample level). Decision (minor cleanup): Agreed.
  + P0154 method 1/P0094/P0172 method 1/P0143/P0518 method 1/JVET-P0281 3: Clip the PROF sample offset to 14-bit. The prediction samples after the PROF refinement is guaranteed within 16-bit value, and an overflow of the 16-bit multiplication logic in the weighted prediction is avoided. (An alternative proposal was to disable PROF when BCW with unequal weights or higher-level weighted prediction is used.) Decision (bug fix): Agreed.
  + P0653/P0281 method 1: remove the dependency between internal bit-depth and the calculation of intermediate parameters, three shifts and one clipping threshold in BDOF. It was commented that parts of P0200 and P0238 are also found in this method. The proposed method unifies the shift parameters for deriving the BDOF parameters for different internal bit-depths. This was said to be partly because of a simplification adopted at the previous meeting that reduced the necessary dynamic range, such that some right shifting is no longer needed to stay within 32 bits. Decision (cleanup): Agreed.
* Decision (SW): Software optimizations (for which the software coordinator has the final call):
  + P0092: Encoder speed-up for SMVD. The first aspect is to reduce the maximum number of initial MV candidates to 5 from 18. The second aspect is to align the distortion calculation in motion search to the regular bi-prediction case. For about 50 lines of code changed, this provides 6% encoder speedup!
  + P0445: Encoder optimization for subblock-based merge candidate search. It is proposed to remove unnecessary chroma motion compensation for luma SATD-based merge candidate selection for affine merge and sbTMVP modes. No change in bitstream content and 2% encoder speedup!
  + P0512: SIMD implementation for motion compensated prediction when the internal bit-depth is larger than 10-bit. The proposal provides SIMD-based software optimization for motion compensation module in VTM for high internal bit-depth. For no change in bitstream or decoded output, for 12 bit video, this provides about 20% encoder speedup and 15% decoder speedup!
* Decision (Ed.): Per below
  + P0214: Change the chroma intra mode from DM to planar in CIIP (this is merely editorial, since the DM mode is always planar in this case).
* Decision (BF): Per below
  + P0595: Align spec with SW on the derivation of weighting factor for CIIP mode. Derive the weighting factor for luma component and apply the same weighting factor to chroma components as well.
  + P0856: Align spec to SW on the two mismatches in SIF and BCW index. Do not use hpelIfIdx and bcw\_idx in the derivation process for history-based merging candidates and in the updating process for the history-based motion vector predictor candidate list. Also store the hpelIfIdx in the HMVP table.
  + P0280: Align the spec to SW on interaction of BCW and (explicit) WP.
  + P0519: Align the spec to the SW on the SAD threshold for the early termination in BDOF.
* Requested items for further discussion in track:
  + P0151/P0260/P0461/P0542/ (one approach in P0490): the derivation of hpelIfIdx for pairwise merge candidate. Two options,

1. Keep the current design (which has an "and" operation)
2. Set hpelIfIdx to 0, as proposed in P0151/P0260/P0461/P0542/P490.

No action seemed necessary on this, and the design philosophy arguments did not converge.

* + P0236/P0617: Enable WP in combination with TPM. Currently, these cannot be used together. It was agreed that this is desirable. P0236 basically cascades the two operations (WP first, then TPM, with clipping after each – this also changes the non-WP case because of the clipping). P0617 combines the two operations and clips the final result. The results were cross-checked and had used the prior CE test conditions for WP. P0236 has a latency issue since it adds an additional stage; P0617 needs an additional multiplier for the blending. One comment was that if TPM doesn't work well together with WP, the encoder could just not choose TPM (or the combination could be prohibited in some way). Some participants commented that we should not add this extra complexity for a benefit that is only found on special content such as fading content. In the fading sequences, a benefit of about 0.9% was reported. It was commented that BCW (and BDOF and DMVR) are also mutually exclusive with WP. Further study was suggested, particularly to consider disallowing the combination and to consider whether the other prohibited combinations should be allowed and to consider subjective effects.
  + P0191/P0311/P0415/P0546/P0598: BDOF and DMVR enabling/disabling condition on POC distance and reference picture type

1. No change to the existing application conditions of BDOF and DMVR.
2. Apply an equal POC distance constraint to both BDOF and DMVR (in the current design, such constraint is applied to DMVR). P1023 reports that this constraint would have almost no impact on coding efficiency.
3. No equal POC distance constraint to both BDOF and DMVR (i.e. applying the current BDOF condition to DMVR).
4. Disable the two tools when any long-term picture is referenced.

P1023 the constraints 2 and 4. Decision (cleanup): Adopt.

* + P0314/P0544/P0314/P0434/P0524/P0601: slice-level (picture-level) on/off control of BDOF, DMVR and PROF

1. Use the same slice-level (picture-level) BDOF and DMVR control flag to control the PROF at the slice level.
2. Use one additional flag for PROF at slice level.

In Draft 6, there is a shared flag for BDOF and DMVR in the SH. These do not have block-level control. Decision (cleanup): Three distinct flags in the PH (presence conditioned on SPS), not in SH.

* + P0320: Add B slice condition for the syntax element slice\_disable\_bdof\_dmvr\_flag flag at slice header. Conditioning syntax element presence on picture types is a minor syntax cleanup issue and was left for further study.
  + P0491: Change the clipped range of BDOF and PROF motion refinement to [-31, 31] instead of [-32, 31]. This would save 8 clippings. In terms of spec impact, it just changes one character. Decision (cleanup): Adopt.
  + P0090: Discuss if the limitation of abs\_mvd\_min2 binarization within 32-bit is needed. Approach #2 is recommended if the limitation agreed. Decision (cleanup): Adopt.
  + P0385: Modify the rounding of offset vector for sbTMVP from “rounded towards negative” to “rounded to zero”. It was said that everywhere else where we have rounding of motion data, we round toward zero. Decision (cleanup): Adopt.
* Further study recommendation:
  + P0444: DMVR without padding and the search range for 8x16 and 16x8 DMVR CUs is reduced from 2 to 1. A substantial decoder runtime reduction is asserted with 0.05% loss in coding efficiency. Some participants said this would have an average memory bandwidth increase and a local buffering increase and suggested that the decoder runtime reduction might just be a matter of code optimization. It was said that this had been studied previously. Some suggested study in an AHG rather than a CE. Further study was recommended, but not in a CE.

[JVET-P0999](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8814) BoG report on palette mode coding modifications [X. Xu]

Discussed in track A Mon. 7 Oct. 1615-1720

This document summarizes the activity of BoG on palette mode coding modifications during the 16th meeting in Geneva, CH.

The Bog met at 18:15-21:15 on Sun. Oct. 6th for the first session.

To summarize, the BoG recommends the following:

1. Adoption to VVC specification and VTM software
   * JVET-P0460/JVET-P0474/JVET-P0399 aspect 1/JVET-P0529 aspect 1, use minimum QP setting in TS mode for minimum QP setting in palette mode escape coding. (0.2~0.3%) gain for RA, almost no change for AI/LDB. Unification.

