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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**  15th Meeting: Gothenburg, SE, 3–12 July 2019 | Document: JVET-O\_Notes\_dB |

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| *Title:* | **Meeting Report of the 15th Meeting of the Joint Video Experts Team (JVET), Gothenburg, SE, 3–12 July 2019** | | |
| *Status:* | Report document from the chairs of JVET | | |
| *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 fifteenth meeting during 3–12 July 2019 at the Clarion Post Hotel in Gothenburg, SE. 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 0900 hours on Wednesday 3 July 2019. Meeting sessions were held on all days (including weekend days) until the meeting was closed at approximately 1351 hours on Friday 12 July 2019. Approximately XXX people attended the JVET meeting, and approximately XXX input documents, 11 CE summary reports, and 17 AHG reports were discussed. The meeting took place in a collocated fashion with a meeting of WG11 – 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 11 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 18 “ad hoc groups” (AHGs) to progress the work on particular subject areas. At this meeting, 8 Core Experiments (CE) were defined. The next four JVET meetings were planned for 1–11 October 2019 under ITU-T SG16 auspices in Geneva, CH, during 8–17 January 2020 under WG 11 auspices in Brussels, BE, during 15–24 April 2020 under WG 11 auspices in Alpbach, AT, and during 23 June – 01 July 2020 under ITU-T SG16 auspices in Geneva, CH.

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 fifteenth meeting during 3–12 July 2019 at the Clarion Post Hotel in Gothenburg, SE. 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_07_O_Gothenburg/>.

## Primary goals

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 11 Core Experiments (CE), reviewing other technical input on novel aspects of video coding technology, and producing the next versions of draft text and VTM, and plan 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):”.

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, 25 June 2019. Any documents uploaded after 1159 hours Paris/Geneva time on Wednesday 26 June 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 fourteenth meeting, contributions related to CE proposals 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 19 June were considered “officially late”. After the positive experience, it was agreed to continue having a 2-week deadline for CE proposal documents, including draft text.

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-O0673 were registered after the “officially late” deadline (and therefore were also uploaded late). Likewise, CE proposal documents with registration numbers higher than JVET-O0132 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, many 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-O0124 (a proposal on …), uploaded 06-20.
* JVET-O0334 (a proposal on …), uploaded 06-26.
* JVET-O0337 (a proposal on …), uploaded 06-30.
* JVET-O0384 (a proposal on …), uploaded 06-30.
* JVET-O0412 (a proposal on …), uploaded 06-28.
* JVET-O0442 (a proposal on …), uploaded 06-30.
* JVET-O0443 (a proposal on …), uploaded 06-26.
* JVET-O0461 (a proposal on …), uploaded 06-28.
* JVET-O0473 (a proposal on …), uploaded 07-03.
* JVET-O0620 (a proposal on …), uploaded 06-28.
* JVET-O0621 (a proposal on …), uploaded 06-27.
* JVET-O0635 (a proposal on …), uploaded 07-02.
* JVET-O0652 (a proposal on …), uploaded 06-26.
* JVET-O0660 (a proposal on …), uploaded 06-27.
* JVET-O0663 (a proposal on …), uploaded 06-27. (initial version rejected)
* JVET-O0674 (a proposal on …), uploaded 06-26.
* JVET-O0681 (a proposal on …), uploaded 06-27.
* JVET-O0682 (a proposal on …), uploaded 07-01.
* JVET-O0699 (a proposal on …), uploaded 06-28.
* JVET-O0700 (a proposal on …), uploaded 06-28.
* JVET-O0706 (a proposal on …), uploaded 06-28.
* JVET-O0737 (a proposal on …), uploaded 06-29.
* JVET-O0741 (a proposal on …), uploaded 06-29.
* JVET-O0748 (a proposal on …), uploaded 06-29.
* JVET-O0755 (a proposal on …), uploaded 06-29.
* JVET-O0783 (a proposal on …), uploaded 06-30.
* JVET-O0789 (a proposal on …), uploaded 07-08.
* JVET-O0793 (a proposal on …), uploaded 06-30.
* JVET-O0795 (a proposal on …), uploaded 07-01.
* JVET-O0803 (a proposal on …), uploaded 06-30.
* JVET-O0848 (a proposal on …), uploaded 07-01.
* JVET-O0888 (a proposal on …), uploaded 07-02.
* JVET-O0891 (a proposal on …), uploaded 07-01.
* JVET-O0914 (a proposal on …), uploaded 07-02.
* JVET-O0919 (a proposal on …), uploaded 07-02.
* JVET-O0928 (a proposal on …), uploaded 07-03.
* JVET-O0935 (a proposal on …), uploaded 07-02.
* JVET-O0946 (a proposal on …), uploaded 07-03.
* JVET-O0963 (a proposal on …), uploaded 07-03.
* JVET-O0976 (a proposal on …), uploaded 07-03.
* JVET-O0979 (a proposal on …), uploaded 07-03.
* JVET-O1037 (a proposal on …), uploaded 07-04.
* JVET-O1048 (a proposal on …), uploaded 07-04.
* JVET-O1061 (a proposal on …), uploaded 07-05.
* JVET-O1075 (a proposal on …), uploaded 07-04.
* JVET-O1098 (a proposal on …), uploaded 07-05.
* JVET-O1109 (a proposal on …), uploaded 07-06.
* JVET-O1120 (a proposal on …), uploaded 07-07.
* JVET-O1124 (a proposal on …), uploaded 07-07.
* JVET-O1126 (a proposal on …), uploaded 07-07.
* JVET-O1127 (a proposal on …), uploaded 07-07.
* JVET-O1130 (a proposal on …), uploaded 07-07.
* JVET-O1136 (a proposal on …), uploaded 07-07.
* JVET-O1140 (a proposal on …), uploaded 07-08.
* JVET-O1142 (a proposal on …), uploaded 07-08.
* JVET-O1143 (a proposal on …), uploaded 07-08.
* JVET-O1150 (a proposal on …), uploaded 07-09.
* JVET-O1153 (a proposal on …), uploaded 07-08.
* JVET-O1161 (a proposal on …), uploaded 07-09.
* JVET-O1164 (a proposal on …), uploaded 07-09.
* JVET-O1166 (a proposal on …), uploaded 07-09.
* JVET-O1168 (a proposal on …), uploaded 07-10.
* JVET-O1169 (a proposal on …), uploaded 07-10.
* JVET-O1170 (a proposal on …), uploaded 07-10.
* JVET-O1171 (a proposal on …), uploaded 07-10.
* JVET-O1172 (a proposal on …), uploaded 07-10.

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-O0756 (a document on …), uploaded 06-29.
* JVET-O0800 (a document on …), uploaded 07-03.
* JVET-O0898 (a document on …), uploaded 07-05.
* JVET-O1040 (a document on …), uploaded 07-04.
* JVET-O1123 (a document on …), uploaded 07-07.

All cross-verification reports at this meeting were registered late and therefore also uploaded late (all with numbers higher than JVET-O0XXX) and therefore are not specifically identified here, in the interest of brevity. 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-O0XXX (withdrawn), JVET-O0XXX (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):

0742, 0839, 0889, 0945, 0961, 0989-0995, 1033, 1059, 1101, 1173

“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-O0XXX and … .

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

* JVET-O0XXX (…)
* …

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-N1000, the Versatile Video Coding specification text (Draft 5) JVET-N1001, the Algorithm description for Versatile Video Coding and Test Model 5 (VTM 5) JVET-N1002, the Guidelines for VVC software development JVET-N1003, the Methodology and reporting template for coding tool testing JVET-N1005, the JVET common test conditions and software reference configurations for SDR video JVET-N1010 and for HDR/WCG video JVET-N1011, and the Description of Core Experiments 1 through 11 (JVET-N1021 through JVET-N1031), had been completed and were approved. The software implementation of VTM (versions 5.0 and 5.1) 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

## 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 1179.

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 set.
* **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.
* **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).
* **GBI**: …
* **GRA**: …
* **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.
* **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.
* **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).
* **PDPC**: Position dependent (intra) prediction combination.
* **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).
* **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.
* **RDOF**: …
* **RDOQ**: Rate-distortion optimized quantization.
* **RDPCM**: …
* **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.
* **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.
* **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**: …
* **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 0900 Wednesday 3 July (initially chaired by GJS and later joined by JRO) were as follows.

* The meeting logistics, agenda, working practices, policies, and document allocation were reviewed.
  + The meeting host is the Swedish Institute for Standards
  + Sponsors: Ericsson, SiS, Dolby, Divideon
  + 1030-1130, 1530-1630
  + 1830 Wed Kajskjul 8, Packhusplatsen 11 (14 min by foot)
  + There is a goal of potential CD ballot at this meeting in the ISO/IEC approval process.
  + In addition to problems of late submission of documents, it was remarked that text is missing for a number of documents. 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
* Principles of standards development were discussed.
* Standardization timelines [CD July, DIS October (possibly January), Consent & FDIS July; or CD October, DIS Jan, Consent & FDIS July]

## 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:

* Wed. 3 July, 1st day
  + 0900–1000 JVET opening plenary (chaired by GJS)
  + 1000-1300, 1430-1615 AHG reports (chaired by GJS & JRO)
  + Track A (chaired by GJS)
    - 1645 CE1 CABAC initialization (4+3) (section 5.1)
    - 1800-2000 CE3 intra prediction and mode coding (12+96) (section 5.3)
    - HLS BoG in Brevesorterarsalen 3
  + Track B (chaired by JRO)
    - 1700-1930 CE4 inter prediction (8)
    - 1930-2100 CE2 luma/chroma dependency (5)
    - 2045-???? BoG on CE4/Merge (chaired by C.-C. Chen) in Brevesorterarsalen 1
* Thu. 4 July, 2nd day
  + Track A (GJS)
    - 0900-1030 CE6: Transforms and transform signalling (4) (section 5.6)
    - 1100 CE7: Quantization and coefficient coding (8) (section 5.7)
    - 1430 CE11: Gradual random access (6)
    - 1800 CE11 related – Gradual random access (2) (section 6.11) (Track A)
    - 1900-2230 Quantization parameter signalling (8) (section 6.12) (Track A)
    - HLS BoG in Brevesorterarsalen 3
    - BoG on CE3-related intra prediction and mode coding (96) (section 6.3)  
      ([JVET-O1093](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7730)) [G. Van der Auwera]
    - BoG on CE6-related Transforms and transform signalling (50) (section 6.6)  
      ([JVET-O1115](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=7752)) [X. Zhao]
    - BoG on CE7-related Quantization and coefficient coding (25) (section 6.7)  
      ([JVET-O1117](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7754)) [Heiko Schwarz]
  + Track B (JRO)
    - 0900–XXX CE5 Loop Filters
    - XXX–XXX CE8 Screen Content Tools
    - XXX–XXX CE9 Decoder Motion Vector Derivation
    - XXX–XXX CE10 Neural network caused AI+related
    - Track B BoGs: CE, CE10 – clarify when ready
* Fri. 5 July, 3rd day
  + Track A (GJS)
    - 0900-1115 Quantization parameter signalling (8) (section 6.12)
    - 1145, 1445 Entropy coding (6) (section 6.13)
    - CE1 related – CABAC initialization (2) (section 6.1) (Track A)
    - XXXX Chroma sampling and chroma formats (2) (section 6.14) (Track A)
  + Track B (JRO)
    - 0900–1330 and 1430-1800 CE8 related Screen Content Tools
    - 1800-2130 section 6.15 Other Coding Tools
* Sat. 6 July, 4th day
  + 0900–1100 BoG CE4 related
  + Track B (chaired by JRO)
    - 1100-1230 Track B Report BoG CE2 (J. Chen)
    - 1230-1340 Track B Report BoG CE4 General (H. Yang)
    - 1445-1600 Track B Report BoG CE4 Merge (C.-C. Chen)
    - 1615-1745 Track B Report BoG CE9 (S. Esenlik)
    - 1745-1830 Track B CE5 Subjective Results (M. Wien)
    - 1830-2215 section 6.5 CE5 related / ALF topics
* Sun. 7 July, 5th day
  + Track B (JRO)
    - 0900–1015 BoG CE8 related (X. Xu)
    - 1015-1345 Track B section 6.5 CE5 related / ALF topics
    - 1415-1800 Track B CE5 deblocking and section 6.5 CE5 related / deblocking topics
* Mon. 8 July, 6th day
  + - Plenary 1400-1945
    - Track A (GJS): 2000-2230 BoG review CE3 related intra prediction and mode coding (section 6.3) ([JVET-O1093](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7730)) [G. Van der Auwera]
    - Track B (JRO): 2000–2140 BoG review CE2 related & CE4 related general
* Tue. 9 July, 7th day
  + Track B (JRO)
    - 0900–1030 BoG review CE4 related merge
    - 1100–1415 BoG review CE4/9 joint and CE9
    - 1530–1800 Revisits
  + Track A (GJS)
    - 1430-1745 Review of BoG on CE6-related transforms and transform signalling (50) (section 6.6) ([JVET-O1115](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=7752)) [X. Zhao]
* Wed. 10 July, 8th day
  + Track A (GJS)
    - 1130-1330 Review of BoG on CE6-related transforms and transform signalling (50) (section 6.6) ([JVET-O1115](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=7752)) [X. Zhao]
    - 1330-1520 Review BoG on CE7-related Quantization and coefficient coding (25) (section 6.7) ([JVET-O1117](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7754)) [Heiko Schwarz]
    - 1545 Non-HLS aspects of reference picture resampling (O0641, O0133, O0134, O0303, O0242; O0240, O0319, O0395, O1164)
    - Review BoG on high-level syntax ([JVET-O1076](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7713))
      * AHG17: General high-level syntax (60) (section 6.17)
      * AHG12: High-level parallelism and coded picture regions (41) (section 6.18)
      * AHG8: Layered coding and resolution adaptation (24) (section 6.19)
      * 360 degree video (4) (section 6.16)
  + Track B (JRO)
    - 1115–1330 and 1430-1815 Revisits, remaining doc reviews
  + Social 1830 Wed Kajskjul 8, Packhusplatsen 11 (14 min by foot)
* Thu. 11 July, 8th day
  + Track A (GJS)
    - 1130-1245 Review BoG on high-level syntax ([JVET-O1076](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7713))
    - 1245-1330 Further discussions for quantization parameter signalling (section 6.12)
    - 1330-1430 Further discussions for intra prediction and mode coding and related (sections 5.3 and 6.3 and BoG report [JVET-O1093](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7730)) [G. Van der Auwera]
    - 1430-1445 Further discussions for CABAC initialization (sections 5.1 and 6.1)
    - 1445-1500 Further discussions for CE11 (section 5.11)
  + Plenary 1530
    - Project planning (section 12, incl. CEs)
    - Establishment of AHGs (section 13)
    - Output documents (section 14)
    - Future meeting plans and concluding remarks (section 15)
  + 1800 CE planning
  + 2100-0130 remainders from Track A
    - Revisit CE11 related (section 6.11)
    - Review BoG on high-level syntax ([JVET-O1076](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7713))
* Fri. 12 July, 9th day
  + - 0830 Review BoG on high-level syntax ([JVET-O1076](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7713))
      * Plenary discuss three text approaches for layered coding
    - 1115 Clarification of decision O0640 – the picture size shall be an integer multiple of 8 *and* MinCbSizeY
    - Review list of adoptions
    - O0537 additional discussion
    - O0650 *et al.*, chroma QP CTC
    - CTC for 4:4:4
    - 1230 [JVET-O0756](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7377) HDRTools
    - 1245 Further discuss CE2

Sunday BoGs: CE2/CE3, CE4/CE9, CE6, HLS

BoG rooms Wed-Sat: Brevesorterarsalen 1, 2, 3.

## 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 (17) (section 3) (Plenary)
* Project development (X) (section 4) (Plenary)
  + Text and software development (1)
  + Test conditions (1)
  + Performance assessment (5)
  + Coding studies on specific use cases (0)
  + Test Material (0)
* Core Experiments (xx) (section 5) with subtopics
  + CE1: CABAC initialization (4) (section 5.1) (Track A)
  + CE2: Luma/chroma dependency reduction (5) (section 5.2) (Track B)
  + CE3: Intra prediction and mode coding (12) (section 5.3) (Track A)
  + CE4: Inter prediction (8) (section 5.4) (Track B)
  + CE5: Loop filtering (7) (section 5.5) (Track B)
  + CE6: Transforms and transform signalling (4) (section 5.6) (Track A)
  + CE7: Quantization and coefficient coding (8) (section 5.7) (Track A)
  + CE8: Screen content coding tools (16) (section 5.8) (Track B)
  + CE9: Decoder motion vector derivation (7) (section 5.9) (Track B)
  + CE10: Neural network based loop filtering (2) (section 5.10) (Track B)
  + CE11: Gradual random access (6) (section 5.11) (Track A)
* Non-CE technology proposals (xx) (section 6) with subtopics
  + CE1 related – CABAC initialization (2) (section 6.1) (Track A)
  + CE2 related – Luma/chroma dependency reduction (23) (section 6.2) (Track B) BoG
  + CE3 related – Intra prediction and mode coding (96) (section 6.3) (Track A)
  + CE4 related – Inter prediction (105) (section 6.4) (Track B) 2 BoGs
  + CE5 related – Loop filtering (38) (section 6.5) (Track B)
  + CE6 related – Transforms and transform signalling (50) (section 6.6) (Track A)
  + CE7 related – Quantization and coefficient coding (25) (section 6.7) (Track A)
  + CE8 related – Screen content coding tools (46) (section 6.8) (Track B) partially done + BoG
  + CE9 related – Decoder motion vector derivation (26) (section 6.9) (Track B) BoG
  + CE10 related – Neural network based loop filtering (2) (section 6.10) (Track B)
  + CE11 related – Gradual random access (2) (section 6.11) (Track A)
  + Quantization parameter signalling (8) (section 6.12) (Track A)
  + Entropy coding (6) (section 6.13) (Track A)
  + Chroma sampling and chroma formats (2) (section 6.14) (Track A)
  + Other coding tools (13) (section 6.15) (Track B) done
  + 360 degree video (4) (section 6.16) (Track A)
  + AHG17: General high-level syntax (60) (section 6.17) (Track A)
  + AHG12: High-level parallelism and coded picture regions (41) (section 6.18) (Track A)
  + AHG8: Layered coding and resolution adaptation (24) (section 6.19) (Track A)
* Complexity analysis and reduction (0) (section 7) (Track X)
* Encoder optimization (4) (section 8) (Track B) TBP
* Metrics and evaluation criteria (1) (section 9) (Track B) TBP
* Withdrawn (6) (Track none)
* Joint meetings, plenary discussions, BoG reports, Summary of actions (section 10)
* 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 (313) was generally chaired by GJS, and Track B (338) by JRO.

# AHG reports (17)

These reports were discussed Wednesday 3 July 0900–1630 (chaired by GJS and JRO).

[JVET-O0001](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7578) JVET AHG report: Project management (AHG1) [J.-R. Ohm, G. J. Sullivan]

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.

At the 14th meeting of the ITU-T/ISO/IEC Joint Video Experts Team (JVET), an *ad hoc* group on Project Management was established with the following mandates:

* Coordinate overall JVET interim efforts.
* Supervise CE and AHG studies.
* Report on project status to JVET reflector.
* Provide a report to next meeting on project coordination status.

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

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\_03\_ N\_Geneva/](http://wftp3.itu.int/av-arch/jvet-site/2019_03_%20N_Geneva/)), particularly including the following:

* The meeting report (JVET-N1000) [Posted 2019-07-03]
* Versatile Video Coding (Draft 5) (JVET-N1001) [Posted 2019-04-09, last update 2019-07-02]
* Algorithm description for Versatile Video Coding and Test Model 5 (VTM 5) (JVET-N1002) [Posted 2019-05-21, last update 2019-06-11]
* Guidelines for VVC software development (JVET-N1003) [Posted 2019-03-28]
* Methodology and reporting template for coding tool testing (JVET-N1005) [Posted 2019-04-11]
* JVET common test conditions and software reference configurations for SDR video (JVET-N1010) [Posted 2019-05-08]
* JVET common test conditions and software reference configurations for HDR/WCG video (JVET-N1011) [Posted 2019-04-12]
* Description of CE 1..11 (JVET-N1021..35) [all first posted 2019-03-27, 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-N1023 [last updated 2019-05-30]
    - JVET-N1024 [last updated 2019-06-23]
    - JVET-N1026 [last updated 2019-06-05]
    - JVET-N1027 [last updated 2019-06-12]
    - JVET-L1029 [last updated 2019-06-10]

The seventeen *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 900 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 120 documents were submitted on aspects of high-level syntax, including tile partitioning.

A preliminary basis for the document subject allocation and meeting notes for the 14th meeting had been made publicly available on the ITU-hosted ftp site.

[JVET-O0002](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7600) JVET AHG report: Draft text and test model algorithm description editing (AHG2) [B. Bross, J. Chen, J. Boyce, S. Kim, S. Liu, Y. Ye]

This document reports the work of the JVET ad hoc group on draft text and test model algorithm description editing (AHG2) between the 14th meeting in Geneva, CH, (19–27 March 2019) and the 15th meeting in Gothenburg, SE, (3–12 July 2019).

At the 14th 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 fifth draft of Versatile Video Coding (VVC D5) and the VVC Test Model 5 (VTM5) encoding.

The normative decoding process for Versatile Video Coding is specified in the VVC draft 5 text specification document. The VVC Test Model 5 (VTM 5) Algorithm and Encoder Description document provides an algorithm description as well as an encoder-side description of the VVC Test Model 5, which serves as a tutorial for the algorithm and encoding model implemented in the VTM5.0 software.

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

JVET-N1001 VVC specification (Draft 5)

List of Integrations

Ten versions of JVET-N1001 were published by the Editing AHG between the the 14th meeting in Geneva, CH, (19–27 March 2019) and the 15th meeting in Gothenburg, SE, (3–12 July 2019).

JVET-N1001 has been established based on JVET-M1001 and now contains the following:

* Incorporated JVET-N0067: NAL unit header.
* Incorporated JVET-N0278: Layer concept without inter-layer referencing.
* Incorporated JVET-N0349: Decoding parameter set (DPS).
* Incorporated JVET-N0869: Semantics of DPS ID equal to 0.
* Incorporated JVET-N0805: APS types (with loop).
* Incorporated JVET-N0100: Signalling information about long-term reference picture POC LSB.
* Incorporated JVET-N0100: Conditional signalling of num\_ref\_idx\_active\_overwrite\_flag.
* Incorporated JVET-N0288: Inference rule for num\_bricks\_in\_slice\_minus1.
* Incorporated JVET-N0124: Inference rule for single\_brick\_per\_slice\_flag and signalling the bottom right brick index as a delta from top left brick index.
* Incorporated JVET-N0047: Ref pic list for IDR.
* Incorporated JVET-N0276: 5 new constraint flags.
* Incorporated JVET-N0276: Sub-profile indication.
* Incorporated JVET-N0865: Gradual random access (GRA).
* Incorporated JVET-N0101: CRA decoding process.
* Incorporated JVET-N0070: Ref pic wraparound cleanups.
* Incorporated JVET-N0352: Conformance window.
* Incorporated JVET-N0438: Loop filtering disabling aross virtual boundaries.
* Incorporated JVET-N0498: Uniform tile partitioning.
* Incorporated JVET-N0150: WPP with 1-CTU lag.
* Incorporated JVET-N0120: Editorial improvements to the general decoding process to clarify the difference between a CVS and a bitstream.
* Incorporated JVET-N0857: Tile and brick partitioning.
* Incorporated JVET-N0706: Decoded picture hash SEI message.
* Incorporated JVET-N0494: Dependent RAP indication SEI message.
* Incorporated JVET-N0353: Buffering period & picture timing SEI messages.
* Incorporated JVET-N0867: Temporal scalability HRD parameters.
* Incorporated JVET-N0063: VUI design.
* Incorporated JVET-N0423 & N0350: HRD starting point.
* Incorporated JVET-N0266: Remove 4x4 unipred, and 4x8/8x4 bipred regular inter modes, and remove the use of for shared merge candidates in the regular merge list.
* Incorporated JVET-N0821: 6-tap interpolation filter for affine MC.
* Incorporated JVET-N0068: Restriction of memory bandwidth consumption of affine MC.
* Incorporated JVET-N0481: BCW index inheritance for constructed affine merge candidate.
* Incorporated JVET-N0334: MV clipping for MMVD, DMVR and CPMV of constructed affine merge candidadates.
* Incorporated JVET-N0407: Disable 8x8/4xN CUs for DMVR.
* Incorporated JVET-N0178: Implicitly split BDOF application region along 16x16 boundaries.
* Incorporated JVET-N0146: Disabling BDOF for BCW and WP, and align the condidtion of DMVR and BIO.
* Incorporated JVET-N0444: Condition check of block height is not equal to 4 for BDOF.
* Incorporated JVET-N0325: 8-bit fixed precision for BDOF calculations.
* Incorporated JVET-N0127: MMVD enabling signalling in SPS
* Incorporated JVET-N0332: disable MVD scaling for MMVD for LTRP.
* Incorporated JVET-N0448/JVET-N0380: infer the number of MMVD base merge candidate to 1.
* Incorporated JVET-N0302: CIIP with position-independent weights.
* Incorporated JVET-N0324: Signal a regular merge flag right after the merge flag and skip flag.
* Incorporated JVET-N0851/N0447/N0400/N0500: align triangle merge candidate number and regular merge candidate number.
* Incorporated JVET-N0340: regular merge candidate list is re-used for triangle.
* Incorporated JVET-N0483: disable sub-block transform when triangle mode is used.
* Incorporated JVET-M0335: Round MVs toward zero.
* Incorporated JVET-N0235: Add an SPS-level flag to turn on and off symmetric MVD
* Incorporated JVET-N0213: Remove TMVP from merge and AMVP list for 4x8 and 8x4 CUs
* Incorporated JVET-N0868: Revised spec text for DMVR reconciling with software ticket [#214](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/214)
* Fixed minor bugs and typos reported in [#94](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/94), [#221](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/221), [#227](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/227), [#248](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/248).
* Fixed bug [#232](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/232): Mismatch between specification and software for triangle merge mode weighted prediction.
* Fixed minor bugs and typos reported in [#249](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/249), [#253](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/253), [#256](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/256).
* Fixed bug [#247](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/247): Fix of size constraint for triangle merge mode when MMVD is disabled in SPS (also in VTM).
* Incorporated JVET-M0471/N0473: Deblocking with long tap filters (including ISP and SBT transform boundaries).
* Incorporated JVET-M0908: Deblocking of CIIP boundaries.
* Incorporated JVET-M0277: Apply pcm\_loop\_filter\_disabled\_flag for ALF.
* Incorporated JVET-N0242: Non-linear ALF with clipping.
* Incorporated fixes for JVET-N0278: Layer concept without inter-layer referencing.
* Fixed some bugs related to reference picture list, tiles and bricks (including the bug reported in [#261](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/261)), presence of the VUI syntax in the SPS, CABAC initialization, HRD, semantics of the picture timing SEI message, etc.
* Incorporated JVET-N0415: CTU-adaptive ALF with fixed filter.
* Incorporated JVET-N0180: ALF line buffer reduction.
* Incorporated JVET-N0220: Simplification of LMCS and other fixes.
* Incorporated JVET-N0477: LMCS with no chroma residue scaling in case of CBF=0.
* Incorporated JVET-N0383/N0251: IBC search range constraint.
* Incorporated JVET-N0175/N0251/N0384: IBC search range increase for CTUs less than 128x128.
* Incorporated JVET-N0843: IBC motion vector prediction unification for merge and MVP mode.
* Incorporated JVET-N0317: Put (0,0) vector as default in IBC merge list.
* Incorporated JVET-N0318/N0427: Disable IBC for 128x128 blocks.
* Fixed bug [#262](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/262): Missing text for IBC with shared merge list.
* Incorporated JVET-N0185: Unified MPM list for intra mode coding.
* Incorporated JVET-N0137: Disable 2x2/4x2/2x4 in dual tree only.
* Incorporated JVET-N0308: Restrict the maximum CU size for ISP to be 64x64.
* Incorporated JVET-N0435: Harmonization between WAIP and intra smoothing filters.
* Incorporated JVET-N0271: CCLM derived from four neighbouring samples.
* Fixed bug [#223](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/223): Fixed ISP interpolation filter conditions.
* Fixed bug [#165](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/165): Removed top-left sample availability derivation process in for CCLM.
* Added SPS flag for ISP.
* Added SPS flag for MRL.
* Incorporated JVET-N0217: Matrix-based intra prediction (MIP).
* Fixed bug [#276](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/276): Added regular\_merge\_flag to context derivation table.
* Fixed bug [#277](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/277): Replaced all occurances of slice-level slice\_loop\_filter\_across\_slices\_enabled\_flag with PPS loop\_filter\_across\_slices\_enabled\_flag.
* Incorporated JVET-N0470: Consider SMVD flag for BDOF condition.
* Added SPS flag for MIP.
* Fixed bugs [#279](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/279), [#280](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/280), [#282](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/282), [#283](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/283), [#284](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/284).
* Incorporated JVET-N0054: Joint coding of chrominance residuals.
* Incorporated JVET-N0188: Unified rice parameter derivation for coefficient level coding.
* Incorporated JVET-N0492: Chroma TU CBF dependent luma TU CBF signalling.
* Incorporated JVET-N0103: Determine coefficient group size based on TB size instead of colour component.
* Incorporated JVET-N0600: Context reduction for amvr\_flag syntax.
* Incorporated JVET-N0286: Context reduction for bcw\_idx syntax.
* Incorporated JVET-N0194: Context selection of last x/y syntax based on non-reduced TU size in case of zero-out.
* Incorporated JVET-N0280: Transform skip residual coding.
* Incorporated JVET-N0413: Block-based quantized residual domain DPCM (BDPCM).
* Fixed bug [#292](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/292): Minor transform skip residual coding issues.
* Fixed bug [#270](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/270): (Bug fix) Changed nuh\_layer\_id to nuh\_layer\_id\_plus1.
* Fixed bug [#298](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/298): typo in IBC BV candidate list derivation.
* Fixed bug [#275](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/275): Wrong bdofUtilizationFlag indexing.
* Fixed bug [#274](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/274): Undefined variables sGxGym and sGxGys.
* Fixed bug [#273](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/273): Wrong HMVP table size.
* Fixed bug [#299](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/299): Minor intra prediction issues.
* Fixed bug [#302](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/302): Fix CBF flags syntax and semantics for implicit TU split.
* Fixed bugs [#307](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/307), [#308](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/308), [#316](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/316): Deblocking issues.
* Fixed the bug that DeltaPocMsbCycleLt was used without being defined.
* Incorporated JVET-N0193: Low frequency non-separable transform (LFNST).
* Incorporated JVET-N0105: Remove mode dependency in LFNST ctx derivation.
* Incorporated JVET-N0866: Unification of implicit transform selection for ISP and SBT.
* Incorporated JVET-N0246: Include square root of 2 factor in levelScale values.
* Incorporated JVET-N0671: Support of 4:4:4 and 4:2:2 chroma formats.
* Incorporated JVET-N0225: Separate color plane id.
* Incorporated JVET-N0847: Default and user-defined scaling matrices
* Incorporated DMVR fixes and editorial improvements.
* Fixed bug [#245](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/245): wrong handling of boundary partitioning for a corner case.
* Fixed bug [#341](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/341): coefficients outside the first coefficient group are considered in 8x8 LFNST.

Integration issues to be discussed

The following items have been discussed during integration of the meeting adoptions and need further discussion/clarification:

* **ALF virtual boundaries in combination with slice/brick/tile boundaries**: The ALF virtual boundary was adopted at the last meeting to remove the ALF line buffer, it is located at 4 luma lines above the bottom CTU boundary (except for those CTUs at the last CTU row of a picture). In the current specification text, the ALF virtual boundary is not present for a CTU if its bottom CTU boundary is also a slice/brick/tile boundary (when the loop-filter across those boundaries is disabled) or a 360 video virtual boundary It is asserted that the current text specification defeats the purpose of the ALF virtual boundary adoption and has the following consequences:
* For decoders, not knowing the slice/brick/tile boundaries upfront (i.e. low-delay applications) means that the ALF line buffer needs to be restored. To process the ALF filtering of the bottom lines of the current CTU (e.g. luma lines 5, 6 and 7 above the bottom CTU boundary), the decoders need to know whether the current bottom CTU boundary coincides with other types of boundaries. This information, however, is unknown until the next slice/brick/tile is decoded.
* Even if the slice/brick/tile boundaries are known upfront (e.g. the CABAC decoding is fully decoupled at frame level), the decoders need to run the loop-filters (de-blocking, SAO and ALF) at a speed of 68 lines per 64x64 VDPU all the time (an overprovision of roughly 6%) in order to avoid using the ALF line buffer.
* **Maximum chroma transform size for 4:4:4 and 4:2:2 chroma formats**: the adoption of N0671 brought the 64x64 transform for chroma for 4:4:4 case. However, having 64x64 chroma transform for the 4:2:2 case was not specifically discussed at the JVET-N Geneva meeting and should be clarified.

The current draft incorporates 64x64 scaling matrices for 4:4:4 chroma.

* **Intra reference sample and interpolation filtering for wide angular and integer slope mode** (JVET-N0435): There have been different understandings of what has been adopted with JVET-N0435 where the available draft text is different from the Intra BoG understanding. It can be summarized as follows:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Int-slope modes**  **2, 34, 66** | **Wide-angle modes**  **(int-slope modes)** | **Wide-angle modes**  **(non-int-slope)** |
| **VTM4** | If (w\*h > 32) then (1 2 1) filter;  else no filter | Gauss Interpolation Filter (0 phase) | Gaussian interpolation filter |
| **JVET-N0435** | Idem VTM4 | If (w\*h > 32) then (1 2 1) filter;  else no filter | Idem VTM4 |
| **JVET-N0435**  **(BoG understanding)** | Idem VTM4 | (1 2 1)-filter | Idem VTM4 |

After some discussion, it was decided to integrate the variant provided in JVET-N0435-v3 in specification text and VTM software.

Open specification tickets

At the time of writing this report, the following in the [JVET VVC bug tracking system](https://jvet.hhi.fraunhofer.de/trac/vvc/query?status=accepted&status=assigned&status=new&status=reopened&component=spec&groupdesc=1&group=version&col=id&col=summary&col=status&col=type&col=priority&col=milestone&col=time&col=reporter&report=13&order=priority):

|  |  |
| --- | --- |
| [#225](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/225) | [Alignment between spec and implementation in Affine Merge](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/225) |
| [#271](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/271) | [Motion vector rounding: tiny contradiction between N0335 integration and the meeting decision](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/271) |
| [#290](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/290) | [Mismatch on collocated subblock location in SbTMVP between VTM and spec](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/290) |
| [#306](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/306) | [Redundant clipping in 8.5.5.6](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/306) |
| [#309](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/309) | [APS with same ID referenced from different slices](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/309) |
| [#310](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/310) | [Type of syntax element slice\_num\_alf\_aps\_ids\_luma](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/310) |
| [#315](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/315) | [Inter issues related to global variables](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/315) |
| [#317](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/317) | [Mismatch with vtm on mvp\_l1\_flag parsing](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/317) |
| [#318](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/318) | [Missing initialization of MvdCpL0 array](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/318) |
| [#319](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/319) | [IBC BV range description](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/319) |
| [#321](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/321) | [mvd\_l1\_zero\_flag semantic](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/321) |
| [#322](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/322) | [Parsing condition for ISP split flag](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/322) |
| [#323](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/323) | [Mismatch in Affine MVP candidate list construction between VTM and spec](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/323) |
| [#324](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/324) | [Mismatch in equation 8-784 with SW](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/324) |
| [#325](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/325) | [Redundant syntax parsing related to IBC restriction for 128x128 blocks](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/325) |
| [#331](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/331) | [cu\_cbf is set to 0 when BDPCM is 1](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/331) |
| [#333](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/333) | [Transform / Quantization Bypass Missing](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/333) |
| [#335](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/335) | [Chroma qp offset syntax element missing](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/335) |
| [#336](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/336) | [Explicit RDPCM syntax element missing](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/336) |
| [#340](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/340) | [Bug in the ISP text](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/340) |
| [#344](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/344) | [spatial merge candidate derivation process with wrong prunings](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/344) |
| [#320](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/320) | [Typos](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/320) |

Model 5 (VTM 5) Algorithm and Encoder Description.

Two versions of JVET-N1002 was published by the Editing AHG between the 14th meeting in Geneva, CH, (19–27 March 2019) and the 15th meeting in Gothenburg, SE, (3–12 July 2019).

JVET-N1002 has been established based on JVET-M1002. It provides the algorithm description for majority of coding tools in VVC. In this editing period, the following changes were included:

* Incorporated JVET-N0866: Unification of implicit transform selection
* Incorporated JVET-N0193: LFNST (Low-Frequency Non-Separable Transform)
* Incorporated JVET-N0105: Simplification of LFNST index coding
* Incorporated JVET-N0217: Matrix weighted intra prediction
* Incorporated JVET-N0246: Modified dequantization scaling
* Incorporated JVET-N0847: Support of quantization matrices
* Incorporated JVET-N0188: Unified rice parameter derivation for coefficient level coding
* Incorporated JVET-N0194: Context selection of last non-zero coefficient position in reduced TU
* Incorporated JVET-N0103: Coefficient group size harmonization
* Incorporated JVET-N0185: Unified MPM list for intra mode coding
* Incorporated JVET-N0137: Intra chroma partitioning and prediction restriction
* Incorporated JVET-N0435: Harmonization between WAIP and intra smoothing filters
* Incorporated JVET-N0308: Restriction of the maximum CU size for ISP to 64×64
* Incorporated JVET-N0271: CCLM derived with four neighbouring samples
* Incorporated JVET-N0415: CTU adaptive ALF, and fixed filter set.
* Incorporated JVET-N0242: Non-Linear Adaptive Loop Filtering (NL-ALF)
* Incorporated JVET-N0180: ALF line buffer reduction
* Incorporated JVET-N0473: Deblocking of ISP/SBT TU boundaries
* Incorporated JVET-N0266: Remove 4x4 unipred, and 4x8/8x4 bipred regular inter modes
* Incorporated JVET-N0340: Simplified Merge list construction for TPM
* Incorporated JVET-N0413: quantized residual DPCM
* Incorporated JVET-N0054: joint coding of chroma residuals
* Incorporated JVET-N0251 item 4 on IBC search range.
* Incorporated JVET-M0253 and JVET-N0247 on hash-based motion estimation.
* Incorporated JVET-N0280: residual coding for transform skip mode
* Incorporated JVET-N0325: using 8-bit fixed precision in BDOF
* Incorporated JVET-N0146: disable BDOF if BCW or WP is used
* Incorporated JVET-N0302: CIIP with position-independent weights
* Incorporated JVET-N0483: disallow the combination of sub-block transform with triangle mode
* Incorporated JVET-N0286: simplified BCW index coding
* Incorporated JVET-M0140: Sub-block transform for inter blocks
* Incorporated JVET-N0481: BCW index inheritance for constructed affine merge candidate
* Incorporated JVET-N0407: Disable 8x8/4xN CUs for DMVR
* Incorporated [JVET-N0868](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6623): DMVR reconciling with software ticket #214, 25 points SAD full search
* Incorporated JVET-N0178: Implicitly split BDOF application region along 16x16 boundaries
* Incorporated JVET-N0146: Align DMVR with BDOF on the conditions
* Incorporated JVET-N0447/N0400/N0500/N0851, signalling of triangle merge candidate number
* Incorporated JVET-M0444: Symmetric MVD coding

The AHG recommended to:

* Approve the edited JVET-N1001 and JVET-N1002 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.
* Integrate fixes for open specification tickets in one document and have these fixes confirmed at this meeting.

[JVET-O0003](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=7606) JVET AHG report: Test model software development (AHG3) [F. Bossen, X. Li, A. Norkin, K. Sühring]

This report summarizes the activities of the AhG3 on Test model software development that has taken place between the 14th and 15th 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/>

VTM 4.2 was tagged on Apr. 1, 2019.

Changes related to VTM 4.1 include:

* Removed JVET-Mxxx macros

After one release candidates, VTM 5.0 was tagged on May 7, 2019.

Changes related to VTM 4.2 include:

* JVET-N0477: N0220 LMCS simplifications
* JVET-N0477: LMCS cleanup
* add encoder config constraint for WrapAroundOffset to be a multiple of the minimum CU size
* JVET-N0332: MMVD Fix for LTRPs
* JVET-N0335: MV Rounding Unification
* JVET-N0137: Intra chroma partitioning restriction
* JVET-N0449: Simplification on MMVD distance table
* JVET-N0242: non-linear ALF (clipping)
* JVET-N0483: disable SBT in TPM
* JVET-N0481: BCW index inheritance for constructed affine merge candidate
* JVET-N0334: MV Overflow Prevention
* JVET-N0325: BDOF improvement
* JVET-N0271: simplified CCLM
* JVET-N0178 CE9-2.4 implicit BDOF split
* JVET-N0185: A Unified MPM List for Intra Mode Coding
* JVET-N600: AMVR flag and Triangle flag context reduction
* JVET-N0286: simplified gbi index coding
* JVET-N0188: Unified rice parameter derivation for coefficient level coding
* JVET-N0462: Fix context modeling of inter\_pred\_idc
* JVET-N0329: IBC Search Improvement
* JVET-N0318/N0467: IBC size
* JVET\_N0317\_ADD\_ZERO\_BV
* JVET-N0383/N0251: bug fix for ibc referring to collocated VPDU in left CTU
* JVET-N0175/N0251/N0384: Re-arrange IBC search range for small CTU sizes
* JVET-N0448/N0380: MMVD fix when MaxNumMergeCand is 1
* JVET-N0235: Added smvd flag in SPS
* JVET-N0266: remove 4x4 uni-pred, 4x8/8x4 bi-pred from regular inter modes.
* JVET-N0407: Disable 4xN/8x8 CUs for DMVR.
* JVET-N0235 bugfix
* JVET-N0470, SMVD RefIdxSymLX derivation, aligned software to spec text.
* JVET-N0146/N0162/N0442/N0153/N0262/N0440/N0086: applicable condition of DMVR and BDOF
* JVET-N0843: Block vector prediction simplification
* JVET-N0103: Coefficient group size harmonization
* JVET-N0280: residual coding for transform skip
* Enable repetition of parameter sets in CTC configs
* JVET-N0196: Use six tap filter for affine motion compensation
* JVET-N0671: Support of 4:4:4 and 4:2:2 chroma formats in VVC
* Refactor: align sps\_fpel\_mmvd\_enabled\_flag with spec text
* Added a config file parameter for ISP
* JVET-N0308: Maximum CU Size for ISP
* JVET-N0068: Affine memory bandwidth reduction
* JVET-N0246 method 6: modified quantization scales.
* JVET-N0127 : MMVD enabling flag in SPS
* JVET-N1011: Updated HDR configuration files to match CTC
* Intra-prediction clean-up requested by Ben and discussed at the meeting in Geneva
* JVET-N0213: TMVP removal at specific sizes
* JVET-N0054: Joint chroma residual mode
* JVET-N0168: AMVR cost calculation modification in motion estimation stage
* JVET-N0363: Modified cost criterion for intra encoder mode decision
* JVET-N0492: disallowing hierarchical CBFs signalling
* Adjust IBC local search range according to JVET-N0251 item4.
* JVET-N0324: on Regular Merge Flag
* JVET-N0473, JVET-N0098: Deblocking of ISP/SBT TU boundaries
* JVET-N0435: WAIP Harmonization
* JVET-N0180: line buffer reduction using symmetric padding
* JVET-N0340: regular merge candidate list is re-used for triangle
* JVET-N0866: unified transform derivation for ISP and implicit MTS - refactored
* JVET-N0302: Simplified CIIP
* JVET-N0247: Improvement of Hash Motion Estimation
* JVET-N0413/N0214: RDPCM
* JVET-N0400: Signal max number of triangle merge candidates
* JVET-N0217: matrix-based intra prediction (MIP)
* JVET-N0217: added missing 'isSameCtu' condition
* JVET-N0193: Low Frequency Non-Separable Transform (LFNST)
* JVET-N0105: LFNST context modelling
* JVET-N0415: CTB-based ALF switch
* Retrained CABAC initialization values
* Various bug fixes

VTM 5.1 is expected to be tagged during the 15th JVET meeting. Changes include:

* JVET-N0047: Ref pic list for IDR
* JVET-M0128: Reference picture management for VVC
* JVET-N0278: HLS for immersive media delivery and access requirement
* JVET-N0070: Reference frame wraparound modifications
* JVET-N0805: APS for LMCS (using different APS types)
* JVET-M0853/N0857: Rectangular Slice
* JVET-N0276: add the subprofile syntax
* JVET-N0276: added 5 new adopted constraint flags
* JVET-N0276: Constraint flags
* JVET-N0847: Support scaling matrices
* JVET-N0063: VUI
* JVET-N0150: One CTU delay WPP
* JVET-N0857: slices/tiles/bricks
* JVET-N0741: Enable Rate Control with In-Loop Reshaping
* JVET-N0438: Loop filter disabled across virtual boundaries
* JVET-N0349: decoding parameter set (DPS)
* JVET-N0067: NAL unit header
* Various bug fixes and cleanups

At the beginning of the 15th meeting, some high-level syntax implementations were still pending:

* JVET-N0494 (dependent RAP indication SEI message): SEI decoding code from HEVC seems valid. Encoder code is going to be provided by the October meeting
* JVET-N0353 (buffering period & picture timing SEI messages): In progress; to be submitted soon.
* JVET-N0867 (temporal scalability HRD parameters): depends on JVET-N0353
* JVET-N0100 (signalling information about long-term reference picture POC LSB, Conditional signalling of num\_ref\_idx\_active\_overwrite\_flag): to be commited soon
* JVET-N0288 (inference rule for num\_tiles\_in\_tile\_group\_minus1): to be committed soon
* JVET-N0865 (gradual random access): No software had been provided to support the adopted HLS. (Efforts to get software had started rather late, and some software had been available within CE11 work.)

CTC Performance

The following table shows **VTM 5.0** performance over **HM 16.20**:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra** |  |  |
|  |  |  | **Over HM-16.20** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -26.64% | -39.80% | -37.26% | 2203% | 187% |
| Class A2 | -24.98% | -25.83% | -19.52% | 3501% | 192% |
| Class B | -20.45% | -24.88% | -32.98% | 3670% | 191% |
| Class C | -21.35% | -22.17% | -27.25% | 4915% | 199% |
| Class E | -24.70% | -24.59% | -29.92% | 2795% | 184% |
| **Overall** | -23.14% | -26.88% | -29.67% | 3410% | 191% |
| Class D | -17.46% | -18.93% | -21.66% | 5662% | 190% |
| Class F | -38.15% | -39.65% | -42.08% | 4768% | 186% |
|  |  |  |  |  |  |
|  |  |  | **Random Access** |  |  |
|  |  |  | **Over HM-16.20** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -34.92% | -39.81% | -43.03% | 910% | 185% |
| Class A2 | -39.04% | -37.01% | -30.74% | 991% | 193% |
| Class B | -32.76% | -37.86% | -40.19% | 984% | 178% |
| Class C | -27.86% | -27.10% | -31.11% | 1259% | 192% |
| Class E |  |  |  |  |  |
| **Overall** | -33.14% | -35.21% | -36.45% | 1036% | 186% |
| Class D | -26.07% | -24.83% | -28.17% | 1436% | 192% |
| Class F | -39.81% | -40.67% | -42.91% | 705% | 150% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay B** |  |  |
|  |  |  | **Over HM-16.20** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -25.94% | -21.75% | -23.44% | 817% | 167% |
| Class C | -22.47% | -18.99% | -21.99% | 965% | 165% |
| Class E | -25.58% | -23.94% | -28.23% | 445% | 123% |
| **Overall** | -24.69% | -21.38% | -24.15% | 742% | 154% |
| Class D | -21.22% | -13.76% | -17.49% | 1040% | 170% |
| Class F | -36.30% | -36.19% | -38.05% | 539% | 126% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay P** |  |  |
|  |  |  | **Over HM-16.20** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -30.41% | -24.95% | -26.60% | 766% | 172% |
| Class C | -24.57% | -19.79% | -22.83% | 897% | 170% |
| Class E | -29.16% | -28.61% | -32.22% | 404% | 125% |
| **Overall** | -28.15% | -24.15% | -26.75% | 688% | 158% |
| Class D | -22.98% | -15.00% | -17.53% | 1000% | 170% |
| Class F | -36.11% | -36.22% | -37.88% | 559% | 131% |

The following table shows **VTM 5.0** performance compared to **VTM 4.2**:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra** |  |  |
|  |  |  | **Over VTM-4.2** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -3.76% | -1.01% | -0.95% | 165% | 110% |
| Class A2 | -2.56% | -1.33% | 0.80% | 169% | 108% |
| Class B | -1.71% | -0.79% | -3.25% | 163% | 105% |
| Class C | -2.40% | -1.49% | -4.15% | 164% | 105% |
| Class E | -2.53% | -0.90% | -4.02% | 158% | 105% |
| **Overall** | -2.48% | -1.09% | -2.52% | 164% | 106% |
| Class D | -1.49% | -0.89% | -2.57% | 171% | 106% |
| Class F | -7.41% | -5.45% | -7.08% | 153% | 102% |
|  |  |  |  |  |  |
|  |  |  | **Random Access** |  |  |
|  |  |  | **Over VTM-4.2** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -3.26% | -1.41% | -1.53% | 128% | 103% |
| Class A2 | -2.50% | -3.39% | -1.17% | 125% | 112% |
| Class B | -2.14% | -1.58% | -3.57% | 128% | 108% |
| Class C | -1.93% | 0.24% | -3.06% | 135% | 110% |
| Class E |  |  |  |  |  |
| **Overall** | -2.38% | -1.42% | -2.55% | 129% | 108% |
| Class D | -0.93% | 0.20% | -3.04% | 147% | 108% |
| Class F | -6.10% | -4.34% | -6.66% | 144% | 109% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay B** |  |  |
|  |  |  | **Over VTM-4.2** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -1.33% | -3.53% | -6.81% | 110% | 109% |
| Class C | -0.81% | -3.78% | -5.94% | 114% | 107% |
| Class E | -1.49% | -2.58% | -5.37% | 118% | 103% |
| **Overall** | -1.20% | -3.38% | -6.16% | 114% | 107% |
| Class D | 0.46% | -3.08% | -7.76% | 124% | 108% |
| Class F | -5.88% | -5.60% | -7.01% | 129% | 109% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay P** |  |  |
|  |  |  | **Over VTM-4.2** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -1.68% | -3.97% | -7.16% | 116% | 110% |
| Class C | -0.78% | -3.54% | -5.97% | 120% | 106% |
| Class E | -2.29% | -4.67% | -6.24% | 126% | 102% |
| **Overall** | -1.53% | -4.00% | -6.53% | 120% | 107% |
| Class D | 0.36% | -3.08% | -7.28% | 137% | 109% |
| Class F | -6.30% | -6.72% | -8.18% | 139% | 107% |

The following table shows expected **VTM 5.1** performance compared to **VTM 5.0**:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra** |  |  |
|  |  |  | **Over VTM-5.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.02% | -0.03% | 0.00% | 102% | 100% |
| Class A2 | 0.01% | 0.00% | 0.01% | 102% | 101% |
| Class B | 0.04% | 0.01% | 0.05% | 102% | 103% |
| Class C | 0.10% | 0.13% | 0.14% | 101% | 103% |
| Class E | 0.12% | 0.15% | 0.07% | 102% | 105% |
| **Overall** | 0.06% | 0.05% | 0.06% | 102% | 102% |
| Class D | 0.33% | 0.33% | 0.26% | 101% | 110% |
| Class F | 0.06% | 0.19% | 0.17% | 103% | 104% |
|  |  |  |  |  |  |
|  |  |  | **Random Access** |  |  |
|  |  |  | **Over VTM-5.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.00% | 0.02% | 0.00% | 102% | 101% |
| Class A2 | 0.05% | 0.19% | 0.00% | 101% | 99% |
| Class B | 0.03% | 0.05% | -0.27% | 102% | 103% |
| Class C | 0.03% | -0.08% | 0.02% | 101% | 106% |
| Class E |  |  |  |  |  |
| **Overall** | 0.03% | 0.04% | -0.09% | 101% | 103% |
| Class D | 0.30% | 0.30% | 0.29% | 101% | 116% |
| Class F | 0.16% | 0.07% | 0.08% | 103% | 107% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay B** |  |  |
|  |  |  | **Over VTM-5.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | TBD | TBD | TBD | TBD | TBD |
| Class C | 0.05% | 0.12% | 0.07% | 102% | 109% |
| Class E | 0.15% | -0.01% | 0.07% | 101% | 107% |
| **Overall** | TBD | TBD | TBD | TBD | TBD |
| Class D | 0.04% | -0.13% | 0.69% | 100% | 116% |
| Class F | -0.04% | -0.16% | -0.62% | 102% | 106% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay P** |  |  |
|  |  |  | **Over VTM-5.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | TBD | TBD | TBD | TBD | TBD |
| Class C | 0.02% | -0.03% | 0.19% | 100% | 107% |
| Class E | 0.19% | 0.17% | 0.39% | 100% | 108% |
| **Overall** | TBD | TBD | TBD | TBD | TBD |
| Class D | 0.07% | 0.62% | -0.25% | 101% | 117% |
| Class F | -0.06% | 0.53% | 0.29% | 103% | 107% |

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

No tests were performed for multi-resolution streaming test conditions with VTM 5.0.