From discussion in track A: It is consistent to implement this the same way as transform skip. In particular when a localized palette or TS block is in a quantization group with QP < 4, it is useful to set it to QP4. Decision: Adopt, text from JVET-P0460

1. Adoption to VTM software
   * JVET-P0526 (note that JVET-P0472 is identical with aspect 1 of P0526), palette encoder optimization, 4% AI gain on average for Dual-Tree off case. Decision (SW): Adopt JVET-P0526 (whole package)
2. Inclusion in the next round CE
   * JVET-P0487/JVET-0529, binarization and de-quantization of palette escape coding (similar as JVET-P0399)
   * JVET-P0573, reset palette predictor at CTU row (similar as JVET-P0424) – requires reasonable (realistic) setting of test conditions in terms of tile width
3. Further discussion in Track A
   * JVET-0475, simplified palette predictor update process for small blocks (4x4/4x8/8x4). Minor coding efficiency impact. Agreed in track A discussion that this is highly relevant for limiting the worst case decoder complexity – might even be useful to study more cases such as restrictions at 8x8. Study in CE.
   * JVET-P0476/JVET-0516, palette mode flag signaling change, prediction\_mode\_flag signaling change Agreed in track A discussion that this sequence of signalling is better understandable and also unifies the mode decision path between I and P/B pictures. JVET-P0476 is different in that it changes the intra slice mode signalling, ibc flag at block level is renamed predmode flag and changes its parity, which may however be confusing and unification of intra and inter signalling not necessary here. Decision: Adopt JVET-P0516
   * JVET-P0483/JVET-P0515, align dequantization of palette escape coding to dequantization of TS mode, or the other way around. From discussion in track A: Such a unification is not really necessary, as palette and TS coding are at completely different path of signalling.
   * JVET-P0577, Palette predictor initializer at high level header (APS/SPS/PPS/picture header) – should bring evidence that this is needed in VVC.

[JVET-P1033](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8848) BoG report on CE5-related loop filter proposals [A. Norkin, C.-Y. Chen]

Presented Thursday 10 Oct. 1415-XXXX in Track B

The BoG reviewed proposals related to the loop filter topics (CE5-related). This report includes the recommendations of the BoG for adopting or further studying of proposals.

The BoG met during the following times:

* Tuesday Oct. 8: 9:00-13:00, 14:30-21:00
* Wednesday Oct. 9: 11:00-13:30, 15:00-20:10
* Thursday Oct. 10: 9:00-12:30

**Recommendations of BoG**

**Deblocking filter**

It is recommended to adopt proposal P0043 (the specification text). The software attached to the proposal needs to be fixed.

Decision: Adopt JVET-P0043. This is correcting some inconsistency of deblocking in case of affine 4x4 and TPM block edges, when they coincide with TU boundary. Text was confirmed to be appropriate, aligned software still needs to be uploaded.

It is suggested to study proposal 1 of P0161 (and similar proposals, see under notes of P0161) in the CE. This would be either or two test cases (depending if proponents of P0586 decided to join the other test or have a separate test).

In track A, it is discussed that this would require storing information about presence of weighted prediction and imposing them in the decision of deblocking.

Also test JVET-P0269 method 1 in CE.

Test in the CE of P0441 (where subjective improvements are expected). This would change some conditions to not apply deblocking at affine inner boundaries unless these are at TU boundaries. This requires one more condition check, so it is not a simplification.

Test P0411 in CE (additional boundary condition that avoids oversmoothing of long DBF). Not a simplification.

It is strongly recommended that, if several proposals propose the same idea, only one of them should be tested. It is further strongly recommended that, if a given proposal suggests multiple solutions to one problem, only one of these solutions shall be tested, as proponent should know best which of them is preferable. It shall be decided already during the setup of the CE, which methods and how many cases would be up to subjective viewing, as otherwise this is not manageable. Furthermore, crosscheckers are mandated to perform subjective viewing prior to the meeting and report if they were able to recognize differences.

It is noted that proposals that would make deblocking somewhat more complicated require a proof to have an improvement in visual quality. It is further noted that in the interest of stability of the DBF design (in particular also the stability of the specification text, it should be demonstrated that a proposal to be adopted should really be solving a problem.

Adopt method 1 of P0571

Decision (BF/SW): Adopt JVET-P0571 method 1 – align SW with spec text.

Adopt solution 2 of P1001: Current deblocking just uses luma QP for chroma deblocking decision. It is proposed to modify this by considering chroma QP offsets. It is agreed that this is a reasonable change, and complexity-wise (additional line buffer) should be OK.

Decision: Adopt JVET-P1001 solution 2

**ALF**

Recommendations:

* Adopt method 1 of P0158, applying ALF VB to all CTU in a picture, including the bottom CTU row.
* Adopt method 2 in P0551, which is also method 4 in P0157 and first aspect of P0053. The software is from P0551.
* Use the check for the unavailable samples as in P0552 (and same as in P0492). This was further discussed in a BoG Thursday evening.

Decision: Adopt JVET-P1038 (combined text and software from the modifications above); agreed in closing plenary (GJS & JRO) at 1100.

Recommended to adopt JVET-P0162: Remove alf\_ctb\_first\_use… flag

Decision (cleanup): Adopt JVET-P0162

Recommended to adopt JVET-P0164 (cleanup of APS syntax)

Decision (cleanup): Adopt JVET-P0164 method 2

Recommendation: Adopt method 2 of P0554 (align text with software).

Decision (BF/text): Adopt JVET-P0554 method 2

Recommendation: BoG recommends fixing the specification text to reflect the desired behaviour (using the correct samples for padding), as implemented in software.

Decision (BF/text): Adopt JVET-P0665 (preferable text from zip version 2, but left to the discretion of the editors if this is the best way for fixing this problem)

In JVET-P0505, it is pointed out that there is a mismatch between text and software in regard to clipping values for chroma: Whereas the VVC6 text derives the clipping values using the same table for luma and chroma, the software still has two different tables where for chroma this would not match the table from the text (this is due to the fact that it was never implemented, in the meantime ticket 551 was issued). The contribution found that if this was fixed, losses would occur in chroma for the 8 bit internal bitdepth case.

The proponents suggest to define another table that would be used for luma and chroma, which would just replace the current table, have very similar performance for bit depth >8 (up to 12 was tested), which would heal the problem with internal 8 bitdepth

Recommendation: Adopt the v5 of JVET-P0505.

Decision: Adopt JVET-P0505

**CCALF**

Recommendation: test P0106 in the CE. Since the shape is highly asymmetric, a test on other chroma locations is required.

Recommendation: study P0173 in the CE.

Recommendation: Test C6-2 of JVET-P0251 in the CE.

Recommendation: test P0372 in the CE.

Recommendation: test method 3 of P0557 in the CE.

Recommendation: test method 5 of P0558 the CE.

Recommendation: Test the results of P0666 with limiting the coefficient range to [-8, 8]. The proponents are advised to discuss offline what coefficient bit depth (range) to test in the CE.

Agreed to test these in CE.

JVET-P1008

**Changes to CE5-2:**

Proposed simplifications:

* Complexity reduction
  + Reduce the number of multipliers in the filter operation
  + Limit dynamic range of coefficient to 6-bits
  + Allow for sharing of multipliers with chroma ALF
* Alignment with ALF
  + Limit filter selection to signaling at a CTU level
  + Removal of the temporal layer coefficient buffers
  + Use of symmetric line selection at virtual boundary

Additionally, as the simplifications reduce coding efficiency, the authors also propose to use up to 4 filters per chroma component (called option 2 below)

* Disallow the use of both CC-ALF and chroma ALF in a CTB
* For each chroma CTB
  + Signal CC-ALF on/off flag
  + If CC-ALF enabled, chroma ALF is disabled
  + Otherwise, signal chroma ALF on/off flag

Benefit: Number of multiplications per pixel are reduced from 19 (called option 1, if CCALF is operated on top of current chroma ALF) to 16 (called option 2, if only one of them is used in a certain region). Number is 15 in current ALF.

The method tested in CE5-2 had 22 multiplications.

Results for Option 1 on RA are Y=0.17%, Cb = -11.53%, Cr -10.99%. This is slightly better than the CE5-2.1 result, same for AI, however loss (relative to CE) occurs for LB

Results for Option 2 were incomplete.

It is suggested to investigate if there might be more severe subjective quality impact towards higher QP values than those used in the CE5-2 subjective test at this meeting. This is definitely something that would be needed to be investigated, to be sure that the VTM encoder in its default settings would not cause problems when used for upcoming VVC verification tests. This should be performed as part of the CE.

It is generally agreed that Option 1 would be implementable in hardware. It is not obvious that option 2 would have advantage in terms of implementation, as it might not be possible to share same circuitry (may be depending on architecture).

An informal viewing session should be organized showing CTC sequences at QP37, to demonstrate that there is no problem with visual quality also for the modified method (P1008 option 1).

It was planned to adopt the proposal (option 1) if nobody who had been in the viewing session raised an objection in terms of visual artefacts.

If not adopted to VVC7, this should be used as anchor in the CE.

There was no action suggested for other categories of proposals.

CCALF was further discussed in the closing plenary 1105 (GJS & JRO).

Some informal viewing had been conducted; participants saw some differences but did not seem to have a clear preference. Further viewing with high QP was suggested.

Some simplifications were suggested to be tested.

Testing with HDR was suggested.

It was agreed to have this as an anchor in a CE.

## List of actions taken affecting the draft text of VVC, the VTM, and 360Lib

The following is a summary, in the form of a brief list, of the actions taken at the meeting that affect the text of the VVC draft text, VTM or 360Lib description. Both technical and editorial issues are included. This list is provided only as a summary – details of specific actions are noted elsewhere in this report and the list provided here may not be complete and correct. The listing of a document number only indicates that the document is related, not that it was adopted in whole or in part. The description given in the “Tool” column is a best effort for the sake of understanding but may not precisely reflect the functionality of the tool. It is also noted that in cases where several contributions proposed the same method, usually only one of the is listed as adoption below; refer to the meeting notes about the adoption to see which other contributions are related.