* + After the MTS code was refactored in VTM-4.0, the integration of LFNST re-introduced some of the previously removed code. This was pointed out to the proponents in MR490. Proponents said they would continue to work further on harmonizing the code. No further improvements have been submitted so far. In ticket #287 it was pointed out that setting MTSIntraMaxCand to different values with LFNST enabled is broken. No solution was provided for this problem.
  + After integration of JVET-N0847 (scaling list), several issues were reported in ticket #311, and then two fix merge requests were submitted. There is more than one normative way to fix for one issue. It is suggested to bring proposals for normative fixes unless a fix is straightforward and agreed on the JVET main reflector.
  + The code for JVET-M0128 (reference picture list handling from the previous meeting) was submitted late in the process, while new adoptions already depended on this.
  + A start code emulation was triggered because the second byte of the NAL unit header was allowed to be zero. A straightforward fix (increment nuh\_layer\_id by 1) was discussed and implemented in the draft and software.
  + It was noticed that HRD parameters were missing due to an open discussion point in the BoG notes. The meeting notes indicated that the HRD parameters should be included and that they should be outside of VUI. A straightforward fix (to put them before the VUI) was discussed and implemented in draft and software (JVET-O0153 contains this fix).
  + Uniform tile signalling (JVET-O0153) was not implemented since they introduce a parsing dependency between SPS and PPS. Contributions to the 15th meeting propose ways to fix the problem or to allow parsing dependencies (JVET-O0236, JVET-O0490, JVET-O0113).
  + There was some confusion about the details of the JVET-N0435 adoption, which led to vigorous discussion on gitlab and the main JVET reflector. After further consultation with the JVET chairs, the code provided by the authors of JVET-N0435 was kept, as it was consistent with the draft text provided with JVET-N0435.

Software manual

Very 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 bit-streams/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

[JVET-O0004](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7544) JVET AHG report: Test material and visual assessment (AHG4) [T. Suzuki, M. Wien, V. Baroncini, R. Chernyak, P. Hanhart, A. Norkin, J. Ye]

The test sequences used for the 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).

No test sequence selections for the CTC were changed at the last meeting.

On determining a new structure at test sequence repository, there was not much progress since the last meeting. There was discussion in the last meeting that the current directory structure of test sequence ftp site is not good for the current activities. The ftp directory was created during the preparation of CfE/CfP and the same directory structure is still used. One possibility is to re-design the directory as follows, for example,

* ctc/ : Contains the active test set of the common testing conditions
* ahg/ : Contains subdirectories with sequences under consideration. The subfolder might be structured by meeting period (e.g. named by the doc-number of the corresponding meeting report?)
* ce/ : Contains subdirectories for data exchange for specific CE (already implemented, see ce/JVET-{K,L}1031\_Deblocking
* upload : stays as before

During the Marrakech meeting, there was a comment that all sequences, all classes should be at the same place. But there is still meaningful to separate SDR, HDR, and 360. Further detail should be discussed in the meeting.

In the discussion, it was suggested to not remove the cfe and cfp directories, but to add the additional ones above (even if there might be some duplication of content or use of symbolic links). This approach was agreed.

The following related contribution was noted.

* JVET-O0451 “AHG4: Subjective comparison of VVC and HEVC”, P. Philippe, J. Fournier (Orange), W. Hamidouche (INSA), JY Aubie (b-com)

The AHG recommended to review related contributions and to continue to collect new test sequences available for JVET with licensing statement.

[JVET-O0005](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7546) JVET AHG report: Memory bandwidth consumption of coding tools (AHG5) [R. Hashimoto, T. Ikai, X. Li, D. Luo, H. Yang, M. Zhou]

The document summarizes activities of AHG on memory bandwidth consumption of coding tools between the 14th and the 15th JVET meetings.

There was no related email discussion during this meeting cycle, and no related contributions were noted at this meeting.

A patch on memory bandwidth measurement tools on VTM-5.0 had been provided by the AHG

<https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/230>

There is a discussion about this patch on git system. This identified a bug, and a merge request had been incorporated into the VTM software to fix it.

The AHG recommended to continue investigation of memory bandwidth via AHG13 activities.

[JVET-O0006](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7543) JVET AHG report: 360° video coding tools, software and test conditions (AHG6) [Y. He, K. Choi, J. Boyce, P. Hanhart, J.-L. Lin]

The document summarizes activities on 360-degree video content conversion software development between the 14th (19 – 27 Mar. 2019) and the 15th (3 – 12 July 2019) JVET meetings.

The 360Lib-9.1 software package included the following changes:

* Projection format conversion for hemisphere cubemap and hemisphere equi-angular cubemap (JVET-M0452).
* Added hemisphere cubemap (HCMP) and hemisphere equi-angular cubemap (HEAC) conversion configuration files.

360Lib-9.1 with the support of VTM-5.0 was released on May 14, 2019.

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

<https://jvet.hhi.fraunhofer.de/svn/svn_360Lib/>

The released version of 360Lib-9.1 can be found at:

<https://jvet.hhi.fraunhofer.de/svn/svn_360Lib/tags/360Lib-9.1/>

360Lib-9.1 testing results can be found at:

[ftp.ient.rwth-aachen.de/testresults/360Lib-9.1](ftp://ftp.ient.rwth-aachen.de/testresults/360Lib-9.1)

360Lib bug tracker

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

The first table below is for the projection formats comparison using VTM-5.0 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-5.0.

The second table below is for PERP coding comparison between VTM-5.0 and HM-16.16.

The third table below is to compare VTM-5.0 with PHEC coding and HM-16.16 with CMP coding.

**VTM-5.0 PHEC vs PERP (VTM-5.0 PERP as anchor)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **PHEC over PERP (VTM-5.0)** | | | | | |
|  | **End-to-end WS-PSNR** | | | **End-to-end S-PSNR-NN** | | |
|  | Y | U | V | Y | U | V |
| Class S1 | -11.25% | -9.22% | -9.34% | -11.17% | -9.13% | -9.29% |
| Class S2 | -5.31% | -6.56% | -6.42% | -5.29% | -6.43% | -6.31% |
| **Overall** | -8.87% | -8.15% | -8.17% | -8.82% | -8.05% | -8.09% |

**VTM-5.0 PERP vs HM-16.16 PERP (HM-16.16 PERP as anchor)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **VTM-5.0 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 | -24.37% | -38.11% | -41.60% | -24.36% | -38.12% | -41.54% |
| Class S2 | -33.30% | -34.64% | -37.28% | -33.30% | -34.69% | -37.32% |
| **Overall** | -27.94% | -36.73% | -39.87% | -27.93% | -36.75% | -39.85% |

**VTM-5.0 PHEC vs HM-16.16 CMP (HM-16.16 CMP as anchor)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **VTM-5.0 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 | -28.60% | -39.70% | -42.56% | -28.48% | -39.67% | -42.51% |
| Class S2 | -36.09% | -38.55% | -40.70% | -36.08% | -38.55% | -40.70% |
| **Overall** | -31.60% | -39.24% | -41.81% | -31.52% | -39.22% | -41.79% |

There were 3 input documents related to syntax for signalling of cubeface layouts that were noted.

* JVET-O0487 Geometry padding for cube based 360 degree video using uncoded areas [J. Sauer, M. Bläser (RWTH Aachen University)]
* JVET-O0488 Parameterizable cubemap for 360 degree video coding [J. Sauer, M. Bläser (RWTH Aachen University)]
* JVET-O0891 AHG6/AHG17: Cubemap-based projection syntax for 360-degree videos [Y.-H. Lee, J.-L. Lin, Y.-J. Chen, C.-C. Ju (MediaTek)]

The AHG recommended:

* To continue software development of the 360Lib software package.
* To generate CTC VTM anchors according to 360° video CTC, and provide the reporting template for the common test conditions.
* Review input contributions

[JVET-O0007](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7596) JVET AHG report: Coding of HDR/WCG material (AHG7) [A. Segall, E. François, W. Husak, D. Rusanovskyy]

This document summarizes the activity of AHG7: Coding of HDR/WCG material (AHG7) between the 14th meeting in Geneva, CH (19–27 March 2019) and the 15th meeting in Gothenburg, SE (3–12 July 2019).

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 comparing the performance of the VTM for HDR/WCG content.

The AhG performed experiments comparing the performance of VTM 5.0 and VTM 4.0 codecs on HDR content. A summary of the performance is provided below.

VTM 5.0 versus VTM 4.0

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | | | | |
|  | **Over VTM-4.0** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | 5.58% | -2.48% | -2.94% | -2.51% | 5.74% | -2.73% | -1.34% | 8.25% | 165% | 109% |
| Class H2 |  |  |  |  |  | -1.31% | -3.96% | -8.62% | 143% | 105% |
| **Overall** | 5.58% | -2.48% | -2.94% | -2.51% | 5.74% | -2.21% | -2.29% | 2.11% | 157% | 108% |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access** | | | | | | | | | |
|  | **Over VTM-4.0** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | 6.47% | -1.44% | -2.15% | -2.02% | 8.75% | -2.04% | -1.65% | 10.99% | 128% | 109% |
| Class H2 |  |  |  |  |  | -2.76% | -3.86% | -9.07% | 112% | 105% |
| **Overall** | 6.47% | -1.44% | -2.15% | -2.02% | 8.75% | -2.30% | -2.46% | 3.70% | 122% | 108% |

VTM 5.0 versus HM 16.18

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | | | | |
|  | **Over VTM-4.0** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | -40.05% | -24.57% | -24.40% | -53.41% | -56.13% | -22.80% | -49.33% | -48.68% | 2386% | 109% |
| Class H2 |  |  |  |  |  | -20.82% | -38.50% | -40.17% | 2198% | 172% |
| **Overall** | -40.05% | -24.57% | -24.40% | -53.41% | -56.13% | -22.08% | -45.39% | -45.59% | 2316% | 129% |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access** | | | | | | | | | |
|  | **Over VTM-4.0** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | -38.75% | -29.15% | -28.91% | -52.95% | -51.45% | -26.84% | -48.47% | -43.51% | 378% | 98% |
| Class H2 |  |  |  |  |  | -26.98% | -44.76% | -48.72% | 563% | 160% |
| **Overall** | -38.75% | -29.15% | -28.91% | -52.95% | -51.45% | -26.89% | -47.12% | -45.41% | 437% | 117% |

There were four contributions related to HDR video coding (and some related cross-checks):

* JVET-O0432 AHG10: LMCS encoder improvement [F. Pu, S. McCarthy, T. Lu, P. Yin, W. Husak, T. Chen (Dolby)]
* JVET-O0661 AHG2/AHG17: Draft text to update BT.2100 references and ICTCP HLG coding equations [S. McCarthy, F. Pu, T. Lu, P. Yin, W. Husak, T. Chen]
* JVET-O0657 AHG7: Tool-on/off experiments for HLG CTC sequences [S. Iwamura, S. Nemoto, A. Ichigaya (NHK)]
* JVET-O0756 HDRTools: VTM software integration [D. Mehlem, A. M. Tourapis, D. Singer]

[Ed. Get sentence about relevant SDR contributions from revised report.]

It was observed that there was a rather large chroma loss between VTM 4.0 and VTM 5.0. This was investigated during the AhG period, and it was identified that the integration of JVET-M0091 resulted in the loss (commit: 65c9bacdf38). It was commented that this relates to QP handling and could be addressed by non-normative approaches.

It was encouraged that QP related adoptions, including those felt to be non-normative, be tested with the HDR CTC.

Computing the metrics for the common test conditions requires the use of the external HDRMetrics package, which in terms requires the management of additional configuration files to control the conversion of decoded YUV sequences to floating point representations in linear light. In one case, a separate configuration file is used for the ShowGirl sequence.

It was noted that JVET-O0756 provides software that incorporates the HDRMetrics packages into the VTM software. This is expected to streamline the calculation of the CTC metrics, and it could have a further benefit of reducing the number of configuration files that need to be managed.

The AHG recommended to review the related input contributions.

[JVET-O0008](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=7610) 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]

AHG08 was established by the 14th meeting (Geneva) to study layered coding and resolution adaptivity. A number of messages were exchanged on the reflector.

There was only limited activity of the AHG between the Marrakech and the Geneva meeting. A total of five emails included the [AHG8] marker.

24 documents related to the subject matter of this ad hoc group were identified. These were listed in the AHG report in the following categories:

* Documents related to reference picture resampling (RPR) (11)
* Scalability (13)

The AHG recommended that those contributions be studied during the meeting.

[JVET-O0009](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7565) JVET AHG report: Neural Networks in Video Coding (AHG9) [S. Liu, K. Kawamura, Y. Li, L. Wang, P. Wu, H. Yang]

This document summarizes the activity of AHG9: Neural network in video coding between the 14th meeting in Geneva, CH (19–27 March 2019) and the 15th Meeting at Gothenburg, SE (3–12 July 2019).

The AHG used the main JVET reflector, [jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de), with [AHG9] in message headers. This AHG worked closely with CE10. Subjects such as software sharing, training data and process, neural network structure and complexity, etc. have been actively discussed among proponents and participants. The following tables summarize the tests for using neural network based filters.

Table 1: CE10 test results with VTM-5.0+ Test Condition 1 (CTC)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | **AI Over VTM-5.0** |  |  |  |  | **RA Over VTM-5.0** |  |  |
|  | **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| In-loop/post filter | CE10-1.2a |  |  |  |  |  | -1.20% | -14.17% | -14.11% | 100% | 117% |
| CE10-1.7a |  |  |  |  |  | -0.80% | -10.56% | -9.93% | 100% | 129% |
| CE10-1.7b |  |  |  |  |  | -0.95% | -10.78% | -10.39% | 100% | 158% |
| CE10-1.11a |  |  |  |  |  | -0.04% | -15.54% | -15.17% | 99% | 190% |
| CE10-1.11b |  |  |  |  |  | 0.25% | -5.04% | -6.01% | 100% | 213% |
| CE10-2.2a | -3.93% | -7.89% | -7.29% | 134% | 74517% | -0.26% | -3.86% | -2.91% | 139% | 132513% |
| CE10-2.2b | -3.05% | -9.02% | -10.47% | 136% | 74083% | -1.89% | -11.91% | -8.90% | 139% | 135869% |
| CE10-2.11a |  |  |  |  |  | -1.10% | -2.94% | -3.35% | 127% | 56667% |
| CE10-2.11b |  |  |  |  |  | -0.32% | -0.66% | -0.81% | 100% | 64536% |

Table 2: CE10 test results with VTM-5.0+ Test Condition 2

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  | **RA Over VTM-5.0** |  |  |
|  | **Test#** | **Description** | **Y** | **U** | **V** | **EncT** | **DecT** |
| Para. precision | CE10-1.10a | 6-bit(int) weights | 0.04% | -0.97% | -2.30% | 100% | 127% |
| CE10-1.10b | 14-bit(int) weights | 0.23% | -15.24% | -13.66% | 100% | 190% |
| CE10-2.1a | 32-bit(float) weights | -0.46% | -4.11% | -2.80% | 142% | 134684% |
| CE10-2.1b | 8-bit(int) weights | 0.79% | -5.06% | -4.73% | 192% | 306401% |
| CE10-2.5a | 32-bit(float) weights | -1.01% | -5.01% | -4.24% | 105% | 5652% |
| CE10-2.5b | 8-bit(int) weights | -0.84% | -4.13% | -2.92% | 107% | 5515% |
| CE10-2.8c | 8-bit(int) weights |  |  |  |  |  |
| CE10-2.10a | 8-bit(int) weights | -1.00% | -2.98% | -3.46% | 128% | 57777% |
| CE10-2.10b | 16-bit(int) weights | -1.16% | -3.21% | -3.59% | 129% | 59072% |

Table 3: CE10 test results with VTM-5.0+ Test Condition 3

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  | **RA Over VTM-5.0** |  |  |
|  | **Test#** | **Description** | **Y** | **U** | **V** | **EncT** | **DecT** |
| QP generation capability | CE10-2.2a | CTC QP for testing | -0.46% | -4.11% | -2.80% | 142% | 134684% |
| CE10-2.3b | CTC QP+5 | -1.52% | -6.15% | -4.31% | 166% | 154379% |
| CE10-2.5a | CTC QP for testing | -1.01% | -5.01% | -4.24% | 105% | 5652% |
| CE10-2.7a | CTC QP-5 | -0.63% | -3.83% | -3.34% | 105% | 5026% |
| CE10-2.7b | CTC QP+5 | -1.15% | -5.01% | -4.47% | 111% | 5525% |

Complexities of above filters are also analyzed. Detailed results and discussions about tool performance and complexity can be found in CE10 report.

AHG9 related input documents for this meeting were listed and summarized in the AHG report (about ten in total).

The AHG recommended to review the related contributions and continue investigating the benefits and complexity of using neural networks in video coding.

[JVET-O0010](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7650) JVET AHG report: Encoding algorithm optimizations (AHG10) [A. Duenas, A. M. Tourapis, C. Helmrich, S. Ikonin, A. Norkin, R. Sjöberg]

The document summarizes the activities of the AHG on Encoding algorithm optimizations between the 14th meeting in Geneva, CH (19-27, March 2019) and the 15th meeting in Gothenburg, SE (3-12, July 2019).

Relevant input contribution documents (5 in total) were listed and summarized in the AHG report.

* JVET-O0256: Non-CE: Fast encoder with adjusted threshold in dependent quantization
* JVET-O0432: AHG10: LMCS encoder improvement
* JVET-O0549: AHG10: Encoder-only GOP-based temporal filter
* JVET-O0635: AHG10 related: Optimized CTU level bit allocation in inter frames
* JVET-O0888: AHG10: Adaptive Coding Sub-set for encoder optimization

It was remarked that there appear to be normative aspects in JVET-O088.

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

[JVET-O0011](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7567) JVET AHG report: Screen Content Coding (AHG11) [S. Liu, J. Boyce, A. Filippov, Y.-C. Sun, J. Xu, M. Zhou]

This document summarizes the activity of AHG11: Screen Content Coding between the 14th meeting in Geneva, CH (19–27 March 2019) and 15th Meeting in Gothenburg, SE (3–12 July 2019).

The AHG used the main JVET reflector, [jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de), with [AHG11] in message headers. There were about a dozen offline emails exchanged with discussions about testing sequences. There were many email exchanges among CE8 participants under [CE8] with tool specific discussions.

In total there were 58 SCC related technical input contributions identified so far, among which 31 were related to IBC, 8 were related to Palette, 3 were related to transform skip, 10 were related to BDPCM, 5 are related to other SCC coding aspects (e.g. some tool on/off switches in SCC scenarios) and 1 related to SCC test materials. They were listed in the AHG report.

It was noted that there were no contributions on in-loop colour transform.

For test sequences and CTC, a contribution was noted:

* JVET-O0483, AHG11: SCC test sequences for VVC standardization and suggestion for class F update, X. Xu, X. Li, S. Liu (Tencent)

The AHG recommended:

* 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-O0012](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7576) 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]

The document summarizes activities of AHG on High-level parallelism and coded picture regions between the 14th and the 15th JVET meetings.

In the JVET email reflector, a kick off message was sent. There was no other discussion on the email reflector regarding AHG12.

A total of 35 input contributions related to AHG12 were listed in the report, categorized as:

* Slice, tile, brick information signalling (13)
* Sub-pictures / independent coded regions (12)
* Non-CE5 / picture boundaries (6)
* WPP (3)

A summarization of the proposals had been submitted in JVET-O0800

The AHG recommended to review all related contributions and continue to study VVC high-level parallelism and coded picture regions aspects.

[JVET-O0013](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7609) JVET AHG report: Tool reporting procedure (AHG13) [W.-J. Chien, J. Boyce, Y.-W. Chen, R. Chernyak, K. Choi, R. Hashimoto, Y.-W. Huang, H. Jang, R.-L. Liao, S. Liu, D. Luo]

This document summarizes the activity of AHG13: “Tool reporting procedure” between the 14th Meeting in Geneva, CH (19–27 March 2019) and the 15th meeting in Gothenburg, SE (3–12 July 2019). Tool on/off experimental results vs. VTM anchors are provided for the tools specified in JVET-N1005.

The initial version of JVET-N1005 “Methodology and reporting template for tool testing” was provided on April 11th. The document contained a reporting template.

All tests described in JVET-N1005 were conducted. VTM tool tests were conducted on VTM-5.0 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.

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.

Full experimental results and configuration files can be found at the link below:

https://hevc.hhi.fraunhofer.de/svn/svn\_VVCTestConfig/branches/VTM-5.0/

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.

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 | 0.41% | 12.73% | 13.50% | 170% | 103% | 172% | 103% |
| DQ | 1.90% | -0.94% | -0.95% | 96% | 108% | 91% | 105% |
| CCLM | 1.85% | 17.20% | 17.54% | 99% | 100% | 98% | 98% |
| MTS | 0.84% | 0.37% | 0.42% | 87% | 99% | 87% | 98% |
| ALF | 2.42% | 2.73% | 3.06% | 98% | 87% | 97% | 87% |
| MRLP | 0.36% | 0.16% | 0.18% | 96% | 99% | 95% | 99% |
| IBC | 0.63% | 0.63% | 0.66% | 68% | 100% | 69% | 97% |
| LMCS | 0.81% | -1.20% | -0.98% | 100% | 99% | 99% | 99% |
| RDPCM on | -0.05% | -0.05% | -0.06% | 104% | 100% | 106% | 100% |
| MIP | 0.36% | 0.10% | 0.14% | 87% | 100% | 86% | 97% |
| LFNST | 1.26% | 0.39% | 0.55% | 77% | 99% | 77% | 100% |
| JCCR | 0.29% | 0.58% | 1.40% | 95% | 100% | 98% | 102% |

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 | 0.14% | 6.05% | 7.57% | 105% | 98% | 101% | 97% |
| DQ | 1.71% | -0.51% | -0.72% | 101% | 104% | 97% | 101% |
| CCLM | 0.90% | 15.85% | 16.95% | 99% | 100% | 98% | 99% |
| MTS | 0.33% | 0.51% | 0.42% | 91% | 100% | 92% | 101% |
| ALF | 4.91% | 4.56% | 4.07% | 97% | 79% | 97% | 83% |
| AFF | 2.53% | 1.83% | 1.75% | 90% | 99% | 89% | 98% |
| SbTMVP | 0.43% | 0.29% | 0.31% | 100% | 100% | 100% | 98% |
| AMVR | 1.05% | 1.51% | 1.48% | 89% | 101% | 89% | 99% |
| TPM | 0.35% | 0.63% | 0.67% | 92% | 100% | 92% | 99% |
| BDOF | 0.78% | 0.24% | 0.15% | 96% | 93% | 99% | 92% |
| CIIP | 0.38% | 0.08% | 0.02% | 96% | 99% | 99% | 99% |
| MMVD | 0.58% | 0.64% | 0.64% | 91% | 100% | 92% | 101% |
| BCW | 0.43% | 0.53% | 0.58% | 96% | 101% | 98% | 102% |
| MRLP | 0.20% | 0.03% | -0.02% | 99% | 100% | 99% | 100% |
| IBC | -0.01% | 0.33% | 0.25% | 94% | 100% | 95% | 102% |
| ISP | 0.13% | 0.04% | 0.08% | 98% | 100% | 98% | 100% |
| DMVR | 0.82% | 1.05% | 1.07% | 101% | 96% | 100% | 96% |
| SBT | 0.41% | -0.02% | 0.07% | 95% | 100% | 96% | 100% |
| LMCS | 1.39% | -2.83% | -2.55% | 94% | 99% | 94% | 99% |
| SMVD | 0.25% | 0.25% | 0.23% | 96% | 101% | 97% | 101% |
| RDPCM on | -0.01% | -0.07% | -0.05% | 100% | 100% | 101% | 101% |
| MIP | 0.27% | 0.26% | 0.32% | 94% | 100% | 93% | 97% |
| LFNST | 0.79% | 0.39% | 0.81% | 85% | 100% | 86% | 100% |
| JCCR | 0.25% | 0.65% | 0.72% | 97% | 99% | 99% | 102% |
| TMVP | 1.19% | 0.93% | 1.03% | 100% | 97% |  |  |

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 | 0.08% | 2.44% | 3.56% | 100% | 99% | 99% | 99% |
| DQ | 1.37% | 1.78% | 1.42% | 99% | 102% | 97% | 102% |
| CCLM | 0.12% | 4.53% | 5.62% | 100% | 100% | 100% | 103% |
| MTS | 0.23% | 0.49% | 0.62% | 97% | 99% | 98% | 99% |
| ALF | 4.16% | 4.74% | 3.85% | 95% | 81% | 94% | 83% |
| AFF | 2.18% | 1.54% | 1.73% | 83% | 97% | 83% | 95% |
| SbTMVP | 0.60% | 0.62% | 0.36% | 101% | 98% | 100% | 97% |
| AMVR | 0.39% | 0.82% | 0.73% | 91% | 97% | 91% | 97% |
| TPM | 0.88% | 1.34% | 1.02% | 87% | 101% | 88% | 103% |
| CIIP | 0.46% | 0.93% | 0.81% | 96% | 98% | 96% | 99% |
| MMVD | 0.57% | 0.39% | 0.18% | 94% | 102% | 94% | 104% |
| BCW | 0.31% | 0.32% | 0.25% | 97% | 99% | 98% | 100% |
| MRLP | 0.12% | 0.06% | 0.11% | 100% | 103% | 100% | 102% |
| IBC | -0.03% | 0.04% | 0.35% | 84% | 100% | 86% | 103% |
| ISP | 0.06% | 0.19% | 0.44% | 99% | 100% | 100% | 102% |
| SBT | 0.69% | 0.48% | -0.08% | 92% | 99% | 93% | 98% |
| LMCS | 0.68% | -2.23% | -2.21% | 94% | 99% | 93% | 100% |
| RDPCM on | -0.02% | 0.16% | 0.10% | 100% | 99% | 102% | 101% |
| MIP | 0.07% | 0.20% | 0.06% | 97% | 100% | 96% | 101% |
| LFNST | 0.34% | -2.30% | -2.60% | 86% | 102% | 85% | 98% |
| JCCR | 0.12% | 3.39% | 5.19% | 99% | 99% | 101% | 101% |
| TMVP | 2.16% | 1.85% | 1.82% | 101% | 97% |  |  |

Pixel usage and memory bandwidth results of VTM tool “off” test. (VTM anchor)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | AI |  | RA |  |  | LDB |  |
| Acronym | Pixel usage | Pixel usage | Ave mem BW | Max mem BW | Pixel usage | Ave mem BW | Max mem BW |
| CCLM | 48.03% | 3.54% |  |  | 0.92% |  |  |
| ALF | 99.00% | 65.38% |  |  | 60.05% |  |  |
| AFF |  | 13.41% |  |  | 19.38% |  |  |
| SBTMC |  | 6.13% |  |  | 7.64% |  |  |
| AMVR |  | 4.79% |  |  | 2.02% |  |  |
| TAP |  | 2.38% |  |  | 5.62% |  |  |
| BDOF |  | 50.03% |  |  |  |  |  |
| CIIP |  | 1.09% |  |  | 1.57% |  |  |
| MMVD |  | 7.67% |  |  | 9.34% |  |  |
| BPWA |  | 9.66% |  |  | 8.37% |  |  |
| MRLP | 6.99% | 0.80% |  |  | 0.27% |  |  |
| DMVR |  | 42.79% |  |  |  |  |  |
| SBT |  | 2.50% |  |  | 4.06% |  |  |
| SMVD |  | 2.68% |  |  |  |  |  |
| MIP | 13.03% | 3.75% |  |  | 2.10% |  |  |
| LFNST | 10.05% | 2.70% |  |  |  |  |  |
| JCCR | 4.38% | 0.22% |  |  | 0.08% |  |  |

Table 7 test results of VTM tool “off” test on various VTM versions

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **VTM RA** |  |
| **Abbreviation** | **VTM3** | **VTM4** | **VTM5** |
| CST | 0.74% | 1.25% | 1.47% |
| DQ | 1.39% | 1.36% | 1.24% |
| CCLM | 4.09% | 4.20% | 4.00% |
| MTS | 1.25% | 0.80% | 0.36% |
| ALF | 3.61% | 3.73% | 4.79% |
| AFF | 2.42% | 2.46% | 2.38% |
| SbTMVP | 0.52% | 0.43% | 0.40% |
| AMVR | 0.98% | 1.13% | 1.14% |
| TPM | 0.43% | 0.43% | 0.41% |
| BDOF | 1.02% | 0.63% | 0.66% |
| CIIP | 0.43% | 0.51% | 0.31% |
| MMVD | 0.81% | 0.52% | 0.59% |
| BiCW | 0.48% | 0.45% | 0.45% |
| MRLP | 0.24% | 0.18% | 0.16% |
| IBC | 0.07% | 0.00% | 0.05% |
| ISP |  | 0.24% | 0.12% |
| DMVR |  | 0.80% | 0.87% |
| SBT |  | 0.33% | 0.33% |
| LMCS |  | 0.62% | 0.57% |
| SMVD |  | 0.26% | 0.24% |
| RDPCM on |  |  | -0.02% |
| MIP |  |  | 0.27% |
| LFNST |  |  | 0.75% |
| JCCR |  |  | 0.34% |
| TMVP |  |  | 1.15% |

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)

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

It was suggested that some things that were not tested should be considered, including SAO and PDPC.

It was suggested to take a hard look at things that add complexity and provide less than 0.3% coding efficiency benefit and that RA is higher priority than AI.

It was commented that the test did not include testing of:

* Inter MTS (which reportedly provides about 0.3% gain for 10% runtime increase and is disabled in the CTC)
* SAO

Some things to consider focusing on were:

* ISP (intra subblock partitioning)
* MIP (matrix-based intra prediction)
* MRLP (multi-reference-line prediction)
* SMVD (symmetric motion vector difference)
* JCCR (joint coding of chroma residuals, although it has higher gain in chroma)
* Triangle prediction (which has a similar tradeoff except in low-delay B and is enabled in the CTC; it provides more gain for low-delay B)

Related contributions were noted to include the following:

* JVET-O0461 AHG13: On chroma tool evaluation in dual tree [T. Poirier, F. Le Léannec, F. Galpin, E. Francois (InterDigital)]
* JVET-O0551 AHG13: Tool-off tests on OpenImage database images [J. Ström, D. Saffar, P. Wennersten, R. Sjöberg]

[JVET-O0014](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7581) JVET AHG report: Operation modes for low latency support (AHG14) [J.-M. Thiesse, S. Deshpande, A. Duenas, Hendry, K. Kazui, R. Sjöberg, A. Tourapis]

The document summarizes activities of the AHG on operation modes for low latency support between the 14th and the 15th JVET meetings.

Eleven related contributions were identified in the report:

* Contributions on CE11 (8)
* High-level syntax (3)

The AHG recommends to review all related contributions.

[JVET-O0015](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7500) JVET AHG report: Quantization control (AHG15) [R. Chernyak, E. François, C. Helmrich, S. McCarthy, A. Segall]

This document summarizes the activity of AHG15: Quantization control between the 14th meeting in Geneva, CH (19–27 Mar. 2019) and the 15th meeting in Gothenburg, SE (3–12 Jul. 2019).

There were about a dozen emails exchanged with discussions related to the AHG.

Discussed topics included:

* VTM QP control techniques
  + Legacy adaptive QP (QP adaptation based on a psycho-visual model
  + Chroma QP adjustment (ported from HEVC, not adopted to VVC yet
  + Perceptual QP adaptation (perceptQPA) – perceptually motivated adaptive QP method
  + QP-RDO – slice and QG level QP adaptation
  + Luma-based QP – used in HDR CTCs – mostly compatible with all the rest
  + Rate control
* Chroma mapping table flexibility, with the following considerations:
  + Coding method: discrete representation or piece-wise linear representation (differences between two neighboring points in the table or pivot points are signalled).
  + Ability to choose one table from a set of predefined tables.
  + Restrictions on the resulting mapping table.
  + Ability to send shared CbCr table or separate Cb and Cr tables.
  + Signalling cost (how much bits are used by each syntax variant for custom QPc signalling).

Relevant contributions were identified in the following areas:

* Chroma mapping table related (5)
* Quantization matrices related (3)
* Delta QP related (3)
* Minimum Allowed QP for Transform Skip Mode (1)
* Derivation of QP predictors for DUAL\_TREE\_CHROMA in deblocking (1)

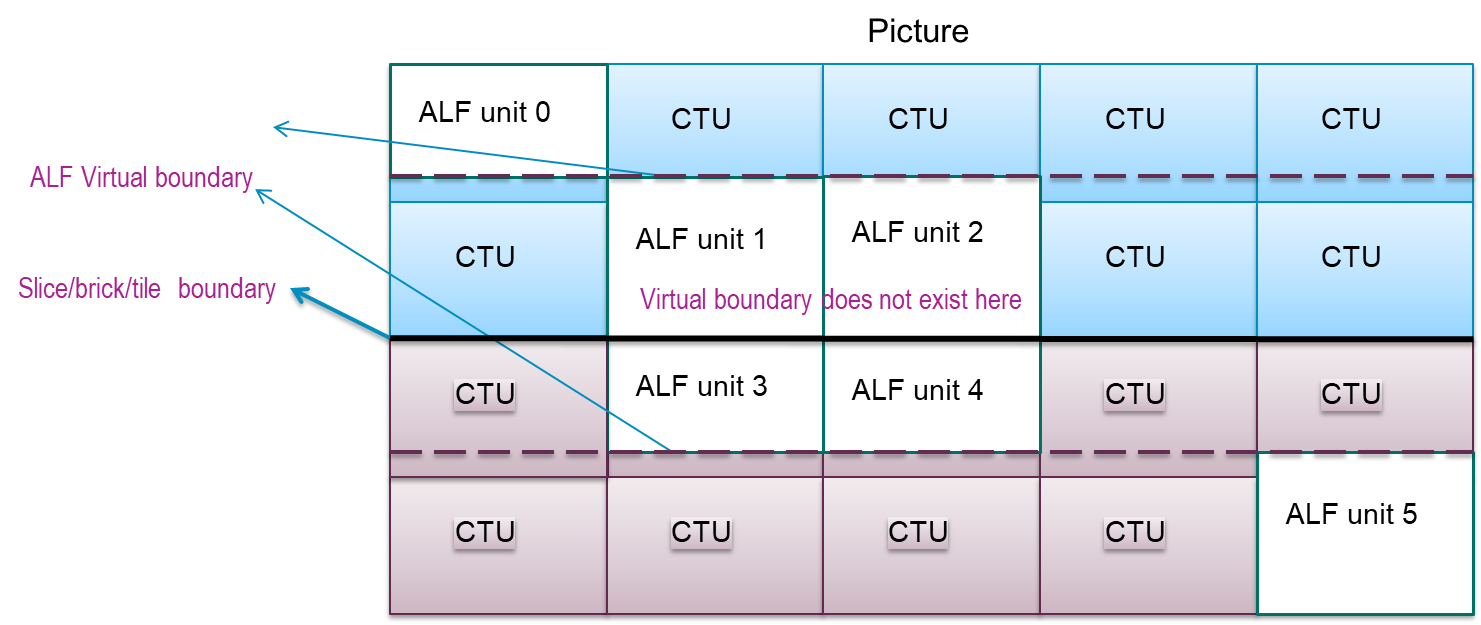
The AHG recommended to:

* Review all related contributions;
* Establish BOG on Chroma mapping table related contributions;
* Continue investigating VTM QP control techniques;
* Encourage people to test VTM QP control techniques more extensively;
* Encourage people to perform refactoring of VTM QP control techniques.

[JVET-O0016](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7349) JVET AHG report: Implementation studies (AHG16) [M. Zhou, J. An, E. Chai, K. Choi, S. Sethuraman, T. Hsieh, X. Xiu]

This document summarizes the activity of AHG16: implementation studies, between the 14th JVET meeting in Geneva, CH (19–27 March 2019) and the 15th JVET meeting in Gothenburg, SE (3-12 July 2019). Comments made on the email reflector are included below.

* Comments on the current VTM5.0 design and some of tools being tested
  + It is strongly recommended to simply remove the 1xN/2xN sub-partitions from the intra sub-partition prediction (ISP) to alleviate implementation difficulties in both the intra prediction and transform parts of the design. It is not desirable to make the design even more complicated by introducing more small size sub-partitions.
  + The CE2 tests aiming for the reduction of the chroma reconstruction latency (caused by the combination of separate tree and CCLM) may not serve the purpose, as the derivation of the cclmEnabled flag is a complex process and the CABAC parsing depends on it. It is hence recommended to seek simplifications outside the CE.
  + There are CE tests going on to move the validity check of luma/chroma IBC vectors to the decoder side. While those methods may make decoder designs safer, it should be investigated whether there are enough cycles on the decoder side to do the check, as the operation is down to 4x4 for luma and 2x2 for chroma in the worst case.
  + The newly adopted residual coding for transform skip is significantly different from the existing residual coding method, requiring yet another building block. It codes the coefficients in reverse order, requires three additional loops through all the coefficients for gt3/gt4/gt5 coding, and does not benefit coding of camera captured content. It is desirable to align it with the existing residual coding in terms of coefficient coding order and to reduce the number of coefficient coding passes/loops for CABAC throughput improvement and cost reduction.
  + For the baseline VVC design, it is generally not recommended to introduce more context coded bins and specific processing logic for minor gain in SCC without benefiting coding of camera captured content, because doing so not only decreases the CABAC throughput but also adds cost. It might be more appropriate to study those for more complex profiles.
  + The maximum number of distinct APSs that a picture can use for the ALF and LMCS should be properly defined, in order to constrain the memory footprint required for storing ALF/LMCS parameters and computational complexity needed for LMCS table derivation (which has divisions in it). For example, the current design allows up to 32 APSs signaled. It would require roughly 13 Kbytes on-chip memory to buffer those APSs if all of them are used for the ALF of a picture (not counting fixed filters that need roughly 1 Kbytes additional memory). Each ALF parameter set has about 410 bytes.
  + The MV context storage of triangle merge mode (in which the triangle MVs are populated to create 4x4 block vectors that are stored as TMVPs and used as spatial MV neighbors of merge/AMVP modes) seems to be unnecessarily complicated, it should be simplified.
  + Removal of small block size (e.g. 2x2) chroma intra-prediction for the shared tree case is essential for high performance decoder implementations (being studied in CE3). The issue was already resolved for the separate (dual) tree case at the last meeting.
  + As the project is approaching the CD stage, more attention should be paid to non-CTC and corner cases, and developing solutions to fix the broken parts of design (if any). For example, in the current VTM5.0 design the merge mode is broken, because the decoder behavior is undefined when all the merge flags are set to zero.
  + In the current design, the LFNST flag is derived at the end of the CU (need to check total number of coefficients inside and outside the LFNST corner regions). For a 128x128 CU, the first PB could not be processed without waiting for the LFNST index that comes after the last PB. Although this does not necessarily break the overall 64x64 based decoder pipeline (if the CABAC could be decoupled), it increases the data buffering by 4x for a certain number of decoder pipeline stages. It is costly. It is desirable to disable the LFNST flag derivation across the 64x64 VDPU boundaries. Potential simplifications could include e.g. moving it to a per TU index rather than a per-CU index, or disabling it for CU size 128x128.
* Implementation issues identified
  + In the newly adopted RDPCM, the residual coefficients could potentially grow significantly larger than the standard 16-bit coefficient range (-32767, 32767) for 10-bit video coding if allowed to grow unbounded across all the columns (or rows). It is desirable to constraint the residual coefficients in 16-bit range. This was fixed by adding a clamping after each step of residual coefficient reconstruction to both the reference software and text.
  + ALF line buffer issue along slice/brick/tile boundary and 360 video virtual boundary

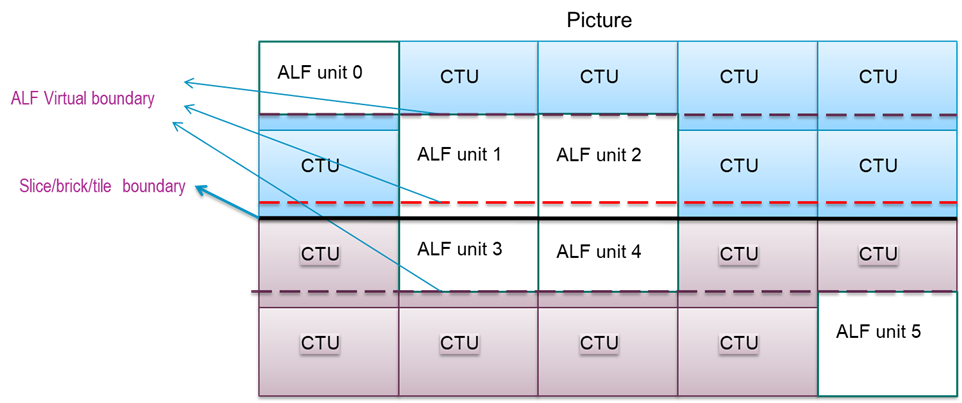


The ALF virtual boundary was adopted at the last meeting to remove the ALF line buffer, it is located at 4 luma lines above the bottom CTU boundary (except for those CTUs at the last CTU row of a picture). In the current specification text, the ALF virtual boundary is not present for a CTU if its bottom CTU boundary is also a slice/brick/tile boundary (when the loop-filter across those boundaries is disabled) or a 360 video virtual boundary (see Fig. 1 for example).

It is asserted that the current text specification defeats the purpose of the ALF virtual boundary adoption and has the following consequences:

* + - For decoders, not knowing the slice/brick/tile boundaries upfront (i.e. low-delay applications) means that the ALF line buffer needs to be restored. To process the ALF filtering of the bottom lines of the current CTU (e.g. luma lines 5, 6 and 7 above the bottom CTU boundary), the decoders need to know whether the current bottom CTU boundary coincides with other types of boundaries. This information, however, is unknown until the next slice/brick/tile is decoded.
    - Even if the slice/brick/tile boundaries are known upfront (e.g. the CABAC decoding is fully decoupled at frame level), the decoders need to run the loop-filters (de-blocking, SAO and ALF) at a speed of 68 lines per 64x64 VDPU all the time (an overprovision of roughly 6%) in order to avoid using the ALF line buffer.

It is therefore recommended to specify the ALF virtual boundary at the fixed location of 4 lines above the bottom CTU boundary, regardless of whether the bottom CTU boundary coincides with a slice/brick/tile boundary or a 360 video virtual boundary (see Figure 2 for example). It is also desirable to unify the padding methods along an ALF virtual boundary, a 360 video virtual boundary and a slice/brick/tile boundary.



Memory bandwidth study for VTM5.0

Broadcom conducted a memory bandwidth study by running both the VTM5.0 and VTM4.0 for CTC with a commercial motion compensation cache model integrated. The summary results of the random access configuration are provided in the the table below (for informational purposes).

The changes which may cause the difference in memory bandwidth consumption between the VTM5.0 and VTM4.0 include: removing the 4x4 uni-pred and 8x4/4x8 bi-pred PUs, using the 6-tap filters for affine MC and restricting the sub-block motion vector spread of the affine mode. Both the average (see ABW\_diff column) and the peak memory bandwidth consumption (see MBW\_diff column) are slightly decreased.

Memory bandwidth comparison (VTM5.0 vs.VTM4.0, RA)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | | | | |
|  | **Over VTM-4.0** | | | | | | | |
|  | Y | U | V | TCM\_diff | ABW\_diff | MBW\_diff | EncT | DecT |
| Class A1 | -3.29% | -1.44% | -1.58% | -2.10% | -2.21% | -1.28% | 118% | 108% |
| Class A2 | -2.56% | -3.40% | -1.19% | -0.92% | -0.99% | -0.95% | 123% | 117% |
| Class B | -2.09% | -1.63% | -3.70% | -0.56% | -0.50% | -4.10% | 124% | 112% |
| Class C | -1.82% | 0.26% | -3.17% | -0.14% | -0.34% | -2.32% | 135% | 112% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -2.35% | -1.44% | -2.63% | -0.93% | -1.01% | -2.16% | 125% | 112% |
| Class D | -0.52% | 0.42% | -2.76% | 0.28% | 0.15% | -3.30% | 148% | 107% |
| Class F (optional) | -6.09% | -4.39% | -6.63% | 1.53% | 1.81% | 1.24% | 141% | 111% |

Where

* TCM\_diff : Total cache misses (over all the frames coded), percentage difference relative to VTM4.0.
* 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 VTM4.0.

MBW\_diff is suggested to be the most important measure, which shows the worst case memory bandwidth consumption difference of VTM5.0 relative to VTM4.0.

Bin to bit ratio study for VTM5.0

It has been reported that the bin to bit ratio continues to increase from VTM4.0 to VTM5.0. The summary results are provided in the table below for informational purposes (data from JVET-O0068).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Bin2bit ratio (peak, weighted)** | | | | | | | | **Bin2bit ratio (peak, unweighted)** | | | | | |
|  | HM16.19 | VTM4.0 | | VTM5.0 | diff (%, VMT4.0 vs. HM16.19) | diff (%, VMT5.0 vs. HM16.19) | diff\* (%, VMT5.0 vs. VTM4.0) | | HM16.19 | VTM4.0 | VTM5.0 | diff (%, VMT4.0 vs. HM16.19) | diff (%, VMT5.0 vs. HM16.19) | diff\* (%, VMT5.0 vs. VTM4.0) |
|  | **QP = (22, 27, 32, 37), CTC** | | | | | | | | | | | | | |
| **AI** | 0.95 | 1.10 | | 1.13 | 15.72% | 19.71% | **3.99%** | | 1.23 | 1.38 | 1.40 | 12.38% | 14.21% | **1.82%** |
| **RA** | 0.93 | 1.09 | | 1.12 | 17.39% | 20.88% | **3.49%** | | 1.21 | 1.38 | 1.40 | 13.75% | 15.25% | **1.50%** |
| **LB** | 0.96 | 1.09 | | 1.13 | 13.34% | 16.99% | **3.64%** | | 1.24 | 1.37 | 1.39 | 11.25% | 12.88% | **1.63%** |
| **LP** | 0.96 | 1.09 | | 1.13 | 13.24% | 17.30% | **4.06%** | | 1.23 | 1.37 | 1.39 | 11.08% | 13.02% | **1.94%** |
|  | **QP = (2, 7, 12, 17), 100 frames** | | | | | | | | | | | | | |
| **AI** | 0.79 | | 0.94 | 0.95 | 18.11% | 20.24% | | **2.12%** | 1.19 | 1.31 | 1.33 | 10.45% | 11.40% | **0.95%** |
| **RA** | 0.74 | | 0.87 | 0.88 | 17.17% | 19.00% | | **1.83%** | 1.18 | 1.28 | 1.28 | 7.63% | 8.39% | **0.76%** |
| **LB** | 0.78 | | 0.92 | 0.93 | 17.67% | 19.67% | | **2.00%** | 1.18 | 1.30 | 1.31 | 9.54% | 10.28% | **0.74%** |
| **LP** | 0.78 | | 0.92 | 0.93 | 17.46% | 19.46% | | **2.00%** | 1.18 | 1.30 | 1.31 | 9.50% | 10.24% | **0.74%** |
| Note\*: Percentage difference between VTM5.0 and VTM4.0 is measured against HM16.19 | | | | | | | | | | | | | | |

It was also reported that the weighted bin to bit ratio in class F sequences is already higher than the average numbers presented in Table 2.