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| --- | --- | --- | --- | --- |
| **Category** | **Sub-Category** | **Rationale** | **Tool** | **Document** |
| **Inloop Filter** | | | | |
| DF | Chroma | Simplification | Longer tap filter application at Chroma CTB boundaries | JVET-P0081 |
| DF | Inter | Cleanup | Deblocking in case of affine 4x4 and TPM block edges | JVET-P0043 |
| DF | Chroma | Cleanup | Chroma QP offsets | JVET-P1001 |
| ALF |  | Cleanup | ALF boundary padding | JVET-P1038 |
| ALF |  | Cleanup | Remove alf\_ctb\_first\_use… flag | JVET-P0162 |
| ALF |  | Cleanup | Cleanup of APS syntax | JVET-P0164 |
| ALF |  | Bug fix | Clean up of coefficient coding of adaptive loop filter | JVET-P0554 |
| ALF |  | Bug fix | Spec fix for ALF filter and transpose index calculation | JVET-P0665 |
| ALF |  | Bug fix/Coding efficiency | Fixing non-linear ALF clipping values for 8-bit video | JVET-P0505 |
| LMCS | Luma mapping | Bug fix | Fix number of segments to 32 regardless of bit depth | JVET-P0254 |
| LMCS | Chroma scaling | Functionality | Signalling of corrective values for chroma residual scaling | JVET-P0371 |
|  |  |  |  |  |
| **Intra** | | | | |
| MIP |  | Simplification | Fixed MIP up-sampling order | JVET-P0054 |
| MIP |  | Simplification | MipSizeId to be equal to 1 for 4 × 16 or 16 × 4 | JVET-P0199 |
| MIP |  | Cleanup | MIP Cleanup (without additional context) | JVET-P0803 |
| DC |  | Bug fix | Removes 1D cases in DC width and height variables | JVET-P0329 |
| Angular |  | Bug fix | Map angular modes from luma to chroma for 4:2:2 | JVET-P0111 |
| Angular | MRL | Complexity reduction | MRL to use the same 3 lines as CCLM | JVET-P0418 |
| Angular | Interpolation | Cleanup | Cleanup of 4-tap interpolation filtering | JVET-P0599 |
| BDPCM |  | Coding efficiency (4:4:4) | Enable BDPCM for chroma | JVET-P0059 |
| Palette |  | Complexity reduction | Line-based CG Palette mode | JVET-P0077 |
| Palette | Scaling | Cleanup | QP setting in TS mode for minimum QP setting in palette mode escape coding | JVET-P0460 |
| Palette | Signalling | Cleanup | Palette mode flag signaling change | JVET-P0516 |
| IBC | Virtual buffer | Simplification | Alternative IBC virtual buffer setting | JVET-P1018 |
| IBC | Merge list | Bug fix | Fix IBC merge list size signaling | JVET-P0457 |
| IBC | Merge list | Simplification | Remove IBC shared merge list | JVET-P0400 |
|  |  |  |  |  |
| **Trafo** | | | | |
| Transform skip |  | Lossless and 4:4:4 | Enable TS for chroma | JVET-P0058 |
| Transform skip | Scaling | Cleanup | Remove transform shift in transform skip mode | JVET-P1000 |
| LFNST | Signalling | Cleanup | Apply LFNST for ISP Blocks and signal MTS index after LFNST index | JVET-P1026 |
| SBT | SPS | Simplification | Remove sps\_sbt\_max\_size\_64\_flag | JVET-P0983 |
| ACT |  | Coding efficiency (4:4:4) | Adaptive colour transform for 4:4:4 | JVET-P0517 |
|  |  |  |  |  |
| **Quantization** | | | | |
| Scaling | Matrices | Cleanup | Removing 2x2 chroma quantization matrices | JVET-P0168 |
| Scaling | Matrices | Cleanup | Scaling matrices for LFNST-coded blocks | JVET-P0365 |
| Scaling | Matrices | Simplification | Improved coding of user defined quantization matrices | JVET-P1034 |
| Signalling | QP delta | Simplification | Remove dependency for CU QP delta and offset | JVET-P0407 |
| Signalling | Chroma QP | Simplification | chroma QP mapping table syntax variant with less bits | JVET-P0410 |
| Signalling | Chroma QP | Cleanup | Not signaling QP offset table for JCbCr in SPS if that mode is not enabled | JVET-P0667 |
| Signalling | Chroma QP | Bug fix | CU chroma QP offset signalling consistent with VPDU | JVET-P0436 |
| Signalling | Chroma QP | Coding efficiency | Efficient coding of qp\_out\_val | JVET-P0469 |
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| **CABAC** | | | | |
| Coefficient coding | Transform skip | Simplification | Modified bypass switch and remainder binarization | JVET-P0072 |
| Coefficient coding | Transform residual | Simplification | Simplified deriviation of ZeroPos[ n ] | JVET-P0170 |
| Coefficient coding | Transform skip | Simplification | Disable “level mapping" in bypass mode | JVET-P0298 |
| Coefficient coding | Transform skip | Simplification | Set Rice parameter to 1 | JVET-P0562 |
| Context | LFNST | Coding efficiency | Add context for LFNST index | JVET-P0350 |
| Context | Inter | Cleanup | Cleanup for inter\_pred\_idc coding | JVET-P0042 |
| Context | Intra | Cleanup | Separate contexts for cclm\_mode\_idx and intra\_chroma\_pred\_mode | JVET-P0615 |
|  |  |  |  |  |
| **Inter** |  |  |  |  |
| RPR | Resampling filter |  | Downsampling - integer 8-tap Lanczos2.67 filter | JVET-P0088 |
| RPR | Resampling filter |  | Downsampling - 2:1 8-tap & 4-tap filter | JVET-P0353 |
| RPR | PROF | Complexity reduction | Disable PROF for RPR | JVET-P0409 |
| MV | MVP | Cleanup | Change the checking order of the first two spatial merge candidates | JVET-P0325 |
| MV | MVD | Cleanup | Limitation of abs\_mvd\_min2 binarization within 32-bit | JVET-P0090 |
| Merge | SbTMVP | Cleanup | Align rounding of offset vector for sbTMVP | JVET-P0385 |
| PROF/BDOF |  | Simplification | 1/32-pel precision of PROF motion refinement | JVET-P0057 |
| PROF/BDOF |  | Cleanup | Align sample offset calculation of BDOF and PROF | JVET-P0091 |
| PROF/BDOF |  | Cleanup | Change clipped range of BDOF and PROF motion refinement to [-31, 31] | JVET-P0491 |
| PROF |  | Bug fix | Clip the PROF sample offset to 14-bit | JVET-P0154 |
| BDOF |  | Cleanup | BDOF and PROF parameter derivation | JVET-P0653 |
| BDOF |  | Bug fix | On SAD threshold for BDOF early termination | JVET-P0519 |
| BDOF/DMVR |  | Cleanup | Reference picture conditions in DMVR and BDOF | JVET-P1023 |
| PROF/BDOF/DMVR |  | Cleanup | High-level flags | JVET-P0314 |
| TPM |  | Cleanup | Chroma format dependend TPM blending matrix | JVET-P0530 |
| CIIP |  | Bug fix | Neighboring locations for CIIP | JVET-P0595 |
| AMVR |  | Bug fix | On switchable interpolation filter and bi-prediction weight indices cleanup | JVET-P0856 |
| BCW |  | Bug fix | Fix the behavior between BCW and WP | JVET-P0280 |
|  |  |  |  |  |
| **Partitioning** | | | | |
| Local dual tree | Intra | Bug fix | Generalization of local dual tree for different chroma formats | JVET-P0406 |
| Local dual tree | Inter | Bug fix | Disallow 4x4 luma inter blocks introduced by local dual tree | JVET-P0063 |
| Block sizes | Intra | Complexity reduction | Removal of 2xN chroma intra blocks | JVET-P0641 |
| MTT | Signalling | Conformance | Maximum MTT Depth and MinCbSize conformance | JVET-P0347 |
|  |  |  |  |  |
| **HLS** |  |  |  |  |
| Profile |  | Functionality | Profiles, tiers and levels | JVET-P0894 |
| Parameter sets | VUI | Conformance | Constraining the maximum number of bits for a CU or CTU | JVET-P0188 |
| SPS | RPR | Functionality | Scaling window for scaling ratio derivation | JVET-P0590 |
| SPS/PH | Virtual boundary | Functionality | Signalling virtual boundaries in SPS or Picture Header | JVET-P1006 |
| NUH |  | extensibility | Reserve nuh\_layer\_id values 56 to 63, inclusive, in VVCv1 | JVET-P0362 |
| NUH |  | BF/cleanup | Rearrange/cleanup the NAL unit types | JVET-P0363 |
| PTL | PTL syntax | BF/cleanup |  | JVET-P0217 |
| PTL | PTL in DPS | cleanup |  | JVET-P0478 |
| RPL | Constraints | expression of existing intent | | JVET-P0978 |
| Scalability | inter\_layer\_ref\_pics\_present\_flag | expression of existing intent | | JVET-P0182, JVET-P0221 |
| Scalability | ilrp\_idc and DirectDependentLayerIdx | expression of existing intent | | JVET-P0221, JVET-P0589 |
| APS | ALF APS constraints | cleanup unnecessary constraints | Remove some ALF APS constraints | JVET-P0122 |
| SEI | self\_contained\_cvs\_flag | cleanup |  | JVET-P0359 |
| General | unavailable reference pictures and max\_dec\_pic\_buffering\_minus1 | clarification |  | JVET-P0184 |
| SPS | Fixed-length coding etc. | cleanup and expression of existing intent | | JVET-P0243, JVET-P0244, JVET-P0429 |
| PTL | General constraint flags | cleanup | Add 8 constraint flags | JVET-P0366 |
| APS | ALF APS constraints | expression of existing intent | Add some ALF APS constraints | JVET-P0438 |
| APS | APS general | cleanup | Specify prefix and suffix APSs | JVET-P0588, JVET-P0452 |
| HRD | BP/PT/DUI SEIs | cleanup and expression of existing intent | | JVET-P0181, JVET-P0183 |
| HRD | BP/PT/DUI SEIs | expression of existing intent | | JVET-P0202, JVET-P0189, JVET-P0203 |
| SEI | Add HEVC/AVC SEIs | cleanup/carry-over | Add 9 HEVC/AVC SEI messages | JVET-P0337 |
| SEI | Omnidirectional video | cleanup/carry-over | Add 4 HEVC/AVC SEI messages on omnidirectional video | JVET-P0462 |
| SEI | Omnidirectional video | enhanced vs. HEVC based on prior work in JVET | Add a new SEI message on omnidirectional video | JVET-P0597 |
| SEI/subpictures | Level | enabling extraction/merging functionality | Add a new SEI message that indicates subpicture level information | JVET-P0984 |
| SEI/RPR | SAR | cleanup for RPR functionality | Add new SEI message that provides information on SAR dynamics | JVET-P0450 |
| Subpictures | Boundary treating | BF |  | JVET-P0378, JVET-P0572 |
| Scalability | Output layers | cleanup |  | JVET-P0228 |
| PPS, PH, SH |  | BF | Remove pps\_temporal\_mvp\_enabled\_idc | JVET-P0206 |
| SPS |  | expression of existing intent | Reserve value 3 of log2\_ctu\_size\_minus5. | JVET-P0580 |
| SPS |  | expression of existing intent | Disallow the min CU size to be greater than Min( 64, CTU size ) | JVET-P0578 |
| Scalability | General decoding process | consequence of agreement on OLS decoding concept | | JVET-P0115 |
| Scalability | PTL | consequence of agreement on OLS decoding concept | | JVET-P0117 |
| Scalability | HRD | consequence of agreement on OLS decoding concept | HRD signalling and process | JVET-P0118 |
| Scalability | HRD | consequence of agreement on OLS decoding concept | Scalable nesting SEI message | JVET-P0190 |
| NUH | Tid and Lid | expression of existing intent | Constraints and rules on values of TemporalId and nuh\_layer\_id | JVET-P0125 |
| SEI | General SEI constraints | consequence of agreement on OLS decoding concept | | JVET-P0125 |
| VPS | Single layer bitstreams | expression of existing intent | | JVET-P0097, JVET-P0205 |
| VPS | VPS ID | expression of existing intent | | JVET-P0205 |
| VPS | Single layer bitstreams | expression of existing intent | | JVET-P0185 |
| PPS, PH, SH |  | BF |  | JVET-P0152 |
| PH |  | cleanup | Add picture header | JVET-P1006 |
| Parameter sets | VUI | Functionality | Move VUI except field sequence flag to the SEI spec | USNB comment 1 |
| SEI |  | Functionality | check/ensure that prior constraints for SEI interface have been preserved. | USNB comment 3 |
| Scalability | OLS | consequence of agreement on OLS decoding concept | OLS signalling | JVET-P1019 |
| Subpictures |  | cleanup | Add single\_slice\_per\_subpic\_flag | JVET-P1024 |
| Scalability | Random access | layered coding support simpler than in SHVC | POC for independent layers | JVET-P0116 |
| Scalability | Random access | layered coding support simpler than in SHVC | POC for dependent layers | JVET-P0101 |
| Scalability | Random access | layered coding support simpler than in SHVC | IRAP AU | JVET-P0116 |
| HRD | Sub-bitstream extraction | existing design intent for extraction process | Keep DPS, VPS, and EOB in extraction | JVET-P0098 |
| Scalability | EOS | existing design intent esp. for independent layers | Specify EOS NUTs to be layer specific | JVET-P0125 |
| Scalability | Output layers and pictures | expression of existing intent | Clarification to the bullet items in setting of PicOutputFlag | JVET-P0097 |
| Scalability | Layer dependency | sensibility constraint | Require that when vps\_independent\_layer\_flag[ i ] is equal to 0 there shall be at least one value of j such that the value of vps\_direct\_dependency\_flag[ i ][ j ] is equal to 1 | JVET-P0135 |
| Subpictures | Extraction and merging | extraction/merge functionality | Mixed IRAP/non-IRAP VCL NALUs within a picture | JVET-P0124, P0095, P0222 |
| HRD | Splicing | BF & functionality | Fix a bug, and add enhancements related to splicing | JVET-P0446 |
| HRD | AU dropping | BF & functionality | Add alternative timings for AU dropping | JVET-P0446 |
| Tiles and slices |  | design simplification | Removal of bricks | JVET-P1004 |
| Tiles and slices |  | cleanup | Refinement that avoids sending an unnecessary syntax element for the last slice under some circumstance | P1012 |
| AUD |  | cleanup |  |  |
| Subpictures |  | cleanup | Signalling of subpicture layout | JVET-P0171 |
| Subpictures |  | extraction/merge functionality | Signalling of subpicture IDs and slice address | JVET-P0126, P0609 |
| Tiles and slices |  | expression of existing intent | | JVET-P0144 |
| Tiles and slices |  | expression of existing intent | | JVET-P0186 |
| Tiles |  | expression of existing intent | Add loop\_filter\_across\_tiles\_enabled\_flag | JVET-P0252 |
| Tiles |  | Cleanup/simplification | Tiles signalling | JVET-P0096 |
|  |  |  |  |  |
| **Editorial/Bugfix** | | | | |
| Intra | TU splitting | Fix | Decoding process of implicit TU partitioning | JVET-P0301 |
| TU | TU cbfs | Cleanup | Remove TU ambiguities | JVET-P0360 |
| CABAC | context | Cleanup | Remove unnecessary text | JVET-P0488 |
| Signalling | Chroma QP | Cleanup | CU adaptive chroma QP offset | JVET-P0436 |
| Partitioning | Local dual tree | Cleanup | Fix on local dual tree | JVET-P0063 |
| Intra | Reference samples | Cleanup | Cleanup of reference sample padding for intra prediction | JVET-P0626 |
| Intra | DM | Cleanup | Change the chroma intra mode from DM to planar in CIIP | JVET-P0214 |
| HLS | Misc. | Cleanup | Misc. | HLS BoG minutes in JVET-P0968 |
| SEI | General | Clarifty |  |  |
| All |  | Cleanup/Bug fix | Editorial input on VVC draft text | JVET-P0113 |
|  |  |  |  |  |
| **Software** | | | |  |
| CTC |  | Speedup | Disable MIP for low delay configuration | Plenary |
| CTC |  | Bug fix | MTSIntraMaxCand config parameter | JVET-P0273 |
| Quantization | Matrices | Speedup | VTM decoder speed-up for handling scaling matrices | JVET-P0257 |
| CTC | LMCS |  | Signalling of corrective values for chroma residual scaling | JVET-P0371 |
| CTC | SBT | Speedup | Not select SBT for sequences below HD | JVET-P0983 |
| CTC | QP | Coding efficiency | Chroma QP mapping table for HDR | JVET-P0335 |
| CTC | LMCS | Coding efficiency | LMCS for HDR | JVET-P0335 |
| Palette |  | Coding efficiency | Palette encoder optimization | JVET-P0526 |
| DF |  | Bug fix | Deblocking Filter for BDPCM coded block | JVET-P0571 |
| SMVD |  | Speedup | Encoder speed-up for SMVD | JVET-P0092 |
| SbTMVP |  | Speedup | Encoder optimization for subblock-based merge candidate search | JVET-P0445 |
| MC |  | Speedup | SIMD implementation for motion compensated prediction when the internal bit-depth is larger than 10-bit | JVET-P0512 |
| RPL |  | Bug fix | bugfix of SPS flags and reference picture list structure | JVET-P0235 |
| CTC |  | Coding efficiency | Enable LMCS for class H1 | JVET-P1037 |
| HLS |  | Bug fix | Bug fix of SPS flags and reference picture list structure | JVET-P0235 |
| CTC |  | Speedup | Extend GOP size for low delay to 8 instead of 4 | JVET-P0345 |