In the table above, 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.

The following contributions are identified for the AHG

* Contributions related to the luma-chroma latency reduction for the combination of CCLM and dual-tree (5)
* Contributions for simplification of IBC vector validity check (4)
* Contributions related to the residual coding of transform skip mode (4)
* Contributions related to the MV context storage of triangle merge mode (11)
* Contributions for the LFNST latency reduction (6)
* Contributions for ALF padding unification and line buffer reduction (1)
* Other AHG16-related contributions (5)

[JVET-O0017](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7615) JVET AHG report: High-level syntax (AHG17) [R. Sjöberg, J. Boyce, S. Deshpande, M. M. Hannuksela, R. Skupin, A. Tourapis, Y.-K. Wang, W. Wan, S. Wenger]

This AHG report summarizes the activities of the AHG on High-level syntax (HLS) between the 14th JVET meeting in Geneva, CH (19–27 Mar. 2019) and the 15th JVET meeting in Gothenburg, SE (3–12 July 2019).

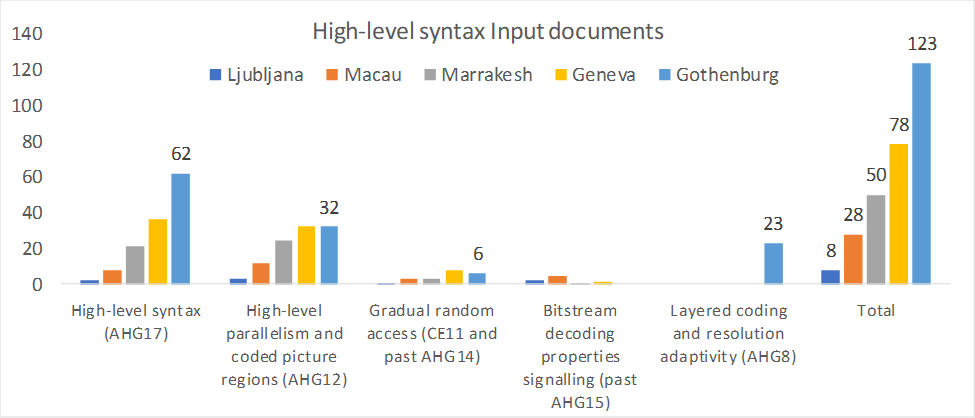
It is reported that the estimated number of input contributions related to high-level syntax has increased from 78 at the 14th JVET meeting to 123 at this 15th meeting.

It is also reported that the highest number of high-level syntax contributions for version 1 of HEVC was recorded at the 11th JCT-VC meeting in Stockholm 2012 with an estimated 96 contribution, excluding 36 documents on profile, level and constraint definitions. The AHG report notes that an additional high-level syntax AHG meeting was held the day before that 11th JCT-VC meeting.

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

As a rough indication, inputs to the meeting were summarized and illustrated as shown below.

|  |  |
| --- | --- |
| **Category** | **HLS inputs (AHG estimation)** |
| Layered coding and resolution adaptivity (AHG8) | 23 |
| High-level parallelism and coded picture regions (AHG12) | 32 |
| General high-level syntax (AHG17) | 62 |
| Gradual random access (CE11) | 6 |
| Total | 123 |



The AHG report included a comparative discussion of HLS activity in the JCT-VC development of HEVC and discussion of how such work was handled at that time.

The AHG recommended that this JVET meeting is planned such that there is enough time allocated to review high-level syntax related contributions. A BoG was thus established to start work right away from the first day of the meeting.

# Project development (X)

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

## Text and software development (1)

[JVET-O0756](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7377) HDRTools: VTM software integration [D. Mehlem, A. M. Tourapis, D. Singer (Apple)] [late]

Presented in closing plenary 1230.

[integrate abstract]

Integration of HDRTools into the VTM software can ease workflow and data handling and increase precision.

The modules are still maintained as an external library.

Some work with the software coordinators was needed.

Decision (SW): Adopt.

## Test conditions (1)

[JVET-O0483](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7090) AHG11: SCC test sequences for VVC standardization and suggestion for class F update [X. Xu, X. Li, S. Liu (Tencent)]

The new sequences were reviewed, and it was agreed with the test chair that the sequences are appropriate for testing. The following set of sequences is proposed

|  |  |
| --- | --- |
| **Sequences** | **Properties** |
| FlyingGraphics | Moving graphics with various patterns |
| Desktop | English text editing, computer programs |
| ChineseEditing | Chinese text editing |
| ArenaOfValor | Gaming scene |
| MissionControlClip2 | Mixed camera/computer contents |
| GlassHalf | Animation |

The first three sequences are from the old TGM class, AoV is from class F, and the other two are new, and of higher resolution.

Reducing screen content test to only 6 sequences would be undesirable, as it might not have enough variety. The two high resolution sequences should not be tested for LB, or only in a downsampled version (which however is critical in case of screen content).

The variety and quality is probably better than the current class F, however for testing screen content not sufficient

in a follow-up discussion Thu 11 July morning, it was agreed to proceed as follows:

- Keep class F and TGM 4:2:0 unchanged, as these have been used for optional tests also in other CEs

- Include GlassHalf in class A for 4:4:4 (which currently only has two sequences)

- As GlassHalf is currently the only screen content sequence of UHD resolution, action should be taken to get more of this resolution (also for other categories, not only animated content), with 4:4:4 color sampling

It is further noted that should also be tested in LDB case, as it only has 240 frames.

It is also remarked that “screen content” might better be designated as “computer generated content”

It is also discussed that it would be appropriate to define CTC for 4:4:4 testing. However, the 4:4:4 mterial of current CE8 is highly related to computer generated material (only two camera captured sequences).

In the closing plenary it was asked whether having a CTC for 4:4:4 with more camera content might also be relevant for AHG18 on TS; lossless etc. It was agreed that the AHG can study this issue.

## Performance assessment (5)

See also JVET-O0641 regarding reference picture resampling.

[JVET-O0451](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7057) AHG4: Subjective comparison of VVC and HEVC [P. Philippe, J. Fournier (Orange), W. Hamidouche (INSA), J. Y. Aubie (b-com)]

This contribution was reviewed in JVET plenary Monday 8 July at 1730 (GJS & JRO)

This document reports a subjective evaluation of VVC. A formal subjective test was carried out to compare HEVC with the latest VVC version (VTM 5.0) on a variety of HD and UHD SDR video sequences over a wide range of bit rates.

Under these testing conditions, it is reported that the performance improvement of VVC over HEVC is in the range of 36% for HD and 40% in UHD.

The presentation deck was promised to be uploaded.

The target image resolutions for this test were HD (i.e. 1920x1080) and UHD (3840x2160), in a standard dynamic range (SDR).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sequence** | **Frame Rate** | **Bit Depth** | **Source** | **HD**  **BD VMAF** | **UHD (SDR)**  **BD VMAF** | **HD**  **Subjective** | **UHD (SDR)**  **Subjective** | **Notes from discussion** |
| AerialCrowd2 | 30 | 10 | Huawei | −27.4 | 35.1 | −32 | −41 | Quality saturated at high end |
| CatRobot1 | 60 | 10 | b<>com | −42.3 | 47.4 | −48 | −47 | VVC curve a bit strange at high end for UHD |
| CrowdRun | 50 | 8 | SVT | −29.5 | 33.2 | −34 | −35 |  |
| DaylightRoad | 60 | 10 | Huawei | −42.5 | 49.2 | −50 | −48 | Strange curves for UHD, flat curves, large gain measured |
| Drums2 | 50 | 10 | b<>com | −31.5 | 35.6 | −35 | −39 |  |
| HorseJumping | 50 | 10 | [4Ever2](http://www.4ever-2.com/) | −38.0 | 40.6 | −37 | −45 |  |
| Sedof | 60 | 8 | 4Ever | −35.0 | 42.0 | −19 | −21 | Strange curves for HD, has water, lowest gain |

Metrics included Y-PSNR, MS-SSIM, VMAF

SAMVIQ has been used.

When computing BD MOS, the confidence intervals were not considered.

In cases where quality saturates, the computation of area between HEVC and VVC graphs may be affecting the real rate reduction. Probably lower rates should be used.

[Get tables as tables rather than pasted graphics.]

Repetition – viewers can navigate freely and view repeatedly.

22 test subjects, 7 rejected

It was commented that it might help if the quality is more widely distributed, as this may have sometimes used excessively high quality.

It was noted that the subjective gain was 5-6% higher than the PSNR gain.

[Bring in more data – psnr’s, averages]

[JVET-O0551](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7164) AHG13: Tool-off tests on Open Images dataset [J. Ström, D. Saffar, P. Wennersten, R. Sjöberg]

Plenary Monday 1800 (GJS & JRO)

This contribution tests the VVC-5.0 all-intra configuration on non-CTC data. The test set used contains 235 images from the OpenImage database. For each tool, the tool is turned off and then compared against the anchor. The results are compared against the CTC on/off tools tests carried out in AHG13.

Trying to use more varied image set. Test set used for training neural nets.

The images are compressed and 8 bit, not raw. Some have heavy compression artefacts. Selected the ones that had high quality JPEG encoding.

The image are still images (e.g., with artistic blur), not frames selected from video.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Test | Description | Acronym | BDR-Y 235 images | AHG13 BDR-Y |
| 1 | Chroma separate tree | CST | **0.61%** | 0.41% |
| 2 | Dependent quantization/sign data hiding | DQ | **2.14%** | 1.90% |
| 3 | Cross-component linear model | CCLM | **1.70%** | 1.85% |
| 4 | Multiple transform set | MTS | **0.99%** | 0.84% |
| 5 | Adaptive loop filter | ALF | **2.19%** | 2.42% |
| 6 | Multi-line reference prediction | MLRP | **0.18%** | 0.36% |
| 7 | Intra sub-partitioning | ISP | **0.24%** | 0.31% |
| 8 | Matrix based intra prediction | MIP | **0.41%** | 0.36% |
| 9 | Low frequency non-separable transform | LFNST | **0.88%** | 1.26% |
| 10 | Sample adaptive offset | SAO | **0.41%** | - |
| 11 | Luma mapping with chroma scaling | LMCS | **-0.22%** | 0.81% |

It was commented that the luma gains are pretty similar with those measured by AHG13. An exception was LMCS, which actually had a loss by disabling it (until getting some new software, in which case the result was roughly neutral).

Most of the images were full range. When the images were converted to narrow range and the test was run again, the tool off test yielded 0.65% BD-Y change.

One participant commented that we should test LMCS against clipping.

It was commented that LMCS expands the signal range [16, 235] to [0, 255], and then scales it back down again.

If very few samples are outside of narrow range, it detects this and clips them.

It was suggested to test LMCS against simple narrow-range clipping.

For chroma features:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test | Description | Acronym | BDR-U no BW | BDR-V no BW | AHG13 BDR-U | AHG13 BDR-V |
| 1 | Chroma separate tree | CST | **18.10%** | **18.63%** | 12.73% | 13.50% |
| 2 | Dependent quantization | DQ | **0.64%** | **0.38%** | -0.94% | -0.95% |
| 3 | Cross-component linear model | CCLM | **25.91%** | **23.27%** | 17.20% | 17.54% |
| 4 | Multiple transform set | MTS | **0.55%** | **0.40%** | 0.37% | 0.42% |
| 5 | Adaptive loop filter | ALF | **3.55%** | **4.09%** | 2.73% | 3.06% |
| 6 | Multi-line reference prediction | MLRP | **0.11%** | **-0.08%** | 0.16% | 0.18% |
| 7 | Intra sub-partitioning | ISP | **0.21%** | **0.02%** | 0.25% | 0.25% |
| 8 | Matrix based intra prediction | MIP | **0.22%** | **0.08%** | 0.10% | 0.14% |
| 9 | Low frequency non-separable transform | LFNST | **0.22%** | **-0.03%** | 0.39% | 0.55% |
| 10 | Sample adaptive offset | SAO | **0.18%** | **0.24%** | - | - |
| 11 | Luma mapping with chroma scaling\* | LMCS | **-0.58%** | **-0.65%** | -1.20% | -0.98% |

The reported chroma gain on CST and CCLM than measured by AHG13.

It was noted that the effect of an off switch is in both tables, not isolating the change to the relevant channels.

It was commented that subjective image coding tests would also be desirable.

[JVET-O0967](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7598) Crosscheck of JVET-O0551 (AHG13: Tool-off tests on OpenImage database images) [P. Cowan, A. Segall (Sharp Labs)]

[JVET-O0657](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7274) AHG7: Tool-on/off experiments for HLG CTC sequences [S. Iwamura, S. Nemoto, A. Ichigaya (NHK)]

Monday plenary 1850

This contribution reports tool on/off experimental results vs. VTM anchor for HLG common test sequences. For a total of 11 tools for all intra and 23 tools for random access configuration, tool-off experiments were conducted.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | All Intra |  |  |  |  |
| Tool off | Y | U | V | Enc | Dec |
| CST | 0.70% | 17.43% | 24.96% | 178% | 98% |
| DQ | 1.89% | -1.02% | -1.67% | 95% | 100% |
| CCLM | 1.95% | 46.16% | 22.71% | 101% | 98% |
| MTS | 1.24% | 1.01% | 0.93% | 87% | 95% |
| ALF | 2.91% | 1.39% | 1.63% | 97% | 80% |
| MRLP | 0.07% | -0.02% | -0.05% | 95% | 97% |
| RDPCM-on | -0.02% | -0.01% | -0.03% | 105% | 98% |
| MIP | 0.36% | 0.18% | 0.13% | 85% | 98% |
| LFNST | 0.71% | -0.49% | -0.57% | 78% | 98% |
| JCCR | 0.11% | 0.03% | 4.03% | 97% | 98% |
| ISP | 0.24% | 0.21% | 0.16% | 91% | 97% |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Random Access | |  |  |  |
| Tool off | Y | U | V | Enc | Dec |
| CST | 0.26% | 10.88% | 19.65% | 105% | 102% |
| DQ | 1.83% | -0.42% | -1.34% | 101% | 104% |
| CCLM | 0.87% | 51.82% | 27.51% | 101% | 102% |
| MTS | 0.64% | 1.04% | 0.28% | 95% | 101% |
| ALF | 3.69% | 2.48% | 1.33% | 97% | 83% |
| AFF | 0.55% | 0.47% | 0.45% | 87% | 100% |
| SbTMVP | 0.39% | 0.23% | 0.14% | 102% | 102% |
| AMVR | 0.55% | 0.95% | 1.36% | 94% | 96% |
| TPM | 0.54% | 0.89% | 0.69% | 93% | 100% |
| BDOF | 0.66% | 0.32% | 0.32% | 94% | 96% |
| CIIP | 0.26% | -0.33% | -0.37% | 97% | 101% |
| MMVD | 0.31% | 0.29% | 0.41% | 88% | 102% |
| BCW | 0.23% | 0.20% | 0.23% | 95% | 103% |
| MRLP | 0.05% | 0.09% | -0.15% | 99% | 100% |
| ISP | 0.11% | 0.20% | 0.07% | 100% | 101% |
| DMVR | 0.89% | 1.19% | 1.02% | 101% | 97% |
| SBT | 0.31% | -0.16% | -0.07% | 97% | 100% |
| SMVD | 0.21% | 0.01% | 0.18% | 96% | 102% |
| RDPCM-on | -0.01% | -0.06% | 0.04% | 102% | 101% |
| MIP | 0.37% | 0.39% | -0.02% | 97% | 102% |
| LFNST | 0.42% | 0.56% | 0.07% | 91% | 101% |
| JCCR | 0.09% | -0.45% | 5.76% | 99% | 100% |
| TMVP | 1.01% | 0.77% | 0.80% | 101% | 101% |

Observation:

* More gain
  + Chroma related tools such as CCLM, CST, and JCCR
    - These tools bring huge gain (~100% BD-rate gain for Cb and Cr) for some specific sequences, which pulls up the average
  + MTS
    - More gain for 4K in SDR as well (~1.4%(AI), -0.8%(RA) for ClassA1)
* Less gain
  + AFF
    - Some sequences do not include affine motion. In SDR, huge gain for ClassA2 pull up the average.
  + MRL
    - Most gain is gone. In SDR, gain for high resolution is smaller (0.07% for ClassA1).
  + CIIP
    - Most gain was gone

There are some significant differences in behaviour relative to SDR (and some of the difference of gain is certainly just a matter of the characteristics of the test sequences – e.g., the types of motion depicted).

[JVET-O0966](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7597) Crosscheck of JVET-O0657 (AHG7: Tool-on/off experiments for HLG CTC sequences) [P. Cowan, A. Segall (Sharp Labs)]

[JVET-O0898](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7520) Extra results to JVET-N0605 “Comparative study of video coding solutions VVC, AV1 and EVC versus HEVC” [E. François (InterDigital)] [late]

Presented in plenary Monday 1900

This contribution presents extra results complementing JVET-N0605 “Comparative study of video coding solutions VVC, AV1 and EVC versus HEVC” by using the latest versions of the reference codecs, on full length sequences (in JVET-N0605 only one second was encoded), with closer test conditions between AV1 and the others.

The experiments were conducted according to the common test condition (CTC) of JVET in random access 10 bit coding but also in a variant with only one intra picture at the first frame of the sequence. Specific investigations were carried out to ensure comparable configuration between AV1 and the others.

The performance according the average BD-rate PSNR variations of VTM-5.0 (VVC following March 2019 JVET meeting), AV1, and ETM 2.01 (EVC after March 2019 MPEG meeting) versus HM-16.18 are respectively -31.4%, -20.1%, and -17.4% with one intra only, and -31.7%, -9.2%, and -16.7% with one second intra period . Reported figures show that the AV1 software is optimized for the streaming use case (-20.1% versus HEVC), with a two-pass encoding process, while VTM5.0 and ETM2.0.1 use one single pass. For use case closer to broadcast using regular random-access points, AV1 performance is much lower (-9.2% versus HEVC). Performance difference between VTM5.0 and EVC2.0.1 is around 14-15% in both scenarios.

Two-pass encoding was used for AV1. A graph was shown of QP settings. AV1 alt-ref frames were inserted at regular intervals.

The test conditions are based on the JVET CTC with two settings:

* Setting 1: random access with one second intra period,
* Setting 2: one intra picture only at the first frame of the sequence (not like our usual low-delay setting, more like an RA but with only one intra frame).

In JVET-N605, HM, VTM and ETM were configured in Setting1, while AV1 was configured in Setting2.

For a fairer comparison, in this contribution, two sets of results are provided for the three codecs, using Setting 1, and using Setting 2. Setting 1 gives more advantage to VTM and EVC as AV1, Setting 2 on the contrary favors more AV1 which is optimized for this setting.

AV1 encoding was not operated in its slowest mode; it was operated about 2.5× faster than the VTM encoder. A participant estimated that 4-5% additional coding gain might be provided if AV1 were operated in its slowest encoding speed, which would be substantially slower than the VTM.

It was commented that the range of QP enabled for AV1 was not limited in the test, which would result in very different bit allocation from what is used in the VTM. The QP adapts somewhat for the alt-ref frames of AV1. A bit allocation analysis might help remove this variability.

Further detail on settings and per-category results was provided in the contribution.

The following software versions were used:

* HM-16.18,
* VTM-5.0,
* ETM2.01 (EVC) from May 14th, 2019,
* AV1 commit cb43f76 from May 19th, 2019.

The performances according to the average BD-rate PSNR metrics of VTM-5.0 (VVC following Geneva meeting March 2019), AV1, and ETM 2.01 (EVC after Geneva meeting) versus HM-16.18 are reportedly -31.4%, -20.1%, and -17.4% gains with one intra only, and -31.7%, -9.2%, and -16.7% gains with one second intra period. The compression gain of the publicly available AV1 software has reportedly been optimized for the streaming use case (-20.1% versus HEVC) with two-passes and without broadcast-like random-access. In this use case (i.e., with relatively infrequent random access), AV1 was reported to be a serious competitor to VVC and EVC.

End of discussion 1940.

## Coding studies on specific use cases (X)

## Test material (X)

# Core Experiments

## CE1: CABAC initialization (4)

[JVET-O0021](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7180) CE1: Summary report on CABAC initialization [F. Bossen, J. Dong, H. Kirchhoffer]

This contribution was discussed in Track A Wednesday 3 July 1645 (chaired by GJS).

Core experiment 1 on CABAC initialization was conducted between the 14th and 15th JVET meeting. Results are reported for five experiments, all aimed at simplifying the CABAC initialization process.

Detailed reports are provided in the following input contributions, which were provided in a timely manner:

* JVET-O0065: CE1-1.2 and CE1-2.1: Simplification of CABAC initialization process
* JVET-O0085: CE1-1.1: Simplification of the initialization process for context variables
* JVET-O0112: CE1: CABAC Initialization, all experiments

Detailed descriptions of experiments are provided in the CE description document JVET-N1021. At a high-level, experiments can be distinguished between:

* Methods that use a 6-bit initValue (CE1-1.1, CE1-1.2, CE1-3.1.b) and methods that use an 8-bit initValue (CE1-2.1, CE1-3.1.a)
* Methods that use a linear space (CE1-1.1, CE1-1.2, CE1-2.1) and methods that use a logarithmic space (CE1-3.1.a, CE1-3.1.b)

In addition to regular CTC conditions, the “random access” configuration was also tested at very low (2-17) and very high (42-57) QP values. The table below captures BD rate difference averages for the luma component.

The table below captures BD rate difference averages for the luma component.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | Experiment | AI | RA | LB | LP | RA (low) | RA (high) |
| 6-bit | Linear Space | CE1-1.1 | -0.02% | 0.01% | 0.04% | 0.00% | -0.01% | 0.66% |
| CE1-1.2 | -0.02% | -0.01% | 0.03% | -0.09% | -0.01% | 0.22% |
| 8-bit | CE1-2.1 | -0.02% | -0.02% | -0.01% | -0.07% | -0.02% | 0.74% |
| Logarithmic Space | CE1-3.1.a | -0.01% | -0.02% | -0.01% | -0.02% | 0.00% | 0.33% |
| 6-bit | CE1-3.1.b | 0.00% | 0.00% | 0.00% | -0.04% | 0.01% | 0.65% |

Coding efficiency differences are minor except for the very high QP values case. In general, no significant differences in coding efficiency are observed between:

* Methods that use a 6-bit initValue (CE1-1.1, CE1-1.2, CE1-3.1.b) and methods that use an 8-bit initValue (CE1-2.1, CE1-3.1.a)
* Methods that use a linear space (CE1-1.1, CE1-1.2, CE1-2.1) and methods that use a logarithmic space (CE1-3.1.a, CE1-3.1.b)

No complexity analysis metric was defined in the CE description. Nevertheless, at a high level, the following can be said about the methods studied in this CE:

* all methods are less complex than the method in the current VVC draft because they avoid a large lookup table
* methods that use a logarithmic space (CE1-3.1.x) are a bit more complex because a log-to-linear conversion needs to be done
* methods that use a 6-bit initValue (CE1-1.1, CE1-1.2, CE1-3.1.b) do not require more operations than those that use an 8-bit initValue (CE1-2.1, CE1-3.1.a)

An analysis of operation counts for each method is provided below, based on the implementations provided in the CE software repository. Note that multiplications by a constant are counted as combinations of shift and add operations. Also note that the bit width of each operation is not considered here. It was remarked that there was not full agreement on the reported necessary operation counts (esp. for CE1-1.1).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Shift  (<<, >>) | Multiplication (×) | Addition (+/-) | AND  (&) | XOR  (^) | Compare (if, Clip3) |
| CE1-1.1 | 7 or 5 | 1 | 5 | 1 | 0 | 4 |
| CE1-1.2 | 5 | 1 | 5 | 1 | 0 | 2 |
| CE1-2.1 | 4 | 1 | 4 | 1 | 0 | 2 |
| CE1-3.1.a | 8 | 1 | 8 | 2 | 1 | 2 |
| CE1-3.1.b | 10 | 1 | 8 | 2 | 1 | 2 |

Additionally, cycle counts based on optimized software implementations are reported in JVET-O0191.

Tools for training were kindly provided by Fraunhofer HHI. It was remarked that training effects could be having some effect on the results.

The following non-CE contributions related to CE1 have been registered:

* JVET-O0191: CE1-related: Simplified CABAC initialization method

It was commented that this is just for the initial state, and in the way it was tested, the initial state value does not matter so much for low QPs.

The current draft has a mapping from log domain to linear domain that serves no function and can be eliminated (apparently without a penalty) by adopting one of the proposed linear domain approaches.

The main motivation here is a cleanup simplification. The mapping is not a rational part of the design; it resulted from a prior design change.

Testing with more frequent probability resets was suggested, to increase the effect of the initialization on the test results. One suggestion was to initialize CABAC for every CTU.

Decision (cleanup): Adopt CE1-1.2, pending consideration of non-CE contributions or additional test results.

[JVET-O0065](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6669) CE1-1.2 and CE1-2.1: Simplification of CABAC initialization process [J. Dong, A. Said, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-O0085](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6689) CE1-1.1: Simplification of the initialization process for context variables [H. Kirchhoffer, D. Marpe, H. Schwarz, T. Wiegand (HHI)]

[JVET-O0112](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6716) CE1: CABAC Initialization, all experiments [F. Bossen (Sharp)]

## CE2: Luma/chroma dependency reduction (5)

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

[JVET-O0022](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7272) CE2: Summary report on luma-chroma dependency reduction [J. Chen, E. François, P. Yin]

This document provides a summary report of Core Experiment 2 (CE2) on luma-chroma dependency reduction. This CE comprises 3 categories, as follows:

* CE2-1: Chroma residual scaling luma-chroma dependency reduction – Single-tree case (8 tests)
* CE2-2: Chroma residual scaling luma-chroma dependency reduction – Dual-tree case (7 tests)
* CE2-3: CCLM luma-chroma dependency reduction in Dual-tree case (2 tests)

All the techniques are implemented on top of VTM5.0 and tested against VTM5.0. The simulation results and crosscheck reports are summarized in this contribution.

|  |  |  |  |
| --- | --- | --- | --- |
| **CE2-1 – Chroma residual scaling luma-chroma dependency reduction – Single-tree case** | | | |
| **Test #** | **Description** | **Source** | **Cross-checker** |
| CE2-1.1 | Derive the scaling factor from the **average value of the top-left 16×16 luma prediction samples** | JVET-O0049 (MediaTek) | J. Chen (alibaba) |
| CE2-1.2 | Derivation of the scaling factor from the **first (upper-left) sample value of the corresponding luma prediction** | JVET-O0098 (Dolby) | C. Chevance (Interdigital) |
| CE2-1.3.a | For intra coded blocks, derivation of the scaling factor from one of the **top-left, top or left neighboring reconstructed luma samples**, based on their availability | JVET-O0087 (Interdigital) | T. Lu (Dolby) |
| ~~CE2-1.3.b~~  (withdrawn) | ~~For intra coded blocks, derivation of the scaling factor from the~~ **~~average value of 2 available neighboring reconstructed luma samples~~** | ~~JVET-O0087 (Interdigital)~~ | ~~J. Chen (Alibaba)~~ |
| CE2-1.3.c | For intra coded blocks, derivation of the scaling factor from the **average value of 4 available neighboring reconstructed luma samples** | JVET-O0087 (Interdigital) | J. Chen (Alibaba) |
| CE2-1.3.d | For intra coded blocks, derivation of the scaling factor from the **average value of 8 available neighboring reconstructed luma samples** | JVET-O0087 (Interdigital) | J. Chen (Alibaba) |
| CE2-1.3.e | For intra coded blocks, derivation of the scaling factor from the **average value of all available neighboring reconstructed luma samples** | JVET-O0087 (Interdigital) | J. Chen (Alibaba) |
| CE2-1.4.a | For intra coded blocks, derivation of the scaling factor from the **top-left reference luma sample** used for intra prediction | JVET-O0102  (Alibaba) | T. Lu (Dolby) |
| CE2-1.4.b | For intra coded blocks, derivation of the scaling factor from the **averaged value of 2 reference luma samples** | JVET-O0102 (Alibaba) | Z.-Y. Lin (MediaTek) |
| CE2-1.4.c | For intra coded blocks, derivation of the scaling factor from the **averaged value of 4 reference luma samples** | JVET-O0102 (Alibaba) | E. Francois (Technicolor) |
| CE2-1.4.d | For intra coded blocks, derivation of the scaling factor from the **averaged value of 8 reference luma samples** | JVET-O0102 (Alibaba) | Z.-Y. Lin (MediaTek) |
| CE2-1.4.e | For intra coded blocks, derivation of the scaling factor from the **averaged value of reference luma samples** used for intra prediction | JVET-O0102 (Alibaba) | E. Francois (Technicolor) |

The major benefit is that it is no longer necessary to wait for prediction of co-located luma samples, but use neighbor blocks, which is beneficial for the processing pipeline.

Most simple solutions are 2-1.3a and 2-1.4a which just use one sample.

It is asked if by reducing the prediction to only 1 sample the chroma scaling could become entirely wrong at certain loactions (e.g. high local contrast). It is reported that it was not possible to identify artifacts. Furthermore, an encoder would would likely not use that mode if the prediction was wrong.

Performance-wise, all solutions are very similar:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | | **Low delay B** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 2-1.1 | 0.00% | -0.04% | -0.04% | 100% | 99% | 0.00% | 0.04% | -0.06% | 100% | 100% |
| 2-1.2 | 0.00% | -0.09% | -0.10% | 99% | 99% | 0.02% | 0.05% | -0.03% | 100% | 98% |
| 2-1.3.a | 0.01% | -0.09% | -0.03% | 101% | 100% | *0.02%* | *0.05%* | *-0.07%* | *100%* | *100%* |
| 2-1.3.c | 0.00% | 0.00% | -0.07% | 99% | 101% | *0.00%* | *0.19%* | *-0.05%* | *100%* | *99%* |
| 2-1.3.d | 0.00% | -0.01% | -0.02% | 100% | 99% | *0.00%* | *0.04%* | *-0.07%* | *99%* | *98%* |
| 2-1.3.e | -0.01% | -0.02% | -0.06% | 99% | 101% | 0.00% | 0.11% | -0.13% | 101% | 102% |
| 2-1.4.a | -0.01% | -0.08% | -0.01% | 100% | 100% | -0.01% | 0.28% | -0.22% | 100% | 99% |
| 2-1.4.b | 0.00% | -0.04% | -0.07% | 100% | 100% | -0.01% | 0.04% | -0.06% | 100% | 99% |
| 2-1.4.c | 0.00% | -0.02% | -0.03% | 100% | 100% | -0.01% | 0.14% | 0.03% | 100% | 99% |
| 2-1.4.d | 0.00% | -0.03% | -0.02% | 100% | 100% | -0.01% | 0.10% | -0.10% | 100% | 99% |
| 2-1.4.e | 0.01% | -0.08% | -0.06% | 100% | 100% | 0.02% | 0.23% | 0.06% | 100% | 99% |

It is concluded from the results of the CE that the luma-chroma dependency in CS can be largely reduced without affecting the performance of LMCS. It is however mentioned that CE-related contributions potentially even further reduce the dependency, or give better performance. Further action to be decided after reviewing the CE2 related documents.

|  |  |  |  |
| --- | --- | --- | --- |
| **CE2-2 – Chroma residual scaling luma-chroma dependency reduction – Dual-tree case** | | | |
| **Test #** | **Description** | **Tester** | **Cross-checker** |
| CE2-2.1.a | CRS on in dual-tree For all intra coded blocks, scaling factor derived from one of the **top-left, top or left reconstructed luma samples** neighboring the collocated luma block, based on their availability | JVET-O0087 (Interdigital) | T. Lu (Dolby) |
| CE2-2.1.b | CRS on in dual-tree For all intra coded blocks, scaling factor derived from the **average of 2 available reconstructed luma samples** neighboring the collocated luma block | JVET-O0087 (Interdigital) | T. Lu (Dolby) |
| CE2-2.1.c | CRS on in dual-tree For all intra coded blocks, scaling factor derived from the **average of 4 available reconstructed luma samples** neighboring the collocated luma block | JVET-O0087 (Interdigital) | T. Lu (Dolby) |
| CE2-2.1.d | CRS on in dual-tree For all intra coded blocks, scaling factor derived from the **average of 8 available reconstructed luma samples** neighboring the collocated luma block | JVET-O0087 (Interdigital) | J. Chen (Alibaba) |
| CE2-2.1.e | CRS on in dual-tree For all intra coded blocks, scaling factor derived from the **average of all available reconstructed luma samples** neighboring the collocated luma block | JVET-O0087 (Interdigital) | J. Chen (Alibaba) |
| CE2-2.2.a | CRS on in dual-tree For all intra coded blocks, scaling factor derived from the **top-left reference luma sample** neighboring the collocated luma block | JVET-O0087 (Interdigital) | J. Chen (Alibaba) |
| CE2-2.2.b | CRS on in dual-tree For all intra coded blocks, scaling factor derived from the **average of 2 reference luma samples** neighboring the collocated luma block | JVET-O0087 (Interdigital) | J. Chen (Alibaba) |
| CE2-2.2.c | CRS on in dual-tree For all intra coded blocks, scaling factor derived from the **average of 4 reference luma samples** neighboring the collocated luma block | JVET-O0087 (Interdigital) | J. Chen (Alibaba) |
| CE2-2.2.d | CRS on in dual-tree For all intra coded blocks, scaling factor derived from the **average of 8 reference luma samples** neighboring the collocated luma block | JVET-O0087 (Interdigital) | J. Chen (Alibaba) |
| CE2-2.2.e | CRS on in dual-tree For all intra coded blocks, scaling factor derived from the **average of all reference luma samples** neighboring the collocated luma block | JVET-O0087 (Interdigital) | J. Chen (Alibaba) |
| CE2-2.3 | CRS on in dual-tree  For intra coded blocks in **dual-tree**, scaling factor derived from the **average of available reconstructed luma samples** neighboring the collocated luma block  For intra coded blocks in **single-tree**, scaling factor derived from the **average of reference luma samples** neighboring the collocated luma block | JVET-O0087 (Interdigital) | J. Chen (Alibaba) |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | **Random Access** | | | | | **Low delay B** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 2-2.1.a | 0.03% | -0.46% | -0.62% | 102.00% | 101.00% | 0.03% | -0.71% | -0.59% | 101% | 100% | 0.00% | -0.60% | -0.19% | 99% | 100% |
| 2-2.1.b | 0.03% | -0.36% | -0.52% | 101.00% | 101.00% | 0.02% | -0.60% | -0.61% | 100% | 102% |  |  |  |  |  |
| 2-2.1.c | 0.02% | -0.37% | -0.51% | 101.00% | 102.00% | 0.03% | -0.65% | -0.66% | 100% | 102% |  |  |  |  |  |
| 2-2.1.d | 0.02% | -0.37% | -0.53% | 101.00% | 100.00% | 0.02% | -0.64% | -0.59% | 101% | 100% |  |  |  |  |  |
| 2-2.1.e | 0.03% | -0.37% | -0.52% | 100.00% | 101.00% | 0.01% | -0.64% | -0.66% | 101% | 101% | -0.01% | -0.39% | -0.50% | 101% | 99% |
| 2-2.2.a | 0.04% | -0.44% | -0.60% | 102.00% | 99.00% | 0.02% | -0.66% | -0.61% | 101% | 101% | *0.01%* | *-0.50%* | *-0.29%* | *99%* | *97%* |
| 2-2.2.b | 0.03% | -0.36% | -0.52% | 101.00% | 101.00% | 0.02% | -0.60% | -0.61% | 100% | 102% | *0.00%* | *-0.68%* | *-0.50%* | *99%* | *98%* |
| 2-2.2.c | 0.02% | -0.37% | -0.51% | 101.00% | 102.00% | 0.03% | -0.65% | -0.66% | 100% | 102% | *0.00%* | *-0.57%* | *-0.49%* | *99%* | *98%* |
| 2-2.2.d | 0.03% | -0.36% | -0.51% | 101.00% | 101.00% | 0.02% | -0.67% | -0.67% | 101% | 101% | *0.01%* | *-0.47%* | *-0.44%* | *99%* | *97%* |
| 2-2.2.e | 0.03% | -0.34% | -0.52% | 102.00% | 101.00% | 0.03% | -0.58% | -0.65% | 101% | 100% | 0.00% | -0.48% | -0.50% | 99% | 100% |
| 2-2.3 | 0.03% | -0.37% | -0.52% | 102.00% | 101.00% | 0.03% | -0.61% | -0.68% | 103% | 101% | 0.02% | -0.45% | -0.41% | 101% | 98% |

For the dual-tree case, the chroma gain is relatively low (at most 0.4%-0.6%), which might not justify to introduce additional dependency from luma to chroma here. Such a step should only be made if really necessary. Currently, the CS part of LMCS is disabled for dual tree it is reported verbally that the benefit of enabling CS in case of single tree is much larger (about 4% for RA). This is however only compared against a configuration that uses LM, which by itself affects the chroma quality, where the CS recovers it partially (see e.g. the results of AHG 13 which indicate that the chroma has some gain while the luma has significant loss when disabling LMCS). As an interpretation, LM performs kind of adaptive quantization on luma, which in case of single tree is inherited by chroma, and CS compensates for that.

It is mentioned that the effect would be larger for HDR-PQ, as per non-CE contributions. For SDR under CTC, the results of the CE do not necessarily indicate the need for action of enabling CS for the dual-tree case. Further action to be decided after reviewing the CE2 related documents.

|  |  |  |  |
| --- | --- | --- | --- |
| **CE2-3 - CCLM luma-chroma dependency reduction in Dual-tree case** | | | |
| **Test #** | **Description** | **Tester** | **Cross-checker** |
| CE2-3.1 | CCLM enabled if chroma block and its collocated luma blocks are inside the same 16x16/32x32 non-overlapping area | E. François (Technicolor) | A. Segall (Sharp) |
| CE2-3.2 | CCLM parameters derived from reconstructed luma/chroma samples neighboring the luma block collocated with the chroma block top-left sample | E. Francois (Technicolor) | A. Segall (Sharp) |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | **Random Access** | | | | | **Low delay B** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 2-3.1 | 0.28% | 2.37% | 2.53% |  |  | 0.07% | 1.08% | 0.96% |  |  | *0.00%* | *0.31%* | *0.24%* | *100%* | *99%* |
| 2-3.2 | 0.33% | 2.17% | 2.28% |  |  | 0.10% | 1.16% | 0.98% |  |  | *-0.01%* | *0.15%* | *-0.48%* | *101%* | *99%* |

*Note: tests 2-3.1 and 2-3.2, LDB configuration, have not been produced by the proponent. Reported results come from the cross-checker.*

None of the solutions fully resolves the latency problem, because the tree structure is different and therefore in worst case it would still be necessary to wait for reconstruction of a 64x64 luma block (even if it is not colocated but a neighbor) before the chroma can be predicted from luma. It is further mentined that better solutions might be available from CE related proposals. Further action to be decided after reviewing the CE2 related documents.

BoG (J. Chen, E. François) to perform a review of CE2 related documents, summarize and suggest actions.

[JVET-O0049](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6653) CE2-1.1: Simplified LMCS [Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0087](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6691) CE2: report of CE2 experiments from InterDigital [E. François, T. Poirier (InterDigital)]

[JVET-O0098](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6702) CE2.1.2: luma-chroma dependency reduction for LMCS [T. Lu, F. Pu, P. Yin, S. McCarthy, W. Husak, T. Chen (Dolby)]

[JVET-O0102](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6706) CE2-1.4: luma-chroma dependency reduction for chroma scaling [J. Chen, R.-L. Liao, Y. Ye (Alibaba)]

## CE3: Intra prediction and mode coding (12)

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

[JVET-O0023](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7250) CE3: Summary Report on Intra Prediction and Mode Coding [G. Van der Auwera, L. Li, A. Filippov]

This contribution was discussed in Track A Wednesday 3 July 1800 (chaired by GJS).

The goal of CE3 is to study intra prediction tools, including mode coding, for potential inclusion into the VVC standard.

The following is the list of defined sub-tests in CE3:

* CE3-1: ISP (9 tests)
* CE3-2: Small chroma block size restrictions for shared tree (3 tests)
* CE3-3: CCLM model improvements (6 tests)

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

Defined tests

|  |  |  |
| --- | --- | --- |
| **Test #** | **Short description** | **Doc. #** |
| 3-1.1.1 | CU-based prediction is applied for CUs whose sub-partition size is 1xN or 2xN. | JVET-O0080 (KDDI) |
| 3-1.1.2 | CU-based prediction is applied for CUs whose sub-partition size is 1xN. |
| 3-1.2.1 | Disable partitions in ISP that can result into either 1xN or 2xN sub-blocks. An 8xN block can be split into 2 4xN blocks | JVET-O0048 (Huawei) |
| 3-1.2.2 | Disable partitions in ISP that can result into 1xN sub-blocks |
| 3-1.3 | Apply CU-based low latency ISP to 4×8, 8×4 CUs, and the sub-partition with 1xN or 2xN partition size is disabled. | JVET-O0099 (InterDigital) |
| 3-1.4.1 | Remove ISP CU if it causes 1xN sub-partition | JVET-O0109 (Kwai) |
| 3-1.4.2 | Remove ISP CU if it causes 1xN or 2xN sub-partition |
| 3-1.6 | 4xN prediction regions for 4xN and 8xN (N > 4) ISP-coded blocks with vertical subpartitions | JVET-O0106 (Qualcomm, HHI) |
| 3-1.7 | Test 3-1.6 with additional restriction of only allowing vertical prediction mode for 4xN ISP-coded blocks with vertical subpartitions | JVET-O0107 (HHI) |

The following tables provide an overview of the aspects of each test. The data is provided for luma CBs that can potentially be split into narrow 1xN and 2xN vertical sub-partitions (if a 4-way ISP split would be performed), i.e., luma CBs with width equal to 4 and 8. The first table specifies the sizes of dependent sub-partitions that require reconstruction of the neighbouring sub-partition to the left for prediction of the current sub-partition. The second table specifies the transform block sizes that are applied to the dependent sub-partitions. The VTM anchor data is provided for reference. Yellow highlights indicate tested changes with respect to the VTM anchor.

Sub-partition sizes with prediction dependency (V: vertical splitting; H: horizontal splitting)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Test# vs. CB size** | **4x4** | **4x8** | **4xN (N>=16)** | **8x4** | **8xN (N>=8)** |
| VTM | No ISP | V: 2x8  H: 4x4 | V: 1xN  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 2xN  H: 8x(N/4) |
| 3-1.1.1 | No ISP | V: 4x8  H: 4x4 | V: 4xN  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 8xN  H: 8x(N/4) |
| 3-1.1.2 | No ISP | V: 2x8  H: 4x4 | V: 4xN  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 2xN  H: 8x(N/4) |
| 3-1.2.1 | No ISP | V: No ISP  H: 4x4 | V: No ISP  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 4xN  H: 8x(N/4) |
| 3-1.2.2 | No ISP | V: 2x8  H: 4x4 | V: No ISP  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 2xN  H: 8x(N/4) |
| 3-1.3 | No ISP | V: No ISP  H: 4x8 | V: No ISP  H: 4x(N/4) | V: 8x4  H: 8x4 | V: 4xN  H: 8x(N/4) |
| 3-1.4.1 | No ISP | V: 2x8  H: 4x4 | V: No ISP  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 2xN  H: 8x(N/4) |
| 3-1.4.2 | No ISP | V: No ISP  H: 4x4 | V: No ISP  H: 4x(N/4) | V: 4x4  H: 8x2 | V: No ISP  H: 8x(N/4) |
| 3-1.6 | No ISP | V: 4x8  H: 4x4 | V: 4xN  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 4xN  H: 8x(N/4) |
| 3-1.7 | No ISP | V: 4x8 (\*)  H: 4x4 | V: 4xN (\*)  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 4xN  H: 8x(N/4) |

(\*) VER pred mode only

Transform block sizes:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Test# vs. CB size** | **4x4** | **4x8** | **4xN (N>=16)** | **8x4** | **8xN (N>=8)** |
| VTM | No ISP | V: 2x8  H: 4x4 | V: 1xN  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 2xN  H: 8x(N/4) |
| 3-1.1.1 | No ISP | V: 2x8  H: 4x4 | V: 1xN  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 2xN  H: 8x(N/4) |
| 3-1.1.2 | No ISP | V: 2x8  H: 4x4 | V: 1xN  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 2xN  H: 8x(N/4) |
| 3-1.2.1 | No ISP | V: No ISP  H: 4x4 | V: No ISP  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 4xN  H: 8x(N/4) |
| 3-1.2.2 | No ISP | V: 2x8  H: 4x4 | V: No ISP  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 2xN  H: 8x(N/4) |
| 3-1.3 | No ISP | V: No ISP  H: 4x4 | V: No ISP  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 4xN  H: 8x(N/4) |
| 3-1.4.1 | No ISP | V: 2x8  H: 4x4 | V: No ISP  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 2xN  H: 8x(N/4) |
| 3-1.4.2 | No ISP | V: No ISP  H: 4x4 | V: No ISP  H: 4x(N/4) | V: 4x4  H: 8x2 | V: No ISP  H: 8x(N/4) |
| 3-1.6 | No ISP | V: 2x8  H: 4x4 | V: 1xN  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 2xN  H: 8x(N/4) |
| 3-1.7 | No ISP | V: 2x8  H: 4x4 | V: 1xN  H: 4x(N/4) | V: 4x4  H: 8x2 | V: 2xN  H: 8x(N/4) |

Test results

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra - Over VTM-5.0** | | | | | **Random Access - Over VTM-5.0** | | | | |
| **Test #** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 3-1.1.1 | 0.03% | 0.02% | 0.02% | 99% | 100% | 0.01% | -0.07% | -0.03% | 100% | 100% |
| 3-1.1.2 | 0.01% | -0.01% | 0.02% | 99% | 100% | 0.02% | 0.01% | -0.10% | 100% | 100% |
| 3-1.2.1 | 0.07% | 0.02% | 0.07% | 98% | 99% | 0.03% | -0.13% | -0.09% | 99% | 98% |
| 3-1.2.2 | 0.01% | -0.02% | 0.03% | 99% | 99% | 0.01% | -0.07% | -0.04% | 99% | 98% |
| 3-1.3 | 0.08% | 0.03% | 0.07% | 100% | 99% | 0.04% | 0.00% | -0.04% | 101% | 100% |
| 3-1.4.1 | 0.01% | -0.02% | 0.03% | 97% | 99% | 0.01% | -0.07% | -0.04% | 99% | 100% |
| 3-1.4.2 | 0.08% | 0.00% | 0.04% | 98% | 101% | 0.02% | -0.10% | -0.05% | 100% | 100% |
| 3-1.6 | 0.03% | -0.01% | 0.01% | 100% | 98% | 0.03% | -0.06% | -0.11% | 99% | 99% |
| 3-1.7 | 0.01% | -0.01% | 0.03% | 99% | 97% | 0.02% | -0.02% | -0.04% | 99% | 100% |

Generally, these are tested simplifications. It was remarked that 3-1.4.2, which removes ISP CU if it causes 1xN or 2xN sub-partition, is clearly a substantial simplification. It was commented that if the main motivation is to remove the 1xN and 2xN prediction dependencies, ways to do that with less penalty are available as 3-1.1.1 or 3-1.6 (which both have narrow transforms over wider predictions – the same transforms as currently). 3-1.1.1 is similar to 3-1.6 in spirit, while disallowing a vertical split of 8xN coding blocks (a very small difference between these two).

Considering that the gain of ISP appears to be quite small currently (~0.13% in RA), it was commented that we should try hard to lose as little of that gain as possible. It was suggested that 3-1.6 is the minimal action necessary to address the identified problem. Decision (complexity): Adopt JVET-O0106 for 3-1.6 (later confirmed Thursday 11 July at 1430 in Track A, GJS).

One participant commented that there would be a throughput benefit from 3-1.3. However, others commented that the worst case is for 4x4 blocks, which is not affected by 3-1.3.

CE3-2 on small chroma block size restrictions for shared tree

Defined tests

|  |  |  |
| --- | --- | --- |
| **Test #** | **Short description** | **Doc. #** |
| 3-2.1.1 | Do not split chroma blocks of smallest chroma intra prediction units (SCIPU)  - SCIPU determined from the coding mode of the first CU inside SCIPU | JVET-O0050 (MediaTek, Huawei) |
| 3-2.1.2 | Do not split chroma blocks of smallest chroma intra prediction units (SCIPU)  - SCIPU determined from a flag in coding\_tree() |
| 3-2.2 | All coded blocks within a parallel-processable region (PPR) of size larger than or equal to 16 chroma samples to be reconstructed in parallel in the single-tree case by removing the dependency between blocks within the PPR. | JVET-O0118 (Qualcomm, MediaTek) |

The following table provides summary of each test:

|  |  |  |
| --- | --- | --- |
| **Test** | **Separate trees** | **Shared trees** |
| 3-2.1.1 | Not changed | Smallest chroma intra CB size is 16 chroma samples. SCIPU(\*) mode (inter or non-inter) is derived from prediction mode of the first luma CB in the SCIPU (without explicit signalling) |
| 3-2.1.2 | Not changed | Smallest chroma intra CB size is 16 chroma samples. SCIPU mode (inter or non-inter) is explicitly signalled on CU level in P,B slice |
| 3-2.2 | Not changed | Parallel-processable region (PPR) of size 16 or 32 chroma samples, where reference samples within PPR are marked as unavailable. VVC reference sample substitution process is used to construct reference sample array for intra prediction. In case of IBC block, the block vector of luma component that leads to an overlap between the reference block of the chroma and its PPR area is restricted. |

(\*) SCIPU: A coding tree node whose chroma block size is larger than or equal to 16 chroma samples (32 or 16 samples) and has at least one child luma block smaller than 64 luma samples. Coding blocks within one SCIPU should be all inter-coded or all non-inter (intra or IBC) coded. Chroma components cannot be further split if the SCIPU is intra/IBC predicted.