P0983 impact may need clarification in list. Benefit would be low, only saves runtime for small resolutions.

# Project planning

## Core experiment planning

From Track A:

* Discontinue CE3, CE6, CE7
* Continue CE8 – Could be renamed as “Palette mode”
* Have new CE on lossless (T. Nguyen)
* Continue CE5

## Drafting of specification text, encoder algorithm descriptions, and software

The following agreement has been established: the editorial team has the discretion to not integrate recorded adoptions for which the available text is grossly inadequate (and cannot be fixed with a reasonable degree of effort), if such a situation hypothetically arises. In such an event, the text would record the intent expressed by the committee without including a full integration of the available inadequate text.

## Plans for improved efficiency and contribution consideration

The group considered it important to have the full design of proposals documented to enable proper study.

Adoptions need to be based on properly drafted working draft text (on normative elements) and HM encoder algorithm descriptions – relative to the existing drafts. Proposal contributions should also provide a software implementation (or at least such software should be made available for study and testing by other participants at the meeting, and software must be made available to cross-checkers in EEs).

Suggestions for future meetings included the following generally-supported principles:

* No review of normative contributions without draft specification text
* VTM algorithm description text is strongly encouraged for non-normative contributions
* Early upload deadline to enable substantial study prior to the meeting
* Using a clock timer to ensure efficient proposal presentations (5 min) and discussions

The document upload deadline for the next meeting was planned to be XXday XX Jan 2020.

As general guidance, it was suggested to avoid usage of company names in document titles, software modules etc., and not to describe a technology by using a company name.

## General issues for experiments

It was emphasized during the opening plenary on January 9 that those rules which had been set up or refined during the 12th meeting should be observed. In particular, for some CEs, results were available late, and some changes in the experimental setup (particularly in CE4) were not discussed on the JVET reflector.

Group coordinated experiments have been planned as follows:

* “Core experiments” (CEs) are the coordinated experiments on coding tools which are deemed to be interesting but require more investigation and could potentially become part of the draft standard by the next meeting.
* A CE is a test of a specific fully described technology in a specific agreed way. It is not a forum for thinking of new ideas (like an AHG). The CE coordinators are responsible for making sure tha the CE description is complete and correct and has adequate detail. Reflector discussions about CE description clarity and other aspects of CE plans are encouraged.
* A description of each experiment is to be approved at the meeting at which the experiment plan is established. This should include the issues that were raised by other experts when the tool was presented, e.g., interference with other tools, contribution of different elements that are part of a package, etc. The experiment description document should provide the names of individual people, not just company names.
* Software for tools investigated in a CE will be provided in one or more separate branches of the software repository. Each CE will have a “fork” of the software, and within the CE there may be multiple branches established by the CE coordinator. The software coordinator will help coordinate the creation of these forks and branches and their naming. All JVET members will have read access to the CE software branches (using shared read-only credentials; the method for members to obtain the credentials is TBA on the reflector).
* During the experiment, revisions of the experiment plans can be made, but not substantial changes to the proposed technology.
* The CE description must match the CE testing that is done. The CE description needs to be revised if there has been some change of plans.
* The CE summary report must describe any changes that were made in the process of finalizing the CE.
* By the next meeting it is expected that at least one independent cross-checker will report a detailed analysis of each proposed feature that has been tested and confirm that the implementation is correct. Commentary on the potential benefits and disadvantages of the proposed technology in cross-checking reports is highly encouraged. Having multiple cross-checking reports is also highly encouraged (especially if the cross-checking involves more than confirmation of correct test results). The reports of cross-checking activities may (and generally should) be integrated into the CE report rather than submitted as separate documents.

It is possible to define sub-experiments within particular CEs, for example designated as CEX.a, CEX.b, etc., where X is the basic CE number.

As a general rule, it was agreed that each CE should be run under the same testing conditions using one software codebase, which should be based on the group test model software codebase. An experiment is not to be established as a CE unless there is access given to the participants in (any part of) the CE to the software used to perform the experiments.