CE3-2: Test results

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access - Over VTM-5.0** | | | | | **Low Delay B - Over VTM-5.0** | | | | |
| **Test #** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 3-2.1.1 | 0.07% | -0.08% | -0.11% | 100% | 100% | 0.14% | 0.16% | 0.07% | 100% | 100% |
| 3-2.1.2 | 0.09% | -0.01% | -0.02% | 99% | 101% | 0.19% | 0.19% | 0.10% | 101% | 103% |
| 3-2.2 | 0.07% | 0.02% | 0.09% | 100% | 100% | 0.05% | 0.13% | -0.16% | 100% | 100% |

It was agreed that these proposals address a problem that requires some action.

Conceptually, the first two method create a separate tree at the CU level (with 3-2.1.1 and 3-2.1.2 having different methods of signalling), while the third method keeps the smallest PUs but makes it possible to process them in parallel. It was commented that the approach of the first two is cheaper to support in hardware and these are more like what we have done in the past). The differences in decoding runtime were agreed to be basically noise here. The potential benefits of the third approach are the LB coding efficiency, and minimal spec changes.

There is a potential problem with the first two approaches in the bottom right corner if the picture size is an odd multiple of 4. Such picture sizes are not supported in HEVC, and another contribution has suggested not to support such picture sizes in VVC.

It was commented that if a single tree is used in an intra slice, the first two approaches have a (small) gain and an encoder runtime reduction (as tested).

Between 3-2.1.1 and 3-2.1.2 proposals, the 3-2.1.1 proposal avoids some signalling redundancy by using somewhat more checking of conditions. It thus has a little better coding efficiency. The spec is simpler and more straightforward for 3-2.1.2. Decision (complexity reduction): Adopt 3-2.1.2 with spec text in JVET-O0050.

CE3-3 on CCLM model improvements

Defined tests

|  |  |  |
| --- | --- | --- |
| **Test #** | **Short description** | **Doc. #** |
| 3-3.1 | Modified beta parameter derivation in context of the CCLM simplification (JVET-N0271). Luma and chroma averaged values are used to derive the CCLM parameter. | JVET-O0088 (Sony) |
| 3-3.2.1 | Filtering is applied to both luma and chroma templates to remove outliers (VTM5 filters luma samples only) | JVET-O0095 (Huawei, HHI) |
| 3-3.2.2 | Test CE3-3.2.1 with calculating mean values for more robust parameter deriving |
| 3-3.2.3 | Test CE3-3.2.2 without template filtering |
| 3-3.2.4 | Test CE3-3.2.1 with calculating mean values for more robustly deriving both parameters and |
| 3-3.2.5 | Test CE3-3.2.4 without template filtering |

The following table provides an overview for assessing the computational complexity of each test. The changes caused by subtests CE3-3 relate to preparing input data for min / max method, namely: template filtering and mean value calculations for CCLM parameter derivation. In particular, for VTM-5.0, the number of fetched samples equals 28 (4 luma samples after down-sampling x 6 luma samples as input values for 6-tap filter + 4 chroma samples = 24 + 4 =28) and the quantity of add operations is equal to 32 (4 luma samples after down-sampling x 6 add ops per each filtering operation + 2 add ops to calculate min for luma + 2 add ops to calculate min for chroma + 2 add ops to calculate max for luma + 2 add ops to calculate max for chroma = 24 + 8 = 32 add operations).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Test # | Chroma 4x4 blocks  (dual-tree type) | | Chroma 4x8 blocks  (dual-tree type) | | Chroma 8x4 blocks  (dual-tree type) | | Other chroma blocks  (any tree type) | |
| Samples fetched | Add ops | Samples fetched | Add ops | Samples fetched | Add ops | Samples fetched | Add ops |
| VTM-5.0 | 28 | 32 | 28 | 32 | 28 | 32 | 28 | 32 |
| Test 3-3.1 | 28 | 34 | 28 | 34 | 28 | 34 | 28 | 34 |
| Test 3-3.2.1 | 34 | 44 | 35 | 44 | 35 | 44 | 36 | 44 |
| Test 3-3.2.2 | 28 | 46 | 28 | 46 | 28 | 46 | 36 | 46 |
| Test 3-3.2.3 | 8 | 10 | 8 | 10 | 8 | 10 | 28 | 34 |
| Test 3-3.2.4 | 35 | 44 | 35 | 44 | 35 | 44 | 36 | 44 |
| Test 3-3.2.5 | 8 | 8 | 8 | 8 | 8 | 8 | 28 | 32 |

CE3-3: Test results

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test #** | **All Intra - Over VTM-5.0** | | | | | **Random Access - Over VTM-5.0** | | | | |
| **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 3-3.1 | -0.01% | -0.11% | -0.07% | 100% | 100% | 0.00% | -0.18% | -0.19% | 99% | 100% |
| 3-3.2.1 | 0.03% | 0.32% | 0.39% | 99% | 99% | 0.02% | 0.44% | 0.48% | 98% | 99% |
| 3-3.2.2 | 0.02% | 0.24% | 0.32% | 99% | 99% | 0.00% | 0.30% | 0.35% | 98% | 99% |
| 3-3.2.3 | 0.00% | 0.04% | 0.08% | 99% | 99% | 0.00% | -0.12% | -0.09% | 98% | 99% |
| 3-3.2.4 | 0.01% | 0.27% | 0.32% | 99% | 99% | 0.01% | 0.31% | 0.39% | 98% | 99% |
| 3-3.2.5 | 0.00% | 0.07% | 0.10% | 99% | 99% | 0.00% | -0.02% | -0.11% | 98% | 99% |

The proposals have a mixture of changes motivated by either coding efficiency or complexity reduction benefits. The test results basically do not show coding efficiency benefit.

It was agreed to focus on 3-3.2.5 as having the most complexity reduction benefit. This proposal introduces a different type of operation for small blocks.

It was noted that CCLM operation depends on a chroma location flag, and only one value of that flag is used in the CTC. The other value of the flag (indicating collocated chroma rather than vertically interstitial chroma) was not considered in this test.

It was commented that CCLM operation for small blocks is not really a problem that requires action.

Further discussed Thursday 1340 (GJS). The proposal skips some filtering. The CE only did this for small block sizes. Results were presented that included skipping the filtering for large blocks as well. It showed some loss. The proponent suggested changing other aspects to try to compensate for that loss. The filtering was proposed to be removed only for dual tree. It was commented that this would introduce an inconsistency in the single tree case.

Some participants said there is not really a problem in this area that requires a change.

Further study was requested (not in a CE).

[JVET-O0048](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6652) CE3: Simplification on Intra sub-partition coding mode (tests 3-1.2.1 and 3-1.2.2) [B. Wang, A. M. Kotra, S. Esenlik, H. Gao, E. Alshina (Huawei)]

[JVET-O0050](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6654) CE3-2.1.1 and CE3-2.1.2: Removing 2x2, 2x4, and 4x2 chroma CBs [Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek), Y. Zhao, H. Yang (Huawei)]

[JVET-O0080](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6684) CE3-1.1: CU-based prediction for 1xN and 2xN sub-partitions [K. Unno, K. Kawamura, S. Naito (KDDI)]

[JVET-O0088](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6692) CE3-3.1: Modified beta derivation for CCLM [M. Ikeda, T. Suzuki (Sony)]

[JVET-O0095](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6699) CE3-3.2: Simplified and robust CCLM parameter derivation [A. Filippov, V. Rufitskiy, E. Alshina (Huawei), C. Helmrich, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

[JVET-O0099](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6703) CE3-1.3: CU-level low latency intra sub-partitions for 4x8 and 8x4 CUs [H. Yang, Y. He, R. Vanam (InterDigital)]

[JVET-O0106](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6710) CE3-1.6: On 1xN and 2xN subblocks of ISP [A. K. Ramasubramonian, G. Van der Auwera, T. Hsieh, V. Seregin, L. Pham Van, M. Karczewicz (Qualcomm), S. De-Luxan Hernandez, B. Bross, T. Nguyen, V. George, B. Stabernack, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

[JVET-O0174](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6778) Crosscheck of JVET-O0106 (CE3-1.6: On 1xN and 2xN subblocks of ISP) [H. Yang (InterDigital)]

[JVET-O0107](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6711) CE3-1.7: On 1xN and 2xN subblocks of ISP with vertical intra mode restriction for 4xN vertically split ISP-coded blocks [A. K. Ramasubramonian, G. Van der Auwera, T. Hsieh, V. Seregin, L. Pham Van, M. Karczewicz (Qualcomm)]

[JVET-O0109](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6713) CE3-1.4: Intra Sub-Partitions Coding without Thin Partitions [T.-C. Ma, X. Xiu, Y.-W. Chen, X. Wang, H.-J. Jhu (Kwai Inc.)]

[JVET-O0118](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6722) CE3-2.2: Enabling parallel reconstruction of small intra-coded chroma blocks [L. Pham Van, G. Van der Auwera, A. K. Ramasubramonian, V. Seregin, H. Huang, T. Hsieh, M. Karczewicz (Qualcomm), Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O1147](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7784) Crosscheck of CE3-3.2.1 additional tests [S. Keating (Sony)]

## CE4: Inter prediction (8)

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

[JVET-O0024](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7289) CE4: Summary report on inter prediction [H. Yang, C.-C. Chen]

This contribution provides a summary report of Core Experiment 4 on inter prediction. This CE comprises 3 categories, as follows:

1. Switchable interpolation filter,
2. Affine motion compensation,
3. Combination of LIC and affine MC.

All techniques as planned in the context of CE4 are implemented on top of and tested against VTM-5.0. Simulation results and crosschecking reports of each test specified in this document are provided.

CE4-1: Switchable interpolation filter

Test specification

|  |  |  |
| --- | --- | --- |
| **Test #** | **Description** | **Source** |
| 4-1.1 | Additional half-pel AMVR mode only (for comparison purposes) | JVET-O0057 (HHI) |
| 4-1.2 | Test 1.1 + one alternative switchable luma half-pel interpolation filter, selected half-pel filter is propagated as part of the spatial merging candidate | JVET-O0057 (HHI) |
| 4-1.3 | Test 1.1 + two alternative switchable luma half-pel interpolation filters, selected half-pel filter is propagated as part of the spatial merging candidate | JVET-O0057 (HHI) |
| 4-1.4 | Test 1.2 without propagation of selected half-pel filter in merge mode | JVET-O0057 (HHI) |
| 4-1.5 | Test 1.3 without propagation of selected half-pel filter in merge mode | JVET-O0057 (HHI) |
| 4-1.6 | Test 1.2 with DMVR disabled for CUs using an alternative half-pel interpolation filter | JVET-O0057 (HHI) |
| 4-1.7 | Test 1.3 with DMVR disabled for CUs using an alternative half-pel interpolation filter | JVET-O0057 (HHI) |

Simulation results

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | | **Low delay B** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 4-1.1 | -0.05% | -0.12% | -0.16% | 103% | 100% | 0.01% | 0.04% | -0.26% | 103% | 100% |
| 4-1.2 | -0.26% | -0.81% | -0.84% | 101% | 99% | -0.10% | -0.02% | -0.27% | 103% | 100% |
| 4-1.3 | -0.34% | -0.98% | -0.93% | 104% | 99% | -0.12% | -0.03% | -0.05% | 106% | 99% |
| 4-1.4 | -0.12% | -0.63% | -0.53% | 102% | 99% | -0.06% | -0.04% | -0.09% | 103% | 99% |
| 4-1.5 | -0.18% | -0.70% | -0.69% | 105% | 100% | -0.04% | -0.12% | -0.23% | 108% | 101% |
| 4-1.6 | -0.26% | -0.85% | -0.85% | 102% | 99% | -0.10% | -0.02% | -0.27% | 103% | 100% |
| 4-1.7 | -0.33% | -0.94% | -0.90% | 105% | 99% | -0.12% | -0.03% | -0.05% | 106% | 99% |

Test 4/5 are same as 2/3, but no inheritance of filter in merge mode (i.e. no alternative filter is used in merge mode). Test 6/7 are same as 2/3, but DMVR is disabled. The results show that DMVR is not useful when the alternative filters are used. This test was requested in the last meeting. This however does not help the worst case complexity. Furthermore, it would require additional check beyond the value of the vector to be checked in DMVR.

The tool introduces an additional building block, the interpretation of MV is an extension of AMVR, and need to switch yet another interpolation filter (which has more smooth characteristics than the current half-pel filter). The best tradeoff is the solution with one filter, which can be interpreted as a straightforward extension of AMVR, wheras the choice of the second filter would need additional logic which is not there in the current decoder design, and it also increases the encoder search without giving much additional gain. From here, the solution 4-1.2 would be the best choice.

Decision: Adopt JVET-O0057 version 4-1.2 (note there was a last-minute software change which was suggested by the cross-checker to match the software with the text; it was later confirmed that the results indicate no change in average performance).

During follow-up consideration Tuesday 9 July afternoon it was clarified that there should not be a high level flag that specifically enables/disables half-pel in AMVR; when AMVR is enabled, it supports ¼, ½, full & 4 pel.

CE4-2: Affine motion compensationspecification

|  |  |  |
| --- | --- | --- |
| **Test #** | **Description** | **Source** |
| 4-2.1a | Prediction refinement with optical flow. The subblock size for affine motion compensation is 4x4 for both uni- and bi-prediction. | JVET-O0070 (InterDigital) |
| 4-2.1b\* | Prediction refinement with optical flow. The subblock size for affine motion compensation is 4x4 for uni-prediction and 8x8 for bi-prediction. | JVET-O0070 (InterDigital) |
| 4-2.1c\* | Prediction refinement with optical flow. The subblock size for affine motion compensation is 4x4 for uni-prediction with and 8x8 for bi-prediction. 8-tap interpolation filter is used for 8x8 subblocks. | JVET-O0070 (InterDigital) |
| 4-2.2a | Withdrawn |  |
| 4-2.2b | Withdrawn |  |
| 4-2.3a | Interweaved prediction for luma component. | JVET-O0069 (Bytedance) |
| 4-2.3b | Interweaved prediction for luma component with equal weighting values | JVET-O0069 (Bytedance) |
| 4-2.3c | Test 4-2.3a + 4-2.1a  PROF is applied on the two auxiliary prediction individually. | JVET-O0069 (Bytedance) |
| 4-2.3d | Test 4-2.3b + 4-2.1a  PROF is applied on the two auxiliary prediction individually. | JVET-O0069 (Bytedance) |
| 4-2.4a | Simplifications of interweaved affine motion compensation in test 4-2.3a, reusing bi-prediction processes. | JVET-O0082 (Tencent) |
| 4-2.4b | Simplifications of interweaved affine motion compensation in test 4-2.3b, reusing bi-prediction processes. | JVET-O0082 (Tencent) |
| 4-2.5a | Phase-variant affine MC. Up to 9 rows and 4 columns of MVx/MVy are derived. | JVET-O0051 (MediaTek) |
| 4-2.5c | Phase-variant affine MC. Test 4-2.5a with fallback mode disabled. | JVET-O0051 (MediaTek) |
| 4-2.5d\*\* | Phase-variant affine MC. The input reference samples of a 4x4 block is limited to be 9x9 square block. | JVET-O0051 (MediaTek) |
| 4-2.5e | Test 4-2.5a + 4-2.1a | JVET-O0051 (MediaTek) |
| \* The software of Test 4-2.1b/c was re-tagged after T3 to fix 2 bugs to make the software align itself with the planned CE descriptions of CE4-2.1b/c.  \*\* The software of Test 4-2.5d was re-tagged after T3 to remove one line of code that triggers compilation error due to an unused variable. | | |

Simulation results

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | | **Low delay B** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 4-2.1a | -0.48% | -0.09% | -0.07% | 101% | 100% | -0.32% | -0.04% | -0.37% | 102% | 100% |
| 4-2.1b | -0.40% | -0.02% | 0.02% | 100% | 101% | -0.27% | 0.02% | -0.21% | 101% | 100% |
| 4-2.1c | -0.46% | -0.05% | -0.06% | 100% | 100% | -0.35% | -0.06% | -0.21% | 101% | 100% |
| 4-2.3a | -0.32% | -0.06% | -0.05% | 100% | 100% | -0.14% | -0.02% | -0.26% | 103% | 100% |
| 4-2.3b | -0.29% | -0.03% | -0.07% | 101% | 101% | -0.10% | 0.08% | -0.26% | 103% | 100% |
| 4-2.3c | -0.53% | -0.10% | -0.05% | 103% | 101% | -0.34% | -0.25% | -0.18% | 105% | 102% |
| 4-2.3d | -0.54% | -0.09% | -0.05% | 103% | 102% | -0.33% | -0.13% | -0.25% | 106% | 103% |
| 4-2.4a | -0.32% | -0.05% | -0.03% | 105% | 102% | -0.11% | 0.00% | -0.17% | 108% | 104% |
| 4-2.4b | -0.28% | -0.09% | -0.07% | 106% | 102% | -0.15% | 0.06% | -0.18% | 108% | 103% |
| 4-2.5a | -0.39% | -0.51% | -0.50% | 101% | 99% | -0.18% | -0.16% | -0.22% | 101% | 99% |
| 4-2.5c | -0.36% | -0.48% | -0.53% | 104% | 99% | -0.15% | -0.17% | -0.69% | 108% | 104% |
| 4-2.5d | -0.38% | -0.50% | -0.56% | 102% | 100% | -0.21% | -0.19% | -0.30% | 103% | 101% |
| 4-2.5e | -0.59% | -0.47% | -0.47% | 103% | 100% | -0.38% | -0.31% | -0.56% | 105% | 105% |

4-2.1 uses PROF, which adds a value to the prediction of each sample that is determined from the optical flow equation and the gradient. This somehow mimics a pixel-wise MC without actually executing. In 4-2.1a, 4x4 subblocks are used for uni and bi pred, 4-2.1b/c uses 8x8 for bipred (where b uses 6-tap interpolation filters, whereas c uses 8-tap for 8x8 and 6-tap for 4x4 which is more consistent with the current VVC design). However, 4-2.1a is still more consistent with the current affine design, because that uses 4x4 subblocks for both uni and bi pred, which otherwise would need to be switched conditionally on PROF on or off.

4-2.3 uses interweaved prediction, which generates two predictions with two different blocks grids and averages them. 4-2.3a uses position-dependent weighting, 4-2.3b constant weighting. 4-2.3c/d are combining those with PROF, which shows that the gains are not additive. 4-2.4 re-uses the regular bi-prediction module which is only showing negligible difference.

4-2.5 uses phase-variant affine MC, which uses different filters for each line and for each column of the 4x4 block. There is a constraint in the variation of the phase, such that for a 4x4 block at most two more columns need to be fetched for performing the horizontal interpolation. For the vertical interpolation, padding is used. For 4-2.5d, padding is also used for horizontal interpolation, such that in this case the memory bandwidth is the same as in current affine MC. Additional loading of filter coefficients is needed for all cases of 4-2.5.

Whereas 4-2.1 and 4-2.3 require additional steps in generating the prediction signal, 4-2.5 has only one step for that.

Complexity analysis:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Test#** | **Number of mults** | **Number of adds** | **Number of shifts** | **Additional memory access** | **Additional local buffer** | **Others** |
| VTM-5.0 | 400/800 | 350/700 | 74/172 | 0 | 0 | Results are shown for uni/bi-prediction separately |
| 4-2.1a | 432/864 | 430/860 | 106/236 | 0 | 96/96 bytes | Delta MV: 4x4x2x1 = 32 bytes Gradient: 4x4x2x2 = 64 bytes  CU level delta MV calculations per reference picture for both uni and bi-prediction: 4x4x2 additions + 4x4x2 shifts + 4x4x2 clippings |
| 4-2.1b | 432/744 | 430/760 | 106/216 | 0 | 96/96 bytes | Delta MV: 4x4x2x1 = 32 bytes Gradient: 4x4x2x2 = 64 bytes  CU level delta MV calculations per reference picture for uni-prediction is the same as 4-2.1a.  CU level delta MV calculations per reference picture for bi-prediction: 8x8x2 additions + 8x8x2 shifts + 8x8x2 clippings. |
| 4-2.1c | 432/976 | 430/984 | 106/224 | 0 | 96/96 bytes | Same as 4-2.1b |
| 4-2.3a | 728 / 800 | 626 / 700 | 164 / 172 | 0 | 20 bytes / 0 |  |
| 4-2.3b | 712 / 800 | 626 / 700 | 164 / 172 | 0 | 20 bytes / 0 |  |
| 4-2.3c | 786/864 | 768/860 | 224/236 | 0 | 20 bytes / 0 |  |
| 4-2.3d | 760/864 | 768/860 | 224/236 | 0 | 20 bytes / 0 |  |
| 4-2.4a | 728 / 800 | 626 / 700 | 164 / 172 | 0 | 20 bytes / 0 |  |
| 4-2.4b | 712 / 800 | 626 / 700 | 164 / 172 | 0 | 20 bytes / 0 |  |
| 4-2.5a | 401.5/803 | 370/740 | 94/212 | 2\*(CU\_Height +L-1) samples for a CU | 28.125 bytes | 4x4-level: 20 “&” operation + 4-sapme of padding  CU-level: 12 adds  + 1 shift + 12 clipping + 2 absolute operation + 2 comparison |
| 4-2.5c | 401.5/803 | 370/740 | 94/212 | 2\*(CU\_Height +L-1) samples for a CU | 28.125 bytes | 4x4-level: 20 “&” operation + 4-sapme of padding  CU-level: 12 adds  + 1 shift + 12 clipping |
| 4-2.5d | 401.5/803 | 370/740 | 94/212 | 0 | 28.125 bytes | 4x4-level: 20 “&” operation + 13-sapme of padding  CU-level: 12 adds  + 1 shift + 12 clipping + 2 absolute operation + 2 comparison |
| 4-2.5e | 433.5/867 | 450/900 | 126/276 | 2\*(CU\_Height +L-1) samples for a CU | 28.125 bytes | 4x4-level: 20 “&” operation + 4-sapme of padding  CU-level: 12 adds  + 1 shift + 12 clipping + 2 absolute operation + 2 comparison |

In terms of results, the methods of 4-2.1 have best compression benefit, with marginal increase of encoding time. Due to the OF solution, it is however less regular than 4-2.3, which can better be parallelized. In terms of computations, neither of the methods is critical. An OF stage is already existing for BDOF, which is however a different one.

From the results of the CE, 4-2.1a is the most convincing solution.

Decision: Adopt JVET-O0070 method 4-2.1a. Appropriateness of text and matching with SW is confirmed by cross-checker. In the BoG report JVET-O1133, it is noted that the contribution JVET-O0594 points out a misalignment aspect between text and software.

It is pointed out that there are non-CE contributions which try to align the OF operations between PROF and BDOF. This would be desirable unless it reduces the compression gain unreasonably.

CE4-3: Combination of LIC and affine MC

Test specification

|  |  |  |
| --- | --- | --- |
| **Test #** | **Description** | **Source** |
| 4-3.1a | Unidirectional LIC with affine MC | JVET-O0066 (Qualcomm, MediaTek, Huawei) |
| 4-3.1b | Test 4-3.1a + encoder fast algorithm | JVET-O0066 (Qualcomm, MediaTek, Huawei) |
| 4-3.2a | Test 4-3.1a + min/max simplification | JVET-O0086 (Huawei) |
| 4-3.2b | Test 4-3.1b + min/max simplification | JVET-O0086 (Huawei) |

Simulation results

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | | **Low delay B** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 4-3.1a | -0.46% | -0.39% | -0.50% | 116% | 100% | -0.37% | 0.03% | -0.30% | 119% | 101% |
| 4-3.1b | -0.32% | -0.22% | -0.40% | 105% | 99% | -0.24% | -0.02% | -0.43% | 108% | 102% |
| 4-3.2a | -0.41% | -0.37% | -0.48% | 117% | 100% | -0.31% | -0.12% | -0.40% | 119% | 101% |
| 4-3.2b | -0.24% | -0.23% | -0.23% | 105% | 101% | -0.13% | -0.19% | -0.24% | 107% | 101% |

The promising gain reported in last meeting (about 0.7%) has dropped to around 0.45% (with approx. 15% encoder run time increase). This is likely due to the fact that the original proposal also used intra reconstruction for LIC (which was inhibited by purpose because it would additional dependencies between intra and inter processing pipelines). No good tradeoff performance versus complexity, also at the decoder the depedency from the neighbor inter reconstruction could be a new burden for parallel processing pipelines (though CIIP also has some similar dependency). No action.

The CE4 summary report also summarizes the CE related contributions. Two major topics are identified: Modifications in context of merge mode (approx. 60) and affine/LIC/BCW/MV coding (approx. 50). It is noted that in the latter category also coordination with CE9 is necessary for proposals that suggest aligning BDOF and PROF.

BoGs are mandated for a review to identify relevant contributions, identfy commonalities and suggest possible actions:

BoG (C,-C. Chen) on CE4 related contributions – merge modifications

BoG (H. Yang) on CE4 related contributions – general inter prediction

[JVET-O0051](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6655) CE4-2.5: Phase-variant affine MC [T.-D. Chuang, C.-Y. Lai, Z.-Y. Lin, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0901](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7523) Crosscheck of JVET-O0051 (CE4-2.5: Phase-variant affine MC) [H. Huang (Qualcomm)]

[JVET-O0057](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6661) CE4: Switchable interpolation filter [A. Henkel, I. Zupancic, B. Bross, M. Winken, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

Test 4-1.1, 4-1.2 and 4-1.3 in JVET-O0057 (HHI)

In JVET-N0309, a switched luma half-pel interpolation filter is proposed. The switching of the half-pel luma interpolation filter is done depending on the motion vector accuracy. In addition to the existing quarter-pel, full-pel, and 4-pel AMVR modes, a new half-pel accuracy AMVR mode is introduced. Only in case of half-pel motion vector accuracy, an alternative half-pel luma interpolation filter can be selected.

* **Half-pel AMVR mode:** An additional AMVR mode for non-affine non-merge inter-coded CUs is proposed which allows signaling of motion vector differences at half-pel accuracy. The existing AMVR scheme of the current VVC draft is extended straightforward in the following way: Directly following the syntax element amvr\_flag, if amvr\_flag == 1, there is a new context-modeled binary syntax element hpel\_amvr\_flag which indicates usage of the new half-pel AMVR mode if hpel\_amvr\_flag == 1. Otherwise, i.e. if hpel\_amvr\_flag == 0, the selection between full-pel and 4-pel AMVR mode is indicated by the syntax element amvr\_precision\_flag as in the current VVC draft.
* **Alternative luma half-pel interpolation filters:** In JVET-N0309, alternative luma half-pel interpolation filters are proposed. For a non-affine non-merge inter-coded CU which uses half-pel motion vector accuracy (i.e., the half-pel AMVR mode), an alternative luma half-pel interpolation filter is used. For test 4-1.2, one alternative luma half-pel interpolation filter is used. For test 4-1.3, a switching between two alternative half-pel interpolation filters is made based on the value of a new syntax element if\_idx. The syntax element if\_idx is only signaled in case of half-pel AMVR mode. In case of skip/merge mode using a spatial merging candidate, the information which interpolation filter is applied for the half-pel position is inherited from the neighbouring block.

Test 4-1.4 and 4-1.5 in JVET-O0057 (HHI)tests 4-1.4 and 4-1.5 correspond to tests 4-1.2 and 4-1.3, with the distinction that in tests 4-1.4 and 4-1.5 the information which interpolation filter is applied for the half-pel position is not inherited from the neighbouring block in case of skip/merge mode using a spatial merging candidate.

Test 4-1.6 and 4-1.7 in JVET-O0057 (HHI)tests 4-1.6 and 4-1.7 correspond to tests 4-1.2 and 4-1.3, with the distinction that in tests 4-1.6 and 4-1.7 the DMVR process is not applied to CUs which are encoded in spatial skip/merge mode and which have inherited the information from the neighbouring block that an alternative interpolation filter is applied for the half-pel position.

[JVET-O0066](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6670) CE4-3.1a and CE4-3.1b: Unidirectional local illumination compensation with affine prediction [V. Seregin, W.-J. Chien, T. Hsieh, N. Hu, M. Karczewicz (Qualcomm), C.-M. Tsai, C.-C. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek), H. Chen, X. Ma, H. Yang (Huawei)]

[JVET-O0069](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6673) CE4-2.3: Interweaved Prediction for Affine Motion Compensation [K. Zhang, L. Zhang, H. Liu, J. Xu, Y. Wang (Bytedance)]

[JVET-O0070](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6674) CE4-2.1: Prediction refinement with optical flow for affine mode [J. Luo, Y. He (InterDigital)]

[JVET-O0082](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6686) CE4-2.4: Simplifications of interweaved affine mode [G. Li, X. Li, X. Xu, S. Liu (Tencent)]

[JVET-O0086](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6690) CE4-3.2a and CE4-3.2b: Unidirectional local illumination compensation with affine prediction and simplified linear model parameter derivation based on min / max method [A. Filippov, V. Rufitskiy, E. Alshina (Huawei)]

[JVET-O0890](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7512) Crosscheck of JVETO0086 (CE4-3.2a and CE4-3.2b: Unidirectional local illumination compensation with affine prediction and simplified linear model parameter derivation based on min / max method) [F. Henry (Orange), G. Clare (bcom)]

## CE5: Loop filtering (7)

Contributions in this category were discussed Thursday 4 July 0900–XXXX in Track B (chaired by JRO).

[JVET-O0025](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7295) CE5: Summary Report on Loop Filtering [A. Norkin, C.-Y. Chen]

This document provides a summary report of Core Experiment 5 on Loop Filtering. There are two categories of the tests: deblocking filter (CE5-1, CE5-2, and CE5-3) and adaptive loop filter (CE5-4). The subjective testing for the deblocking filter category 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-5.0. Configurations and test conditions in JVET-N1010 [1] for SDR sequences are used. Results for additional configuration with ALF turned off are also reported. For the subjective viewing of deblocking proposals, additional encodes with different QPs have been generated, including two sequences in 4:4:4 chroma format.

CE5-1 Sub-PU deblocking and longer tap filter

Proposal in this sub-CE investigate changes to sub-PU deblocking and longer deblocking filter of VVC.

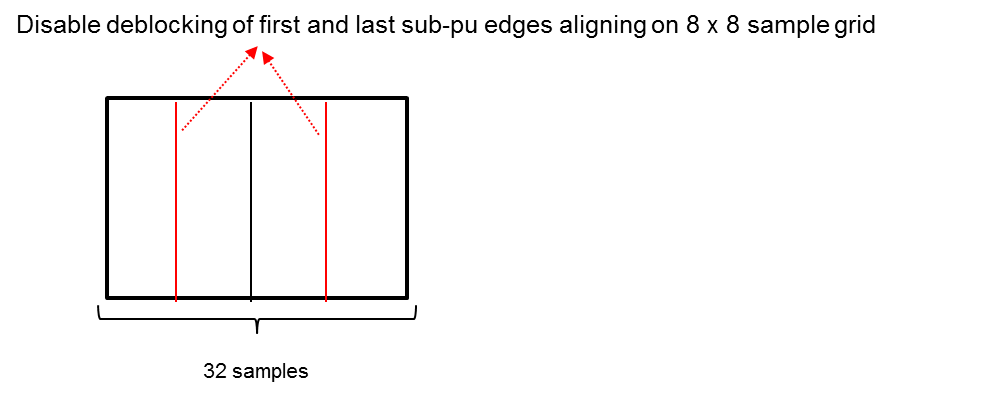
|  |  |  |
| --- | --- | --- |
| **Test** | **Proponent(s)** | **Cross-checker(s)** |
| CE5-1.1 | Anand Meher Kotra [Anand.meher.kotra@huawei.com](mailto:Anand.meher.kotra@huawei.com)  [JVET-O0083](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6687) | Chia-Ming Tsai  [chia-ming.tsai@mediatek.com](mailto:chia-ming.tsai@mediatek.com) |

*CE5-1.1: Modification of sub-PU deblocking and longer tap filter* [JVET-O0083](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6687)

This test proposes two modifications to the current deblocking filter design in VTM.

The first modification disables application of longer tap filter for implicit TU boundaries.

The second modification disables the filtering for first and last sub-PU edges for a block which uses sub-PU tools. This reportedly has an effect that the longer tap filter can directly be applied to the coding unit edge without any further checks.



The target of this proposal is simplification, in particular avoiding switching between different tap numbers for the long filters under certain conditions.

Some concern is expressed that this might cause artifacts under certain conditions (for both modifications). Two questions arise:

- Is the current switching to a 5-tap filter critical in terms of complexity, i.e. how large is the benefit of simplification?

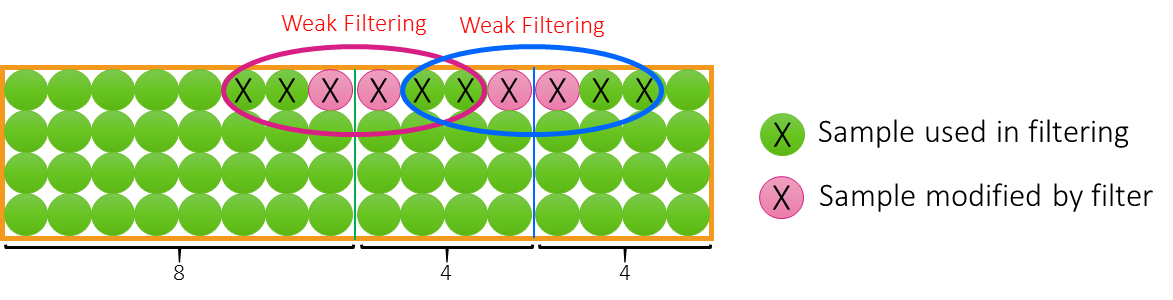
- How useful would a subjective test be, when it only happens rarely with the current test material?

From the discussion, it appears that in general the experts don’t believe that there is a serious complexity problem with the longer tap deblocking filters. The specific switching is necessary to support parallelism which is of prior importance, and the suggested changes would not provide a big benefit in reducing implementation complexity, whereas some concern exists that it might cause artifacts for some specific partitioning cases. More discussion is needed under which circumstances we would like to change the current design (after it had been clearly proven that the longer filters have subjective benefit). Some experts express that such changes should be considered extremely carefully, as deblocking has evolved as proven concept where it is sometimes difficult to foresee how small changes may impact other cases that are not commonly tested in CTC. Proof of “no subjective loss” with the current test material may not be sufficient, if the special cases don’t occur frequently. No action on this specific proposal.

CE5-2 Deblocking at 4x4 block boundaries

|  |  |  |
| --- | --- | --- |
| **Test** | **Proponent(s)** | **Cross-checker(s)** |
| CE5-2.1  (without chroma) | Kenneth Andersson [kenneth.r.andersson@ericsson.com](mailto:kenneth.r.andersson@ericsson.com)  Anand Meher Kotra [Anand.meher.kotra@huawei.com](mailto:Anand.meher.kotra@huawei.com)  Chia-Ming Tsai  [chia-ming.tsai@mediatek.com](mailto:chia-ming.tsai@mediatek.com)  [JVET-O0060](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6664) | Hyeongmun Jang  [hm.jang@lge.com](mailto:hm.jang@lge.com) |
| CE5-2.2 (with chroma) | Kenneth Andersson [kenneth.r.andersson@ericsson.com](mailto:kenneth.r.andersson@ericsson.com)  Anand Meher Kotra [Anand.meher.kotra@huawei.com](mailto:Anand.meher.kotra@huawei.com)  Chia-Ming Tsai  [chia-ming.tsai@mediatek.com](mailto:chia-ming.tsai@mediatek.com)  [JVET-O0060](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6664) | Hyeongmun Jang  [hm.jang@lge.com](mailto:hm.jang@lge.com) |
| CE5-2.3 (without chroma) | Hyeongmun Jang  [hm.jang@lge.com](mailto:hm.jang@lge.com)  [JVET-O0091](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6695) | Kenneth Andersson [kenneth.r.andersson@ericsson.com](mailto:kenneth.r.andersson@ericsson.com) |
| CE5-2.4 (with chroma) | Hyeongmun Jang  [hm.jang@lge.com](mailto:hm.jang@lge.com)  [JVET-O0091](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6695) | Kenneth Andersson [kenneth.r.andersson@ericsson.com](mailto:kenneth.r.andersson@ericsson.com) |
| CE5-2.5 Chroma on 4x4 chroma grid | Hyeongmun Jang  [hm.jang@lge.com](mailto:hm.jang@lge.com)  [JVET-O0092](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6696) | Misra Kiran  [misrak@sharplabs.com](mailto:misrak@sharplabs.com) |

*CE5-2.1* Deblocking for 4xN, Nx4, 8xN and Nx8 blocks [JVET-O0060](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6664)



As shown in the figure above, the proposed method enforces the Luma weak filter with one or no sample modification, when any of the blocks sharing the edge has a size of 4 samples (i.e. width = 4 samples for vertical edge, height = 4 samples for horizontal edge).

The different steps performed for a vertical edge are illustrated below:

* Check if filter on/off condition is evaluated to true i.e. d < *Beta*, where d = d0 + d3 and d0 = dp0 + dq0 and d3= dp3 + dq3) is evaluated to true for the respective edge. If true then
* Check if the one of the blocks has a block width of 4 samples, if true, then
* Enforce weak filter with maximum one sample modification. Therefore the following condition is checked, and if the condition is evaluated to true, then samples and are modified, otherwise no filtering is applied.

*CE5-2.2* Deblocking for 4xN, Nx4, 8xN and Nx8 blocks [JVET-O0060](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6664)

This test would check the CE5-2.1 + chroma deblocking performed on the 4x4 chroma grid.

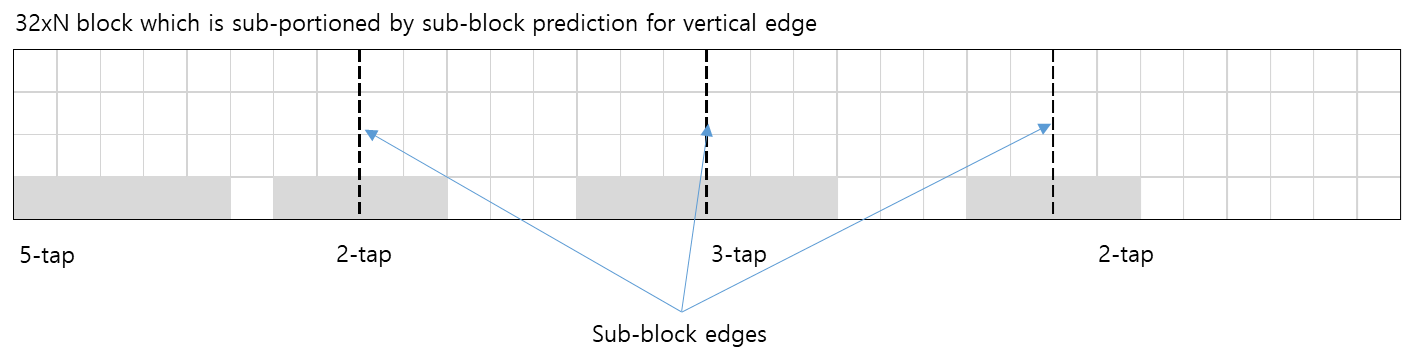
*CE5-2.3* Parallel deblocking filter [JVET-O0091](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6695)

Deblocking filter can be processed in parallel because it is not applied to 4x4 TU and PU boundaries. Within this CE, the performance of the parallel deblocking method described in JVET-D0044 is studied in terms of subjective quality and computational complexity. Chroma deblocking is performed in the same way as in the current deblocking. [Cross-checker points out that chroma is also modified and may be filtered more often, e.g. if at an 8x8 chroma position a 4xN or Nx4 block boundary exists, see cross-checkers notes]

Filter length decision process for luma is as follows:

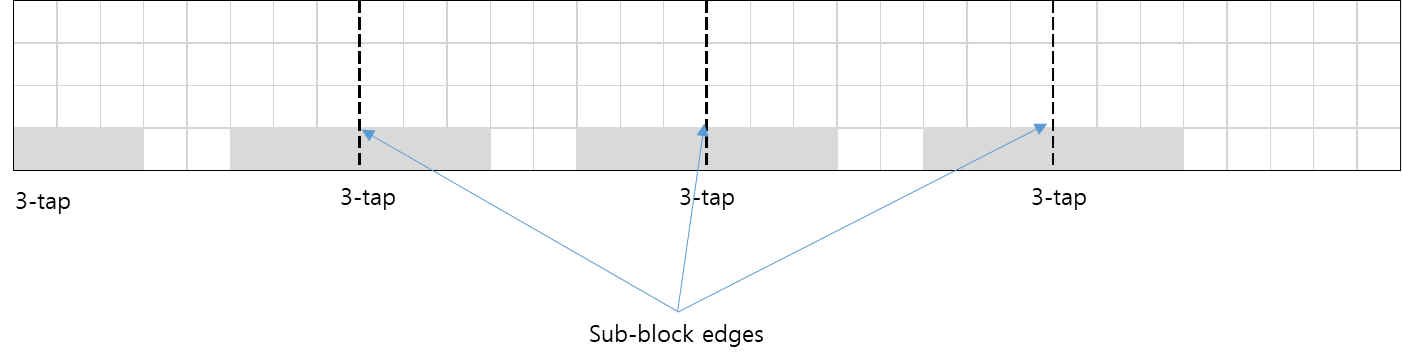
* If the distance of Q side is smaller than or equal to 4, filter length is set equal to 0.
* Otherwise, if the distance of the each side is smaller than or equal to 8, filter length is equal to 3.
* Otherwise if the distance of the each side is smaller than or equal to 16, filter length is equal to 5.
* Otherwise, filter length is set equal to 7.

In the proposal, different filter lengths than in VTM5.0 be derived in some cases as shown in the example below.



Example filter length for VTM-5.0 (different filter lengths).

The filter length of the proposed method is only decided based on the distance between neighboring blocks as shown in the figure below.



Same filter length for blocks of the same size by the proposed method.

For the latter change, some concern is expressed that the change of the long filter at the left might have subjective impact under certain cases (similar arguments as made on CE5-1.2).

Due to the fact that various modifications are combined, it might be difficult to identify what the individual impacts are.

*CE5-2.4* Parallel deblocking filter [JVET-O0091](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6695)

This test study the CE5-2.3 + some more chroma deblocking changes as in JVET-N0463.

* If the distance of Q side is smaller than or equal to 2, filter length is set equal to 0
* Otherwise, if the distance of the each side is smaller than or equal to 4, filter length is set equal to 1.
* Otherwise, filter length is set equal to 3.

To support various color formats, distance condition for filter length decision is adaptively applied. For example, chroma filter length decision for 4:4:4 chroma format is applied as bellow.

* If the distance of Q side is smaller than or equal to 4, filter length is set equal to 0
* Otherwise, if the distance of the each side is smaller than or equal to 8, filter length is equal to 1.
* Otherwise, filter length is set equal to 3.

*CE5-2.5* Deblocking chroma on 4x4 chroma grid [JVET-O0092](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6696)

Chroma deblocking is performed on the 4x4 chroma grid (current VTM chroma deblocking is done on the 8x8 chroma grid).

In this proposal, three parts are modified compared with deblocking filtering of VTM-5.0.

1. Enable filtering for chroma sub-pu edge.
2. Enable filtering for chroma edge whose boundary strength is not 0.
3. Perform filtering on 4x4 chroma sample grid.

Reportedly, filtering process is applied at edges which are aligned with 8x8 grid for luma and edges which are aligned with 4x4 grid for chroma component, which makes filtering process aligned between luma and chroma component for 4:2:0 format.

This is conceptually similar to the chroma deblocking of CE5-2.2, but uses the VTM5 luma deblocking. THis way, it may be concluded from here what the standalone benefit of 4x4 chroma deblocking is. Some implementation details (e.g. BS condition, and choice of weak/strong filter) may be different from the method of CE5-2.2

CE5-3 MV difference threshold in deblocking decisions

|  |  |  |
| --- | --- | --- |
| **Test** | **Proponent(s)** | **Cross-checker(s)** |
| CE5-3.1 | Kenneth Andersson  [kenneth.r.andersson@ericsson.com](mailto:kenneth.r.andersson@ericsson.com)  [JVET-O0061](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6665) | Chia-Ming Tsai  [chia-ming.tsai@mediatek.com](mailto:chia-ming.tsai@mediatek.com) |

*CE5-3.1 Sub-sample MV threshold for* deblocking *decisions* [JVET-O0061](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6665)

It has been shown in JVET-N0359 that block artifacts can occur between two blocks for a magnitude difference in horizontal or vertical motion vector component smaller than one luma sample.

The test investigates the effect of different sub-sample thresholds in deblocking decisions. It is proposed to set the MV component difference threshold for determination of boundary strength to 2 in units of quarter luma samples to enable more efficient reduction of blocking artifacts.

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 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | N |
| CE5-2.1 | All 4x4: 1+1 | All 4x4: 3+3 | All 4x4: 16 (6/2/5/3) | All 4x4: 4 (6/2/5/3)/4 | ~4 + 1.1875= 5.1875 | All 4x4: 4.75 (2.1875/0.5/1.5625/0.5) | same as VTM-5.0 | N |
| CE5-2.2 | All 4x4: 1+1 | All 4x4: 3+3 | All 4x4: 16 (6/2/5/3) | All 4x4: 4 (6/2/5/3)/4 | ~4 + 1.1875= 5.1875 | All 4x4: 4.75 (2.1875/0.5/1.5625/0.5) | same as VTM-5.0 | N |
| CE5-2.3 | All 4x4: 0 Other : same as VTM-5.0 | All 4x4: 0 Other : same as VTM-5.0 | All 4x4: 0 Other : same as VTM-5.0 | All 4x4: 0 Other : same as VTM-5.0 | All 4x4 : 0 Other : same as VTM-5.0 | All 4x4 : 0 Other : same as VTM-5.0 | same as VTM-5.0 | N |
| CE5-2.4 | All 4x4: 0 Other : same as VTM-5.0 | All 4x4 : 0 Other : same as VTM-5.0 | All 4x4 : 0 Other : same as VTM-5.0 | All 4x4 : 0 Other : same as VTM-5.0 | All 4x4 : 0 Other : same as VTM-5.0 | All 4x4 : 0 Other : same as VTM-5.0 | same as VTM-5.0 | N |
| CE5-2.5 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | N |
| CE5-3.1 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | 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 | longer tap filters on 7 + 7, 3 + 7 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 |  | same as VTM-5.0 |
| CE5-2.1 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | N |
| CE5-2.2 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | N |
| CE5-2.3 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | N |
| CE5-2.4 | all 2x2 : 0 same as VTM-5.0 | all 2x2 : 0 same as VTM-5.0 | all 2x2 : 0 same as VTM-5.0 | all 2x2 : 0 same as VTM-5.0 | all 2x2 : 0 same as VTM-5.0 | all 2x2 : 0 same as VTM-5.0 | same as VTM-5.0 | N |
| CE5-2.5 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | N |
| CE5-3.1 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | same as VTM-5.0 | N |

Subjective tests on CE5-2: Cactus, Christen&Sara, Kayak, FourPeople, Kimono444, LupoCandle444. QP32 and 37

Subjective tests on CE5-3: Foodmarket, Campfire, Cactus, Christen&Sara, Kayak, Johnny. QP32 and 37

Mathias and Kenneth will set up the test equipment. Minimum of 12 experts needed for around 2.5 hrs.

Tests should be run with ALF-on

[JVET-O1118](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7755) Core Experiment Viewing Test Procedure and Results [M. Wien]

Tests on 5-2 and 5-3 were reported Sat. 6 July 1745-1830

CE5-3.1:

* One case (Campfire) where for QP 37 confidence interval indicates slightly better quality
* Three more cases (Foodmarket, Cactus, Redkayak) where for QP37 the zero line is close to the edge of the confidence interval
* One case (Kristen and Sara) where for QP32 the mean is at approx. -0.4, but with large confidence interval, edge clearly above zero

As a conclusion, the method does not harm the quality, but by tendency slightly increases quality in up to 4 out of 6 sequences for QP37

The suggested change is straightforward (replaces threshold 1 by ½)

Decision: Adopt JVET-O0061

CE5-2:

* Only 12 participants in the test
* Confidence intervals by tendency larger, even though it could be possible to read the results such that deblocking is needed at more granular level
* Another round of tests to be run with 6 additional experts

Results based on a group of 18 experts were presented Sun 7 July 1430

The following observations were made:

* According to the test coordinator the Lupo sequence might not be optimum to look at due to the very fast motion, whereas block artifacts could appear mostly in the background.
* For chroma, no action is necessary. CE5-2.5 which only modifies chroma deblocking on a finer grid is in terms of significance intervals never better than VTM anchor, in one case worse. Also CE5-2.2 which is the same as CE5-2.1 but with additional finer grid of chroma deblock is often worse than the luma-only change.
* For luma, both 5-2.1/5-2.3 which both exclusively/mainly target luma deblocking on a finer grid show some tendency for improvement over the VTM anchor.
  + 5-2.1 has 3 cases where it is significantly (statistically proven) better, 2 cases where the edge of the confidence interval is almost touching the 0 line towards the better. 1 case is worse than the anchor, but this is the Lupo sequence.
  + 5-2.3 has 1 case where it is significantly (statistically proven) better, 3 cases where the edge of the confidence interval is almost touching the 0 line towards the better (one of which is Lupo).

As a conclusion, there seems to be need for action. It is however difficult to decide from the visual results which of the two is better. Therefore, technical/complexity analysis is needed.