The general agreed common conditions for single-layer coding efficiency experiments are described in the output document JVET-N1010.

Experiment descriptions should be written in a way such that it is understood as a JVET output document (written from an objective “third party perspective”, not a proponent perspective – e.g. not referring to methods as “improved”, “optimized”, etc.). The experiment descriptions should generally not express opinions or suggest conclusions – rather, they should just describe what technology will be tested, how it will be tested, who will participate, etc. Responsibilities for contributions to CE work should identify individuals in addition to company names.

CE descriptions contain a basic description of the technology under test, but should not contain excessively verbose descriptions of a technology (at least not unless the technology is not adequately documented elsewhere). Instead, the CE descriptions should refer to the relevant proposal contributions for any necessary further detail. However, the complete detail of what technology will be tested must be available – either in the CE description itself or in documents that are referenced in the CE description that are also available in the JVET document archive.

Any technology must have at least one cross-check partner to establish a CE – a single proponent is not enough. It is highly desirable have more than just one proponent and one cross-checker.

[Add info on software access.]

Some agreements relating to CE activities were established as follows:

* Only qualified JVET members can participate in a CE.
* Participation in a CE is possible without a commitment of submitting an input document to the next meeting. Participation is requested by contacting the CE coordinator.
* All software, results, and documents produced in the CE should be announced and made available to JVET in a timely manner.
* A JVET CE reflector will be established and announced on the main JVET reflector. Discussion of logistics arrangements, exchange of data, minor refinement of the test plans, and preparation of documents shall be conducted on the JVET CE reflector, with subject lines prefixed by “[CEx: ]”, where “x” is the number of the CE. All substantial communications about a CE other than such details shall take place on main JVET reflector. In the case that large amounts of data are to be distributed, it is recommended to send a link to the data rather than the data itself, or upload the data as an input contribution to the next meeting.

General timeline for CEs

Reviewed Thursday 11 July 2019 1900 (Y. Ye).

T1= 3 weeks after the JVET meeting: To revise the CE description and refine questions to be answered. Questions should be discussed and agreed on JVET reflector. Any changes of planned tests after this time need to be announced and discussed on the JVET reflector. Initially assigned description numbers shall not be changed later. If a test is skipped, it is to marked as “withdrawn”.

T2 = Test model software release + 2 weeks or X XX, whichever is earlier: Integration of all tools into a separate CE branch of the VTM is completed and announced to JVET reflector.

* Initial study by cross-checkers can begin.
* Proponents may continue to modify the software in this branch until T3
* 3rd parties are encouraged to study and make contributions to the next meeting with proposed changes

T3: 3 weeks before the next JVET meeting or T2 + 1 week, whichever is later: Any changes to the CE test branches of the software must be frozen, so the cross-checkers can know exactly what they are cross-checking. A software version tag should be created at this time. The name of the cross-checkers and list of specific tests for each tool under study in the CE plan description shall be documented in an updated CE description by this time.

T4: Regular document deadline – 1 week: CE contribution documents including specification text and complete test results shall be uploaded to the JVET document repository (particularly for proposals targeting to be promoted to the draft standard at the next meeting).

The CE summary reports shall be available by the regular deadline. This shall include documentation about crosscheck of software, matching of CE description and confirmation of the appropriateness of the text change, as well as sufficient crosscheck results to create evidence about correctness (crosscheckers must send this information to the CE coordinator at least 3 days ahead of the document deadline). Furthermore, any deviations from the timelines above shall be documented. The numbers used in the summary report shall not be changed relative to the description document.

CE reports may contain additional information about tests of straightforwared combinations of the identified technologies. Such supplemental testing needs to be clearly identified in the report if it was not part of the CE plan.

New branches may be created which combine two or more tools included in the CE document or the VTM (as applicable).

It is not necessary to formally name cross-checkers in the initial version of the CE description document. To adopt a proposed feature at the next meeting, we would like see comprehensive cross-checking done, with analysis that the description matches the software, and recommendation of value of the tool given tradeoffs.

The establishment of a CE does not indicate that a proposed technology is mature for adoption or that the testing conducted in the CE is fully adequate for assessing the merits of the technology, and a favourable outcome of CE does not indicate a need for adoption of the technology.

Availability of spec text is important to have a detailed understanding of the technology and also to judge what its impact on the complexity of the spec will be. There must also be sufficient time to study it in detail. CE contributions without sufficiently mature draft spec text in the CE input document should not be considered for adoption.

Plans for the CEs to be conducted were established Thursday 11 July (Y. Ye); CE plan documents were reviewed Thursday 11 July (Y. Ye).

Lists of participants in CE documents should be pruned to include only the active participants. Read access to software will be available to all members.

## Software development and anchor generation

The planned timeline for software releases was established as follows:

* VTM7.0 will be released by 2019-11-11 including all adoptions necessary for CTC and CE basis references. VTM7.1 with non-CTC adoptions will be released later. Further versions of VTM may be released for additional bug fixing, as appropriate.
* Preparation of the VTM software will include immediate removal of macros that were added in the previous meeting cycle. The software coordinator has the discretion to retain some such macros.
* No change of of 360lib or HDRTools was noted in response to meeting.

# Establishment of ad hoc groups

The ad hoc groups established to progress work on particular subject areas until the next meeting are described in the table below. The discussion list for all of these ad hoc groups was agreed to be the main JVET reflector ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de)).