Luma deblocking complexity of the two proposals

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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)** |
| CE5-2.1 | All 4x4: 1+1 | All 4x4: 3+3 | All 4x4: 16 (6/2/5/3) | All 4x4: 4 (6/2/5/3)/4 | ~4 + 1.1875= 5.1875 | All 4x4: 4.75 (2.1875/0.5/1.5625/0.5) | same as VTM-5.0 | N |
| CE5-2.3 | All 4x4: 0 Other : same as VTM-5.0 | All 4x4: 0 Other : same as VTM-5.0 | All 4x4: 0 Other : same as VTM-5.0 | All 4x4: 0 Other : same as VTM-5.0 | All 4x4 : 0 Other : same as VTM-5.0 | All 4x4 : 0 Other : same as VTM-5.0 | same as VTM-5.0 | N |

In terms of pixel processing, there should be no problem.

It is noted that already the current VTM requires substantial checking of conditions to determine the appropriate type of pixel processing.

More analysis to be performed on the additional amount of comparisons that is needed per edge/per pixel to determine the way of pixel processing, also in comparison with the current VTM.

Proponents are also asked to send the software to M. Zhou for some more complexity insight.

The analysis was provided in an update of the CE summary document (JVET-O0025v6). A complexity analysis has been done comparing the decision complexity of the CE5-2.1 and CE5-2.3. This was done on the request when discussing the deblocking CE proposals. The worst case for the number of decisions has been identified for VTM5.0 and two proposals for both luma and chroma components.

Luma decision complexity

The worst case in the possible number of decisions per block boundary for all three approaches if the 128x128 CTU split into 8x8 CUs. The numbers are given for 4 sample segment of the block boundary (two 4-line segments of the block boundary in case of CE5-2.1 and CE5-2.3).

|  |  |  |  |
| --- | --- | --- | --- |
| Codec | VTM5.0 | CE5-2.1 | CE5-2.3 |
| Decisions  (number of checks in brackets) | 1. 8x8 grid (1) 2. TrSize P >= 32 (1) 3. TrSize Q >= 32 (1) 4. SubBlocks on P (1) 5. SubBlocks on Q (1) 6. Filter on/off (1) 7. Strong/Weak (3) 8. Filter off (1) 9. 1 or 2 samples (2) | 1. Side Q <= 4 (1) 2. Side P <= 4 (1) 3. VTM checks (12) 4. 4x4 grid (1) 5. 4x4 grid Q<=4 (1) 6. 4x4 grid P<=4 (1) | 1. 8x8 grid (1) 2. Q side == 4 (1) 3. Q side >= 8 (1) 4. P side >= 8 (1) 5. 4x4 grid (1) 6. SubBlocks on P (1) 7. SubBlocks on Q (1) 8. Filter on/off (1) 9. Strong/Weak (3) 10. Filter off (1) 11. 1 or 2 samples (2) 12. Q side (4x4) == 4 (1) |
| Checks Total | 12 checks / edge | 17 checks / 2 edges  (operating on two edges:  14 checks / 2 edges) | 15 checks / 2 edges  (operating on two edges:  13 checks / 2 edges) |

Chroma decision complexity

The worst case in the possible number of decisions per block boundary for all three approaches is when there are 8x8 chroma blocks (in chroma samples). The numbers are given for a 4 sample segment of the block boundary.

|  |  |  |  |
| --- | --- | --- | --- |
| Codec | VTM5.0 | CE5-2.1 | CE5-2.3 |
| Decisions  (number of checks in brackets) | 1. 8x8 grid (1) 2. TrSize P >= 8 (1) 3. TrSize Q >= 8 (1) 4. Bs check (2) 5. Filt on / off (1) 6. Strong/Weak (3) | 1. VTM checks (9) | 1. 8x8 grid edge (1) 2. Bs check (1) 3. Q side == 4 (1) 4. Q side >= 8 (1) 5. P side >= 8 (1) 6. Filter on/off (1) 7. Strong/Weak (3) |
| Checks Total | 9 checks / edge | 9 checks / edge | 9 checks / edge |

From hardware perspective, a configuration with only 8x8 blocks is without doubt the worst complexity case in terms of number of checks. This worst case complexity is not reduced by any of the two proposals. Among the two proposals, 5-2.3 would be somewhat simpler than 5-2.1. Nevertheless, both are implementable, so the subjective quality should be highest priority.

A non-proponent points out that the changes that are made in 5-2.3 regarding the filter at edges of large transform blocks might be critical.

In terms of number of cases better than the anchor, 5-2.1 has slight advantage.

Decision: Adopt JVET-O0060, solution 5-2.1.

CE5-4 Adaptive loop filter [JVET-O0090](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6694)

In the JVET-N0415 proposal, which was adopted for VTM5.0, ALF process can now either use filter sets of previously received APS (temporal filter sets) or use predefined luma filter sets. However it is not possible to signal more than one new luma filter set in a given APS. In ALF tool, the filter coefficients of one new luma filter set can be predicted by using the coefficients of one of the predefined luma filter set. For chroma filter, it is possible to choose one temporal filter or signaling one new filter, but it is not possible to switch between chroma filters at CTU level.

In JVET-N0243, alternative luma filter sets are signaled at tile group level, so that more than one luma filter set can be signaled at once per tile group (i.e. they could be put in a same APS). JVET-N0243 also contained some syntax reduction mechanism that enables to further merge filter indexes between successive filter sets. Filters from different filter sets defined at tile group level can be mixed in a CTU specific filter set, through an additional signaling in the CTU data that enables to indicate an alternative luma filter set index for each luma filter index.

In JVET-N0243, alternative chroma filters can be also signaled at tile group level, so that more than one chroma filter can be signaled at once per tile group (i.e. they could be put in the same APS). One alternative chroma filter can be thus selected per chroma component and per CTU through an additional signaling in the CTU data that enables to indicate one alternative chroma filter index per chroma component processed by ALF.

In JVET-N0243, there are no pre-trained fixed filter sets, nor temporal filter sets, which are introduced in VTM5.0 with adoption of JVET-N0415. The following tests would allow clarifying gains of each sub-tool of JVET-N0243 and their potential overlap with adopted JVET-N0415.

Five tests were planned to be performed (according to the CE5 description).

1. CE5-4.1 will provide results of mixing different luma filters at CTU level coming from the different filters signaled in the APS(s).
2. CE5-4.2 will provide results when enabling the signaling of additional luma filter sets in APS.
3. CE5-4.3 will provide combined results of CE5-4.1 and CE5-4.2.
4. CE5-4.4 will provide results when enabling alternative chroma filters in VTM5.0 at CTU level.
5. CE5-4.5 will provide results of the combination of tests CE5-4.1, CE5-4.2 and CE5-4.4.

In the final CE5-4 results, the proponents of CE5-4 decided to withdraw the CE5-4.1 and CE5-4.3 tests. Accordingly, the tests CE5-4.2, CE5-4.4 and CE5-4.5 were renamed are CE5-4.1, CE5-4.2 and CE5-4.3. The following names and subtests are reported in this summary report.

The proposed modifications are summarized in the following.

CE5-4.1:

1. Allow one additional luma filters set in one APS   
   (totally up to two luma filter sets in one APS)
2. Signal the filter selection from different luma filter sets in one APS for each class at CTB level

CE5-4.2:

1. Allow at most seven additional chroma filters in one APS   
   (totally up to eight chroma filters in one APS)
2. Signal the filter selection from different chroma filters in one APS for each chroma component at CTB level

CE5-4.3:

1. The combination of CE5-4.1 + CE5-4.2

|  |  |  |  |
| --- | --- | --- | --- |
| **Test** | **Description** | **Tester** | **Cross-checker** |
| CE5-4.1 | VTM5.0 + additional luma filter sets signalled in APS [JVET-O0090](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6694) | Canon | Nan Hu  [nanh@qti.qualcomm.com](file:///C:\Users\ohm\AppData\Local\Temp\nanh@qti.qualcomm.com) |
| CE5-4.2 | VTM5.0 + alternative chroma filters + CTU chroma filter selection [JVET-O0090](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6694) | Canon | Nan Hu  [nanh@qti.qualcomm.com](file:///C:\Users\ohm\AppData\Local\Temp\nanh@qti.qualcomm.com) |
| CE5-4.3 | Combination of test 5-4.3 and 5-4.4 [JVET-O0090](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6694) | Canon | Nan Hu  [nanh@qti.qualcomm.com](file:///C:\Users\ohm\AppData\Local\Temp\nanh@qti.qualcomm.com) |

Results:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | **Random Access** | | | | | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | | **DecT** | **Y** | | **U** | | **V** | | **EncT** | | **DecT** |
| CE5-4.1 | 0.01 | 0.00 | -0.01 | 101% | 98% | | -0.08 | 0.09 | | 0.06 | | 101% | | 101% | |
| CE5-4.2 | 0.08 | -0.88 | -1.23 | 100% | 99% | | 0.09 | -1.96 | | -2.36 | | 100% | | 100% | |
| CE5-4.3 | 0.08 | -0.88 | -1.23 | 100% | 100% | | 0.01 | -1.91 | | -2.28 | | 101% | | 100% | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low Delay B** | | | | | | | | | **Low Delay P** | | | | | | | | |
| **Test#** | **Y** | | **U** | | **V** | | **EncT** | | **DecT** | **Y** | | **U** | | **V** | | **EncT** | | **DecT** |
| CE5-4.1 | -0.15 | 0.28 | | 0.04 | | 104% | | 98% | | -0.19 | 0.26 | | 0.04 | | 105% | | 100% | |
| CE5-4.2 | 0.08 | -2.43 | | -2.78 | | 101% | | 100% | | 0.04 | -2.33 | | -2.59 | | 100% | | 101% | |
| CE5-4.3 | -0.12 | -2.45 | | -2.64 | | 104% | | 100% | | -0.17 | -2.51 | | -2.62 | | 104% | | 99% | |

Complexity:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test #** | **Time complexity**  N = num. classes | **Filter sets** | **Filters storage (bits)** | **CTB level storage** |
| VTM5.0 |  |  | 3060 bits |  |
| CE5-4.1 | O (N) | x2 luma filter set | 6060 bits | 25 indices (1 bit each) |
| CE5-4.2 | O (1) | x8 chroma filter | 3480 bits | 2 indices (3 bits each) |
| CE5-4.3 | O (N) | x2 luma filter set +  x8 chroma filter | 6480 bits | 25 luma indices (1 bit each) + 2 indices (3 bits each) |

Filters are switched at CTU level. Having more choice of filters does not have much effect on luma (except for low delay). The benefit for chroma (5-4.2) is larger. Chroma filters are still not based on classification, only one filter is selected for each CTU. Also here, the additional need for storage is small.

It is noted that in the non-CE category there is no proposal that directly competes with the approach of improving chroma ALF by increasing the number of filters that can be selected at CTU level.

Decision: Adopt JVET-O0090 variant CE5-4.2. From the CE, the adoption relates to the desire of having a mechanism that allows adapting the chroma ALF at CTU level. The harmonization of the specific way of APS signalling with the overall APS concept shall be coordinated with HLS decisions (e.g. JVET-O0247 also suggests an APS modification with multiple chroma filter APSs aligned with luma). For the signalling method, see further notes under JVET-O0247.

[JVET-O0060](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6664) CE5-2.1 and CE5-2.2: Deblocking on 4x4 sample grids [K. Andersson, J. Enhorn, Z. Zhang, R. Sjöberg (Ericsson), A. M. Kotra, S. Esenlik, B. Wang, H. Gao, E. Alshina (Huawei), C.-M. Tsai, C.-W. Hsu, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0061](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6665) CE5-3.1 Sub-sample MV threshold for deblocking decisions [K. Andersson, J. Enhorn (Ericsson)]

[JVET-O0083](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6687) CE5-1.1: Modification of sub-pu deblocking and longer tap filter [A. M. Kotra, S. Esenlik, B. Wang, H. Gao, E. Alshina (Huawei)]

[JVET-O0090](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6694) CE5-4: alternative luma filter sets and alternative chroma filters for ALF [J. Taquet, P. Onno, C. Gisquet, G. Laroche (Canon)]

[JVET-O0091](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6695) CE5-2.3 and CE5-2.4: filter length decision which support parallel processing and aligned filtering block edge [H. Jang, J. Nam, N. Park, J. Lim, S. Kim (LGE)]

[JVET-O0092](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6696) CE5-2.5: De-block filtering with 4x4 chroma sample grid [H. Jang, J. Nam, N. Park, J. Lim, S. Kim (LGE)]

## CE6: Transforms and transform signalling (4)

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

[JVET-O0026](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7166) CE6: Summary Report on Transforms and Transform Signalling [X. Zhao, H.E. Egilmez]

This contribution was discussed Thursday 4 July 0900 (GJS)

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

(1) CE6-1: Primary transformation (10 tests)

(2) CE6-2: Secondary transformation (2 tests)

In this CE all experiments were done using based on the VTM-5.0 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-O0076 | MTS design with both encoder changes | C.-H. Hung (Qualcomm) | M. Siekmann  (HHI) |
| 6-1.1b | Both encoder changes | C.-H. Hung (Qualcomm) | M. Siekmann  (HHI) |
| 6-1.1c | Encoder change 1 only | C.-H. Hung (Qualcomm) | M. Siekmann  (HHI) |
| 6-1.1d | Encoder change 2 only | C.-H. Hung (Qualcomm) | M. Siekmann  (HHI) |
| 6-1.1e | MTS design without encoder changes | C.-H. Hung (Qualcomm) | M. Siekmann  (HHI) |
| 6-1.2a | JVET-O0062 | The sorting algorithm as proposed in JVET-N0491 based on the intra mode, compared against CTC anchor | C. Hollmann (Ericsson) | X. Zhao (Tencent) |
| 6-1.2b | The sorting algorithm without the described intra prediction mode dependency, compared against CTC anchor | C. Hollmann (Ericsson) | X. Zhao (Tencent) |
| 6-1.2c | Reducing the number of fully evaluated transform candidates to 2 without the sorting algorithm, compared against CTC anchor | C. Hollmann (Ericsson) | X. Zhao (Tencent) |
| 6-1.2d | Test CE6-1.2a versus test CE6-1.2c as an anchor (which uses 2 candidates) | C. Hollmann (Ericsson) | X. Zhao (Tencent) |
| 6-1.2e | Test CE6-1.2b versus test CE6-1.2c as an anchor (which uses 2 candidates) | C. Hollmann (Ericsson) | X. Zhao (Tencent) |
| 6-2.1a | JVET-O0094 | Simplification of the Reduced Secondary Transform using 48x16 RST matrices | M. Siekmann  (HHI) | C.-H. Hung (Qualcomm) |
| 6-2.1b | Simplification of the Reduced Secondary Transform using 64x16 RST matrices | M. Siekmann  (HHI) | C.-H. Hung (Qualcomm) |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | **Random Access** | | | | | **Low Delay B** | | | | |
| **Test #** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE6-1.1a | 0.00% | 0.00% | 0.01% | 104% | 101% | -0.01% | -0.07% | -0.04% | 102% | 102% | -0.03% | 0.29% | -0.05% | 100% | 99% |
| CE6-1.1b | 0.00% | 0.00% | 0.00% | 104% | 101% | 0.00% | 0.00% | 0.00% | 102% | 101% | 0.00% | 0.12% | 0.17% | 100% | 99% |
| CE6-1.1c | 0.24% | 0.11% | 0.22% | 96% | 101% | 0.14% | 0.23% | 0.21% | 96% | 101% | 0.01% | -0.02% | 0.10% | 100% | 100% |
| CE6-1.1d | 0.00% | 0.00% | 0.00% | 101% | 100% | 0.00% | 0.00% | 0.00% | 101% | 101% | -0.04% | 0.08% | 0.56% | 100% | 97% |
| CE6-1.1e | 0.00% | 0.00% | 0.01% | 101% | 100% | -0.01% | -0.07% | -0.04% | 101% | 101% | 0.03% | 0.07% | 0.26% | 100% | 99% |
| CE6-1.2a | 0.00% | -0.01% | 0.01% | 98% | 100% | 0.01% | -0.02% | -0.03% | 99% | 98% | 0.01% | 0.23% | -0.03% | 99% | 100% |
| CE6-1.2b | 0.00% | -0.01% | 0.00% | 100% | 101% | 0.00% | -0.05% | -0.07% | 98% | 95% | 0.05% | 0.12% | 0.17% | 98% | 100% |
| CE6-1.2c | 0.00% | -0.02% | 0.01% | 98% | 99% | 0.00% | -0.02% | -0.05% | 101% | 101% | 0.06% | -0.02% | 0.22% | 98% | 98% |
| CE6-2.1a | 0.06% | -0.02% | 0.05% | 90% | 99% | 0.02% | 0.01% | -0.01% | 97% | 100% |  |  |  |  |  |
| CE6-2.1b | 0.21% | 0.75% | 0.84% | 76% | 99% | 0.13% | 0.43% | 0.44% | 93% | 99% |  |  |  |  |  |

The following table summarizes the results of CE6-1.2d and CE6-1.2e tests using CTC configuration and CE6-1.2c as anchor, the test methods are CE6-1.2a and CE6-1.2b, respectively.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | **Random Access** | | | | | **Low Delay B** | | | | |
| **Test #** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE6-1.2d | 0.00% | 0.01% | 0.00% | 100% | 101% | 0.01% | 0.00% | 0.02% | 98% | 97% | -0.05% | 0.25% | -0.25% | 102% | 102% |
| CE6-1.2e | 0.00% | 0.01% | -0.01% | 102% | 101% | 0.00% | -0.03% | -0.02% | 97% | 94% | -0.01% | 0.14% | -0.04% | 100% | 103% |

The following table summarizes the results of CE6 tests using CTC configuration and VTM-5.0 with inter MTS enabled (--MTS=3) as anchor.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | | **Low Delay B** | | | | |
| **Test #** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE6-1.1a | 0.01% | 0.04% | 0.04% | 102% | 102% | -0.03% | -0.06% | 0.18% | 101% | 104% |
| CE6-1.1b | 0.00% | 0.00% | 0.00% | 101% | 101% | -0.03% | -0.03% | 0.11% | 100% | 105% |
| CE6-1.1c | 0.12% | 0.24% | 0.23% | 97% | 101% | 0.02% | 0.08% | 0.38% | 100% | 105% |
| CE6-1.1d | 0.00% | 0.00% | 0.00% | 101% | 102% | -0.05% | -0.05% | 0.39% | 101% | 104% |
| CE6-1.1e | 0.01% | 0.04% | 0.04% | 101% | 101% | 0.01% | -0.06% | 0.49% | 101% | 105% |
| CE6-1.2a |  |  |  |  |  |  |  |  |  |  |
| CE6-1.2b |  |  |  |  |  |  |  |  |  |  |
| CE6-1.2c |  |  |  |  |  |  |  |  |  |  |
| CE6-1.2d |  |  |  |  |  |  |  |  |  |  |
| CE6-1.2e |  |  |  |  |  |  |  |  |  |  |
| CE6-2.1a | 0.02% | 0.04% | 0.07% | 97% | 99% |  |  |  |  |  |
| CE6-2.1b | 0.14% | 0.50% | 0.53% | 93% | 100% |  |  |  |  |  |

The following table summarizes the results of CE6 tests using Low QP configuration and VTM-5.0, as specified in JVET-N1026.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | **Random Access** | | | | |
| **Test #** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE6-2.1a | 0.11% | 0.14% | 0.11% | 83% | 102% | 0.03% | 0.00% | 0.01% | 95% | 100% |
| CE6-2.1b | 0.12% | 0.18% | 0.18% | 67% | 98% | 0.04% | 0.00% | 0.04% | 84% | 98% |

The 6-1 category is for techniques trying to get coding gain. None of the methods seem to show compelling gain. It was commented that a change of the encoding search method that was adopted with the secondary transform may have had some effect on the coding gain that was observed.

For the 6-2 category:

* In VTM5, the secondary transform operates on an L-shaped area of 48 primary transform coefficients and produces a 4x4 region of potentially non-zero secondary transform coefficients (with zeroing out of the remaining 32 coefficients). The coefficients of the primary transform that are outside of the L-shaped 48-coefficient area may be nonzero. The VTM has two candidates for the secondary transform kernel, and the encoder needs to choose whether to use the secondary transform and which kernel to use.
* The benefit of having two candidate 48-coefficient secondary transform kernels rather than one 64-coefficient secondary transform kernel was said to be about 0.25% for AI (less for RA).
* The evaluated proposal is intended to have a cleaner design and some complexity reduction. It sets all coefficients outside of the 48-coefficient area to zero. As tested, it reduces encoder runtime. These proposals also eliminate a need to count nonzero coefficients in the decoding process. Variant 6-2.1a is otherwise basically the same as in the VTM, and variant 6-2.1b uses a single 64-coefficient secondary transform kernel. The 6-2.1b variant has less decoder memory (but more multiplies).
* It was commented that there is a pipeline problem, such that it is necessary to determine at the CU whether to apply the secondary transform or not, which requires excess data buffering for large CUs. This was said to be an orthogonal issue relative to this proposal.
* It was commented that there could be some subjective effect of zeroing out. This may be too small to measure, and it was commented that it is not clear whether such a subjective effect might be positive or negative.
* There were said to be some non-CE related proposals that affect some of this.

Decision (simplification): Adopt 6-2.1a from JVET-O0094.

Further study the need to have two selectable kernels.

The summary report also listed 50 related proposals in the following categories:

* Context reduction for transform signaling (10 Proposals)
* Simplification on LFNST (24 Proposals)
* Transform kernel selection (12 Proposals)
* Maximum TU size for chroma format 4:2:2 and 4:4:4 (1 proposal)
* Mismatch between text specification and reference software on MTS for IBC-coded block (1 proposal)
* Configurable maximum transform size (1 proposal)
* Modified DCT8/DST7 Transform Matrices for Faster Implementation (1 proposal)

[JVET-O0062](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6666) CE6-1.2 Transform Candidate Ordering [C. Hollmann, D. Saffar, P. Wennersten, J. Ström (Ericsson)]

[JVET-O0076](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6680) CE6-1.1: An Explicit MTS Design with Fast Encoder [C.-H. Hung, H. E. Egilmez, N. Hu, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-O0094](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6698) CE6-2.1: Simplification of Low Frequency Non-Separable Transform [M. Siekmann, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

## CE7: Quantization and coefficient coding (8)

[JVET-O0027](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6795) CE7: Summary report on quantization and coefficient coding [H. Schwarz, M. Coban]

This contribution was discussed Thursday 4 July 1100 (chaired by GJS).

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 topics of transform coefficient coding, joint chroma residual coding, transform skip residual coding, and CBF coding.

The purpose of this core experiment is to explore the coding efficiency and complexity impact of proposed algorithms for quantization and transform coefficient/residual coding.

The following tools were considered in this CE.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Proponent** | **Document** | **Tool description** |
| 1 | Mediatek | JVET-N0091 | TB-level constraints on context-coded bins for coefficient coding |
| 2 | Qualcomm | JVET-N0106 | TU-level limits on context-coded bins for coefficient coding |
| 3 | HHI | JVET-N0282 | Joint chroma residual coding with multiple modes |
| 4 | Qualcomm | JVET-N0347 | Joint coding of chroma residuals |
| 5 | Mediatek | JVET-N0094 | Context modelling of transform skip mode |
| 6 | HHI | JVET-N0357 | Context modelling of sign for TS residual coding |
| 7 | Tencent | JVET-N0366 | Modified limitation on context coded bins for TS residual coding |
| 8 | Qualcomm | JVET-N0455 | Sign context modelling and level mapping for TS residual coding |
| 9 | Kwai | JVET-N0326 | Simplification of cbf coding |

The following related contribution documents were submitted.

|  |  |  |
| --- | --- | --- |
| **document** | **authors** | **title** |
| JVET-O0052 | T.-D. Chuang, C.-Y. Chen, S.-T. Hsiang, Y.-W. Huang, S.-M. Lei (MediaTek), M. Coban, M. Karczewicz (Qualcomm) | CE7-1: TB-level constraints on context-coded bins for coefficient coding |
| JVET-O0089 | T. Nguyen, B. Bross, H. Schwarz., D. Marpe, T. Wiegand (HHI) | CE7-3.3/4: Context Modelling of sign for TS residual coding |
| JVET-O0104 | X. Zhao, X. Li, X. Xu, S. Liu (Tencent) | CE7: Modified limitation on context coded bins for residual coding of Transform Skip mode (CE7-3.5 and CE7-3.6) |
| JVET-O0105 | C. Helmrich, H. Schwarz, T. Nguyen, C. Rudat, D. Marpe, T. Wiegand (Fraunhofer HHI), B. Ray, G. Van der Auwera, A. K. Ramasubramonian, M. Coban, M. Karczewicz (Qualcomm) | CE7: Joint chroma residual coding with multiple modes (tests CE7-2.1, CE7-2.2) |
| JVET-O0110 | Y.-W. Chen, X. Xiu, T.-C. Ma, X. Wang (Kwai Inc.) | CE7-4.1: Simplification of cbf coding |
| JVET-O0115 | B. Ray, G. Van der Auwera, A. K. Ramasubramonian, M. Coban, M. Karczewicz (Qualcomm) | CE7-2.3: Joint coding of chroma residuals |
| JVET-O0122 | M. Karczewicz, H. Wang, M. Coban, Y.-H. Chao, Y. Han (Qualcomm) | CE7: Sign context, level mapping, and bitplane coding for TS residual coding (CE7-3.7, CE7-3.8, CE7-3.9, CE7-3.10, and CE7-3.11) |
|  | | |
| **CE related contributions (excluding crosschecks)** | | |
| JVET-O0068 | M. Zhou (Broadcom) | AHG16/Non-CE7: A study of bin to bit ratio for VTM5.0 |
| JVET-O0193 | Y. Zhao, H. Yang (Huawei) | CE7-related: Remove transform depth in cbf coding |
| JVET-O0223 | P. de Lagrange, F. Le Léannec, E. François, K. Naser (InterDigital) | Non-CE7: Quantization matrices with single identifier and prediction from larger ones |
| JVET-O0231 | S. Esenlik, Y. Zhao, A. M. Kotra, H. Gao, B. Wang, E. Alshina (Huawei) | Non-CE7: Modified chroma coded block flag signalling |
| JVET-O0295 | S.-T. Hsiang, S.-M. Lei (MediaTek) | CE7-related: Modified subblock coding passes for coding TS residual |
| JVET-O0375 | A. Nalci, H. E. Egilmez, A. Said, M. Coban, V. Seregin, M. Karczewicz (Qualcomm) | Non-CE7: A Simplified CBF Coding for Luma and Chroma |
| JVET-O0383 | T. Hashimoto, E. Sasaki, T. Chujoh, T. Ikai (Sharp) | Non-CE7: Harmonization of scaling matrix and LFNST |
| JVET-O0400 | J. Choi, S. Yoo, J. Heo, J. Choi, J. Lim, S. Kim (LGE) | CE7-related: Context-coded bin restriction |
| JVET-O0406 | Y. Kato, K. Abe, T.Toma (Panasonic) | Non-CE7: Unification of syntaxes after CCB count exceeds the maximum number between transform residual and transform skip residual |
| JVET-O0409 | Y. Kato, K. Abe, T. Toma (Panasonic) | Non-CE7: Unification of CCB count method between transform residual and transform skip residual |
| JVET-O0527 | P. de Lagrange, Y. Chen (InterDigital) | Non-CE7: Use INTER quantization matrices for IBC |
| JVET-O0543 | C. Helmrich, H. Schwarz, T. Nguyen, C. Rudat, D. Marpe, T. Wiegand (Fraunhofer HHI) | CE7-related: Alternative configuration for joint chroma residual coding |
| JVET-O0556 | M. Karczewicz, Y. Han, Y.-H. Chao, M. Coban (Qualcomm) | CE7-related: Alternative method to RDPCM with TS level mapping |
| JVET-O0557 | Y.-H. Chao, M. Coban, M. Karczewicz (Qualcomm) | Non-CE7: Context modeling unification in significant flag of coefficient group |
| JVET-O0558 | M. Karczewicz, Y.-H. Chao, H. Wang, M. Coban (Qualcomm) | CE7-related: Reduction of Gtx passes in transform skip residual coding |
| JVET-O0559 | M. Karczewicz, Y.-H. Chao, M. Coban (Qualcomm | CE7-related: QP dependent binarization in TS residual coding |
| JVET-O0575 | W. Zhu, L. Zhang, J. Xu, K. Zhang, H. Liu (Bytedance) | CE7-related: Reduction for Context Coded Bins in Transform Skip Mode |
| JVET-O0596 | X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.) | CE7-related: On chroma CBF signaling of subblock transform mode |
| JVET-O0613 | C. Auyeung, X. Li, S. Liu (Tencent) | CE7-related: Unification of Rice parameter tables in residual coding |
| JVET-O0617 | C. Auyeung, X. Zhao, X. Li, S. Liu (Tencent) | CE7-related: Context reduction of transform coefficient significance flag |
| JVET-O0619 | M. G. Sarwer, Y. Ye (Alibaba) | Non-CE7: Simplification of transform skip residual coding |
| JVET-O0623 | M. Karczewicz, H. Wang, M. Coban, Y.-H. Chao (Qualcomm) | CE7-related: Interleaved coefficient coding for transform-skip mode |
| JVET-O0670 | B. Ray, G. Van der Auwera, M. Karczewicz (Qualcomm) | CE7-related: Alternative joint coding of chroma residuals |
| JVET-O0928 | S.-T. Hsiang, S.-M. Lei (MediaTek) | CE7-related: Context reduction for entropy coding sig\_coeff\_flag |
| JVET-O0935 | C. Helmrich, H. Schwarz, T. Nguyen, C. Rudat, D. Marpe, T. Wiegand (Fraunhofer HHI, B. Ray, G. Van der Auwera, A. K. Ramasubramonian, M. Coban, M. Karczewicz (Qualcomm) | CE7-related: Alternative configuration of CE7-2.2 joint chroma residual coding |

**Category 1: Transform coefficient coding**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Tester** | **Tool** | **Cross checker** |
| CE7-1.1 | T.-D. Chuang, M. Coban (Mediatek / Qualcomm) | TB-level constraints on context-coded bins for coefficient coding based on the non-zero out region size of TB. | Yi-Wen Chen (Kwai) |
| CE7-1.2 | T.-D. Chuang, M. Coban (Mediatek / Qualcomm) | TB-level constraints on context-coded bins for coefficient coding based on the last coded subblock position (area covered in non-zero out region up to the last subblock position) of TB. | Yi-Wen Chen (Kwai) |

**Category 2: Joint chroma residual coding**

|  |  |  |  |
| --- | --- | --- | --- |
| CE7-2.1 | Christian Helmrich (HHI) | Joint chroma residual coding with multiple modes: JVET-N0282 configuration 1 (three modes with single chroma residual) | Ray Bappaditya (Qualcomm) |
| CE7-2.2 | Christian Helmrich (HHI / Qualcomm) | Joint chroma residual coding with multiple modes: JVET-N0282, configuration 2 (two modes with single chroma residual and one mode with Hadamard transform) | Jani Lainema (Nokia) |
| CE7-2.3 | Ray Bappaditya (Qualcomm) | Joint coding of chroma residuals: JVET-N0347 | Jani Lainema (Nokia) |

**Category 3: Transform skip residual coding**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Tester** | **Tool** | **Cross checker** |
| CE7-3.1 | [test withdrawn] | | |
| CE7-3.2 | [test withdrawn] | | |
| CE7-3.3 | Tung Nguyen (HHI) | Context modelling of sign for TS residual coding: Configuration as in JVET-N0357 | Muhammed Coban (Qualcomm) |
| CE7-3.4 | Tung Nguyen (HHI) | Context modelling of sign for TS residual coding: Alternative configuration using different parameters | Muhammed Coban (Qualcomm) |
| CE7-3.5 | Xin Zhao (Tencent) | Modified limitation on context coded bins for TS residual coding, parity flag signaled after gt2 flag and up to 8 contexts coded gt2 flags per coefficient | Yi-Wen Chen (Kwai) |
| CE7-3.6 | Xin Zhao (Tencent) | Modified limitation on context coded bins for TS residual coding, parity flag is bypass coded and signaled after gt2 flag, up to 8 contexts coded gt2 flags per coefficient | Yi-Wen Chen (Kwai) |
| CE7-3.7 | Muhammed Coban (Qualcomm) | Sign context for TS residual coding | Tung Nguyen (HHI) |
| CE7-3.8 | Muhammed Coban (Qualcomm) | Level mapping for TS residual coding | Tung Nguyen (HHI) |
| CE7-3.9 | Muhammed Coban (Qualcomm) | Bitplane coding for TS residual coding | Tung Nguyen (HHI) |
| CE7-3.10 | Muhammed Coban (Qualcomm) | Sign context and level mapping for TS residual coding | Tung Nguyen (HHI) |
| CE7-3.11 | Muhammed Coban (Qualcomm) | Sign context, level mapping, and bitplane coding for TS residual coding | Tung Nguyen (HHI) |

**Category 4: CBF coding**

|  |  |  |  |
| --- | --- | --- | --- |
| CE7-4.1 | Yi-Wen Chen (Kwai) | Two CABAC contexts could be utilized to coding the tu\_cbf\_luma and the context selection is derived based on trDepth | Guichun Li (Tencent) |

All proposals were integrated into the VTM-5 software (outcome of the Geneva meeting). Results were reported for the VTM-5 software and the common test conditions (standard configuration files).

All tools were tested against the VTM-5 anchor (same set of tools, except the tool to be tested).

Results were provided for two ranges of QP values:

* Standard QPs (37, 32, 27, 22): AI, RA, and LD configurations as specified in CTC (all frames);
* Low QPs (17, 12, 7, 2): AI, RA, and LD configurations with 100 frames only (i.e., by using the encoder option “--FramesToBeEncoded=100”).

For category 2 tests (joint chroma coding), additional HDR results according to JVET-N1011 have to be provided. For HDR, only tests for the standard QP set (22, 27, 32, 37) are required (visual testing is not required).

For category 3 tests (transform skip residual coding), additional results for screen coding content sequences (class TGM with YUV 4:2:0 format) have to be provided using class F CTC configuration. For category 3 tests, proponents are also encouraged to provide additional IBC off tests for screen content sequences (class F and TGM).

Category 1 focuses on reducing the worst-case number of context-coded bins.

**Average results of CE7-1 for Common Test Conditions (CTC) and low QP (QP values 2, 7, 12, 17).**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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 |
| **CE7-1.1** | -0.01% | -0.06% | -0.03% | 102% | 104% | 0.00% | -0.07% | 0.02% | 102% | 100% | -0.01% | -0.17% | 0.35% | 102% | 102% |
| **CE7-1.2** | 0.00% | -0.02% | 0.00% | 102% | 103% | 0.02% | -0.04% | -0.09% | 103% | 99% | 0.01% | 0.39% | 0.29% | 100% | 99% |
| **CE7-1.2b** | -0.01% | -0.05% | -0.04% | 101% | 97% | 0.00% | -0.09% | -0.05% | 101% | 100% | 0.02% | 0.24% | 0.16% | 100% | 103% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **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 |
| **CE7-1.1** | 0.06% | -0.06% | -0.04% | 99% | 99% | 0.10% | 0.04% | 0.06% | 100% | 98% | 0.03% | 0.00% | 0.00% | 100% | 99% |
| **CE7-1.2** | 0.08% | -0.08% | -0.05% | 99% | 97% | 0.12% | 0.09% | 0.11% | 100% | 98% | 0.05% | 0.09% | 0.10% | 100% | 99% |
| **CE7-1.2b** | 0.01% | -0.06% | -0.05% | 100% | 96% | 0.03% | -0.06% | -0.03% | 102% | 99% | 0.00% | -0.09% | -0.10% | 102% | 104% |

**Bin-to-bit ratio analysis for CE7-1 and Common Test Conditions (CTC).**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **AI** | **Max B2B** | | | **TRF of Max B2B** | | | **Avg TRF B2B** | | | **Avg B2B** | | |
| ref | test | inc | ref | test | inc | ref | test | inc | ref | test | inc |
| **CE7-1.1** | 1.14 | 1.17 | 2.86% | 1.50 | 1.57 | 4.92% | 1.50 | 1.58 | 4.90% | 1.14 | 1.17 | 2.66% |
| **CE7-1.2** | 1.14 | 1.16 | 1.82% | 1.50 | 1.55 | 3.24% | 1.50 | 1.55 | 3.15% | 1.14 | 1.16 | 1.71% |
| **CE7-1.2b** | 1.14 | 1.16 | 2.06% | 1.50 | 1.56 | 3.72% | 1.50 | 1.55 | 3.50% | 1.14 | 1.17 | 1.89% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **RA** | **Max B2B** | | | **TRF of Max B2B** | | | **Avg TRF B2B** | | | **Avg B2B** | | |
| ref | test | inc | ref | test | inc | ref | test | inc | ref | test | inc |
| **CE7-1.1** | 1.12 | 1.15 | 2.93% | 1.46 | 1.53 | 4.89% | 1.62 | 1.69 | 3.91% | 1.16 | 1.18 | 1.72% |
| **CE7-1.2** | 1.12 | 1.14 | 1.65% | 1.46 | 1.51 | 2.99% | 1.62 | 1.66 | 2.41% | 1.16 | 1.17 | 1.07% |
| **CE7-1.2b** | 1.12 | 1.15 | 2.11% | 1.46 | 1.52 | 3.68% | 1.62 | 1.67 | 2.84% | 1.16 | 1.18 | 1.26% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **LB** | **Max B2B** | | | **TRF of Max B2B** | | | **Avg TRF B2B** | | | **Avg B2B** | | |
| ref | test | inc | ref | test | inc | ref | test | inc | ref | test | inc |
| **CE7-1.1** | 1.13 | 1.16 | 2.64% | 1.53 | 1.59 | 4.08% | 1.98 | 2.02 | 2.03% | 1.21 | 1.22 | 0.93% |
| **CE7-1.2** | 1.13 | 1.15 | 1.84% | 1.53 | 1.57 | 2.99% | 1.98 | 2.01 | 1.52% | 1.21 | 1.22 | 0.70% |
| **CE7-1.2b** | 1.13 | 1.15 | 1.84% | 1.53 | 1.57 | 2.74% | 1.98 | 2.01 | 1.58% | 1.21 | 1.22 | 0.72% |

**Bin-to-bit ratio analysis for CE7-1 and low QP configuration (QP values 2, 7, 12, 17).**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **AI** | **Max B2B** | | | **TRF of Max B2B** | | | **Avg TRF B2B** | | | **Avg B2B** | | |
| ref | test | inc | ref | test | inc | ref | test | inc | ref | test | inc |
| **CE7-1.1** | 0.95 | 0.94 | -1.71% | 1.14 | 1.12 | -1.39% | 1.14 | 1.13 | -1.20% | 0.96 | 0.94 | -1.59% |
| **CE7-1.2** | 0.95 | 0.93 | -2.77% | 1.14 | 1.10 | -2.81% | 1.14 | 1.11 | -2.62% | 0.96 | 0.93 | -2.64% |
| **CE7-1.2b** | 0.95 | 0.94 | -1.47% | 1.14 | 1.12 | -1.14% | 1.14 | 1.13 | -0.95% | 0.96 | 0.95 | -1.35% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **RA** | **Max B2B** | | | **TRF of Max B2B** | | | **Avg TRF B2B** | | | **Avg B2B** | | |
| ref | test | inc | ref | test | inc | ref | test | inc | ref | test | inc |
| **CE7-1.1** | 0.89 | 0.85 | -3.78% | 1.01 | 0.97 | -4.12% | 1.44 | 1.43 | -0.57% | 1.10 | 1.09 | -0.95% |
| **CE7-1.2** | 0.89 | 0.84 | -4.57% | 1.01 | 0.96 | -5.14% | 1.44 | 1.42 | -1.37% | 1.10 | 1.08 | -1.51% |
| **CE7-1.2b** | 0.89 | 0.86 | -2.98% | 1.01 | 0.98 | -3.08% | 1.44 | 1.44 | -0.15% | 1.10 | 1.09 | -0.58% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **LB** | **Max B2B** | | | **TRF of Max B2B** | | | **Avg TRF B2B** | | | **Avg B2B** | | |
| ref | test | inc | ref | test | inc | ref | test | inc | ref | test | inc |
| **CE7-1.1** | 0.93 | 0.91 | -1.86% | 1.09 | 1.07 | -1.61% | 1.49 | 1.49 | 0.33% | 1.12 | 1.11 | -0.27% |
| **CE7-1.2** | 0.93 | 0.91 | -2.88% | 1.09 | 1.06 | -3.11% | 1.49 | 1.48 | -0.50% | 1.12 | 1.11 | -0.82% |
| **CE7-1.2b** | 0.93 | 0.92 | -1.53% | 1.09 | 1.08 | -1.31% | 1.49 | 1.49 | 0.47% | 1.12 | 1.11 | -0.09% |

Category 1 focuses on reducing the worst-case number of context-coded bins. Currently there are at most 2 such bins per coefficient level value. HEVC had 1.56. One aspect is to move the constraint from the CG level to the TB level, which would be similar to what is done for transform skip. Another aspect is to reduce the worst-case number of context coded bins to a point similar to HEVC. The scheme was said not to make any aspect more complicated.

It was commented that CE7-1.1 is the most straightforward in this category. This has a little loss in the low-QP range, but the impact is small (and no loss in the ordinary QP range).

It was asked why this is different for luma and chroma. It was suggested to not have a difference between them, and thus to set the limit for chroma to be the same as luma.

Decision (throughput/worst-case): Adopt CE7-1.1 as in JVET-O0052 with the limit for chroma set the same as for luma.

Category 2 is for joint chroma residual coding for the two chroma channels.

**Average results of CE7-2 for SDR Common Test Conditions (CTC) and low QP (QP values 2, 7, 12, 17).**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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 |
| **CE7-2.1** | -0.18% | -0.57% | 0.07% | 100% | 98% | -0.11% | -1.10% | 0.18% | 99% | 101% | 0.08% | -0.67% | 1.07% | 101% | 102% |
| **CE7-2.2** | -0.22% | -0.42% | -0.06% | 102% | 99% | -0.15% | -0.58% | 0.55% | 102% | 101% | 0.10% | 0.41% | 1.60% | 103% | 104% |
| **CE7-2.3** | -0.12% | -0.18% | 0.54% | 102% | 99% | -0.06% | 0.18% | 0.59% | 100% | 100% | -0.02% | 3.44% | 0.83% | 99% | 101% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **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 |
| **CE7-2.1** | -0.05% | -0.14% | 0.10% | 104% | 107% | -0.02% | -0.24% | -0.13% | 104% | 102% | -0.01% | -0.26% | -0.19% | 104% | 101% |
| **CE7-2.2** | -0.18% | 0.00% | -0.04% | 108% | 102% | -0.09% | -0.19% | -0.14% | 106% | 100% | -0.06% | -0.13% | -0.25% | 104% | 100% |
| **CE7-2.3** | -0.19% | 0.20% | 0.13% | 104% | 102% | -0.10% | 0.06% | 0.02% | 101% | 98% | -0.06% | 0.16% | -0.17% | 102% | 102% |

**Average results of CE7-2 for HDR Common Test Conditions.**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **AI** |  |  | **wPSNR** | | | **PSNR** | | |  |  |
| DE100 | L100 | Y | Cb | Cr | Y | Cb | Cr | Enc | Dec |
| **CE7-2.1** | -3.05% | -0.05% | -0.06% | -4.26% | 0.75% | -0.07% | -3.33% | 0.42% | 100% | 100% |
| **CE7-2.2** | -2.98% | -0.06% | -0.04% | -3.85% | -0.85% | -0.05% | -2.81% | -0.96% | 103% | 100% |
| **CE7-2.3** | -1.69% | 0.00% | 0.01% | -2.52% | 0.89% | -0.01% | -2.05% | 0.91% | 101% | 103% |
|  |  |  |  |  |  |  |  |  |  |  |
| **RA** |  |  | **wPSNR** | | | **PSNR** | | |  |  |
| DE100 | L100 | Y | Cb | Cr | Y | Cb | Cr | Enc | Dec |
| **CE7-2.1** | -2.58% | -0.01% | -0.03% | -3.98% | 1.52% | -0.06% | -3.06% | 0.64% | 99% | 100% |
| **CE7-2.2** | -2.84% | -0.03% | -0.03% | -3.85% | -0.24% | -0.05% | -2.63% | -0.66% | 101% | 100% |
| **CE7-2.3** | -1.70% | -0.01% | 0.00% | -2.07% | 0.82% | -0.03% | -1.58% | 0.91% | 101% | 104% |

NOTE: For the test CE7-2.3, the HDR results of the crosschecker are listed in the table (the tester haven’t provided the HDR results).

This has three proposals aimed to improve coding gain. The existing version of this provides about 0.29% (luma) benefit for RA.

The CE7-2.1 variant adds a sign flag at the slice level. The CE7-2.2 and CE7-2.3 variants can send two residuals rather than one, using a Hadamard transform to reconstruct the final chroma residuals.

It was remarked that this mode is basically only helpful for intra.

It was remarked that it would be nice to bring up the gain for joint chroma coding, and that CE7-2.1 was the simplest approach to do that. See additional notes in section 11.X, wherein it was agreed that action is justified to resolve an issue left open at the previous meeting regarding details of how joint chroma mode should operate.

Decision (closing an open detail in the joint chroma mode): Adopt CE7-2.1 from JVET-O0105.

Category 3 is for transform skip residual coding.

**Average results of CE7-3 for 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 |
| **CE7-3.3** | 0.00% | -0.03% | -0.01% | 100% | 100% | -0.01% | -0.05% | -0.07% | 100% | 100% | 0.03% | 0.23% | 0.07% | 100% | 102% |
| **CE7-3.4** | 0.00% | 0.00% | -0.01% | 100% | 100% | 0.01% | -0.05% | -0.04% | 99% | 100% | 0.00% | 0.16% | 0.05% | 100% | 101% |
| **CE7-3.5** | 0.01% | -0.02% | 0.02% | 100% | 100% | -0.01% | -0.04% | -0.08% | 101% | 101% | -0.02% | 0.09% | -0.07% | 101% | 100% |
| **CE7-3.6** | 0.01% | -0.02% | 0.00% | 100% | 100% | 0.00% | -0.05% | -0.05% | 101% | 101% | 0.02% | -0.12% | 0.11% | 100% | 98% |
| **CE7-3.7** | -0.02% | -0.05% | -0.01% | 100% | 100% | -0.03% | -0.05% | -0.13% | 100% | 100% | -0.02% | 0.20% | -0.09% | 100% | 101% |
| **CE7-3.8** | 0.00% | -0.04% | 0.02% | 101% | 100% | 0.00% | 0.01% | -0.08% | 101% | 101% | 0.00% | 0.06% | -0.09% | 100% | 99% |
| **CE7-3.9** | 0.00% | -0.02% | -0.01% | 100% | 100% | 0.00% | -0.03% | -0.03% | 100% | 100% | 0.03% | 0.22% | 0.25% | 100% | 100% |
| **CE7-3.10** | -0.03% | -0.05% | -0.01% | 101% | 100% | -0.01% | -0.02% | -0.06% | 100% | 101% | 0.00% | 0.16% | -0.02% | 101% | 100% |
| **CE7-3.11** | -0.03% | -0.07% | -0.02% | 101% | 100% | -0.01% | -0.01% | -0.08% | 100% | 100% | -0.02% | 0.18% | -0.07% | 101% | 104% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **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 |
| **CE7-3.3** | -0.14% | -0.02% | -0.03% | 100% | 101% | -0.04% | -0.08% | 0.08% | 100% | 102% | -0.11% | 0.00% | -0.19% | 100% | 102% |
| **CE7-3.4** | -0.10% | -0.01% | 0.06% | 100% | 101% | -0.05% | -0.01% | 0.03% | 99% | 101% | -0.07% | 0.20% | 0.01% | 100% | 102% |
| **CE7-3.5** | -0.11% | -0.13% | -0.26% | 100% | 99% | -0.12% | -0.05% | 0.05% | 101% | 103% | 0.02% | 0.20% | -0.51% | 101% | 101% |
| **CE7-3.6** | -0.09% | -0.16% | -0.05% | 101% | 100% | -0.09% | -0.19% | 0.03% | 102% | 105% | 0.04% | -0.34% | 0.05% | 101% | 99% |
| **CE7-3.7** | -0.44% | -0.33% | -0.25% | 101% | 103% | -0.37% | -0.05% | -0.21% | 101% | 100% | -0.30% | -0.37% | -0.38% | 100% | 101% |
| **CE7-3.8** | -0.31% | -0.31% | -0.40% | 102% | 99% | -0.28% | -0.25% | -0.33% | 101% | 100% | -0.23% | -0.31% | -0.87% | 100% | 99% |
| **CE7-3.9** | -0.03% | 0.08% | 0.02% | 101% | 101% | -0.06% | 0.02% | 0.00% | 100% | 100% | -0.07% | 0.05% | -0.05% | 100% | 100% |
| **CE7-3.10** | -0.78% | -0.62% | -0.82% | 102% | 100% | -0.57% | -0.58% | -0.46% | 101% | 100% | -0.41% | -0.55% | -0.95% | 100% | 99% |
| **CE7-3.11** | -0.79% | -0.66% | -0.71% | 102% | 100% | -0.62% | -0.70% | -0.57% | 101% | 99% | -0.46% | -0.35% | -0.86% | 102% | 104% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **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 |
| **CE7-3.3** | -0.14% | -0.07% | -0.06% | 100% | 101% | -0.19% | -0.02% | -0.11% | 99% | 101% | -0.04% | -0.12% | 0.05% | 99% | 101% |
| **CE7-3.4** | -0.13% | -0.07% | -0.06% | 100% | 102% | -0.14% | -0.05% | -0.06% | 99% | 101% | -0.01% | -0.09% | 0.04% | 99% | 100% |
| **CE7-3.5** | -0.42% | -0.45% | -0.44% | 101% | 100% | -0.20% | -0.23% | -0.27% | 101% | 100% | -0.10% | -0.16% | -0.20% | 102% | 102% |
| **CE7-3.6** | -0.12% | -0.23% | -0.20% | 100% | 98% | 0.01% | -0.02% | -0.08% | 102% | 100% | 0.12% | 0.09% | 0.10% | 100% | 98% |
| **CE7-3.7** | -0.54% | -0.43% | -0.46% | 101% | 100% | -0.46% | -0.32% | -0.42% | 101% | 101% | -0.30% | -0.44% | -0.29% | 100% | 100% |
| **CE7-3.8** | -0.62% | -0.62% | -0.65% | 104% | 99% | -0.52% | -0.44% | -0.58% | 103% | 100% | -0.24% | -0.41% | -0.39% | 103% | 101% |
| **CE7-3.9** | -0.07% | -0.06% | -0.07% | 100% | 100% | -0.09% | -0.03% | -0.13% | 100% | 100% | 0.00% | -0.06% | 0.01% | 101% | 103% |
| **CE7-3.10** | -1.23% | -1.13% | -1.15% | 104% | 99% | -0.89% | -0.83% | -0.93% | 103% | 98% | -0.57% | -0.79% | -0.71% | 104% | 100% |
| **CE7-3.11** | -1.30% | -1.24% | -1.20% | 104% | 99% | -0.92% | -0.78% | -0.87% | 102% | 98% | -0.67% | -0.76% | -0.83% | 104% | 104% |

**Average results of CE7-3 for low QP configuration (QP values 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 |
| **CE7-3.3** | 0.00% | 0.01% | 0.01% | 100% | 100% | 0.00% | -0.01% | 0.00% | 100% | 103% | 0.00% | 0.00% | -0.03% | 100% | 99% |
| **CE7-3.4** | 0.00% | 0.01% | 0.00% | 100% | 100% | 0.00% | 0.01% | 0.01% | 100% | 100% | 0.00% | 0.02% | -0.03% | 100% | 100% |
| **CE7-3.5** | 0.00% | -0.01% | 0.00% | 100% | 100% | 0.00% | -0.01% | -0.01% | 100% | 100% | 0.00% | 0.01% | -0.03% | 100% | 100% |
| **CE7-3.6** | 0.01% | 0.00% | 0.00% | 100% | 100% | 0.00% | -0.01% | 0.00% | 100% | 100% | 0.00% | 0.01% | -0.01% | 100% | 99% |
| **CE7-3.7** | -0.01% | 0.00% | 0.00% | 100% | 100% | -0.01% | 0.00% | 0.02% | 100% | 101% | -0.02% | -0.01% | -0.03% | 102% | 104% |
| **CE7-3.8** | 0.02% | 0.01% | 0.01% | 101% | 100% | 0.02% | 0.00% | 0.04% | 101% | 102% | 0.02% | 0.00% | -0.02% | 102% | 102% |
| **CE7-3.9** | 0.00% | 0.00% | 0.00% | 100% | 100% | 0.00% | -0.01% | -0.01% | 100% | 100% | -0.01% | 0.01% | -0.04% | 100% | 102% |
| **CE7-3.10** | 0.01% | 0.01% | 0.01% | 102% | 101% | 0.02% | 0.00% | 0.02% | 101% | 101% | 0.01% | 0.01% | -0.02% | 102% | 103% |
| **CE7-3.11** | 0.01% | 0.01% | 0.01% | 101% | 100% | 0.02% | 0.00% | 0.01% | 101% | 101% | 0.01% | 0.00% | -0.03% | 101% | 100% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **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 |
| **CE7-3.3** | -0.01% | -0.05% | -0.05% | 101% | 101% | -0.12% | 0.01% | -0.02% | 100% | 103% | 0.08% | 0.16% | 0.17% | 101% | 102% |
| **CE7-3.4** | -0.02% | -0.01% | -0.06% | 101% | 102% | -0.19% | 0.02% | -0.06% | 101% | 103% | 0.01% | 0.06% | 0.12% | 102% | 102% |
| **CE7-3.5** | 0.17% | 0.11% | 0.08% | 100% | 100% | 0.33% | 0.11% | 0.10% | 100% | 100% | 0.09% | 0.00% | 0.04% | 100% | 100% |
| **CE7-3.6** | 0.10% | 0.03% | 0.02% | 100% | 100% | 0.28% | 0.18% | 0.13% | 100% | 99% | 0.21% | 0.14% | 0.21% | 100% | 100% |
| **CE7-3.7** | -0.14% | -0.12% | -0.15% | 100% | 99% | -0.66% | -0.15% | -0.09% | 100% | 100% | -0.12% | -0.10% | -0.05% | 100% | 100% |
| **CE7-3.8** | -0.13% | -0.21% | -0.24% | 103% | 103% | 0.08% | -0.09% | -0.15% | 102% | 101% | 0.03% | -0.15% | -0.10% | 102% | 103% |
| **CE7-3.9** | -0.10% | -0.16% | -0.09% | 100% | 100% | -0.12% | -0.07% | -0.13% | 100% | 101% | -0.04% | 0.00% | -0.05% | 100% | 100% |
| **CE7-3.10** | -0.26% | -0.38% | -0.38% | 103% | 100% | -0.56% | -0.23% | -0.34% | 102% | 99% | -0.22% | -0.13% | -0.26% | 103% | 103% |
| **CE7-3.11** | -0.39% | -0.43% | -0.47% | 103% | 102% | -0.92% | -0.30% | -0.33% | 101% | 100% | -0.30% | -0.35% | -0.37% | 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 |
| **CE7-3.3** | -0.12% | -0.07% | -0.06% | 100% | 101% | -5.53% | -0.05% | -0.05% | 100% | 101% | -0.32% | -0.11% | -0.19% | 100% | 100% |
| **CE7-3.4** | -0.08% | -0.07% | -0.06% | 100% | 102% | 1.14% | -0.15% | -0.12% | 100% | 101% | -0.30% | 0.03% | 0.00% | 99% | 101% |
| **CE7-3.5** | 0.42% | 0.19% | 0.20% | 101% | 100% | -23.69% | 0.22% | 0.22% | 101% | 100% | 0.37% | 0.37% | 0.33% | 101% | 101% |
| **CE7-3.6** | 0.36% | 0.13% | 0.12% | 101% | 99% | -5.40% | 0.06% | 0.08% | 101% | 98% | 0.03% | 0.15% | 0.08% | 100% | 98% |
| **CE7-3.7** | -0.38% | -0.30% | -0.30% | 101% | 101% | -15.55% | -0.17% | -0.16% | 100% | 98% | -0.63% | -0.33% | -0.31% | 100% | 101% |
| **CE7-3.8** | -1.22% | -0.89% | -0.93% | 104% | 97% | -1.53% | -0.81% | -0.85% | 103% | 100% | -1.00% | -0.64% | -0.71% | 105% | 101% |
| **CE7-3.9** | -0.37% | -0.29% | -0.29% | 100% | 102% | -0.81% | -0.37% | -0.35% | 101% | 101% | -0.92% | -0.39% | -0.41% | 100% | 101% |
| **CE7-3.10** | -1.63% | -1.27% | -1.28% | 105% | 99% | -1.07% | -1.19% | -1.21% | 103% | 99% | -1.19% | -0.95% | -1.03% | 104% | 102% |
| **CE7-3.11** | -1.94% | -1.55% | -1.57% | 105% | 100% | -1.74% | -1.44% | -1.45% | 103% | 99% | -1.50% | -1.19% | -1.30% | 103% | 101% |

Since this is for transform skip, the coding efficiency differences are basically only for class F and TGM.

It was remarked that the design has an issue at very low QP, when the quantization step size becomes smaller than 1.

It was suggested that CE7-3.10 (a combination of CE7-3.7 and CE7-3.8) is promising. It was said to be simple and provide coding gain.

A participant remarked in favour of CE7-3.9 (or CE7-3.11, which includes that) as a cleaner approach, to avoid having different ways of scanning bins – always using bit plane scanning. Others said it would be more conservative to just take CE7-3.10 and do further study, considering the number of scanning loops.

Decision (coding efficiency for SCC): Adopt CE7-3.10 of JVET-O0122.

Category 4 is a modification for coding the CBF.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **CE7-4.1** | **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 |
| **CTC** | 0.01% | -0.05% | -0.01% | 100% | 100% | 0.01% | -0.08% | 0.00% | 100% | 100% | 0.00% | 0.04% | 0.17% | 100% | 99% |
| **lowQP** | 0.00% | -0.01% | 0.01% | 100% | 100% | 0.00% | -0.01% | 0.00% | 100% | 100% | -0.01% | 0.01% | -0.02% | 100% | 100% |

The motivation of this is to reduce the number of contexts.

It was commented that we should not focus on removing contexts at this time, so no action was taken on this at this time.

[JVET-O0052](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6656) CE7-1: TB-level constraints on context-coded bins for coefficient coding [T.-D. Chuang, C.-Y. Chen, S.-T. Hsiang, Y.-W. Huang, S.-M. Lei (MediaTek), M. Coban, M. Karczewicz (Qualcomm)]

[JVET-O0089](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6693) CE7-3.3/4: Context Modelling of sign for TS residual coding [T. Nguyen, B. Bross, H. Schwarz., D. Marpe, T. Wiegand (HHI)]

[JVET-O0104](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6708) CE7: Modified limitation on context coded bins for residual coding of Transform Skip mode (CE7-3.5 and CE7-3.6) [X. Zhao, X. Li, X. Xu, S. Liu (Tencent)]

[JVET-O0105](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6709) CE7: Joint chroma residual coding with multiple modes (tests CE7-2.1, CE7-2.2) [C. Helmrich, H. Schwarz, T. Nguyen, C. Rudat, D. Marpe, T. Wiegand (Fraunhofer HHI), B. Ray, G. Van der Auwera, A. K. Ramasubramonian, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-O0110](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6714) CE7-4.1: Simplification of cbf coding [Y.-W. Chen, X. Xiu, T.-C. Ma, X. Wang (Kwai Inc.)]

[JVET-O0115](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6719) CE7-2.3: Joint coding of chroma residuals [B. Ray, G. Van der Auwera, A. K. Ramasubramonian, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-O0122](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6726) CE7: Sign context, level mapping, and bitplane coding for TS residual coding (CE7-3.7, CE7-3.8, CE7-3.9, CE7-3.10, and CE7-3.11) [M. Karczewicz, H. Wang, M. Coban, Y.-H. Chao, Y. Han (Qualcomm)]

[JVET-O0692](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7312) Crosscheck of JVET-O0122: CE7-3.9 + parity plane change [T. Nguyen (HHI)]

## CE8: Screen content coding tools (16)

Contributions in this category were discussed Thursday 4 July 1140–1330 and 1430-1800 in Track B (chaired by JRO).

[JVET-O0028](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7052) CE8: Summary Report on 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 screen content coding tools. 20 tests have been tested in CE8 in between JVET-N and JVET-O meetings, to study and evaluate technologies related to screen content coding. In this report, coding performance and complexity of these tests are reported and analyzed. In particular, test results against VTM-5.0 anchors (CTC 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 or 444 testing conditions. Crosschecking results for the performed tests are integrated in this contribution.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test** | **Tester** | **Document** | **Tool description** | **Cross checker** |
| CE8-1.1 | S.-T. Hsiang (MediaTek) | JVET-O0053 | Coding BVDs and MVDs | J. Li  (Panasonic) |
| CE8-1.2a | M. Salehifar (LGE) | JVET-O0114 | MVD coding with 3 additional context coded bins | Y. Han  (Qualcomm) |
| CE8-1.2b | M. Salehifar (LGE) | JVET-O0114 | MVD coding with 1 additional context coded bin | Y. Han  (Qualcomm) |
| CE8-1.3a | J. Nam  (LGE) | JVET-O0093 | Context modelling and binarization process for BVD coding | Y. Sun  (Hikvision) |
| CE8-1.3b | J. Nam  (LGE) | JVET-O0093 | Context modeling and binarization process for both BVD and MVD coding | Y. Sun  (Hikvision) |
| CE8-1.4 | J. Li  (Panasonic)  Y. Han  (Qualcomm)  H. Jang  (LGE) | JVET-O0117 | Default IBC mode in case of invalid vector | Y.-W. Chen  (Kwai) |
| CE8-1.5a | J. Li  (Panasonic)  Y. Han  (Qualcomm)  H. Jang  (LGE) | JVET-O0117 | CE8-1.4 + CU based Chroma BV | Y.-W. Chen  (Kwai) |
| CE8-1.5b | J. Li  (Panasonic)  Y. Han  (Qualcomm)  H. Jang  (LGE)H. Jang  (LGE) | JVET-O0117 | CE8-1.4  + Subblock based Chroma BV with default BV | Y.-W. Chen  (Kwai) |
| CE8-1.6b | J. Xu  (ByteDance) | JVET-O0073 | Dedicated IBC buffer with 96x128 in 8-bit precision | X. Xu  (Tencent) |
| CE8-1.6c | J. Xu  (ByteDance) | JVET-O0073 | Dedicated IBC buffer with 96x128 in 10-bit precision | X. Xu  (Tencent) |
| CE8-1.7 | L. Zhang  (ByteDance)  X. Li  (Tencent)  S. H. Wang (PKU) | JVET-O0078 | Single HMVP table for all CUs inside the shared merge list region for IBC | C.-C. Chen  (MediaTek) |
| CE8-2.1 | Y.-H. Chao  (Qualcomm)  Y.-C. Sun  (Alibaba)  W. Zhu  (ByteDance) | JVET-O0119 | Palette mode in HEVC SCC + palette flag signaling improvement | J. Lai (MediaTek) |
| CE8-2.2 | Y.-C. Sun  (Alibaba) | JVET-O0059 | Palette mode and with neighboring pixel copy | W. Zhu  (ByteDance) |
| CE8-2.3 | W. Zhu  (ByteDance) | JVET-O0071 | Palette PLT mode and IBC combination | Y.-C. Sun  (Alibaba) |
| CE8-2.4 | Y.-H. Chao  (Qualcomm) | JVET-O0120 | Line-based CG Palette mode | Y.-C. Sun  (Alibaba) |
| CE8-2.5 | Y.-C. Sun  (Alibaba)  W. Zhu  (ByteDance) | JVET-O0072 | Combination test of CE8-2.2 and CE8-2.3 | C.-H. Hung (Qualcomm) |
| CE8-3.1a | Santiago de Luxán (HHI)  T.-C. Ma (Kwai Inc.) | JVET-O0097 | Enable TS for ISP TUs at the TU level | Y.-H. Chao (Qualcomm) |
| CE8-3.2 | T. Tsukuba, Y. Yagasaki (Sony) | JVET-O0081 | Chroma TS support | T. Nguyen (HHI) |
| CE8-4.2 | Y.-H. Chao (Qualcomm) | JVET-O0121 | Dual tree disabled for YUV4:4:4 format | W. Zhu  (ByteDance) |
|  |  |  |  |  |

Table 3: CE8 test results with VTM-5.0 CTC

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **AI Over VTM-5.0** | | | | | **RA Over VTM-5.0** | | | | |
|  | **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CTC | VTM+IBC | -0.62% | -0.62% | -0.65% | 146% | 100% | 0.01% | -0.32% | -0.25% | 107% | 100% |
| CE8-1.1 | -0.67% | -0.69% | -0.69% | 149% | 100% | -0.04% | -0.28% | -0.35% | 107% | 98% |
| CE8-1.2a | -0.64% | -0.64% | -0.68% | 148% | 103% | -0.01% | -0.31% | -0.23% | 108% | 103% |
| CE8-1.2b | -0.64% | -0.62% | -0.67% | 148% | 103% | 0.00% | -0.23% | -0.28% | 108% | 103% |
| CE8-1.3a | -0.64% | -0.63% | -0.67% | 147% | 98% | 0.01% | -0.24% | -0.22% | 106% | 100% |
| CE8-1.3b | -0.64% | -0.63% | -0.67% | 147% | 98% | 0.17% | -0.18% | -0.07% | 105% | 100% |
| CE8-1.4 | -0.62% | -0.62% | -0.65% | 149% | 99% | 0.01% | -0.32% | -0.25% | 107.00% | 99% |
| CE8-1.5a | -0.64% | -0.68% | -0.73% | 150% | 99% | 0.00% | -0.38% | -0.29% | 107% | 99% |
| CE8-1.5b | -0.64% | -0.67% | -0.70% | 150% | 99% | 0.00% | -0.31% | -0.28% | 106% | 99% |
| CE8-1.6b | -0.56% | -0.57% | -0.57% | 151% | 100% | 0.03% | -0.24% | -0.21% | 109% | 100% |
| CE8-1.6c | -0.57% | -0.57% | -0.60% | 151% | 98% | 0.03% | -0.25% | -0.21% | 109% | 99% |
| CE8-1.7 | -0.62% | -0.59% | -0.64% | 144% | 99% | 0.01% | -0.28% | -0.18% | 105% | 89% |
| CE8-2.1 | 0.04% | 0.03% | 0.02% | 108% | 105% | 0.03% | -0.06% | -0.08% | 102% | 102% |
| CE8-2.2 | 0.04% | 0.03% | 0.03% | 110% | 108% | 0.03% | 0.00% | -0.06% | 101% | 101% |
| CE8-2.3 | 0.04% | 0.03% | 0.04% | 107% | 100% | 0.03% | -0.02% | -0.06% | 103% | 98% |
| CE8-2.4 | 0.04% | 0.03% | 0.01% | 112% | 103% | 0.03% | -0.06% | -0.09% | 101% | 101% |
| CE8-2.5 | 0.04% | 0.03% | 0.02% | 107% | 99% | 0.03% | -0.02% | -0.05% | 103% | 97% |
| CE8-3.1a | 0.00% | 0.00% | 0.02% | 100% | 100% | -0.02% | -0.05% | -0.05% | 100% | 100% |
| CE8-3.2 | 0.02% | 0.04% | 0.02% | 101% | 100% | 0.03% | -0.01% | 0.15% | 102% | 100% |
| CE8-4.2 |  |  |  |  |  |  |  |  |  |  |
| Class F | CE8-1.1 | -0.50% | -0.29% | -0.41% | 101% | 100% | -0.40% | -0.31% | -0.25% | 101% | 99% |
| CE8-1.2a | -0.31% | -0.37% | -0.30% | 102% | 107% | -0.26% | -0.35% | -0.09% | 101% | 104% |
| CE8-1.2b | -0.24% | -0.27% | -0.21% | 102% | 106% | -0.20% | -0.17% | -0.10% | 101% | 105% |
| CE8-1.3a | -0.34% | -0.24% | -0.28% | 101% | 97% | -0.30% | -0.17% | -0.13% | 101% | 102% |
| CE8-1.3b | -0.34% | -0.24% | -0.28% | 101% | 97% | -0.16% | -0.15% | -0.04% | 100% | 101% |
| CE8-1.4 | 0.00% | 0.00% | 0.00% | 99% | 99% | 0.00% | 0.00% | 0.00% | 98% | 97% |
| CE8-1.5a | -0.04% | -0.07% | -0.06% | 101% | 99% | 0.00% | -0.10% | -0.02% | 98% | 97% |
| CE8-1.5b | -0.06% | -0.13% | -0.14% | 101% | 98% | -0.08% | -0.09% | -0.07% | 98% | 97% |
| CE8-1.6b | 0.14% | 0.16% | 0.21% | 102% | 101% | 0.13% | 0.15% | 0.27% | 101% | 99% |
| CE8-1.6c | 0.13% | 0.07% | 0.08% | 102% | 98% | 0.11% | 0.16% | 0.12% | 101% | 98% |
| CE8-1.7 | 0.00% | 0.01% | 0.08% | 100% | 99% | 0.00% | 0.08% | 0.09% | 94% | 83% |
| CE8-2.1 | -0.72% | -0.56% | -0.83% | 107% | 108% | -0.55% | -0.83% | -0.77% | 107% | 107% |
| CE8-2.2 | -0.75% | -0.76% | -0.75% | 109% | 107% | -0.67% | -0.89% | -0.87% | 104% | 102% |
| CE8-2.3 | -0.76% | -0.63% | -0.75% | 106% | 101% | -0.60% | -0.79% | -0.74% | 105% | 99% |
| CE8-2.4 | -0.81% | -0.73% | -0.94% | 109% | 107% | -0.65% | -1.01% | -0.76% | 111% | 107% |
| CE8-2.5 | -0.78% | -0.76% | -0.82% | 106% | 101% | -0.72% | -0.91% | -0.83% | 106% | 98% |
| CE8-3.1a | 0.02% | 0.05% | -0.05% | 101% | 99% | -0.01% | 0.12% | 0.10% | 100% | 101% |
| CE8-3.2 | 0.02% | -0.10% | -0.09% | 101% | 100% | 0.05% | -0.09% | -0.11% | 102% | 100% |
| CE8-4.2 |  |  |  |  |  |  |  |  |  |  |
| SCC TGM | CE8-1.1 | -1.19% | -1.07% | -1.06% | 100% | 102% | -1.14% | -0.89% | -0.94% | 100% | 100% |
| CE8-1.2a | -0.81% | -0.79% | -0.77% | 101% | 105% | -0.82% | -0.74% | -0.75% | 101% | 106% |
| CE8-1.2b | -0.67% | -0.61% | -0.63% | 102% | 105% | -0.59% | -0.60% | -0.63% | 102% | 106% |
| CE8-1.3a | -0.83% | -0.82% | -0.83% | 99% | 99% | -0.46% | -0.38% | -0.40% | 100% | 100% |
| CE8-1.3b | -0.83% | -0.82% | -0.83% | 99% | 99% | -0.38% | -0.38% | -0.41% | 100% | 101% |
| CE8-1.4 | 0.00% | 0.00% | 0.00% | 99% | 99% | 0.00% | 0.00% | 0.00% | 98% | 98% |
| CE8-1.5a | -0.16% | -0.21% | -0.19% | 98% | 99% | 0.01% | -0.06% | -0.11% | 98% | 97% |
| CE8-1.5b | -0.33% | -0.43% | -0.47% | 99% | 98% | -0.14% | -0.20% | -0.27% | 98% | 97% |
| CE8-1.6b | 0.68% | 0.71% | 0.71% | 101% | 101% | 0.47% | 0.44% | 0.43% | 103% | 101% |
| CE8-1.6c | 0.52% | 0.54% | 0.53% | 101% | 100% | 0.25% | 0.25% | 0.23% | 102% | 102% |
| CE8-1.7 | -0.02% | -0.01% | -0.01% | 100% | 101% | -0.07% | -0.03% | -0.08% | 100% | 101% |
| CE8-2.1 | -4.29% | -4.53% | -3.89% | 102% | 102% | -1.71% | -2.54% | -2.15% | 102% | 102% |
| CE8-2.2 | -5.02% | -4.95% | -4.32% | 103% | 96% | -2.02% | -2.78% | -2.43% | 102% | 101% |
| CE8-2.3 | -4.65% | -4.69% | -4.04% | 101% | 98% | -1.84% | -2.56% | -2.20% | 101% | 98% |
| CE8-2.4 | -4.35% | -4.70% | -4.04% | 104% | 99% | -1.60% | -2.46% | -2.04% | 104% | 101% |
| CE8-2.5 | -5.29% | -5.12% | -4.47% | 103% | 97% | -2.13% | -2.80% | -2.45% | 102% | 98% |
| CE8-3.1a | -0.02% | 0.02% | 0.03% | 102% | 102% | -0.04% | 0.01% | -0.09% | 100% | 100% |
| CE8-3.2 | 0.02% | -0.57% | -0.85% | 102% | 101% | -0.03% | -0.72% | -0.98% | 103% | 99% |
| CE8-4.2 |  |  |  |  |  |  |  |  |  |  |

CE8-1.1 … CE8-1.3 target improving the BV and MV coding for screen content. This is achieved by increasing the number of context coded bins and modifying contexts. Whereas CE8-1.1 suggests doing this in a switchable way (depending on enabling IBC), CE8-1.2 and CE8-1.3 would also use this in regular MV coding. Generally, for CTC the methods are no giving benefit.

The question is raised if same coding for MV and BV is still necessary. Why should MV coding become more complicated than necessary just for the purpose of “harmonization”? It is likely that due to the different role of IBC also the BV coding could be improved if it is done different from MV coding (to show this, was exactly the purpose of this CE). In a perfect world, BV coding could even be simpler than MV coding without losing performance or even gaining. The current proposals make it more complicated (by increasing number of context coded bins), where the results show gain for classes F and TGM – compared to the gain that IBC itself gives (e.g. 35% for TGM in AI), the modified BV coding gives relatively low gain (1.2%). Proponents are asked to provide additional results where the modified coding is only applied for BV, not for MV. The current results are not showing how much of the gain in RA is due to also modifying the MV coding (as modifying the MV coding without benefit for regular content or switching it would be undesirable). Even then, it is still to be decided if the gain (0.5% for class F AI 1.2% for TGM) would justify 3 additional context coded bins per BV. See further notes under CE8 BoG and Monday plenary.

CE8-1.4 proposes to make a validity check of the BV at the decoder. This would put an additional burden on decoder manufacturers as a kind of “normative concealment” (except very simple checks such as clipping). E.g. complicated checks such as BV availability depending on scan order are undesirable, whereas simple range checks and subsequent conversion as clipping are probably appropriate. It would require additional conformance test (with “invalid” BVs) to check if a decoder performs these checks, which would to be generated by JVET as part of the confromance package. Decoder manufacturers are free to implement such checks, they might also want to combine it with other concealment mechanisms. No action here, leave it as is (with bitstream/encoder constraint). This is agreed in spirit and should be used as a guideline also in the review of CE related proposals.

It is also pointed out that the VTM SW IBC encoder implementation may produce invalid BV for chroma in the dual-tree case. JVET-O0706 mentions this issue, proponents are asked to submit a bug report to make SW coordinators aware.

CE8-1.5 is based on 8-1.4. This method in its current implementation benefits from turning off the encoder restriction (as done in 8-1.4) and therefore getting better suitable BV for chroma in the dual tree case. The gain is relatively low, and might even be lower without 8-1.4. No action.

CE8-1.6b/c is targeting a more regular structure of the local memory with the goal of simplifying availability check. CE8-1.b reduces the bit depth to 8, and therefore reduces the dedicated memory for IBC by 20% compared to VTM5. Both 8-1.6b and c come with some loss (0.7%/0.5% for TGM) Additional results are given for b in low QP range, which has slightly more loss.

There is a CE related proposal (JVET-O0074) related to case b, which uses 8 bit precision and a memory size of 120x128, which is equal to the current memory size and comes with some gain.

It is suggested that the complexity impact in terms of the management of the local buffer is studied in more detail. Even though the availability check becomes simpler, the memory read/write processes need some additional operations compared to VTM5, where the 64x64 regions are aligned with the VPDU boundaries. Furthermore, the conversion from 10 bit to 8 bit requires some additional effort.

It is agreed that further reduction of the dedicated memory is not needed.

No action on 8-1.6 methods.

CE8-1.7 simplifies the HMVP process for the case of the BVs of IBC, by using only one buffer. It comes with no loss (neither in CTC+IBC, nor for screen content), and also simplifies the spec text.

Decision: Adopt JVET-O0078, Single HMVP table for all CUs inside the shared merge list region for IBC. Matching of text and SW was confirmed by crosscheckers.

8-2: Palette related proposals:

CE8-2.1 is the basic palette (similar as HEVC, with modifications for dual-tree plus CU-level signalling modification) – giving 4.3% for TGM in AI (0.7% for class F)

CE8-2.2 uses the neighbored sample across CU boundary with special palette index, adds another 0.7% on top of base configuration (<0.1% for class F)

CE8-2.3 has a special palette index to use the colocated sample from an IBC predictor, adds another 0.4% on top of base configuration (<0.1% for class F). The gain appears rather small, and it introduces some more operations in addressing the IBC samples.

CE8-2.4 is line-based palette which allows parsing/reconstruction line by line instead of the entire CU as in HEVC (which is due to the grouping of index and escape). No loss. It is noted that the grouping was introduced in HEVC for better CABAC throughput, which is not as severe anymore. On the other hand, as VVC has larger CUs, the issue of saving local memory is more important.

CE8-2.5 combines 2.2 and 2.3, giving a total of 1% for TGM (gains are almost additive) (<0.1% for class F)

Additional results are reported for 4:4:4 YUV materials. For natural video, palette has no benefit. For dual-tree case, the results of TGM1080 are slightly higher than 4:2:0 (6.5% for base configuration, with similar additional gains as above). Higher gains are reported for TGM1080 class in case of single-tree configuration (HEVC palette plus CU level signalling modification). Results are -16.4% for CE8-2.1, -17.8% for CE8-2.2, 17.4% for CE8-2.3, and no loss for CE8-2.4. CE8-2.5 again shows that gains of 8-2.2 and 8-2.3 are almost additive. These gains are relative to dual-tree-off without palette (which by itself already gives 6.2% compared to dual tree).

It is noted that the gain is much lower (slightly more than 4% for the base conf.) for the TGM720 4:4:4 class, and the additional elements of CE8-2.2/3 provide almost no additional gain. It is however noted that these are extremely simple sequences.

Preliminary conclusion:

* Palette mode shows interesting gain for 4:4:4 (tested so far with YUV), and here it provides in particular more gain for the single-tree case, which is likely due to less overhead and ability to utilize the redundancy between the components in a single palette
* For 4:2:0, the gain is not large enough (even with the additional tools of CE8-2.2/3/5) to justify a complete different sample coding at CU level. It is noted that the gain of the baseline has even become lower in VTM5.
* Investigation of palette on 4:2:0 should be discontinued in CE
* It is suggested to include a palette mode in VVC, which shall only be invoked for coding of 4:4:4 content. This should be the well-understood “base palette mode” from CE8-2.1, which can be used for both single tree and dual tree cases. Further investigation should be performed in CE to verify the gains with more 4:4:4 material, and further study improvements or simplifications. There is no need to stick to the HEVC palette method.

See further discussion in the Monday plenary session about adoption of “base palette”.

CE8-3.1a enables transform skip for TUs that exist due to ISP. This had previously been reported to give gain of around 0.4% for TGM, which is now no longer the case (no gain / no loss). It is argued that this could also be seen as a simplification, as the current syntax at TU level has an exception that the TS flag is not parsed in case of ISP. However, for SBT still this exception would be there, and furthermore the encoding runtime is increased, as otherwise the additional signalling of the flag causes loss. No action.

CE8-3.2 introduces TS for chroma. It is shown to have benefit at low QP. However, it is mentioned that there may be a problem with the interpretation of the results, as for QP less than 4 and 8 bit video (as in the TGM class) already the lossless coding is reached for TS blocks. This may result in a saturation of quality at the highest and second highest rate point. As QP 2 is used here as lowest QP, this effect is likely present. Proponents are asked to provide BD results for the range of QP 7, 12, 17, 22 which is still fairly low, to get an understanding for the true benefit at high rates.

The requested results were presented Tuesday 7 July afternoon (to be uploaded in version 2 of O0081).

For 4:2:0 AI, the class TGM has a luma gain of 1.3%, chroma 3.2%.

For 4:4:4 AI, luma gain is 3.8%, chroma 6.3%/6.4%

For 4:4:4 RA, luma gain 4.2%, chroma 7.5%/7.6%

All for Dual Tree on

It is proposed to use the specific coding method that was adopted for TS, but additional context models are proposed to be added for the chroma part: One for signalling the mode, and one for the sign (question: why is the latter one needed?)

Concern is raised that the maximum number of context coded bins is larger in the TS residual entropy coding method, such that the overall number of context coded bins would further increase if it was extended to chroma. It would be desirable to have the same limit of maximum number of context coded bins (1.75 per coefficient) for both the conventional and the TS residual method. It is mentioned that there was an adoption in CE7-3.10 (JVET-O0122) that simplifies the TS residual coding. It is verbally reported that on top of that method, when limiting the max number of context coded bins to 1.75 per coefficient, the drop in performance would be 0.23% for the chroma in CTC TGM. As the gain is relatively low for CTC, this is not attractive – more relevant in low QP range, and towards lossless coding.

A new contribution is announced by M. Coban on the aspect of limiting the number of context coded bins. Number of this contribution is JVET-O1169, which was suggested to not consider at this moment by some Track discussion.

It had been discussed in track B that, if the number of context coded bins was limited to the same number, TS for chroma could be a good starting point for further investigations in that direction – should be studied in the new AHG on TS etc. aspects.

CE8-4.2 is disabling dual tree for the case of 4:4:4 content, which gives 6.2% rate reduction for TGM, and still 1.7% for mixed content, but loss for natural video (in AI). This information is interesting to see that 4:4:4 screen content coding benefits from using single tree. Pure encoder choice, no action necessary (except that experimentation with 4:4:4 screen content and mixed content should use single tree.

The CE8 related proposals to be further discussed in BoG (X. Xu) after an initial review and identification of issues in track B.

[JVET-O0053](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6657) CE8-1.1: Unified MVD coding for inter and IBC [S.-T. Hsiang, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0989](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7625) Crosscheck of JVET-O0053 (CE8-1.1: Unified MVD coding for inter and IBC) [J. Li (Panasonic)]

[JVET-O0059](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6663) CE8: Palette mode with neighboring pixel copy (CE8-2.2) [Y.-C. Sun, T.-S. Chang, J. Lou (Alibaba)]

[JVET-O0071](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6675) CE8-2.3: Compound Palette Mode [W. Zhu, J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)]

[JVET-O0072](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6676) CE8-2.5: Combined test of CE8-2.2 and CE8-2.3 [W. Zhu, J. Xu, L. Zhang, K. Zhang, H. Liu (Bytedance), Y.-C. Sun, T.-S. Chang, J. Lou (Alibaba)]

[JVET-O0073](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6677) CE8-1.6: Dedicated IBC Buffer [J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)]

[JVET-O0078](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6682) CE8-1.7: Single HMVP table for all CUs inside the shared merge list region for IBC [S.H. Wang (PKU), X. Zheng (DJI), S. S. Wang, S. W. Ma (PKU), L. Zhang, K. Zhang, H. Liu, J. Xu, Y. Wang (Bytedance), X. Xu, X. Li, G. Li, S. Liu (Tencent)]

[JVET-O0081](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6685) CE8-3.2: Chroma Transform Skip [T. Tsukuba, M. Ikeda, Y. Yagasaki, T. Suzuki (Sony)]

Was presented Tue 9 July afternoon

Presentation deck not uploaded

[JVET-O0093](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6697) CE8-1.3: BVD coding method [J. Nam, H. Jang, J. Choi, J. Heo, J. Lim, S. Kim (LGE)]

[JVET-O0097](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6701) CE8-3.1: Enable Transform Skip in CUs using ISP [S. De-Luxán-Hernández, T. Nguyen, B. Bross, H. Schwarz, D. Marpe, T. Wiegand (HHI), T.-C. Ma, X.-Y. Xiu, Y.-W. Chen, X. Wang (Kwai)]

[JVET-O0114](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6718) CE8: Unified MVD and Block Vector Difference Coding (CE8-1.2) [M. Salehifar, S. Paluri, S. Kim (LGE)]

[JVET-O0117](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6721) CE8-1.4 and CE8-1.5: Default Processing for IBC Mode [Y. Han, W.-J. Chien, M. Karczewicz (Qualcomm), J. Li, C. Lim (Panasonic), H. Jang, J. Nam, J. Lim (LGE)]

[JVET-O0119](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6723) CE8-2.1: Palette mode in HEVC [Y.-H. Chao, C.-H. Hung, W.-J. Chien, V. Seregin, M. Karczewicz (Qualcomm), Y.-C. Sun, T.-S. Chang, J. Lou (Alibaba), W. Zhu, L. Zhang, J. Xu, K. Zhang, H. Liu (Bytedance)]

[JVET-O0120](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6724) CE8-2.4: Line-based CG Palette Mode [Y.-H. Chao, C.-H. Hung, W.-J. Chien, T. Hsieh, M. Karczewicz (Qualcomm)]

[JVET-O0121](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6725) CE8-4.2: Dual tree disabled for YUV4:4:4 format [Y.-H. Chao, C.-H. Hung, H. Wang, W.-J. Chien, V. Seregin, M. Karczewicz (Qualcomm)]

## CE9: Decoder motion vector derivation (7)

Contributions in this category were discussed Thursday 4 July 1800–1915 in Track B (chaired by JRO).

[JVET-O0029](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7161) CE9: Summary report on decoder motion vector derivation [S. Esenlik, X. Xiu]

The tools in the scope of this CE include bi-directional optical flow (BDOF) and decoder motion vector refinement (DMVR).

The core experiment summary report is organized into 2 sub-tests as follows:

* CE9-1: BDOF early termination (5 tests)
* CE9-2: DMVR/BDOF enabling conditions (4 tests)

This report summarises the status of each experiment. Crosscheck results are integrated in the report.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Test** | **Description** | **Y** | **U** | **V** | **EncT** | **DecT** | **Doc#** |
| CE9-1.1 | Use integer-distance DMVR cost to disable BDOF with threshold equal to 4x4 level TH/32 (only keep BDOF early termination when DMVR is disabled) | -0.02% | 0.00% | -0.02% | 100% | 98% | [JVET-O0054](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6658) |
| CE9-1.2 | Use integer-distance DMVR cost to disable BDOF with threshold equal to 4x4 level TH/32 and disable BDOF early termination in all cases. | -0.02% | 0.00% | -0.02% | 100% | 100% | [JVET-O0055](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6659) |
| CE9-1.3 | withdrawn | | | | | | |
| CE9-1.4 | Difference from CE9-1.2 is only threshold value.  BDOF early termination by using the min SAD in DMVR first SAD stage or in integer search stage | 0.01% | -0.05% | -0.03% | 100% | 98% | [JVET-O0055](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6659) |
| CE9-1.5a | Disabling application of BDOF based on best cost computed or derived in DMVR, when both DMVR and BDOF are applied.  Use only best SAD cost obtained from integer distance refinement positions.  When only BDOF is applied, VTM5 16x16 early termination is applied.  Threshold used is same as that will be used in VTM5 for 16x16  4x4 early termination check is disabled for all cases | -0.01% | 0.01% | -0.02% | 100% | 100% | [JVET-O0096](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6700) |
| CE9-1.5b | Use a derived best cost from parametric error surface when applicable. Otherwise, same as (CE9-1.5a). | -0.02% | 0.02% | -0.02% | 100% | 100% | [JVET-O0096](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6700) |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **the SAD calculated in DMVR used to disable BDOF** | **Threshold** | **SAD comp. for Early Termination of BDOF, when DMVR is enabled** | **Early Termination of BDOF, when DMVR is disabled** |
| CE9-1.1 | integer-distance SAD | BDOF 4x4Level TH | None / reuse DMVR | Subblock level, 4x4 level |
| CE9-1.2 | integer-distance SAD | BDOF 4x4Level TH | None / reuse DMVR | Disable |
| CE9-1.3 | integer-distance SAD | 4\*W\*(H>>1) for center position, otherwise 8\*W\*(H>>1) (=4x4 block level TH for BDOF) | None / reuse DMVR | Disable |
| CE9-1.4 | integer-distance SAD | 16\*W\*(H>>1) | None / reuse DMVR | Disable |
| CE9-1.5a | integer-distance SAD | BDOF Subblock-level  TH | None / reuse DMVR | Subblock level |
| CE9-1.5b | fractional-distance SAD;  integer-distance SAD, if no fractional-distance SAD | BDOF Subblock-level TH | None / reuse DMVR | Subblock level |

No significant impact on compression. In terms of simplification, CE9-1.2 and CE9-1.4 would be the preferable solutions by completely removing the separate BDOF SAD computation. On the other hand, these would give up any early termination of BDOF in case where DMVR is disabled, and the runtime of BDOF would decrease (which is not the case in CTC, as the combination of DMVR and BDOF is used frequently). The case of disabling DMVR is not the worst complexity case of decoder, therefore the increase of BDOF runtime should not be a big issue.

CE9-1.2 is agreed to be the better choice, also with slightly better results.

Decision: Adopt JVET-O0055, version CE9-1.2. The alignment of text and SW implementation was confirmed by cross-checker.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Test** | **Description** | **Y** | **U** | **V** | **EncT** | **DecT** | **Doc#** |
| CE9-2.1a | Harmonization of DMVR and MMVD with MMVD distance threshold (for reference). | -0.10% | -0.10% | -0.15% | 104% | 101% | [JVET-O0077](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6681) |
| CE9-2.1b | CE9-2.1.a + encoder speed up | -0.10% | -0.10% | -0.13% | 102% | 100% | [JVET-O0077](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6681) |
| CE9-2.2 | The CIIP with disabled DMVR and BDOF. | -0.01% | -0.02% | -0.01% | 99% | 98% | [JVET-O0108](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6712) |
| CE9-2.3 | The CIIP with disabled BDOF | 0.00% | -0.01% | -0.02% | 99% | 98% | [JVET-O0103](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6707) |

CE9-2.1 uses DMVR in combination with MMVD (this is where the encoder runtime increase comes in place). Compared to the encoder runtime vs compression benefit of DMVR itself (which was about 1% versus 0.8% gain, the encoder time increase of 2% for another 0.1% appears low. On the other hand, the decoder was more significantly increased by DMVR. There is some logic that here DMVR improves MMVD, where for the larger range the precision of the MV is worse. It is noted that the benefit of MMVD has recently decreased to approx. 0.6% (was >1% originally).

There is some support from experts on adopting this, whereas others expressed concern about the tradeoff. This is obviously meant for coding efficiency improvement, not for unification. Not possible to reach consensus on adoption.

CE9-2.2 and CE9-2.3 are disabling DMVR and/or BDOF in case of CIIP. This comes without change of compression performance, indicating that the combination of these tools is not beneficial. It slightly decreases SW run time. For hardware, does not have much impact in terms of reducing complexity. The text change is straighforward.

(it is noted that JVET-O0103 covers a subset of this, by only disabling BDOF)

Decision: Adopt JVET-O0108, disabling DMVR and BDOF when CIIP is used.

BoG (S. Esenlik) for reviewing CE9 related proposals and suggest actions from these.

[JVET-O0054](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6658) CE9-1.1: BDOF early termination [C.-Y. Lai, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek), K. Kondo, M. Ikeda, T. Suzuki (Sony)]

[JVET-O0055](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6659) CE9-1.2 and CE9-1.4: BDOF early termination [C.-Y. Lai, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek), K. Kondo, M. Ikeda, T. Suzuki (Sony), K. Unno, K. Kawamura, S. Naito (KDDI), T. Chujoh, T. Ikai (Sharp)]

[JVET-O0077](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6681) CE9-2.1: Harmonization of DMVR and MMVD [E. Sasaki, T. Hashimoto, T. Chujoh, T. Ikai (Sharp)]

[JVET-O0096](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6700) CE9-1.5: Best DMVR cost based early termination for BDOF [S. Sethuraman (Ittiam)]

[JVET-O0103](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6707) CE9-2.3: CIIP with disabled BDOF [L. Zhao, X. Li, X. Zhao, S. Liu (Tencent)]

[JVET-O0108](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6712) CE9-2.2: Disabled decoder-side motion refinement (DMVR) and bidirectional optical flow (BDOF) for combined inter and intra prediction (CIIP) [X. Xiu, Y.-W. Chen, T.-C. Ma, X. Wang (Kwai Inc.)]

## CE10: Neural network based loop filtering (9)

Contributions in this category were discussed Thursday 4 July 1915–2020 in Track B (chaired by JRO).

[JVET-O0030](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7063) CE10: Summary Report on Neural Network based Filter for Video Coding [Y. Li, S. Liu, K. Kawamura]

This contribution provides a summary report of Core Experiment 10 on neural network based filter for video coding. 21 tests have been tested in CE10 in between JVET-N and JVET-O meetings, to study and evaluate technologies related to neural network based filter. In this report, coding performance and complexity of these tests are reported and analyzed. Crosschecking results for the performed tests are integrated in this contribution.

CE10-1.x is online training (sequence adaptive with signalling of network parameters)

CE10-2.x is offline training

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Test #** | **Test Part** | **Description** | **Source** | **Tester** | **Crosschecker** |
| CE10-1.2a | in-loop/ post filter | CNNLF as in-loop filter | JVET-N0110 | Y.-L. Hsiao (Mediatek) | R. Yang (Intel) |
|  |  |  |  |
| CE10-1.7a | in-loop/ post filter | NN Filter as in-loop filter | JVET-N0480 | H. Yin (Intel) | Y.-L. Hsiao (Mediatek) |
| CE10-1.7b | NN Filter as post filter | Y.-L. Hsiao (Mediatek) |
| CE10-1.10a | bit-depth | 6-bit(int) weights | JVET-N0712 | K. Kawamura (KDDI) | H. Yin (Intel) |
| CE10-1.10b | 14-bit(int) weights | H. Yin (Intel) |
| CE10-1.11a | in-loop/ post filtering | CNNF as in loop filter | K. Kawamura (KDDI) | H. Yin (Intel) |
| CE10-1.11b | CNNF as post filter | H. Yin (Intel) |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| CE10-2.1a | bit-depth | 32-bit(float) weights | JVET-N0133 | Shuai Wan (NPU) | T. Ouyang (Wuhan Univ) |
| CE10-2.1b | 8-bit(int) weights |
| CE10-2.2a | in-loop/ post filter | CNNF as in-loop filter | C.-Y Lin (Hikvision) |
| CE10-2.2b | CNNF as post filter |
|  | generalization capability (QP) |  |  |
| CE10-2.3b | CTC QP+5 | T. Ouyang (Wuhan Univ) |
| CE10-2.5a | bit-depth | 32-bit(float) weights | JVET-N0254 | Y. Wang  (Wuhan Univ.) | M. Wang (NPU) |
| CE10-2.5b | 8-bit(int) weights | M. Wang (NPU) |
| CE10-2.7a | generalization capability (QP) | CTC QP-5 | M. Wang (NPU) |
| CE10-2.7b | CTC QP+5 | M. Wang (NPU) |
| ~~CE10-2.8a~~ | bit-depth | ~~4-bit(int) weights~~ | JVET-N0513 | Y. Dai(USTC)  H. Zhao(USTC) |  |
| ~~CE10-2.8b~~ | ~~6-bit(int) weights~~ |  |
| CE10-2.8c | 8-bit(int) weights | C.-Y Lin (Hikvision) |
| ~~CE10-2.8d~~ | ~~16-bit(int) weights~~ |  |
| CE10-2.10a | bit-depth | 8-bit(int) weights | JVET-N0710 | K. Kawamura (KDDI) | H. Yin (Intel) |
| CE10-2.10b | 16-bit(int) weights | H. Yin (Intel) |
| CE10-2.11a | in-loop/ post filtering | CNNF as in loop filter | K. Kawamura (KDDI) | H. Yin (Intel) |
| CE10-2.11b | CNNF as post filter | H. Yin (Intel) |

Specifically, this CE shall use the following these test conditions:

- Test Condition1: Common Test Conditions (CTC).

- Test Condition2: CTC, but short test, which only need to test the first intra period.

- Test Condition3: Based on Test Condition2, test QP=CTC QP +/- 5

The followings are summary tables of the tests in this CE.

Table 1: CE10 test results with VTM-5.0+ Test Condition 1 (CTC)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **AI Over VTM-5.0** | | | | | **RA Over VTM-5.0** | | | | |
|  | **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CTC Full test | CE10-1.2a |  |  |  |  |  | -1.20% | -14.17% | -14.11% | 100% | 117% |
| CE10-1.7a |  |  |  |  |  | -0.80% | -10.56% | -9.93% | 100% | 129% |
| CE10-1.7b |  |  |  |  |  | -0.95% | -10.78% | -10.39% | 100% | 158% |
| CE10-1.11a |  |  |  |  |  | -0.04% | -15.54% | -15.17% | 99% | 190% |
| CE10-1.11b |  |  |  |  |  | 0.25% | -5.04% | -6.01% | 100% | 213% |
| CE10-2.2a | -3.93% | -7.89% | -7.29% | 134% | 74517% | -0.26% | -3.86% | -2.91% | 139% | 132513% |
| CE10-2.2b | -3.05% | -9.02% | -10.47% | 136% | 74083% | -1.89% | -11.91% | -8.90% | 139% | 135869% |
| CE10-2.8c | -0.51% | -0.30% | -0.60% | 92% | 188% |  |  |  |  |  |
| CE10-2.11a |  |  |  |  |  | -1.10% | -2.94% | -3.35% | 127% | 56667% |
| CE10-2.11b |  |  |  |  |  | -0.32% | -0.66% | -0.81% | 100% | 64536% |

Table 2: CE10 test results with VTM-5.0+ Test Condition 2

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  |  | **RA Over VTM-5.0** | | | | |
|  | **Test#** | | **Description** | **Y** | **U** | **V** | **EncT** | **DecT** |
| Test Condition2 | CE10-1.10a | | 6-bit(int) weights | 0.04% | -0.97% | -2.30% | 100% | 127% |
| CE10-1.10b | | 14-bit(int) weights | 0.23% | -15.24% | -13.66% | 100% | 190% |
| CE10-2.1a | | 32-bit(float) weights | -0.46% | -4.11% | -2.80% | 142% | 134684% |
| CE10-2.1b | | 8-bit(int) weights | 0.79% | -5.06% | -4.73% | 192% | 306401% |
| CE10-2.5a | | 32-bit(float) weights | -1.01% | -5.01% | -4.24% | 105% | 5652% |
| CE10-2.5b | | 8-bit(int) weights | -0.84% | -4.13% | -2.92% | 107% | 5515% |
| ~~CE10-2.8c~~ | | ~~8-bit(int) weights~~ |  |  |  |  |  |
| CE10-2.10a | | 8-bit(int) weights | -1.00% | -2.98% | -3.46% | 128% | 57777% |
| CE10-2.10b | | 16-bit(int) weights | -1.16% | -3.21% | -3.59% | 129% | 59072% |

Table 3: CE10 test results with VTM-5.0+ Test Condition 3

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  |  | **RA Over VTM-5.0** | | | | |
|  | **Test#** | | **Description** | **Y** | **U** | **V** | **EncT** | **DecT** |
| Test Condition3 | CE10-2.2a | | CTC QP for testing | -0.46% | -4.11% | -2.80% | 142% | 134684% |
| CE10-2.3b | | CTC QP+5 | -1.52% | -6.15% | -4.31% | 166% | 154379% |
| CE10-2.5a | | CTC QP for testing | -1.01% | -5.01% | -4.24% | 105% | 5652% |
| CE10-2.7a | | CTC QP-5 | -0.63% | -3.83% | -3.34% | 105% | 5026% |
| CE10-2.7b | | CTC QP+5 | -1.15% | -5.01% | -4.47% | 111% | 5525% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Information in the Inference Stage Combining with Codec** | | | | | | | | |
|  | **Network Details** | | | | | | | |
| Total Conv. Layers | Total FC Layers | Framework | Param. Num | Param. Precision | Mem.P(MB) | Mem.T(MB)(e.g., 4K input) |
| CE10-1.2 | 3 | 0 | NA | 1506 | 6(I), 32(I) | 0.001282 | 0.344 (128x128, CTU based) |
| CE10-1.7 | 2 | 0 | NA | 732x3 (Luma), 402x3 (Chroma) | 6(I), 32(I) | 0.0028 | 0.0448 |
| CE10-1.10 | 3 | 0 | Caffe | 1478 | CE10-1.10a: 6(I), 15(I) CE10-1.10b: 14(I), 15(I) | CE10-1.10a: 0.001152 CE10-1.10b: 0.002592 | 0.344 (128x128, CTU based) |
| CE10-2.1 | 39 | 36 | Tensorflow | 519112 | 32(F) | 4.93 | H\*W\*2.68\*10e-3 |
| CE10-2.5 | 21 | 0 | PyTorch | 22371 | CE10-2.5a: 32(F),  CE10-2.5b: 8(I) | CE10-2.5a: 0.09,  CE10-2.5b: 0.02 | 196.23(block based, 80000pixels) |
| CE10-2.8 | 11 | 0 | cuDNN | 7521 | 8(I)32(I) | 0.01 | 3659(4K as input) |
| CE10-2.10 | 4 | 0 | Caffe | 56481 | CE10-2.10a: 8(I), 15(I) CE10-2.10b: 16(I), 15(I) | CE10-1.10a: 0.056762 CE10-1.10b: 0.112922 | 10.063 (128x128, CTU based) |

Observations / from the discussion in track B:

- The gain is typically higher for the chroma components. This may be due to ths fact that the chroma benefits more from cross-component effects.

- It is noted that the encoding time for CE10-1.x does not consider the time for the online training.

- Post filtering seems to give similar gains (and in some cases better) than in-loop filtering. The performance of post filtering versus loop filtering should be also investigated subjectively. Post filtering would not need normative description, unless parameters would need to be transmitted to the decoder.

- Quantization of network parameters incurs some loss.

- It is well possible to use the same network for a larger range of QPs.

- The complexity in terms of computation and memory need of decoder is quite high for the CE10-2.x category (though it had been largely reduced here compared to some of the initially proposed approaches) – except 10-2.8 which achieves 0.5% for 90% decoder run time increase.

- For CE10-1.x category, the decoder complexity tradeoff is in a more acceptable range, such as 1.2% luma gain (and considerably higher chroma gain) with 17% run time increase, and very shallow network with compact parameter representation. On the other hand, this requires excessive encoding time for offline training, and in terms of benefit might be better compared to some approach of lookahead encoding.

- From the results, better gains are achieved in AI case. This may be due to the fact that the training is performed by using intra coded pictures.

* To do as action during the meeting - Informal viewing to identify:Whether the NN based approaches are providing subjective benefit
* Whether it is equivalent to operate them as a post filter or a loop filter

The outcome of subjective viewing was presented (slides to be included in new version of CE summary report). Only 2 sequences were viewed at QP37 (Campfire, Ritual Dance). Though some improvements could be seen in still frames, in video the viewers were not able to see differences. Further work on investigating more sequences and operation points to be studied by AHG. Also examples with non-CTC sequences might be useful to get better insight about the potential benefit of NN technology. Also tests at lower rates than CTC might be useful.

[JVET-O0056](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6660) CE10-1.2: Convolutional neural network loop filter [Y.-L. Hsiao, O. Chubach, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0346](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6951) Crosscheck of JVET-O0056 (CE 10-1.2: Convolutional neural network loop filter) [H. Yin, R. Yang, X. Fang, S. Ma (Intel)]

[JVET-O0063](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6667) CE10-1.7: Adaptive convolutional neural network loop filter [H. Yin, R. Yang, X. Fang, S. Ma (Intel)]

[JVET-O0079](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6683) CE10: Integrated in-loop filter based on CNN (Tests 2.1, 2.2 and 2.3) [S. Wan, M.-Z. Wang, H. Gong, C.-Y. Zou (NPU), Y.-Z. Ma, J.-Y. Huo (Xidian Univ.), Y.-F. Yu, Y. Liu (OPPO)]

[JVET-O0101](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6705) CE10: Dense Residual Convolutional Neural Network based In-Loop Filter (Tests 2.5 and 2.7) [Y. Wang, T. Ouyang, C. Zou, Y. Li, Z. Chen (Wuhan Univ.), L. Zhao, S. Liu, X. Li (Tencent)]

[JVET-O0175](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6779) Crosscheck of JVET-O0101 (CE10: Dense Residual Convolutional Neural Network based In-Loop Filter (Tests 2.5 and 2.7)) [S. Wan, M.-Z. Wang, H. Gong, C.-Y. Zou (NPU), Y.-Z. Ma, J.-Y. Huo (Xidian Univ.), Y.-F. Yu, Y. Liu (OPPO)]

[JVET-O0131](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6735) CE10-1.10/CE10-1.11: Evaluation results of CNN-based filtering with on-line learning model [Y. Kidani, K. Kawamura, K. Unno, S. Naito (KDDI)]

[JVET-O0132](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6736) CE10-2.10/CE10-2.11: Evaluation results of CNN-based filtering with off-line learning model [Y. Kidani, K. Kawamura, K. Unno, S. Naito (KDDI)]

[JVET-O0347](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6952) CE10: Neural Network based Filter for Video Coding [H. Zhao, Y. Dai, D. Liu, N. Yan, H. Li (USTC)] [miss] [late]

## CE11: Gradual random access (6)

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

[JVET-O0031](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7308) CE11: Summary Report on Gradual Random Access [K. Kazui, J.-M. Thiesse, Hendry, K. Kawamura]

A summary of Core Experiment 11 (CE11) on Gradual Random Access (GRA) is reported. The goal of CE11 is to study GRA tools/methods, for potential inclusion into the VVC standard.

Eight tests were defined in CE11:

* CE11-1: Encoder-only scheme (1 test)
* CE11-2: Virtual boundary (4 tests) (1 test was withdrawn)
* CE11-3: Tile/sub-picture (2 tests)
* CE11-4: Distributed IDR picture (1 test)

All tests are evaluated based on the common test conditions defined in JVET-N1031. All tests and crosscheck results are integrated in this report.

The report was somewhat late, as some results were uploaded late. The v2 version was presented, while some cross-checking was still under way.

CTC conditions for SDR as agreed at the 14th JVET meeting are used for the evaluation of objective performance The following constraints are further applied as specified in the CE11 document.

* Low-delay B configuration only
* Interval of GRA 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 immediate preceding pictures in decoding order

The anchor is the ‘VVC Test Model’ or VTM. The VTM version 5.0 software is used with ‘vtm’ configuration files to produce the VTM anchor. Tools are implemented into the VTM version 5.0 software. Proposals are primarily compared with respect to objective compression efficiency while bitrate fluctuation and “exact match” aspects are also assessed.

Defined tests in CE11

|  |  |  |  |
| --- | --- | --- | --- |
| Test # | Short description | Doc. # | Cross-checker |
| CE11-1 | Encoder-only scheme   * No explicit signalling of refresh boundary * Encoder-side restriction on MV and intra prediction mode * Redundant intra-coded region for disabling in-loop filter at refresh boundary | JVET-N0080  JVET-O0057  (Fujitsu) | Huawei |
| CE11-2.1.a | Virtual boundary   * Refresh boundary = virtual boundary signalled at slice level * Encoder-side restriction on MV * Restriction on intra prediction with CIP at picture level * Disabling in-loop filter at refresh boundary | JVET-N0391  JVET-O0100  (VITEC) | KDDI |
| CE11-2.1.b | Virtual boundary   * CE11-2.1.a * Enabling CIP locally with slice-level signalling | Huawei |
| CE11-2.1.c | Virtual boundary   * CE11-2.1.b * Treating virtual boundary as picture boundary   [Withdrawn] | *n/a* |
| CE11-2.2 | Virtual boundary   * CE11-2.1.b * Dedicated signalling of GRA position with associated constraint derivation, and CU-level flags skipping. | Kimihiko Kazui  (Fujitsu) |
| CE11-3.1 | Tile   * Refresh boundary = tile boundary * Asymmetric MV restriction by treating tile boundary as picture boundary * Disabling intra prediction across tile boundary. This is inherited from tile, not particularly new for this test. * Disabling in-loop filtering across tile boundary | JVET-N0115  JVET-O0124  (Futurewei) | VITEC |
| CE11-3.2 | Sub-picture   * Asymmetric MV restriction at sub-picture boundary * Refresh boundary = sub-picture boundary * Disabling intra prediction across tile boundary * Disabling in-loop filtering across tile boundary | JVET-N0310  JVET-O0063  (Nokia) | Huawei |
| CE11-4 | Distributed IDR   * Extra intra-coded picture as reference for random access picture * Extra intra-coded picture is transmitted “slowly” and not output | JVET-N0116  JVET-O0116  (Huawei) | Nokia |

**Refreshing scheme**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Test # | Shape of refreshed area | Signalling of area | Precision of boundary position | Spatial direction of refresh |
| CE11-1 | Vertically striped | *n/a* | 8 luma samples | Left to right |
| CE11-2 | Vertically striped | Virtual boundary | 8 luma samples | Left to right |
| CE11-3.1 | Vertically striped | Tile | New refresh area is coded as 1 tile (i.e., 1 intra slice) with width 1 CTU column | Left to right |
| CE11-3.2 | Vertically striped | Sub-picture | 8 luma samples | Left to right |
| CE11-4 | Picture | *n/a* | *n/a* | *n/a* |

**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 |
| CE11-1 | Encoder-side mode restriction | Encoder-side MV restriction | Disabled at random access picture | Redundant intra-coded area |
| CE11-2 | Constrained intra prediction | Encoder-side MV restriction | Constrained by limiting the reference frame buffer when recycling (encoder-side) | Disabled at virtual boundary |
| CE11-3.1 | Disabled at tile boundary by default | Intrinsically constrained by treating clean area in the reference picture as picture boundary. This will effectively make blocks in the clean area never takes information (e,g., pel values, MV, etc) from non-clean area in the reference picture(s) | Intrinsically constrained by treating clean area in the reference picture as picture boundary | Disabled at tile boundary |
| CE11-3.2 | Disabled at sub-picture boundary by default | Encoder constraint such that blocks in clean area refer to clean area in the reference pictures. | Constrained by limiting area within the reference picture | Intrinsically disabled |
| CE11-4 | *n/a* | *n/a* | *n/a* | *n/a* |

**Other aspects**

|  |  |  |
| --- | --- | --- |
| Test # | Additional normative changes | Decoding unit |
| CE11-1 | *n/a* | One tile = One decoding unit = 1 CTU row |
| CE11-2 | CIP signalling (CE11-2.1.a)  Virtual boundaries slice signalling (CE11-2.1.a)  CIP enabled only at refreshed area and adjacent to refresh boundary coded in intra (CE11-2.1.b)  Dedicated signalling method of CIP and virtual boundary (CE11-2.2)  No explicit signalling of pred\_mode\_flag and cu\_skip\_flag of CU in in refreshed area (CE11-2.2) | If DU operation is desired, each CTU column can be coded as one tile. One tile one slice. |
| CE11-3.1 | Signalling of clean area in slice header  Treating clean area boundary as picture boundary | If DU operation is desired, each CTU column can be coded as one tile. One tile one slice. |
| CE11-3.2 | Clean area and dirty areas are two different sub-pictures, width and height are signalled separately. |  |
| CE11-4 | Two NAL unit types are proposed with corresponded definitions | One tile = One decoding unit |

**Other aspects**

|  |  |  |
| --- | --- | --- |
| Test # | Encoding condition | Cross-checker’s comment |
| CE11-1 | Hash ME is disabled for Class-F  GRA cycle of “BQSquare” is exceptionally set to 52. |  |
| CE11-2 | Hash ME is disabled for Class F |  |
| CE11-3.1 | ALF and LMCS are disabled | ALF and LCMS are disabled in both the anchor and the CE test. |
| CE11-3.2 | Class F case needs further investigation. | Slight mismatch between Windows and Linux simulations. Class F need more investigations. |
| CE11-4 | Encoder side ReuseCU is switched off (anchor doesn’t work with ReuseCU off) |  |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Low-delay B – Over VTM-5.0 with CE11 condition | | | | | | | | | |
|  | Tester | | | | | Cross-checker | | | | |
| Test # | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| CE11-1 | 19.13% | 15.50% | 17.61% | 95% | 102% | (\*1) |  |  |  |  |
| CE11-2.1.a | 9.54% | 11.28% | 16.61% | 96% | 114% |  |  |  |  |  |
| CE11-2.1.b | 7.96% | 8.66% | 13.02% | 101% | 115% | 7.99% | 8.60% | 13.02% | 98% | 102% |
| CE11-2.2 | 6.69% | 6.72% | 10.89% | 100% | 115% | 6.67% | 6.75% | 10.95% | 97% | 102% |
| CE11-3.1 | 2.41% | 7.25% | 11.27% | 139% | 125% | (\*2) |  |  |  |  |
| CE11-3.2 | 6.26% | 4.05% | 7.90% | 98% | 109% | 6.26% | 4.05% | 7.90% | 97% | 98% |
| CE11-4 | 3.51% | -2.41% | -2.31% | 99% | 100% | (\*2) |  |  |  |  |

(\*1) Only Class D sequences are tested so far and reportedly matched.

(\*2) Only Class C, D and E sequences are tested so far and reportedly matched.

Due to the bug reported in ticket #281, there is a mismatch between on Windows and Linux. In the CE11 anchor case, the error is within 0.1% (Class-D, U component). In each subtest, the error within the similar range is observed if the tester and cross-checker use different platform. Some BD-rate and runtime numbers are obtained on Windows. Others are on Linux.

**Bitrate fluctuation**

|  |  |  |
| --- | --- | --- |
| Test # | Tester | Cross-checker |
| CE11-1 |  |  |
| CE11-2 | Fully smooth with fluctuation only due to content. |  |
| CE11-3.1 |  |  |
| CE11-3.2 |  |  |
| CE11-4 | Spikes after RA points are near to mean value of average bit-stream. Few times less than IRAP pictures |  |

**Exact match at recovery point picture**

|  |  |  |
| --- | --- | --- |
| Test # | Tester | Cross-checker |
| CE11-1 | 1st GRA, matched  Note: 4 mismatches at 2nd, 3rd, 5th GRA | Matched (Class-D) |
| CE11-2.1.a | 1st GRA, matched |  |
| CE11-2.1.b | 1st GRA, matched |  |
| CE11-2.2 | 1st GRA, matched | 1st GRA, matched |
| CE11-3.1 | Matched. | 1st GRA, matched for Class C D E and F |
| CE11-3.2 | 1st GRA, matched |  |
| CE11-4 | Matched |  |

It was asked whether block-wise areas predicted from “clean” regions were considered “clean”. This was sometimes not done.

CE11-2 schemes use a “virtual boundary” (horizontal or vertical) for ALF/SAO/deblock disable, with syntax at the slice level. The tested schemes also use some form of constrained intra prediction (CIP). We do not currently have CIP in VVC. There was no test that used the virtual boundary and did not use CIP.

Virtual boundaries are already supported (for 360° reasons).

It was commented that extending the ME search area into the clean area would help, whereas this test just restricted the search to a part of the ordinary ME seach area.

VVC does not have CIP. CE11-2.1a uses whole-slice (whole-picture) CIP. CE11-2.1b has a block level flag for CIP. CIP may not be easy to support in VVC, at least in an implementation if not in the text. The group was reluctant to consider supporting CIP because of this implementation issue.

It was commented that it may not be necessary to have an exact match. Allowing some “drift” may be possible.

It was commented that at the previous meeting there had been substantial interest in being able to treat tile boundaries as picture boundaries, and software was contributed for this meeting for such an approach.

It was commented that refreshes with horizontal boundaries rather than vertical boundaries are also possible.

It was commented that the tested schemes were basically for picture-level operation, rather than DU-level operation.

CE11-3.1 uses tiles, while CE11-3.2 concerns sub-pictures. A sub-picture is proposed to be a rectangular arrangement of tiles. The boundary of a sub-picture is treated as a picture boundary. Each reference picture has its own sub-picture structure that needs to be accounted for when referencing it. As proposed, each sub-picture would have its own PPS.

CE11-4 uses non-output reference pictures to build up a reference picture that sent in fragments and is not referred to by other pictures until all fragments have been sent. It was commented that this is somewhat similar in concept to the “composite reference picture” concept that had previously been investigated. A participant commented that, the way this was proposed, it requires buffering too much state information for partially decoded pictures. It also requires an increase of “pixel processing rate”. Another participant commented that this produces bit rate fluctuations, since when that picture becomes used, it is temporally distant from the current picture being predicted.

Further discussion was suggested regarding treating tile boundaries as picture boundaries after discussion of that in other contexts. It was suggested that we may also want to move the syntax for virtual boundaries to the slice level. The outcome on this is recorded in the sections discussing high-level syntax.

[JVET-O0075](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6679) CE11-1: GRA support by restriction to encoder operation [K. Kazui (Fujitsu)]

[JVET-O0100](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6704) CE11: Gradual Random Access (GRA) using encoder and normative restrictions (Tests CE11-2.1.a, CE11-2.1.b and CE11-2.2) [D. Gommelet, J.-M. Thiesse, D. Nicholson (VITEC)]

[JVET-O0116](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6720) CE11-4: Distributed decoding refresh DDR [M. Sychev (Huawei)]

[JVET-O0124](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6728) CE11/AHG14: Test 3.1 − Support of gradual random access / gradual decoding refresh [Hendry, Y.-K. Wang, J. Chen, S. Hong (Futurewei)] [late]

[JVET-O0663](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7280) CE11-3.2: Gradual Random Access (GRA) with Sub-Pictures [K. K. Sreedhar, M. M. Hannuksela, A. Aminlou (Nokia)] [late]

Further discussion of CE

Further discussion Thursday 1445.

Test 1: Encoder constraint

Test 2: CIP with virtual boundary concept

Test 3: Proposed to use a flag in the slice header to indicate “clean area”

The “subpicture” scheme as agreed thus far does not allow the boundary that is treated as a picture boundary to move within a CVS. This does not enable GRA functionality.

It was suggested not to couple the GRA and subpicture concepts.

The 3.1 implementation used multiple PPSs. It has been a design principle that PPSs could be sent out of band, which would be an issue if we need to change PPS on every picture. It was agreed in principle that we should be able to change tile structure of a picture in some way without changing the PPS. For example, syntax in the AUD or SH or an APS could be used. Further study is needed to define how to do that. It was suggested for the existing syntax to remain as it is, with this being just some optional different mode.

# Non-CE Technology proposals

## CE1 related – CABAC initialization (2)

[JVET-O0191](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6796) CE1-related: Simplified CABAC initialization method [F. Bossen (Sharp)]

This contribution was discussed Friday 5 July at 1700 (chaired by GJS).

Several CABAC initialization methods have been studied in CE1. An alternative is proposed, which is asserted to have lower complexity. It is asserted that 25% faster code can be realized in software compared to the fastest CE1 method. From a coding efficiency point of view, the proposed method is asserted to be as good if not better than the methods studied in CE1 under the conditions defined in CE1: considering averages, in the worst case, it is reportedly 0.01% worse than the best CE1 result (RA: −0.01% vs −0.02%); in the best case it is 0.11% better than the best CE1 result (RA, high QP: 0.11% vs 0.22%).

JVET-O0946 was written in response to this, and is thus closely related.

It was commented that at the high QP range there are only 8 valid probabilities that can be used, and in this region there would not be enough bins coded to sufficiently adapt the probabilitites to refine them. The proponent said that extremely high QPs may not be so important to optimize for.

See also the notes for O0677 and O0946.

[JVET-O0677](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7296) Crosscheck of JVET-O0191 (CE1-related: Simplified CABAC initialization method) [J. Dong (Qualcomm)]

This contribution was discussed Friday 5 July at 1730 (chaired by GJS).

The cross-checker said that the JVET-O0191 proposal had some loss compared to CE1-1.2 in the very high QP range. A report of these data will be put into a revision of the chrosscheck document.

[JVET-O0946](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7573) CE1-related: Simplification of JVET-O0191 using 4 or 6 bit per initialization value [H. Kirchhoffer, D. Marpe, H. Schwarz, T. Wiegand (HHI)] [late]

[JVET-O1097](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7734) Crosscheck of JVET-O0946 (CE1-related: Simplification of JVET-O0191 using 4 or 6 bit per initialization value) [F. Bossen (??)]

This contribution was discussed Friday 5 July at 1740 (chaired by GJS).

This was submitted in response to proposal JVET-O0191.

Three simplified variants of the context model initialization method of JVET-O0191 are proposed. The first one reduces the computational complexity by simplifying the computation of initialization values. The second variant reduces the number of bits required per initialization value from 6 to 4 bit. This allows to store the three initialization values and the 4 bit window size parameter in 16 bits per context model instead of 22 bit as necessary for the 6 bit variant. For the 6 bit variant, the luma BD rates over VTM-5.0 are 0.00% for AI, -0.01% for RA, 0.05% for LB, -0.01% for LP, 0.19% for RA-HighQP. For the 4 bit variant, the luma BD rates over VTM-5.0 are 0.07% for AI, 0.10 % for RA, 0.xx% for LB, 0.xx% for LP, and 0.48% for RA-HighQP. The third variant only changes the clipping operation with virtually no BD rate change for common test conditions, but it reportedly improves the BD rate from 0.11% to -0.01% for RA-HighQP.

The second variant has some loss and was not suggested to be used. The third variant was suggested to focus on.

Some experiment results were not yet available.

This was further discussed in Track A Thursday 11 July at 1430 (GJS) after side activity for study and experiments.

Testing was done for one CTU per slice. It was reported that there was some bug in the VTM regarding memory, but different testers got very very similar results.

So there were three variants that were all quite similar in complexity and performance: CE1-1.2, O0191, and O0946v3. Since one of these was a CE test, it was agreed that it should have a preference by default. Decision: Adopt CE1-1.2.

## CE2 related – Luma/chroma dependency reduction (23)

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

[JVET-O0129](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6733) Non-CE2: CCLM with Chroma Separate Tree [C.-W. Kuo, J. Li, C. Lim (Panasonic)]

[JVET-O0797](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7418) Crosscheck of JVET-O0129 on CCLM with Chroma Separate Tree [C. Chevance (Interdigital)]

[JVET-O0130](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6734) Non-CE2: CRS with Chroma Separate Tree [C.-W. Kuo, J. Li, C. Lim (Panasonic)]

[JVET-O0723](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7343) Crosscheck of JVET-O0130 (Non-CE2: CRS with Chroma Separate Tree) [T. Biatek (Qualcomm)]

[JVET-O0196](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6801) CE2-related: CCLM for dual tree with 32x32 latency [Y. Zhao, H. Yang (Huawei)]

[JVET-O0805](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7426) Crosscheck of JVET-O0196 (CE2-related: CCLM for dual tree with 32x32 latency) [C.-M. Tsai (MediaTek)]

[JVET-O0212](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6817) On an enable condition for LMCS [T.Chujoh, T.Ikai (Sharp)]

[JVET-O0715](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7335) Crosscheck of JVET-O0212 (On an enable condition for LMCS) [P. Bordes (InterDigital)]

[JVET-O0232](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6837) CE2-related: No-latency LMCS Chroma Residual Scaling [J. Zhao, S. Kim (LGE)]

[JVET-O0745](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7366) Crosscheck of JVET-O0232 (CE2-related: No-latency LMCS Chroma Residual Scaling) [T. Lu (Dolby)]

[JVET-O0233](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6838) CE2-related: Linear LMCS [J. Zhao, S. Paluri, S. Kim (LGE)]

[JVET-O0796](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7417) Crosscheck of JVET-O0233 on Linear LMCS [C. Chevance (Interdigital)]

[JVET-O0262](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6867) Non-CE2: Removal of division operations in LMCS [K. Zhang, L. Zhang, H. Liu, J. Xu, Y. Wang (Bytedance)]

[JVET-O0746](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7367) Crosscheck of JVET-O0262 (Non-CE2: Removal of division operations in LMCS) [T. Lu (Dolby)]

[JVET-O0271](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6876) CE2-related: Chroma scaling for CIIP [Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0781](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7402) Crosscheck of JVET-O0271: CE2-related: Chroma scaling for CIIP [X. Xiu (Kwai Inc.)]

[JVET-O0272](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6877) CE2-related: Simplified inverse luma mapping [Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0910](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7532) Crosscheck of JVET-O0272: CE2-related: Simplified inverse luma mapping [W. Zhu (Bytedance)]

[JVET-O0273](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6878) CE2-related: Luma-chroma latency reduction for chroma separate tree [C.-M. Tsai, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O1013](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7649) Crosscheck of JVET-O0273: CE2-related: Luma-chroma latency reduction for chroma separate tree [T. Poirier (InterDigital)]

[JVET-O0274](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6879) CE2-related: Luma-chroma dependency reduction for chroma separate tree by constraining CCLM usage [C.-M. Tsai, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0754](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7375) Crosscheck of JVET-O0274 (CE2-related: Luma-chroma dependency reduction for chroma separate tree by constraining CCLM usage) [Y. Zhao (Huawei)]

[JVET-O0428](file:///D:\2019\JVET\JVET-O\current_document.php%3fid=7033) AHG16/AHG17: LMCS related clean-ups [T. Lu, F. Pu, P. Yin, S. McCarthy, W. Husak, T. Chen (Dolby), J. Zhao, S.H. Kim (LGE)]

Note that if the 3rd part of this proposal is agreed, the specification text for that part should be reviewed and confirmed by HLS experts.

[JVET-O0842](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7463) Crosscheck of JVET-O0428: AHG16/AHG17: LMCS related clean-ups [J. Chen (Alibaba)]

[JVET-O0429](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7034) Non-CE2: alternative solutions for chroma residual scaling factors derivation for dualTree [T. Lu, P. Yin (Dolby), E. François, F. Hiron (InterDigital)]

[JVET-O0744](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7365) Crosscheck of JVET-O0429 (Non-CE2: alternative solutions for chroma residual scaling factors derivation for dualTree) [K. Zhang (Bytedance)]

[JVET-O1044](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7681) Crosscheck of JVET-O0429 (Non-CE2: alternative solutions for chroma residual scaling factors derivation for dualTree) [Y. Zhang, D. Rusanovskyy (Qualcomm)]

[JVET-O0448](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7054) Non-CE2: Inverse LUT carriage for LMCS [P. Andrivon, E. François, C. Chevance, H. Hiron, R. Jullian (InterDigital)]

[JVET-O0992](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7628) Crosscheck of JVET-O0448 (Non-CE2: Inverse LUT carriage for LMCS) [C.-W. Kuo (Panasonic)]

[JVET-O0524](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7131) Non-CE2: alternative solutions for reducing the luma-chroma latency [T. Poirier, E. François, F. Le Léannec (InterDigital)]

[JVET-O0806](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7427) Crosscheck of JVET-O0524 (Non-CE2: Alternative solutions for reducing the luma-chroma latency) [C.-M. Tsai (MediaTek)]

[JVET-O0550](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7163) CE2-related: Further simplification of chroma residual scaling factors derivation [M. Sychev, E. Alshina (Huawei)]

[JVET-O1064](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7701) Crosscheck of JVET-O0550 (CE2-related: Further simplification of chroma residual scaling factors derivation) [S.-T. Hsiang (MediaTek)]

[JVET-O0603](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7218) CE2-related: Prediction dependent luma residual scaling for adaptive in-loop re-shaper [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, S. Ye, X. Wang (Kwai Inc.)]

[JVET-O0844](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7465) Crosscheck of JVET-O0603: CE2-related: Prediction dependent luma residual scaling for adaptive in-loop re-shaper [J. Chen (Alibaba)]

[JVET-O0608](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7223) CE2-related: On latency reduction for chroma residual scaling [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, S. Ye, X. Wang (Kwai Inc.)]

[JVET-O1026](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7663) Crosscheck of JVET-O0608 (CE2-related: On latency reduction for chroma residual scaling) [Z.-Y. Lin (MediaTek)]

[JVET-O0611](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7226) CE2-3 related: On CCLM restriction for 32x32 luma latency [K. Kawamura, K. Unno, S. Naito (KDDI)]

[JVET-O0708](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7328) Crosscheck of JVET-O0611 (CE2-3 related: On CCLM restriction for 32x32 luma latency) [K. Abe (Panasonic)]

[JVET-O0618](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7233) CE2-related: Removal of luma-chroma dependency in LMCS [Z. Deng, L. Zhang, H. Liu, K. Zhang, Y. Wang (Bytedance)]

[JVET-O0767](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7388) Crosscheck of JVET-O0618: CE2-related: Removal of luma-chroma dependency in LMCS [J. Zhao (LGE)]

[JVET-O0627](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7242) CE2-related: luma-chroma dependency reduction on chroma scaling [J. Chen, R.-L. Liao, Y. Ye, J. Luo (Alibaba)]

[JVET-O0691](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7311) Crosscheck of JVET-O0627 (CE2-related: luma-chroma dependency reduction on chroma scaling) [Y. Sun, S. Ye, F. Chen, L. Wang (Hikvision)]

[JVET-O0747](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7368) Crosscheck of JVET-O0627 (CE2-related: luma-chroma dependency reduction on chroma scaling) [T. Lu (Dolby)]

[JVET-O0668](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7285) Non-CE2: CCLM latency reduction for single tree [T. Biatek, G. Van Der Auwera, M. Karczewicz (Qualcomm)]

[JVET-O1077](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7714) Crosscheck of JVET-O0668 (Non-CE2: CCLM latency reduction for single tree) [C. Chevance (InterDigital)]

[JVET-O1109](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7746) Non-CE2: unification of chroma residual scaling design [E. François (InterDigital)] [late]

[JVET-O1141](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7778) Crosscheck of JVET-O1109 (Non-CE2: unification of chroma residual scaling design) SDR Test [G. Li (Tencent)]

[JVET-O1124](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7761) Draft text for CCLM restriction to reduce luma-chroma latency for chroma separate tree [Y. Zhao, H. Yang (Huawei), C.-M. Tsai, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)] [late]

See CE2 BoG notes.

## CE3 related – Intra prediction and mode coding (96)

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

[JVET-O0084](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6688) 8-bit implementation and simplification of MIP [J. Pfaff, T. Hinz, P. Helle, P. Merkle, B. Stallenberger, M. Schäfer, H. Schwarz, D. Marpe, T. Wiegand (Fraunhofer HHI)]

[JVET-O1049](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7686) Crosscheck of JVET-O0084 (8-bit implementation and simplification of MIP) [F. Bossen (Sharp)]

[JVET-O0111](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6715) Non-CE3: Modified CABAC Coding for Intra Prediction Mode [B. Wang, A. M. Kotra, S. Esenlik, H. Gao, E. Alshina (Huawei)]

[JVET-O1003](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7639) Crosscheck of JVET-O0111 (Non-CE3: Modified CABAC Coding for Intra Prediction Mode) [L. Li (LGE)]

[JVET-O0139](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6743) CE3 Related: Low Memory and Computational Complexity Matrix Based Intra Prediction (MIP) [M. Salehifar, S. Kim (LGE)]

[JVET-O0721](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7341) Crosscheck of JVET-O0139 (CE3 Related: Low Memory and Computational Complexity Matrix Based Intra Prediction (MIP)) [T. Biatek (Qualcomm)]

[JVET-O0957](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7587) Crosscheck of JVET-O0139 (CE3 Related: Low Memory and Computational Complexity Matrix Based Intra Prediction (MIP)) [J. Pfaff, B. Stallenberger (HHI)]

[JVET-O0160](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6764) Non-CE3: Sample value clipping on MIP reduced prediction [Z. Zhang, K. Andersson, R. Sjöberg, J. Ström, P. Wennersten, R. Yu (Ericsson)]

[JVET-O0961](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7591) Crosscheck of JVET-O0160 (Non-CE3: Sample value clipping on MIP reduced prediction) [J. Pfaff, M. Schäfer (HHI)]

[JVET-O0161](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6765) Non-CE3: Simplification on MIP boundary sample downsampling process [Z. Zhang, K. Andersson, R. Sjöberg, J. Ström, P. Wennersten, R. Yu (Ericsson)]

[JVET-O0960](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7590) Crosscheck of JVET-O0161 (Non-CE3: Simplification on MIP boundary sample downsampling process) [J. Pfaff, M. Schäfer (HHI)]

[JVET-O0168](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6772) Non-CE3: MIP low resolution clipping [T. Biatek, G. Van der Auwera, M. Karczewicz (Qualcomm)]

[JVET-O0882](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7504) Crosscheck of JVET-O0168 (Non-CE3: MIP low resolution clipping) [Z. Zhang (Ericsson)]

[JVET-O0169](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6773) CE3 Related: No MPM Derivation for Matrix Based Intra Prediction (MIP) [M. Salehifar, S. Kim (LGE)]

[JVET-O0722](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7342) Crosscheck of JVET-O0169, (CE3 Related: No MPM Derivation for Matrix Based Intra Prediction (MIP)) [T. Biatek (Qualcomm)]

[JVET-O0958](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7588) Crosscheck of JEVT-O169 (CE3 Related: No MPM Derivation for Matrix Based Intra Prediction (MIP)) [J. Pfaff, B. Stallenberger (HHI)]

[JVET-O0170](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6774) Non-CE3: Simplification on Matrix-based intra prediction [B. Wang, A. M. Kotra, S. Esenlik, H. Gao, E. Alshina (Huawei)]

[JVET-O0883](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7505) Crosscheck of JVET-O0170 (Non-CE3: Simplifications of Intra Mode Coding for Matrix-based Intra Prediction) [Z. Zhang (Ericsson)]

[JVET-O0171](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6775) Non-CE3: Simplifications for MIP [L. Zhao, X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-O0850](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7471) Crosscheck of JVET-O0171 (Non-CE3: Simplifications for MIP) [Jie Yao (Fujitsu)]

[JVET-O0943](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7570) Crosscheck of JVET-O0171 (Non-CE3: Simplifications for MIP) [T.-C. Ma (Kwai Inc.)]

[JVET-O0187](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6791) Non-CE3: MIP simplifications [A. K. Ramasubramonian, G. Van der Auwera, T. Biatek, L. Pham van, M. Karczewicz (Qualcomm)]

[JVET-O0192](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6797) Non-CE3: MPM flag first signaling for intra luma mode coding [Jie Yao, Jianqing Zhu, Wenting Cai, Kimihiko Kazui (Fujitsu)]

[JVET-O0768](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7389) Crosscheck of JVET-O0192: Non-CE3: MPM flag first signaling for intra luma mode coding [L. Pham Van, G. Van der Auwera, M. Karczewicz (Qualcomm)]

[JVET-O0197](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6802) Non-CE3: cleanup for ISP flag and MRL index signalling [H. Liu, L. Zhang, K. Zhang, N. Zhang, J. Xu, Y. Wang (Bytedance)]

[JVET-O0851](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7472) Crosscheck of JVET-O0197 (Non-CE3: Cleanup for ISP flag and MRL index signalling) [Jie Yao (Fujitsu)]

[JVET-O0202](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6807) Non-CE3: MIP Modifications [Y.-U. Yoon, D.-H. Park, J.-G. Kim (KAU), J. Lee, J. Kang (ETRI)]

[JVET-O1024](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7661) Crosscheck of JVET-O0202 (Non-CE3: MIP Modifications) [Z.-Y. Lin (MediaTek)]

[JVET-O0203](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6808) CE3-related: Simplification of Matrix-Based Intra Prediction (MIP) [A. Filippov, V. Rufitskiy, B. Wang, S. Esenlik, E. Alshina (Huawei)]

[JVET-O0811](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7432) Crosscheck of JVET-O0203 (CE3-related: Simplification of Matrix-based Intra Prediction (MIP)) [[T.-H. Li](mailto:thli@fginnov.com), J.-Y. Deng (Foxconn)]

[JVET-O0224](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6829) CE3-related: Further simplifications of the unified MPM list for intra mode coding [G. Rath, F. Racapé, F. Urban (InterDigital)]

[JVET-O0968](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7599) Crosscheck of JVET-O0224 (Non-CE3: Further simplifications of the unified MPM list for intra mode coding) [S. De-Luxán-Hernández (HHI)]

[JVET-O0229](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6834) CE3-related: Simplifications of PDPC for diagonal and adjacent diagonal directions [G. Rath, F. Racapé, F. Urban (InterDigital)]

[JVET-O0533](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7140) Crosscheck of JVET-O0229 (CE3-related: Simplifications of PDPC for diagonal and adjacent diagonal directions)) [L. Zhao (Tencent)]

[JVET-O0230](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6835) CE3-related: Interpolation filtering for intra prediction in non-diagonal directions [G. Rath, F. Racapé, F. Urban, F. Le Léannec (InterDigital)]

[JVET-O1030](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7667) Crosscheck of JVET-O0230 (Non-CE3: Interpolation filtering for intra prediction in non-diagonal directions) [J. Lee, S.-C. Lim, H. Lee, J. Kang (ETRI)]

[JVET-O0255](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6860) Non-CE3: Fixed MPMs for MIP [K. Zhang, Z. Deng, L. Zhang, H. Liu, N. Zhang (Bytedance)]

[JVET-O1005](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7641) Crosscheck of JVET-O0255 (Non-CE3: Fixed MPMs for MIP) [J. Choi (LGE)]

[JVET-O0260](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6865) Non-CE3: Rounding offset removal for intra prediction [Z. Deng, H. Liu, L. Zhang, K. Zhang, Y. Wang (Bytedance)]

[JVET-O0862](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7483) Cross-check of JVET-O0260: "Non-CE3: Rounding offset removal for intra prediction" [F. Le Léannec (Interdigital)]

[JVET-O0261](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6866) Non-CE3: MIP with one-stage boundary sample downsampling [Z. Deng, H. Liu, K. Zhang, L. Zhang, Y. Wang (Bytedance)]

[JVET-O0826](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7447) Crosscheck of JVET-O0261 (Non-CE3: MIP with one-stage boundary sample downsampling) [H. Chen (Huawei)]

[JVET-O0275](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6880) CE3-related: Chroma DM derivation for IBC and PCM [M.-S. Chiang, O. Chubach, C.-W. Hsu, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0823](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7444) Crosscheck of JVET-O0275 (CE3-related: Chroma DM derivation for IBC and PCM) [S. Yoo, J. Lim (LGE)]

[JVET-O0276](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6881) CE3-related: Simplifications for MIP [Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0827](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7448) Crosscheck of JVET-O0276 (CE3-related: Simplifications for MIP) [H. Chen (Huawei)]

[JVET-O0277](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6882) CE3-related: Simplification and unification for intra reference sample filtering [C.-M. Tsai, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0825](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7446) Crosscheck of JVET-O0277 (CE3-related: Simplification and unification for intra reference sample filtering) [J. Shingala (Ittiam)]

[JVET-O0311](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6916) CE3-related: Intra sub-partition improvement for low decoding latency and hardware implementation efficiency [[H. Yang](mailto:Hua.Yang@InterDigital.com), [Y. He (InterDigital)](mailto:Yuwen.He@InterDigital.com)]

[JVET-O0974](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7607) Crosscheck of JVET-O0311 (CE3-related: Intra sub-partition improvement for low decoding latency and hardware implementation efficiency) [L. Zhao (Tencent)]

[JVET-O0312](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6917) Non-CE3: Simplifications of MIP [P.-H. Lin (Foxconn)]

[JVET-O1001](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7637) Crosscheck of JVET-O0312 (Non-CE3: Simplifications of MIP) [C.-C. Kuo, C.-H. YauLin, C.-L. Lin (ITRI)]

[JVET-O0316](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6921) Non-CE3：Unification of ISP and Non-ISP [D. Jiang, J. Lin, F. Zeng, C. Fang (Dahua)]

[JVET-O0317](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6922) CE3-related: MPM List Modification for Zero Reference Line [D. Jiang, J. Lin, F. Zeng, C. Fang (Dahua)]

[JVET-O0318](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6923) Non-CE3: Intra Combined predict [D. Jiang, J. Lin, F. Zeng, C. Fang (Dahua)]

[JVET-O0320](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6925) Non-CE3: CCLM simplification [J.-Y. Huo, Y.-Z. Ma, X.-W. Li, F.-Z. Yang (Xidian Univ.), S. Wan (NPU), Y.-F. Yu, Y. Liu, M. Li (OPPO)]

[JVET-O0978](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7613) Crosscheck of JVET-O0320 (Non-CE3: CCLM simplification) [X. Ma (Huawei)]

[JVET-O0321](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6926) Non-CE3: Removal of MIP mapping table [J.-Y. Huo, Y.-Z. Ma, X.-W. Li, H.-X. Wang, F.-Z. Yang (Xidian Univ.), S. Wan (NPU), Y.-F. Yu, Y. Liu, M. Li (OPPO)]

[JVET-O1007](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7643) Crosscheck of JVET-O0321 (Non-CE3: Removal of MIP mapping table) [J. Choi (LGE)]

[JVET-O0322](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6927) Non-CE3: Simplification of PDPC for chroma component [J.-Y. Huo (Xidian Univ.), S. Wan (NPU), Y.-Z. Ma (Xidian Univ.), J.-K. Guo (NPU), F.-Z. Yang (Xidian Univ.), Y.-F. Yu, Y. Liu, M. Li (OPPO)]

[JVET-O0980](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7616) Crosscheck of JVET-O0322 (Non-CE3: Simplification of PDPC for chroma component) [X. Ma (Huawei)]

[JVET-O0323](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6928) Non-CE3: Unification of shifting for MIP mode [J.-Y. Huo (Xidian Univ.), S. Wan (NPU), Y.-Z. Ma (Xidian Univ.), J.-K. Guo (NPU), H.-X. Wang, F.-Z. Yang (Xidian Univ.), Y.-F. Yu, Y. Liu, M. Li (OPPO)]

[JVET-O0717](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7337) Crosscheck of JVET-O0323 (CE3-related: Unification of shifting for MIP mode) [L. Xu, F. Chen, L. Wang (Hikvision)]

[JVET-O0324](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6929) Non-CE3: MIP Simplification [J.-Y. Huo (Xidian Univ.), S. Wan (NPU), Y.-Z. Ma (Xidian Univ.), J.-K. Guo (NPU), F.-Z. Yang (Xidian Univ.), Y.-F. Yu, Y. Liu, M. Li (OPPO)]

[JVET-O0718](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7338) Crosscheck of JVET-O0324 (Non-CE3: MIP Simplification) [L. Xu, F. Chen, L. Wang (Hikvision)]

[JVET-O0341](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6946) Non-CE3: Unification of intra interpolation filter selection [J. Lee, J. Kang, H. Lee, S.-C. Lim, H. Y. Kim (ETRI)]

[JVET-O0765](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7386) Crosscheck of JVET-O0341: Non-CE3: Unification of intra interpolation filter selection [F. Racapé, G. Rath (Interdigital)]

[JVET-O0343](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6948) CE3-related: Simplification on CCLM process [D.-Y. Kim, J.-O. Lee (Chips&Media), S.-C. Lim, J. Lee, J. Kang (ETRI)]

[JVET-O0845](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7466) Crosscheck of JVET-O0343 (CE3-related: Simplification on CCLM process) [M. Ikeda (Sony)]

[JVET-O0345](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6950) Non-CE3: MIP simplification [C.-H. Yau, C.-C. Lin, C.-L. Lin (ITRI)]

[JVET-O0971](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7603) Crosscheck of JVET-O0345 (Non-CE3: MIP simplification) [M.-S. Chiang (MediaTek)]

[JVET-O0351](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6956) Non-CE3: Clean-up intra type signaling [J. Heo, J. Nam, J. Choi, J. Lim, S. Kim (LGE)]

[JVET-O1047](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7684) Crosscheck of JVET-O0351 (Non-CE3: Clean-up intra type signaling) [D. Kim, J. Jung, G. Ko, J. Son, J. Kwak (WILUS)]

[JVET-O0353](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6958) Non-CE3: Simplification on transform selection for multiple reference line (MRL) [J. Heo, M. Koo, J. Choi, J. Lim, S. Kim (LGE)]

[JVET-O0707](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7327) Crosscheck of JVET-O0353 (Non-CE3: Simplification on transform selection for multiple reference line (MRL)) [L. Zhao (Tencent)]

[JVET-O0355](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6960) Non-CE3: MRL restriction [J. Heo, J. Choi, H. Jang, J. Lim, S. Kim (LGE)]

[JVET-O0942](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7569) Crosscheck of JVET-O0355 (Non-CE3: MRL restriction) [T.-C. Ma (Kwai Inc.)]

[JVET-O0356](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6961) Non-CE3: Restriction on WAIP for MRL and ISP intra prediction [J. Heo, J. Choi, L. Li, J. Lim, S. Kim (LGE)]

[JVET-O0836](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7457) Crosscheck of JVET-O0356 (Non-CE3: Restriction on WAIP for MRL and ISP intra prediction) [A. Tamse (Samsung)]

[JVET-O0363](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6968) CE3-related: Context reduction for intra MPM related syntax element [L. Xu, X. Cao, F. Chen, L. Wang (Hikvision)]

[JVET-O0816](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7437) Crosscheck of JVET-O0363 (CE3-related: Context reduction for intra MPM related syntax element) [T. Ikai (Sharp)]

[JVET-O0364](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6969) On general intra sample prediction [F. Bossen (Sharp)]

[JVET-O0365](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6970) CE3-related: Simplification of Multi-reference line prediction scheme [L. Xu, X. Cao, F. Chen, L. Wang (Hikvision)]

[JVET-O0749](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7370) Crosscheck of JVET-O0365 (CE3-related: Simplification of Multi-reference line prediction scheme) [?? (??)]

[JVET-O0369](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6974) CE3-related: Context reduction for ISP related syntax element [L. Xu, X. Cao, F. Chen, L. Wang (Hikvision)]

[JVET-O0817](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7438) Crosscheck of JVET-O0369 (CE3-related: Context reduction for ISP related syntax element) [T. Ikai (Sharp)]

[JVET-O0371](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6976) CE3-related: On 1xN and 2xN sub-partition in ISP [Y. Sun, L. Xu, X. Cao (Hikvision)]

[JVET-O0771](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7392) Crosscheck of JVET-O0371 (CE3-related: On 1xN and 2xN sub-partition in ISP) [Y.-W. Chen (Kwai Inc.)]

[JVET-O0377](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6982) CE3-related: Context reduction for CCLM syntax element [L. Xu, X. Cao, F. Chen (Hikvision)]

[JVET-O0818](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7439) Crosscheck of JVET-O0377 (CE3-related: Context reduction for CCLM syntax element) [T. Ikai (Sharp)]

[JVET-O0396](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7001) Non-CE3: Simplified mode mapping in MIP [J. Choi, J. Heo, J. Lim, S. Kim (LGE)]

[JVET-O0750](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7371) Crosscheck of JVET-O0396 (Non-CE3: Simplified mode mapping in MIP) [?? (??)]

[JVET-O0397](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7002) Non-CE3: MIP mode reduction [J. Choi, J. Heo, J. Lim, S. Kim (LGE)]

[JVET-O0918](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7540) Crosscheck of JVET-O0397 (Non-CE3: MIP mode reduction) [K. Zhang (Bytedance)]

[JVET-O0399](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7004) Non-CE3: CCLM block size restriction [J. Choi, J. Heo, J. Lim, S. Kim (LGE)]

[JVET-O1014](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7651) Crosscheck of JVET-O0399 (Non-CE3: CCLM block size restriction) [F. Chen (Hikvision)]

[JVET-O0401](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7006) Non-CE3: MIP mode simplifications [[C. Rosewarne](mailto:chris.rosewarne@canon.com.au), J. Gan (Canon)]

[JVET-O0404](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7009) Non-CE3: Linear Model-based Intra Prediction [R. Ghaznavi-Youvalari (Nokia)]

[JVET-O0407](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7012) Non-CE3: On adaptive rounding offset of MIP [K. Kondo, M. Ikeda, T. Suzuki (Sony)]

[JVET-O1006](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7642) Crosscheck of JVET-O0407 (Non-CE3: On adaptive rounding offset of MIP) [J. Pfaff, M. Schäfer (HHI)]

[JVET-O0408](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7013) Non-CE3: On rounding shift of MIP [K. Kondo, M. Ikeda, T. Suzuki (Sony)]

[JVET-O1011](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7647) Crosscheck of JVET-O0408 (Non-CE3: On rounding shift of MIP) [J. Pfaff, M. Schäfer (HHI)]

[JVET-O0412](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7017) CE3-related: Sampling point extension for CCLM [M. Ikeda, Y. Yagasaki, T. Suzuki (Sony)] [late]

[JVET-O0833](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7454) Crosscheck of JVET-O0412 (CE3-related: Sampling point extension for CCLM) [S.-C. Lim, J. Lee, H. Lee, J. Kang (ETRI)]

[JVET-O0416](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7021) Non-CE3: Removal of CCLM context derivation dependency [J. Q. Zhang (PKU), X. Zheng (DJI), S. S. Wang, S. W. Ma (PKU)]

[JVET-O0841](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7462) Crosscheck of JVET-O0416: Non-CE3: Removal of CCLM context derivation dependency [J. Chen (Alibaba)]

[JVET-O0426](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7031) Non-CE3: DC intra prediction mode alignment [A. K. Ramasubramonian, G. Van der Auwera, L. Pham Van, M. Karczewicz (Qualcomm)]

[JVET-O0762](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7383) Crosscheck of JVET-O0426 (Non-CE3: DC intra prediction mode alignment) [H.-J. Jhu (Kwai Inc.)]