|  |  |  |
| --- | --- | --- |
| **Title and Email Reflector** | **Chairs** | **Mtg** |
| **Project Management (AHG1)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Coordinate overall JVET interim efforts. * Supervise CE and AHG studies. * Report on project status to JVET reflector. * Provide a report to the next meeting on project coordination status. | J.-R. Ohm, G. J. Sullivan (co-chairs) | N |
| **Draft text and test model algorithm description editing (AHG2)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Produce and finalize JVET-P2001 VVC text specification draft 7. * Produce and finalize JVET-P2002 VVC Test Model 7 (VTM 7) Algorithm and Encoder Description. * Gather and address comments for refinement of these documents. * Coordinate with test model software development AhG to address issues relating to mismatches between software and text. | B. Bross, J. Chen (co-chairs), J. Boyce, S. Kim, S. Liu, Y.-K. Wang, Y. Ye (vice-chairs) | N |
| **Test model software development (AHG3)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Coordinate development of test model (VTM) software and associated configuration files. * Produce documentation of software usage for distribution with the software. * Discuss and make recommendations on the software development process. * Propose improvements to the guideline document for developments of the test model software. * Perform tests of VTM behaviour relative to HEVC and the previous VTM using the VTM common test conditions. * Coordinate with AHG on Draft text and test model algorithm description editing (AHG2) to identify any mismatches between software and text, and make further updates and cleanups to the software as appropriate. * Coordinate with AHG6 for integration with 360lib software. | F. Bossen, X. Li, K. Sühring (co-chairs) | N |
| **Test material and visual assessment (AHG4)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Maintain the video sequence test material database for development of the VVC standard. * Identify and recommend appropriate test materials for use in the development of the VVC standard. * Identify missing types of video material, solicit contributions, collect, and make available a variety of video sequence test material. * Evaluate new test sequences. * Maintain and update the directory structure for the test sequence repository as necessary. * Prepare availability of viewing equipment and facilities arrangements for the next meeting, and prepare testing upon consultation with CE coordinators. * Begin planning for verification testing of VVC capability. * Coordinate with AHG11 on test material for screen content coding. | V. Baroncini, T. Suzuki, M. Wien (co-chairs), R. Chernyak, A. Norkin (vice-chairs) | N |
| **Conformance testing (AHG5)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study the requirements of VVC conformance testing to ensure interoperability. * Propose a work plan, including timeline, for preparation of a conformance testing specification and conformance bitstream database. * Study potential testing methodology to fulfil the requirements of VVC conformance testing. | J. Boyce and W. Wan (co-chairs), E. Alshina, I. Moccagatta, K. Kawamura, S. McCarthy, K. Sühring (vice-chairs) | N |
| **360° video coding tools, software and test conditions (AHG6)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study the effect on compression and subjective quality of different projections formats, resolutions, and packing layouts. * Discuss refinements of common test conditions, test sequences, and evaluation criteria. * Solicit additional test sequences, and evaluate suitability of test sequences on head-mounted displays and normal 2D displays. * Study coding tools dedicated to 360° video, their impact on compression, and implications to the core codec design, including consideration of subpicture segmentations and adaptive viewport usage. * Study the effect of viewport resolution, field of view, and viewport speed/direction on visual comfort. * Study complexity of GPU rendering of projection formats. * Study syntax for signalling of projection formats, cubeface layouts, spherical rotations. * Prepare and deliver the 360Lib-10 software version and common test condition configuration files according to JVET-M1012. * Generate CTC anchors and PERP results for the VTM according to JVET-M1012 within two weeks of availability of SDR CTC anchors. * Produce documentation of software usage for distribution with the software. | J. Boyce and Y. He (co-chairs), K. Choi, J.-L. Lin, Y. Ye (vice-chairs) | N |
| **Coding of HDR/WCG material (AHG7)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study and evaluate available HDR/WCG test content. * Study objective metrics for quality assessment of HDR/WCG material, including investigation of the correlation between subjective and objective results. * Compare the performance of the VTM and HM for HDR/WCG content. * Generate CTC anchors for the VTM according to JVET-P2011 within two weeks of availability of SDR CTC anchors. * Prepare for expert viewing of HDR content at the next JVET meeting if feasible. * Coordinate implementation of HDR anchor aspects in the test model software with AHG3. * Study additional aspects of coding HDR/WCG content. | A. Segall (chair), E. François, W. Husak, S. Iwamura, D. Rusanovskyy (vice-chairs) | N |
| **Layered coding and resolution adaptivity (AHG8)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study adaptive-resolution coding approaches for real-time communication, adaptive streaming, and 360-degree viewport-dependent streaming, including subpicture-based resampling, reference picture management and related scope and signalling. * Study approaches for temporal scalability to avoid temporal judder when temporal scalability sub-bitstream extraction is used for achieving lower frame rate, and consider whether this should have a normative impact. * Develop software for layered coding and resolution adaptivity modalities in the context of the VTM software. * Propose common test conditions for layered coding and resolution adaptivity. * Study approaches for support of layered coding scalability including spatial, temporal, quality, view, and region-of-interest scalability; and analyse their coding efficiency and complexity characteristics | S. Wenger and A. Segall (co-chairs), M. M. Hannuksela, Hendry, S. McCarthy, Y.-C. Sun, P. Topiwala, M. Zhou (vice-chairs) | N |
| **XYZ (AHG9)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * BYOB | LKL (co-chairs), YAY(vice-chairs) | N |
| **Encoding algorithm optimization (AHG10)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study the impact of using techniques such as GOP structures and perceptually optimized adaptive quantization for encoder optimization. * Study quality metrics for measuring subjective quality using e.g. the CfP response MOS scores. * Study the impact of adaptive quantization on individual tools in the test model. * Investigate other methods of improving objective and/or subjective quality, including adaptive coding structures and multi-pass encoding. * Study methods of rate control and their impact on performance, subjective and objective quality. | A. Duenas, A. Tourapis (co-chairs), S. Ikonin, A. Norkin, R. Sjöberg, J. Le Tanou, J.-M. Thiesse (vice-chairs) | N |
| **Screen content coding (AHG11)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Investigate coding tools targeted at screen content in terms of compression benefit and implementation complexity. * Identify test materials, discuss testing conditions for screen content coding, and propose associated updated common test conditions. * Study the impact of loop filters on screen content coding. | S. Liu (chair), J. Boyce, A. Filippov, Y.-C. Sun, J. Xu, H. Yang (vice-chairs) | N |
| **High-level parallelism and coded picture regions (AHG12)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study wavefront processing including the relationship with tiles and low delay characteristics. * Study flexible loop filter control and tile size restrictions, including identifying implications on coding tools and implementation. * Study support of independently coded picture regions, including easy extraction and merging of such regions into conforming bitstreams. * Prepare software and configurations for the test model to facilitate parallel processing tests. * Study the coding efficiency impact of parallel processing and coded picture regions. | S. Deshpande (chair), B. Choi, M. M. Hannuksela, R. Sjöberg, R. Skupin, W. Wan, Y.-K. Wang (vice-chairs) | N |
| **Tool reporting procedure and testing (AHG13)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Prepare output document JVET-P2005, which describes the methodology of tool-off testing and a list of tools to be tested by identified testers, including non-CTC configurations as appropriate. * Provide configurations files, bitstreams, and results of tool-on/tool-off testing. * Maintain VTM software aspects for memory bandwidth analysis in coordination with AHG3. * Use the tool usage counts and memory bandwidth usage to study the decoder complexity of features in on/off testing. * Prepare a report with results of the tests. | W.-J. Chien, J. Boyce (co-chairs), W. Chen, Y.-W. Chen, R. Chernyak, K. Choi, R. Hashimoto, Y.**-**W. Huang, H. Jang, R.-L. Liao, S. Liu (vice-chairs) | N |
| **UIU (AHG14)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * HJH | GHG (chair), POP (vice-chairs) | N |
| **Quantization control (AHG15)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Identify methods for quantization step size control for luma and chroma, including spatially and frequency-adaptive approaches. * Develop methods for evaluating quantization step size control operation. * Study the association between transforms and quantization scaling matrices. * Develop testing conditions for evaluating QP signalling improvements including rate control and perceptual optimization strategies as appropriate. * Evaluate the performance of the current VVC QP design using the adaptive quantization control techniques currently available in the VTM. | R. Chernyak (chair), E. François, C. Helmrich, S. McCarthy, A. Segall (vice-chairs) | N |
| **Implementation studies (AHG16)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study current and proposed coding tools to identify implementation issues relating to decoder pipelines, decoder throughput, and other aspects of implementation difficulty. * Solicit hardware analysis of complex tools. * Provide feedback on potential solutions to address identified issues. | M. Zhou (chair), J. An, E. Chai, K. Choi, S. Sethuraman, T. Hsieh, X. Xiu (vice-chairs) | N |
| **High-level syntax (AHG9) [Move]**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study NAL unit header, decoding parameter set, video parameter set, sequence parameter set, picture parameter set, adaptation parameter set, picture header, and slice header syntax designs. * Study reference picture buffering and list construction. * Study random access signalling and random access approaches. * Study detection of AU and picture boundaries and properties. * Study the appropriate syntax level and signalling approaches for high-level signalling of control information for lower-level coding tools. * Coordinate with AHG2 and AHG3 for text drafting and software development for the high-level syntax in the VVC design. * Study syntax approaches for interoperability point signalling. * Study selection of constraint flags and their impact on syntax, semantics, and decoding process. | R. Sjöberg, J. Boyce (co-chairs), B. Choi, S. Deshpande, M. M. Hannuksela, R. Skupin, A. Tourapis, Y.-K. Wang, W. Wan (vice-chairs) | N |
| **Lossless and near-lossless coding (AHG14) [Move]**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study lossless and near-lossless coding, including transform skip, BDPCM, and other potential technologies. * Consider the interaction between coding tools and other processing such as loop filtering and LMCS for lossless and near-lossless coding. * Develop proposals for lossless and near-lossless coding for chroma and non-YCbCr colour space content. * Consider throughput bottlenecks for lossless and near-lossless coding at high resolutions and frame rates. | T. Nguyen and T.-C. Ma (co-chairs), M. Ikeda, H. Jang, X. Zhao (vice-chairs) | N |

# Output documents

The following documents were agreed to be produced or endorsed as outputs of the meeting. Names recorded below indicate the editors responsible for the document production. Where applicable, dates of planned finalization and corresponding parent-body document numbers are also noted.