[JVET-O0449](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7055) Non-CE3: Decoder-side Intra Mode Derivation (DIMD) with prediction fusion using Planar [M. Abdoli, T. Guionnet, E. Mora, M. Raulet (ATEME), S. Blasi, A. Seixas Dias, G. Kulupana (BBC)]

[JVET-O0720](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7340) Crosscheck of JVET-O0449 Decoder-side Intra Mode Derivation with Prediction Fusion Using Planar [V. Drugeon (Panasonic)]

[JVET-O0464](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7071) Non-CE3: Unification of Neighbouring Location for MPM List Construction [D. Kim, J. Jung, G. Ko, J. Son, J. Kwak (WILUS)]

[JVET-O0467](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7074) Non-CE3: simplified MRL and ISP mode coding [F. Le Léannec, Y. Chen, T. Poirier (InterDigital)]

[JVET-O0856](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7477) Crosscheck of JVET-O0467 (Non-CE3: simplified MRL and ISP mode coding) [H. Liu (Bytedance)]

[JVET-O0469](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7076) Non-CE3: Simplification of MIP MPM Derivation [D. Kim, J. Jung, G. Ko, J. Son, J. Kwak (WILUS)]

[JVET-O0477](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7084) Non-CE3: Simplified entropy coding for intra prediction mode [D. Park, Y.-U. Yoon, J. Do, J.-G. Kim (KAU), J. Lee, J. Kang (ETRI)]

[JVET-O1009](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7645) Crosscheck of JVET-O0477 (Non-CE3: Simplified entropy coding for intra prediction mode) [J. Choi (LGE)]

[JVET-O0481](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7088) Variations of the 8-bit implementation of MIP [P. Helle, J. Pfaff, T. Hinz, P. Merkle, B. Stallenberger, M. Schäfer, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

[JVET-O1112](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7749) Crosscheck of JVET-O0481: Variations of the 8-bit implementation of MIP [S.Esenlik (Huawei)]

[JVET-O0484](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7091) CE3-related: Improved intra mode coding based on unified MPM list generation [J. Pfaff, T. Hinz, P. Merkle, P. Helle, B. Stallenberger, M. Schäfer, H. Schwarz, D. Marpe, T. Wiegand (HHI), B. Wang, S. Esenlik, A. M. Kotra, H. Gao, E. Alshina (Huawei)]

[JVET-O0938](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7563) Crosscheck of JVET-O0484 (CE3-related: Improved intra mode coding based on unified MPM list generation) [M. Salehifar (LGE)]

[JVET-O0485](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7092) Non-CE3: Harmonization of 8-Bit MIP with Unified-MPM and LFNST [J. Pfaff, T. Hinz, P. Helle, P. Merkle, B. Stallenberger, M. Schäfer, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

[JVET-O0885](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7507) Crosscheck of JVET-O0485 (Non-CE3: Harmonization of 8-Bit MIP with Unified-MPM and LFNST) [Z. Zhang (Ericsson)]

[JVET-O0486](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7093) Non-CE3: Harmonization of 8-Bit MIP with Unified-MPM and LFNST using a single type of MIP prediction modes [J. Pfaff, T. Hinz, P. Helle, P. Merkle, B. Stallenberger, M. Schäfer, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

[JVET-O0886](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7508) Crosscheck of JVET-O0486 (Non-CE3: Harmonization of 8-Bit MIP with Unified-MPM and LFNST using a single type of MIP prediction modes) [Z. Zhang (Ericsson)]

[JVET-O0502](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7109) Non-CE3: Proposed ISP cleanup [S. De-Luxán-Hernández, V. George, G. Venugopal, J. Brandenburg, B. Bross, T. Nguyen, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

[JVET-O0944](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7571) Crosscheck of JVET-O0502 (Non-CE3: Proposed ISP cleanup) [T.-C. Ma (Kwai Inc.)]

[JVET-O0507](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7114) Non-CE3: Intra-sub-partition coding mode only performing on non-square blocks [W. Gwun, W. Lee, D. Y. Lee, T. H. Kim, G. H. Park (KHU), G. Bang, W. Lim, H.Y. Kim (ETRI)]

[JVET-O0988](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7624) Cross-check of Non-CE3: Intra-sub-partition coding mode only performing on non-square blocks (JVET-O0507) [M. W. Park (Samsung)]

[JVET-O0509](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7116) Non-CE3: MPM flag signaling first [D. Y. Lee, W. Gwun, W. Lee, T. H. Kim, G. H. Park (KHU), J. Lee, J. Kang (ETRI)]

[JVET-O1056](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7693) Cross-check of Non-CE3: MPM flag signaling first (JVET-O0509) [M. W. Park (Samsung)]

[JVET-O0510](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7117) CE3-related: Extensions to CCLM reference sample filtering in CE3-3.2.1 [S. Keating, K. Sharman (Sony)]

[JVET-O1086](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7723) Crosscheck report of JVET-O0510 (CE3-related: Extensions to CCLM reference sample filtering in CE3-3.2.1) [[A. Filippov](mailto:alexey.filippov@huawei.com), [V. Rufitskiy (Huawei)](mailto:vasily.rufitskiy@huawei.com)]

[JVET-O0512](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7119) Non-CE3: CCLM Coding bug fix [S. Keating, K. Sharman (Sony)]

[JVET-O0716](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7336) Crosscheck of JVET-O0512 (Non-CE3: CCLM Coding bug fix) [L. Xu, F. Chen, L. Wang (Hikvision)]

[JVET-O0514](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7121) Non-CE3: Analysis of Matrix-based Intra Prediction (Informative) [S. Keating, K. Sharman (Sony)]

[JVET-O0515](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7122) Non CE3: Intra mode coding of non-MPM modes [S. Blasi, G. Kulupana, A. Seixas Dias (BBC)]

[JVET-O1096](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7733) Cross-check of JVET-O0515: Non CE3: Intra mode coding of non-MPM modes [F. Racapé, T. Poirier, G. Rath (InterDigital)]

[JVET-O0523](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7130) CE3-related: simplification of Matrix Intra Prediction [T. Dumas, F. Galpin, G. Rath, F. Racapé (InterDigital)]

[JVET-O1051](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7688) Crosscheck of JVET-O0523 (CE3-related: simplification of Matrix Intra Prediction (MIP)) [C. Rosewarne (Canon)]

[JVET-O0535](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7142) Non-CE3: Unification of PDPC for diagonal intra prediction modes [L. Zhao, X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-O0766](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7387) Crosscheck of JVET-O0535: Non-CE3: Unification of PDPC for diagonal intra prediction modes [F. Racapé, G. Rath (Interdigital)]

[JVET-O0536](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7143) CE3-related: Redundant bit saving for CE3-2.2 [L. Zhao, X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-O0779](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7400) Crosscheck of JVET-O0536: CE3-related: Redundant bit saving for CE3-2.2 [L. Pham Van, G. Van der Auwera, M. Karczewicz (Qualcomm)]

[JVET-O0547](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7159) Non-CE: Modified MIP Matrices for Fast Implementation [K. Naser, L. Kerofsky, F. Le Léannec, T. Poirier (InterDigital)]

[JVET-O0962](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7592) Crosscheck of JVET-O0547 (Non-CE: Modified MIP Matrices for Fast Implementation) [J. Pfaff, M. Schäfer (HHI)]

[JVET-O0571](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7186) Non-CE3: Up-sampling with a fixed order in MIP [H. Liu, L. Zhang, K. Zhang, Z. Deng, J. Xu (Bytedance)]

[JVET-O0843](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7464) Crosscheck of JVET-O0571: Non-CE3: Up-sampling with a fixed order in MIP [J. Chen (Alibaba)]

[JVET-O0598](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7213) CE3-related: Simplification on MIP Look-up Table [T.-C. Ma, X. Xiu, Y.-W. Chen, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-O0693](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7313) Crosscheck of JVET-O0598 (CE3-related: Simplification on MIP Look-up Table) [L. Zhao (Tencent)]

[JVET-O0599](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7214) CE3-related: Simplification on MIP flag context model [T.-C. Ma, X. Xiu, Y.-W. Chen, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-O0815](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7436) Crosscheck of JVET-O0599 (CE3-related: Simplification on MIP flag context model) [J. Heo, L. Li (LGE)]

[JVET-O0606](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7221) Non-CE3: Context Reduction for MPM Signaling [H.-J. Jhu, X. Xiu, Y.-W. Chen, T.-C. Ma, X. Wang (Kwai Inc.)]

[JVET-O1020](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7657) Crosscheck of JVET-O0606 (Non-CE3: Context Reduction for MPM Signaling) [?? (??)]

[JVET-O0621](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7236) Non-CE3: MIP simplification [Y. Yasugi, T. Ikai (Sharp)] [late]

[JVET-O0855](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7476) Crosscheck of JVET-O0621 (Non-CE3: MIP simplification) [Z. Deng (Bytedance)]

[JVET-O0632](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7247) Non-CE3: WAIP restriction for square sub-CU blocks partitioned by ISP [A. Kumar, S. Shrestha, B. Lee (Chosun Univ), Y. Lee, J. Park (Humax)]

[JVET-O1079](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7716) Crosscheck of JVET-O0632 (Non-CE3: WAIP restriction for square sub-CU blocks partitioned by ISP) [G. Ko, D. Kim, J. Jung, J. Son, J. Kwak (WILUS)]

[JVET-O0640](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7256) CE3-related: On 2x2/2x4/4x2 chroma blocks at the corner of pictures [L. Pham Van, G. Van der Auwera, A. K. Ramasubramonian, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-O0647](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7263) Non-CE3: On signalling of intra coded blocks [L. Pham Van, G. Van der Auwera, A. K. Ramasubramonian, V. Seregin, H. Huang, M. Karczewicz (Qualcomm)]

[JVET-O0649](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7265) Non-CE3: Simplification of reference sample smoothing in intra prediction [A. K. Ramasubramonian, G. Van der Auwera, M. Karczewicz (Qualcomm)]

[JVET-O0655](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7271) Non-CE3: On chroma DM derivation table for 4:2:2 chroma format [S. Iwamura, S. Nemoto, A. Ichigaya (NHK)]

[JVET-O0687](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7306) Crosscheck of JVET-O0655 (Non-CE3: On chroma DM derivation table for 4:2:2 chroma format) [T. Chujoh (Sharp)]

[JVET-O0671](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7288) Non-CE3: Intra chroma mode coding simplification [B. Ray, G. Van der Auwera, M. Karczewicz (Qualcomm)]

[JVET-O1092](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7729) Crosscheck of JVET-O0671 Non-CE3: Intra chroma mode coding simplification [M. Abdoli, T. Guionnet (ATEME)]

[JVET-O0672](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7290) Non-CE3: MRL intra prediction for chroma DM [C.-C. Kuo, C.-C. Lin, C.-L. Lin (ITRI)]

[JVET-O0673](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7291) Harmonized MIP/CCLM boundary downsampling [T. Biatek, G. Van Der Auwera, M. Karczewicz (Qualcomm)]

[JVET-O1036](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7673) Crosscheck of JVET-O0673 (Harmonized MIP/CCLM boundary downsampling) [Christophe Chevance (InterDigital)]

[JVET-O0674](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7292) Non-CE3: Multiple reference set for CCLM [P.-H. Lin, J.-Y. Deng (Foxconn)] [late]

[JVET-O0760](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7381) Crosscheck of JVET-O0674 (Non-CE3: Multiple reference set for CCLM) [H.-J. Jhu (Kwai Inc.)]

[JVET-O0748](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7369) Non-CE3: On signalling for intra coding mode in the MPM list [L. Pham Van, G. Van der Auwera, A. K. Ramasubramonian, M. Karczewicz (Qualcomm)] [late]

[JVET-O1038](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7675) Crosscheck of JVET-O0748 (Non-CE3: On signalling for intra coding mode in the MPM list) [L. Zhao (Tencent)]

[JVET-O1094](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7731) Crosscheck of JVET-O0748 (Non-CE3: On signalling for intra coding mode in the MPM list) [J. Nam (LGE)]

[JVET-O0755](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7376) Non-CE3: On signalling of MIP parameters [A. K. Ramasubramonian, G. Van der Auwera, T. Hsieh, T. Biatek, L. Pham Van, M. Karczewicz (Qualcomm)] [late]

[JVET-O0793](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7414) CE3-related: MIP with simplified mode index coding [Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)] [late]

[JVET-O1158](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7795) Crosscheck of JVET-O0793 (CE3-related: MIP with simplified mode index coding) [A. K. Ramasubramonian (Qualcomm)]

[JVET-O0848](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7469) Non CE3: Modification of MIP interpolation [B.-J. Fuh, C.-H. Yau, C.-C. Lin, C.-C. Kuo, C.-L. Lin (ITRI)] [late]

[JVET-O1043](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7680) Crosscheck of JVET-O0848 (Non CE3: Modification of MIP interpolation) [[T.-H. Li](mailto:thli@fginnov.com), J.-Y. Deng (Foxconn)]

[JVET-O0925](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7550) Non-CE3: Simplifications of MIP [J. Pfaff, P. Merkle, P. Helle, H. Schwarz, D. Marpe, T. Wiegand (HHI), A. K. Ramasubramonian, T. Biatek, G. Van der Auwera, L. Pham Van, M. Karczewicz (Qualcomm), J. Choi, J. Heo, J. Lim, M. Salehifar, S. Kim (LGE), K. Kondo, M. Ikeda, T. Suzuki (Sony), Z. Zhang, K. Andersson, R. Sjöberg, J. Ström, P. Wennersten (Ericsson)] [late]

[JVET-O1128](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7765) Crosscheck of JVET-O0925 (Non-CE3: Simplifications of MIP) [J. Sauer, M. Bläser (RWTH)]

[JVET-O1127](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7764) Non-CE3: Fixed downshifting for 8-bit MIP [J.-Y. Huo, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.), K. Kondo, M. Ikeda, T. Suzuki (Sony), S. Wan (NPU), Y.-F. Yu (OPPO)] [late]

See notes relating to BoG report. To be studied in a CE.

[JVET-O1153](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7790) Non-CE3: Revised intra chroma mode coding simplification [B. Ray, G. Van der Auwera, M. Karczewicz (Qualcomm), J. Q. Zhang (PKU), X. Zheng (DJI), S. S. Wang, S. W. Ma (PKU), S. Keating, K. Sharman (Sony)] [late]

Discussed in Track A Thursday 11 July 1415 (GJS)

This is a combination of three things the BoG had recommended for adoption. It was commented that a version of the text needs improvement, and an author said a new version of the text had been developed.

This fixes a parsing dependency problem in O0671. Some editorial aspects were discussed.

Decision: Adopted (some editorial refinements needed).

[JVET-O1178](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7815) Crosscheck of JVET-O1153 (Non-CE3: Revised intra chroma mode coding simplification) [H. Schwarz (HHI)]

## CE4 related – Inter prediction (105)

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

[JVET-O0123](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6727) Non-CE4: Alignment of BDOF refinement process with PROF [J. Li, C. Lim (Panasonic)]

[JVET-O0733](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7354) Crosscheck of JVET-O0123: Non-CE9: Alignment of BDOF refinement process with PROF [[W. Chen (InterDigital)](mailto:Wei.Chen@InterDigital.com)]

[JVET-O0125](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6729) Non-CE4: Alignment of DMVR padding process with specification [J. Li, C. S. Lim (Panasonic)]

[JVET-O0714](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7334) Crosscheck of JVET-O0125: Non-CE9: Alignment of DMVR padding process with specification [X. Xiu (Kwai Inc.)]

[JVET-O0126](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6730) Non-CE4: Align coding of BPWA index with normal truncated rice binarization process [J. Li, C. S. Lim (Panasonic)]

[JVET-O0794](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7415) Crosscheck of JVET-O0126 (Non-CE4: Align coding of BPWA index with normal truncated Rice binarization process) [S.-T. Hsiang (MediaTek)]

[JVET-O0128](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6732) Non-CE4: simplification of triangle mode MV context storage [J. Li, C. S. Lim (Panasonic)]

[JVET-O0724](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7344) Crosscheck of JVET-O0128 (Non-CE4: Simplification of triangle mode MV context storage) [R.-L. Liao (Alibaba)]

[JVET-O0163](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6767) Non-CE4: Simplification on SbTMVP [H. Chen, H. Yang (Huawei)]

[JVET-O0926](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7551) Crosscheck of JVET-O0163 (Non-CE4: Simplification on SbTMVP) [Y.-C. Lin (MediaTek)]

[JVET-O0164](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6768) Non-CE4: Simplification on AMVP list construction [H. Chen, H. Yang (Huawei)]

[JVET-O0742](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7363) Crosscheck of JVET-O0164 (Non-CE4: Simplification on AMVP list construction) [J. Li (Bytedance)]

[JVET-O0801](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7422) Crosscheck of JVET-O0164 (Non-CE4: Simplification on AMVP list construction) [J. Li (Bytedance)]

[JVET-O0167](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6771) Non-CE4: On SbTMVP motion data derivation [J. Zhao, S. Kim (LGE)]

[JVET-O0867](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7488) Crosscheck of JVET-O0167 (Non-CE4: On SbTMVP base motion data derivation) [N. Zhang (Bytedance)]

[JVET-O0190](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6794) Non-CE4: LIC model parameters using forward mapped luma samples in LMCS [J. Shingala, A. Natesan (Ittiam)]

[JVET-O0804](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7425) Crosscheck of JVET-O0190 (Non-CE4: LIC model parameters using forward mapped luma samples in LMCS) [C.-M. Tsai (MediaTek)]

[JVET-O0217](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6822) Non-CE4: Simplification of motion vector storing process for triangle merge mode [Y. Ahn, D. Sim (Digital Insights)]

[JVET-O0220](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6825) Non-CE4: On maximum number of subblock merge candidates [R. Yu, D. Liu (Ericsson)]

[JVET-O0221](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6826) Non-CE4: On merge data syntax [[R. Yu](mailto:ruoyang.yu@ericsson.com), D. Liu (Ericsson)]

[JVET-O0222](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6827) Non-CE4: Modification of triangle merge mode enabling criterion [D. Liu, R. Yu (Ericsson)]

[JVET-O1041](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7678) Crosscheck of JVET-O0222 (Non-CE4: Modification of triangle merge mode enabling criterion) [F. Chen (Hikvision)]

[JVET-O0249](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6854) Non-CE4: Merge Modes Signalling [H. Huang, W.-J. Chien, V. Seregin, M. Karczewicz (Qualcomm)]

Author list should be changed – is now a multi-company proposal

[JVET-O0728](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7348) Crosscheck of JVET-O0249 (Non-CE4: Merge Modes Signaling) [R.-L. Liao (Alibaba)]

[JVET-O0951](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7580) Crosscheck of JVET-O0249 Merge Modes Signaling [J. Ye, X. Li]

[JVET-O0252](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6857) CE4-related: Alignment and simplification of PROF and BDOF [H. Huang, W.-J. Chien, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-O0688](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7307) Crosscheck of JVET-O0252: CE4-related: Alignment and simplification of PROF and BDOF [X. Xiu (Kwai Inc.)]

[JVET-O0253](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6858) Non-CE4: Simplification of HMVP in AMVP mode [H. Huang, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-O0949](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7577) Cross-check of JVET-O253 (Non-CE4: Simplification of HMVP in AMVP mode) [F. Galpin (InterDigital)]

[JVET-O0254](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6859) Non-CE4: Size constrain for inherited affine motion prediction [H. Huang, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-O0990](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7626) Crosscheck of JVET-O0254 (Non-CE4: Size constrain for inherited affine motion prediction) [J. Li (Panasonic)]

[JVET-O0257](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6862) CE4-related: Simplified local illumination compensation [N. Zhang, H. Liu, L. Zhang, K. Zhang, Y. Wang (Bytedance)]

[JVET-O0712](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7332) Crosscheck of JVET-O0257 (CE4-related: Simplified local illumination compensation) [N. Park (LGE)]

[JVET-O0263](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6868) Non-CE4: Cleanups on syntax design for sub-block coding tools [K. Zhang, L. Zhang, H. Liu, N. Zhang, Z. Deng, Y. Wang (Bytedance)]

[JVET-O0265](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6870) Non-CE4: Simplified motion field storage for TPM [N. Zhang, H. Liu, L. Zhang, K. Zhang, Y. Wang (Bytedance)]

[JVET-O0676](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7294) Crosscheck of JVET-O0265: Non-CE4: Simplified motion field storage for TPM [J. Zhao (LGE)]

[JVET-O0278](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6883) CE4-related: On signalling of merge flags [Y.-L. Hsiao, C.-C. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0828](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7449) Crosscheck of JVET-O0278 (CE4-related: On signalling of merge flags) [H. Chen (Huawei)]

[JVET-O0279](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6884) CE4-related: Simplification of motion vector storing process for triangle prediction mode [Y.-L. Hsiao, C.-C. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0835](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7456) Crosscheck of JVET-O0279 (CE4-related: Simplification of motion vector storing process for triangle prediction mode) [H. Lee, S.-C. Lim, J. Lee, J. Kang (ETRI)]

[JVET-O0280](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6885) CE4-related: SIMD implementation for weighted sample prediction process of triangle prediction mode [Y.-L. Hsiao, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0859](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7480) Crosscheck of JVET-O0280 (CE4-related: SIMD implementation for weighted sample prediction process of triangle prediction mode) [T. Hashimoto (Sharp)]

[JVET-O0281](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6886) CE4-related: Alignment of displacement bitdepths for BDOF and PROF [C.-Y. Lai, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0900](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7522) Crosscheck of JVET-O0281 (CE4-related: Alignment of displacement bitdepths for BDOF and PROF) [H. Huang (Qualcomm)]

[JVET-O0283](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6888) CE4-related: Simplification for SbTMVP [Y.-C. Lin, C.-C. Chen, C.-W. Hsu, T.-D. Chuang, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O1071](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7708) Crosscheck report of JVET-O0283: CE4-related: Simplification for SbTMVP [X. Xu (Tencent)]

[JVET-O0284](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6889) CE4-related: Interaction between symmetric MVD and mvd\_l1\_zero\_flag [M.-S. Chiang, C.-W. Hsu, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0285](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6890) CE4-related: On merging candidate list construction [Y.-C. Lin, C.-C. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0879](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7501) Crosscheck of JVET-O0285 (CE4-related: On merging candidate list construction) [H. Gao (Huawei)]

[JVET-O0286](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6891) CE4-related: Extension of phase-variant affine subblock motion compensation in CE4-2.5 [T.-D. Chuang, C.-Y. Lai, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0820](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7441) Crosscheck of JVET-O0286 (CE4-related: Extension of phase-variant affine subblock motion compensation in CE4-2.5) [T.-S Chang (Alibaba)]

[JVET-O0305](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6910) Non-CE4: Undefined condition of merge mode syntax [K. Abe, T. Toma, J. Li, V. Drugeon (Panasonic)]

[JVET-O0309](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6914) Non-CE4: Merge mode signalling overhead reduction [G. Ko, D. Kim, J. Jung, J. Son, J. Kwak (WILUS)]

[JVET-O0829](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7450) Crosscheck of JVET-O0309 (Non-CE4: Merge mode signalling overhead reduction) [H. Chen (Huawei)]

[JVET-O0313](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6918) CE4-related: On Conditions for enabling PROF [Y.-C. Yang, P.-H. Lin (Foxconn)]

[JVET-O0734](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7355) Crosscheck of JVET-O0313: CE4-related: On Conditions for enabling PROF [[W. Chen (InterDigital)](mailto:Wei.Chen@InterDigital.com)]

[JVET-O0314](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6919) Non-CE4: Modification of MV storage in triangle merge mode [P.-H. Lin (Foxconn)]

[JVET-O0759](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7380) Crosscheck of JVET-O0314 (Non-CE4: Modification of MV storage in triangle merge mode) [H.-J. Jhu (Kwai Inc.)]

[JVET-O0328](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6933) Non-CE4: On Sub-block Merge Candidates List [H. Lee, S.-C. Lim, J. Lee, J. Kang, H. Y. Kim (ETRI)]

[JVET-O0329](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6934) Non-CE4: Simplification of motion vector storage process for triangle merge mode [H. Lee, S.-C. Lim, J. Lee, J. Kang, H. Y. Kim (ETRI)]

[JVET-O0881](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7503) Crosscheck of JVET-O0329 (Non-CE4: Simplification of motion vector storage process for triangle merge mode) [[R. Yu](mailto:ruoyang.yu@ericsson.com), D. Liu (Ericsson)]

[JVET-O0790](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7411) Crosscheck of JVET-O0328 (Non-CE4: On sub-block merge candidates list) [Y.-L. Hsiao (MediaTek)]

[JVET-O0330](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6935) Non-CE4: Syntax element ‘regular\_merge\_flag’ signalling [H. Lee, S.-C. Lim, J. Lee, J. Kang, H. Y. Kim (ETRI)]

[JVET-O0770](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7391) Crosscheck of JVET-O0330 (Non-CE4: Syntax element ‘regular\_merge\_flag’ signaling) [Y.-W. Chen (Kwai Inc.)]

[JVET-O0361](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6966) Non-CE4: Remove the redundancy among the flag coding for merge modes [F. Chen, L. Wang (Hikvision)]

[JVET-O1008](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7644) Crosscheck of JVET-O0361 (Non-CE4: Remove the redundancy among the flag coding for merge modes) [J. Choi (LGE)]

[JVET-O0362](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6967) Non-CE4: Modified enabling condition for triangle mode [F. Chen, L. Wang (Hikvision)]

[JVET-O0725](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7345) Crosscheck of JVET-O0362 (Non-CE4: Modified Enabling Condition for Triangle Mode) [R.-L. Liao (Alibaba)]

[JVET-O0366](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6971) Non-CE4: Simplifications on BCW index derivation process [N. Park, J. Nam, H. Jang, J. Lim, S. Kim (LGE)]

[JVET-O0685](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7304) Crosscheck of JVET-O0366 (Non-CE4: Simplifications on BCW index derivation process) [T. Chujoh (Sharp)]

[JVET-O0367](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6972) Non-CE4: The proposed BCW index derivation for pairwise candidate [N. Park, J. Nam, H. Jang, J. Lim, S. Kim (LGE)]

[JVET-O0991](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7627) Crosscheck of JVET-O0367 (Non-CE4: The proposed BCW index derivation for pairwise candidate) [J. Li (Panasonic)]

[JVET-O0378](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6983) Non-CE4: Simplification of MV context storage for triangle mode [F. Chen, L. Wang (Hikvision)]

[JVET-O0880](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7502) Crosscheck of JVET-O0378 (Non-CE4: Simplification of MV context storage for triangle mode) [[D. Liu](mailto:du.liu@ericsson.com), R. Yu (Ericsson)]

[JVET-O0379](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6984) Non-CE4: Modified mode decision process for triangle mode [F. Chen, L. Wang (Hikvision)]

[JVET-O0726](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7346) Crosscheck of JVET-O0379 (Non-CE4: Modified Mode Decision Process for Triangle Mode) [R.-L. Liao (Alibaba)]

[JVET-O0384](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6989) CE4-related: CIIP Simplification [J. Y. Lee (Sejong Univ.), W. Lim, G. Bang, H. Y. Kim (ETRI)] [miss] [late]

[JVET-O1022](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7659) Crosscheck of JVET-O0384 (CE4-related: CIIP Simplification) [K. Choi (Samsung)]

[JVET-O0388](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6993) Non-CE4: On the context of triangle merge index [F. Chen, L. Wang (Hikvision)]

[JVET-O0727](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7347) Crosscheck of JVET-O0388 (Non-CE4: On the Context of Triangle Merge Index) [R.-L. Liao (Alibaba)]

[JVET-O0411](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7016) Non-CE4: Simplification of bi-prediction MV generation for triangle partition mode storage [K. Reuzé, C.-C. Chen, W.-J. Chien, H. Huang, M. Karczewicz (Qualcomm)]

[JVET-O0414](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7019) Non-CE4: Symmetric-MVD control considering the reference picture type [N. Park, J. Nam, H. Jang, J. Lim, S. Kim (LGE)]

[JVET-O0730](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7351) Crosscheck of JVET-O0414: Non-CE4 : Symmetric-MVD control considering the reference picture type [[Y. He (InterDigital)](mailto:yuwen.he@interdigital.com)]

[JVET-O0415](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7020) Non-CE4: Fix of POC distance condition for MMVD [N. Park, J. Nam, H. Jang, J. Lim, S. Kim (LGE)]

[JVET-O0868](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7489) Crosscheck of JVET-O0415 (Non-CE4: Fix of POC distance condition for MMVD) [N. Zhang (Bytedance)]

[JVET-O0418](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7023) CE4-related: Simplification of motion vector storage operation for triangle merge mode [X. W. Meng (PKU), X. Zheng (DJI), S. S. Wang, S. W. Ma (PKU)]

[JVET-O0995](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7631) Crosscheck of JVET-O0418 (CE4-related: Simplification of motion vector storage operation for triangle merge mode) [J. Li (Panasonic)]

[JVET-O0420](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7025) CE4-related: Reduce scaling operation number for MMVD [S. H. Wang (PKU), X. Zheng (DJI), S. S. Wang, S. W. Ma (PKU)]

[JVET-O0761](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7382) Crosscheck of JVET-O0420 (CE4-related: Reduce scaling operation number for MMVD) [H.-J. Jhu (Kwai Inc.)]

[JVET-O0421](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7026) Non-CE4: On CIIP Merge mode with no residual [G. Laroche, C. Gisquet, J. Taquet, P. Onno (Canon)]

[JVET-O1083](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7720) Crosscheck report of JVET-O0421 (Non-CE4: On CIIP Merge mode with no residual) [A. Filippov, V. Rufitskiy (Huawei)]

[JVET-O0422](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7027) Non-CE4: On mode flags signalling for Merge [G. Laroche, C. Gisquet, J. Taquet, P. Onno (Canon)]

[JVET-O1084](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7721) Crosscheck report of JVET-O0422 (JVET-O0422 Non-CE4: On mode flags signalling for Merge) [A. Filippov, V. Rufitskiy (Huawei)]

[JVET-O0423](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7028) Non-CE4: On SbTMVP derivation using HMVP [C. Gisquet, G. Laroche, P. Onno, J. Taquet (Canon)]

[JVET-O0887](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7509) Crosscheck of JVET-O0423 (Non-CE4: On SbTMVP derivation using HMVP) [F. Henry (Orange), G. Clare (bcom)]

[JVET-O0424](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7029) Non-CE4: On TMVP reference frame selection using HMVP [C. Gisquet, G. Laroche, P. Onno, J. Taquet (Canon)]

[JVET-O0869](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7490) Crosscheck of JVET-O441

0424 (Non-CE4: On TMVP reference frame selection using HMVP) [N. Zhang (Bytedance)]

[JVET-O0431](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7036) Non-CE4: On Merge data signaling [H. Chen, X. Chen, H. Yang (Huawei)]

[JVET-O1025](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7662) Crosscheck of JVET-O0431 (Non-CE4: On Merge data signalling) [Z.-Y. Lin (MediaTek)]

[JVET-O0434](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7039) Non-CE4: Simplification of TMVP [H. Chen, H. Yang (Huawei)]

[JVET-O0947](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7574) Crosscheck of JVET-O0434 (Non-CE4: Simplification of TMVP) [G. Ko, D. Kim, J. Jung, J. Son, J. Kwak (WILUS)]

[JVET-O0438](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7043) Non-CE4: Cleanup for affine AMVR enabling flag in SPS level [G. Ko, D. Kim, J. Jung, J. Son, J. Kwak (WILUS)]

[JVET-O1102](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7739) Crosscheck of JVET-O0438 (Non-CE4: Cleanup for affine AMVR enabling flag in SPS level) [A. Kumar, B. Lee (Chosun Univ)]

[JVET-O0439](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7044) Non-CE4: Modification of the temporal merging candidate for the regular merge mode [G. Lee, G. Kim, S. Cha, D. Nam, J. Han (Sejong University)]

[JVET-O0834](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7455) Crosscheck of JVET-O0439 (Non-CE4: Modification of the temporal merging candidate for the regular merge mode) [S.-C. Lim, H. Lee, J. Kang, J. Lee (ETRI)]

[JVET-O0440](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7045) Non-CE4: A modified method to derive the temporal merge candidate for long-term reference picture [G. Lee, G. Kim, S. Cha, D. Nam, J. Han (Sejong University)]

[JVET-O0441](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7046) Non-CE4: Short-tap interpolation for bi-prediction [[X. W. Meng (PKU)](mailto:xwmeng@pku.edu.cn), [X. Zheng (DHI)](mailto:xiaozhen.zheng), S. S. Wang, S. W. Ma (PKU)]

[JVET-O0870](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7491) Crosscheck of JVET-O0441 (Non-CE4: Short-tap interpolation filter for bi-prediction) [N. Zhang (Bytedance)]

[JVET-O0456](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7062) Non-CE4: Grouping the syntax elements of motion vector differences [Y.-J. Chang, Y. Zhang, C.-C. Chen, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-O0802](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7423) Crosscheck of JVET-O0456: Non-CE4: Grouping the syntax elements of motion vector differences [Y. He (InterDigital)]

[JVET-O0457](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7064) CE4-related: LIC flag inherited per component [P. Bordes, F. Urban, F. Le Léannec, F. Galpin, T. Poirier (InterDigital)]

[JVET-O0686](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7305) Crosscheck of JVET-O0457 (CE4-related: LIC flag inherited per component) [T. Chujoh (Sharp)]

[JVET-O0468](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7075) Non-CE4: simplified SMVD mode coding [F. Le Léannec, Y. Chen, T. Poirier (InterDigital)]

[JVET-O0470](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7077) CE4-related: encoder simplification of local illumination compensation [F. Urban, P. Bordes, F. Le Léannec, F. Galpin, T. Poirier (InterDigital)]

[JVET-O1065](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7702) Crosscheck of JVET-O0470 on encoder simplification of local illumination compensation [V. Seregin (Qualcomm)]

[JVET-O1066](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7703) Crosscheck of JVET-O0466 (Non-CE6: interaction between MTS and LFNST) [H. E. Egilmez (Qualcomm)]

[JVET-O0489](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7096) Non-CE4: Geometrical partitioning for inter blocks [S. Esenlik, H. Gao, A. Filippov, V. Rufitskiy, A. M. Kotra, B. Wang, E. Alshina (Huawei), M. Bläser, J. Sauer (RWTH Aachen)]

[JVET-O1010](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7646) Crosscheck of JVET-O0489 (Non-CE4: Geometrical partitioning for inter blocks) [A. Wieckowski (HHI)]

[JVET-O0500](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7107) Non-CE4: Affine and sub-block modes coding clean-up [F. Galpin, F. Le Léannec, A. Robert, T. Poirier (InterDigital)]

[JVET-O0903](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7525) Crosscheck of JVET-O0500 (non-CE4: affine and sub-block modes coding clean-up) [H. Huang (Qualcomm)]

[JVET-O0501](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7108) Non-CE4: Temporal merge modes simplification [F. Galpin, F. Le Léannec, A. Robert, T. Poirier (InterDigital)]

[JVET-O0904](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7526) Crosscheck of JVET-O0501 (non-CE4: temporal merge modes simplification) [H. Huang (Qualcomm)]

[JVET-O0516](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7123) Non-CE4: BCW for pairwise candidate [A. Robert, F. Le Léannec, T. Poirier, F. Galpin (InterDigital)]

[JVET-O1023](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7660) Crosscheck of JVET-O0516 (Non-CE4: BCW for pairwise candidate) [N. Park (LGE)]

[JVET-O0522](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7129) Non-CE4: CIIP using triangular partitions [S. Blasi, G. Kulupana, A. Seixas Dias (BBC)]

[JVET-O1029](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7666) Crosscheck of JVET-O0522 (Non-CE4: CIIP using triangular partitions) [I. Zupancic (HHI)]

[JVET-O0530](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7137) Non-CE4: Adaptive subblock size for affine motion compensation [G. Li, X. Li, X. Xu, S. Liu (Tencent)]

[JVET-O0531](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7138) Non-CE4: On LIC for Affine [G. Li, X. Li, X. Xu, S. Liu (Tencent)]

[JVET-O0713](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7333) Crosscheck of JVET-O0531: Non-CE4: On LIC for Affine [X. Xiu (Kwai Inc.)]

[JVET-O0534](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7141) Non-CE4: Redundancy removal for merge mode signaling [J. Ye, X. Li, S. Liu (Tencent)]

[JVET-O1152](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7789) Crosscheck report of JVET-O0534 (Non-CE4: Redundancy removal for merge mode signaling) [?? (??)]

[JVET-O0552](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7165) Non-CE4: Extension of triangle partition mode to P-slices [K. Reuzé, C.-C Chen, W.-J. Chien, H. Huang, M. Karczewicz (Qualcomm)]

[JVET-O1028](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7665) Crosscheck of JVET-O0552 (Non-CE4: Extension of triangle partition mode to P-slices) [I. Zupancic (HHI)]

[JVET-O0553](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7167) Non-CE4: On prediction refinement with optical flow [X. Li, G. Li, X. Xu, S. Liu (Tencent)]

[JVET-O0736](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7357) Crosscheck of JVET-O0553: Non-CE4: On prediction refinement with optical flow [W. Chen (InterDigital)]

[JVET-O0560](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7174) Merge Mode Syntax [L. Wang, K. Panusopone (Nokia)]

[JVET-O0567](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7182) Non-CE4: Cleanups on MVD ranges [Z. Deng, H. Liu, L. Zhang, K. Zhang, Y. Wang (Bytedance)]

[JVET-O0572](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7187) Non-CE4: On availability of default reference pictures used in SMVD [H. Liu, L. Zhang, K. Zhang, Z. Deng, N. Zhang, Y. Wang (Bytedance)]

[JVET-O0579](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7194) Non-CE4: SMVD processing when mvd\_l1\_zero\_flag is set equal to 1 [H. Jang, N. Park, J. Nam, S. Kim, J. Lim (LGE)]

[JVET-O0864](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7485) Crosscheck of JVET-O0579: "Non-CE4: SMVD processing when mvd\_l1\_zero\_flag is set equal to 1" [F. Le Léannec (Interdigital)]

[JVET-O0580](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7195) CE4-related: Additional tests for prediction refinement with optical flow for affine mode (CE4-2.1) with 4x8 sub-block size [Y. He, W. Chen (InterDigital), W. Zeng, E. Cai (Ubilinx)]

[JVET-O0930](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7555) Crosscheck of JVET-O0580 (CE4-related: Additional tests for prediction refinement with optical flow for affine mode (CE4-2.1) with 4x8 sub-block size) [G. Li (Tencent)]

[JVET-O0583](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7198) CE4-related: Prediction refinement with optical flow for chroma components for affine mode [Y. He, W. Chen (InterDigital)]

[JVET-O0812](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7433) Crosscheck of JVET-O0583 (CE4-related: Prediction refinement with optical flow for chroma components for affine mode) [[T.-H. Li](mailto:thli@fginnov.com), J.-Y. Deng (Foxconn)]

[JVET-O0585](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7200) Non-CE4: Merge syntax for removing redundant syntax signaling or fall back merge mode [H. Jang, N. Park, J. Nam, S. Kim, J. Lim (LGE)]

[JVET-O0973](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7605) Crosscheck of JVET-O0585 (Non-CE4: Merge syntax for removing redundant syntax signaling or fall back merge mode) [M.-S. Chiang (MediaTek)]

[JVET-O1132](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7769) Crosscheck of JVET-O0585 (Non-CE4: Merge syntax for removing redundant syntax signaling or fall back merge mode) [W. Lim, S. Cho (ETRI)]

[JVET-O0586](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7201) Non-CE4: Redundancy removal in merge modes signaling [Y.-W. Chen, X. Xiu, T.-C. Ma, H.-J. Jhu, S. Ye, X. Wang (Kwai Inc.)]

[JVET-O0697](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7317) Crosscheck of JVET-O0586 (Non-CE4: Redundancy removal in merge modes signaling) [Y.-H. Chao (Qualcomm)]

[JVET-O0587](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7202) Non-CE4: Simplification of MVP list construction [Y.-W. Chen, X. Xiu, T.-C. Ma, X. Wang (Kwai Inc.)]

[JVET-O0931](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7556) Crosscheck of JVET-O0587 (Non-CE4: Simplification of MVP list construction) [G. Li (Tencent)]

[JVET-O0588](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7203) CE4-related: On SbTMVP motion shift derivation [Y.-W. Chen, X. Xiu, T.-C. Ma, X. Wang (Kwai Inc.)]

[JVET-O0780](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7401) Crosscheck of JVET-O0588: CE4-related: On SbTMVP motion shift derivation [Y.-C. Sun (Alibaba)]

[JVET-O0589](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7204) Non-CE4: Simplification of HMVP in merge list construction [Y.-W. Chen, X. Xiu, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-O0698](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7318) Crosscheck of JVET-O0589 (Non-CE4: Simplification of HMVP in merge list construction) [Y.-H. Chao (Qualcomm)]

[JVET-O0592](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7207) CE4-related: Motion estimation improvements [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-O0932](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7557) Crosscheck of JVET-O0592 (CE4-related: Motion estimation improvements) [G. Li (Tencent)]

[JVET-O0593](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7208) CE4-related: Harmonization of BDOF and PROF [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-O0735](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7356) Crosscheck of JVET-O0593: CE4-related: Harmonization of BDOF and PROF [[W. Chen (InterDigital)](mailto:Wei.Chen@InterDigital.com)]

[JVET-O0594](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7209) CE4-related: Prediction sample padding unification for BDOF and PROF [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-O0905](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7527) Crosscheck of JVET-O0594 (CE4-related: Prediction sample padding unification for BDOF and PROF) [H. Huang (Qualcomm)]

[JVET-O0595](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7210) CE4-related: Modified adaptive motion vector resolution (AMVR) for affine mode [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-O0933](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7558) Crosscheck of JVET-O0595 (CE4-related: Modified adaptive motion vector resolution (AMVR) for affine mode) [G. Li (Tencent)]

[JVET-O0601](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7216) CE4-related: On motion vector population under triangle prediction mode [X. Wang, Y.-W. Chen, X. Xiu, T.-C. Ma (Kwai Inc.)]

[JVET-O1034](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7671) Crosscheck of JVET-O0601: CE4-related: On motion vector population under triangle prediction mode [H. Wang (Qualcomm)]

[JVET-O0604](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7219) CE4-related: Simplification on block location validation in SbTMVP [Y.-W. Chen, X. Xiu, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-O0785](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7406) Crosscheck of JVET-O0604: CE4-related: Simplification on block location validation in SbTMVP [Y.-C. Sun (Alibaba)]

[JVET-O0605](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7220) CE4-related: On exclusively applying LIC and PROF [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-O0830](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7451) Crosscheck of JVET-O0605 (CE4-related: On exclusively applying LIC and PROF) [H. Chen (Huawei)]

[JVET-O0607](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7222) CE4-related: On handling the interaction of the mvd\_l1\_zero\_flag and sym\_mvd\_flag [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-O0624](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7239) CE4-related: Unified padding for BDOF and PROF [K. Zhang, L. Zhang, H. Liu, J. Xu, Y. Wang (Bytedance)]

[JVET-O0814](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7435) Crosscheck of JVET-O0624 (CE4-related: Unified padding for BDOF and PROF) [[T.-H. Li](mailto:thli@fginnov.com), J.-Y. Deng (Foxconn)]

[JVET-O0629](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7244) Non-CE4: Simplification of motion field for triangle partition [R.-L. Liao, Y. Ye, J. Chen (Alibaba)]

[JVET-O0792](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7413) Crosscheck of JVET-O0629 (Non-CE4: Simplification of motion field for triangle partition) [Y.-L. Hsiao (MediaTek)]

[JVET-O0630](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7245) Non-CE4: DMVR on merge mode [R.-L. Liao, J. Chen, Y. Ye, J. Luo (Alibaba)]

[JVET-O0906](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7528) Crosscheck of JVET-O0630 (Non-CE4: DMVR on merge mode) [H. Huang (Qualcomm)]

[JVET-O0631](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7246) Non-CE4: DMVR on SMVD and AMVP mode [R.-L. Liao, Y. Ye, J. Chen, J. Luo (Alibaba)]

[JVET-O0907](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7529) Crosscheck of JVET-O0631 (Non-CE4: DMVR on SMVD and AMVP mode) [H. Huang (Qualcomm)]

[JVET-O0633](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7248) Non-CE4: On MMVD candidate flag coding [X. Chen, H. Yang (Huawei)]

[JVET-O0927](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7552) Crosscheck of JVET-O0633 (Non-CE4: On MMVD candidate flag coding) [T. Hashimoto, T. Ikai (Sharp)]

[JVET-O0639](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7255) Non-CE4: Context reduction for merge mode [J. Ye, X. Li, C. Auyeung, S. Liu (Tencent)]

[JVET-O0911](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7533) Crosscheck of JVET-O0639: Non-CE4: Context reduction for merge mode [W. Zhu (Bytedance)]

[JVET-O0652](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7268) CE4-related: Line buffer size reduction method for switchable interpolation filter [T. Solovyev, S. Ikonin, E. Alshina (Huawei)] [late]

[JVET-O1087](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7724) Crosscheck of JVET-O0652 (CE4-related: Line buffer size reduction method for switchable interpolation filter) [M. Winken (HHI)]

[JVET-O0653](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7269) Non-CE4: Motion field storage simplification for triangular prediction mode [T. Solovyev, S. Ikonin, E. Alshina (Huawei)]

[JVET-O1053](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7690) Crosscheck of JVET-O0653 (Non-CE4: Motion field storage simplification for triangular prediction mode) [M. Bläser, J. Sauer (RWTH Aachen University)]

[JVET-O0660](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7277) Simplification of MV storage for blending block in triangle mode [K. Panusopone, L. Wang (Nokia)] [late]

[JVET-O0664](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7281) CE4-related: Simplifications on PROF [H. Chen, H. Yang (Huawei)]

[JVET-O0732](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7353) Crosscheck of JVET-O0664: CE4-related: Simplifications on PROF [[Y. He (InterDigital)](mailto:yuwen.he@interdigital.com)]

[JVET-O0666](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7283) Non-CE4: Fix for missing MV in 4xN and Nx4 triangle partition mode [K. Reuzé, C.-C Chen, W.-J. Chien, H. Huang, M. Karczewicz (Qualcomm)]

[JVET-O1059](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7696) Crosscheck of JVET-O0666 (Non-CE4: Fix for missing MV in 4xN and Nx4 triangle partition mode) [F. Henry (Orange), G. Clare (bcom)]

[JVET-O0789](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7410) CE4-related: On the context variables and syntax elements of merge index [C.-Y. Lai (MediaTek)] [late]

[JVET-O0795](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7416) CE4-related: On the context variables and syntax elements of merge index [?? (Mediatek)] [late]

[JVET-O0849](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7470) Crosscheck of JVET-O0795 (CE4-related: On the context variables and syntax elements of merge index) [R.-L. Liao (Alibaba)]

## CE5 related – Loop filtering (38)

ALF contributions in this category were discussed Saturday 6 July 1830–2215 in Track B (chaired by JRO). Further discussion of ALF Sunday 7 July 9:20-13.45, followed by deblocking related contributions 14:15-18:00

For Track B review (no BoG)

[JVET-O0047](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6651) Non-CE5: Alternative signalling for ALF clipping parameters [A. M. Kotra, V. Stepin, S. Esenlik, S. Ikonin, B. Wang, H. Gao, E. Alshina (Huawei)]

The current contribution proposes an alternative way of signalling the Adaptive loop filter (ALF) clipping parameters. In VTM-5.0, the clipping parameters are signalled using Kth order Exponential golomb codes. As the clipping parameter is only an index, whose values can range from 0 to 3 inclusive, it is reported that signalling using Kth order Exponential golomb codes is inefficient and therefore a simpler scheme using fixed length code (or) truncated unary code is proposed.

The objective results with “fixed length code” signalling scheme are as follows: Over VTM5.0 Anchor (AI, RA, LDB, LDP): Luma BD-Rate of -0.01%, -0.02%, 0.00%, -0.04% is achieved.

The objective results with “truncated unary code” signalling scheme are as follows: Over VTM5.0 Anchor (AI, RA, LDB, LDP): Luma BD-Rate of -0.02%, -0.03%, -0.02%, -0.07% is achieved.

Other contributions related to this issue: 0058, 0064, 0067, 0290, 0301, 0430

The original proponents of non-linear ALF express that the coding of clipping index might benefit from some redesign for cleanup.

This is a subset of JVET-O0064 which was adopted.

JVET-O0058, JVET-O0301 and JVET-O0430 are identical.

[JVET-O0997](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7633) Crosscheck of JVET-O0047 on alternative signalling for ALF clipping parameters [P. Onno (Canon)]

[JVET-O0058](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6662) Non-CE5: Simplification on ALF clipping parameter coding [S.-C. Lim, J. Kang, H. Lee, J. Lee, H. Y. Kim (ETRI)]

See under JVET-O0047

[JVET-O0999](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7635) Crosscheck of JVET-O0058 on Simplification on ALF clipping parameter coding [J. Taquet (Canon)]

[JVET-O0064](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6668) Non-CE5: Modification of clipping value signalling for adaptive loop filter [N. Hu, H. E. Egilmez, V. Seregin, M. Karczewicz (Qualcomm)]

In VTM-5.0, clipping parameters of non-linear adaptive loop filter are exponential-Golomb coded with adaptive orders. At decoder side, filter coefficients are reconstructed at first, then only clipping parameters for non-zero coefficients are parsed. This may cause delay when parsing a bitstream. To remove the filter coefficient dependency, it is proposed that clipping parameters are always signalled. In addition, it is also proposed that the exponential-Golomb codes are replaced by fixed-length codes or truncated unary codes. Compared to VTM-5.0, experimental results show that proposed methods achieve similar coding efficiency and encoding/decoding time under common test condition.

This removes the dependency in parsing the clipping parameters. This is an additional aspect to O0047.

This is identical with JVET-O0067 but has some more options.

[JVET-O0839](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7460) Crosscheck of JVET-O0064: Non-CE5: Modification of clipping value signalling for adaptive loop filter [L. Zhang (Bytedance)]

[JVET-