It was reminded that in cases where the JVET document is also made available as MPEG output document, a separate version under the MPEG document header should be generated. This version should be sent to GJS and JRO for upload.

JVET-P2000 Meeting Report of the 15th JVET Meeting [G. J. Sullivan, J.-R. Ohm] (2019-xx-xx, near next meeting)

Initial versions of the meeting notes (d0 … d9) were made available on a daily basis during the meeting.

JVET-P2001 Versatile Video Coding (Draft 7) [B. Bross, J. Chen, S. Liu, Y.-K. Wang] [WG 11 DIS 23090-3, N18873] (2019-11-09)

(Initial version planned to be made available by 2019-10-18.)

(Resolution impact: Adding Y.-K. Wang as editor)

DoCR also output by MPEG.

See the list of elements under section 11.7, [revisit to check].

JVET-P2002 Algorithm description for Versatile Video Coding and Test Model 6 (VTM 6) [J. Chen, Y. Ye, S. Kim] [WG 11 N 18874] (2019-11-22)

(Initial version planned to be made available by 2019-10-31.)

Remains valid – not updated: [JVET-N1003](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6638) Guidelines for VVC reference software development [K. Sühring] (2019-04-01)

Remains valid – not updated: [JVET-M1004](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=5757) Algorithm descriptions of projection format conversion and video quality metrics in 360Lib (Version 9) [Y. Ye, J. Boyce] (2019-02-15)

JVET-P2005 Methodology and reporting template for coding tool testing [W.-J. Chien and J. Boyce] (2019-11-25)

Initial version to be available by 2019-10-25; final version expected by two weeks after VTM 7 availability.

Remains valid – not updated: [JVET-M1006](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=5758) Methodology and reporting template for neural network coding tool testing [Y. Li, S. Liu, K. Kawamura] (2019-02-01)

This output was produced to capture aspects specific to enable study of neural network techniques.

JVET-P2007 Supplemental enhancement information messages for coded video bitstreams [J. Boyce, G. J. Sullivan, Y.-K. Wang] [WG 11 DIS 23002-7, N18873] (2019-11-09)

DoCR also output by MPEG.

See the list of elements under section 11.8 [revisit to check].

JVET-P2008 Conformance testing for versatile video coding (Draft 1) [J. Boyce, E. Alshina, K. Kawamura, S. McCarthy, I. Moccagatta, W. Wan] (2019-11-22)

List volunteers (may be recruited later also).

No output P2009

Remains valid – not updated: JVET-N1010 JVET common test conditions and software reference configurations for SDR video [F. Bossen, J. Boyce, X. Li, V. Seregin, K. Sühring] (2019-04-12)

JVET-P2011 JVET common test conditions and evaluation procedures for HDR/WCG video [A. Segall, E. François, W. Husak, S. Iwamura, D. Rusanovskyy] (2019-07-31)

(Will include correction of description of quantization aspects.)

Remains valid – not updated: [JVET-L1012](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=4840) JVET common test conditions and evaluation procedures for 360° video [P. Hanhart, J. Boyce, K. Choi, J.-L. Lin] (2018-10-26)

Drafts of CE plans were not reviewed during the meeting due to lack of time.

[JVET-P2021](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7821) Description of Core Experiment 1 (CE 1): Deblocking filtering [K. Andersson, A. Norkin]

See track A notes about what to test.

[JVET-P2022](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7823) Description of Core Experiment 2 (CE2): Palette mode coding [X. Xu, Y.-H. Chao, Y.-C. Sun, J. Xu]

See track A notes about what to test.

[JVET-P2023](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7816) Description of Core Experiment 3 (CE3): Lossless coding [T.-C. Ma, A. Nalci, T. Nguyen]

See track A notes about what to test.

[JVET-P2024](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7820) Description of Core Experiment 4 (CE4): Inter prediction with geometric partitioning [C.-C. Chen, R.-L. Liao, H. Yang, X. Xiu]

To test P0884/P0885; also to test current design with TPM off

Combination with CIIP P0071 to also test

(P0174 and P0250 were not reviewed in detail, not to be tested in the CE, more complex)

P0583 (which part of P0248) disallows SBT with GEO, to also test.

It was suggested and agreed to test P0449

Also test blending disabling

[JVET-P2025](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7822) Description of Core Experiment 5 (CE5): Cross-component adaptive loop filtering [C.-Y. Chen, A. Segall]

See track A notes about what to test.

[JVET-O2026](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7817) Description of Core Experiment 6 (CE6): Transforms and transform signalling [H. E. Egilmez, M. Salehifar, X. Zhao]

CE tests that retrain the basis functions will provide the training software, training data, and version information of the VTM software used to conduct the training.

The CE test condition will include some non-CTC sequences.

[JVET-O2027](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7818) Description of Core Experiment 7 (CE7): Quantization and coefficient coding [H. Schwarz, M. Coban, C. Auyeung]

Bug fix to ensure that bin-to-bit ratio is accurate will be included in VTM6.0.

[JVET-O2028](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7819) Description of Core Experiment 8 (CE8): 4:4:4 Screen Content Coding Tools [X. Xu, Y.-H. Chao, Y.-C. Sun, J. Xu]

It was noted that CTC for 4:4:4 content has not been decided yet.

In the context of CE8, it was agreed that palette mode should be turned on in the anchors.

# Future meeting plans, expressions of thanks, and closing of the meeting

Future meeting plans were established according to the following guidelines:

* Meeting under ITU-T SG 16 auspices when it meets (ordinarily starting meetings on the Tuesday of the first week and closing it on the Wednesday of the second week of the SG 16 meeting – a total of 9 meeting days), and
* Otherwise meeting under ISO/IEC JTC 1/SC 29/WG 11 auspices when it meets (ordinarily starting meetings on the Tuesday prior to such meetings and closing it at lunchtime on the last day of the WG 11 meeting – a total of 9.5 meeting days).

In cases where an exceptionally high workload is expected for a meeting, an earlier starting date may be defined. For the upcoming meeting in October 2019, the SG16 parent-level meeting dates had been shifted after the JVET and MPEG meeting plans were established, which has caused an additional adjustment in the JVET dates.

Some specific future meeting plans (to be confirmed) were established as follows:

* Tue. 7 – Fri. 17 January 2020, 17th meeting under WG 11 auspices in Brussels, BE.
* Wed. 15 – Fri. 24 April 2020, 18th meeting under WG 11 auspices in Alpbach, AT.
* Tue. 23 June – Wed. 1 July 2020, 19th meeting under ITU-T auspices in Geneva, CH.
* Wed. 7 – Fri. 16 October 2020, 20th meeting under WG 11 auspices in Rennes, FR.

The agreed document deadline for the 17th JVET meeting was planned to be Tuesday 31 December 2019. CE proposal documents are due one week ahead of that date. HLS only on 1st day if Tuesday.

ITU was thanked for the excellent hosting of the 16th meeting of the JVET.

EBU, GBTech, ITU-T and Sharp Labs of America were thanked for providing equipment used for subjective viewing during the 16th JVET meeting. Kenneth Andersson, Vittorio Baroncini, Andrey Norkin, Andrew Segall, and Mathias Wien were thanked for preparing and conducting the subjective test efforts. Frans de Jong was thanked for support in providing the displays from EBU and helping in conducting HDR related viewing at EBU premises. The experts who participated in the role as test subjects were also thanked.

The 16th JVET meeting was closed at approximately 1245 hours on Friday 11 Oct. 2019.

# Annex A to JVET report: List of documents

# Annex B to JVET report: List of meeting participants

The participants of the sixteenth meeting of the JVET, according to an attendance sheet circulated during the meeting sessions (approximately XXX people in total), were as follows: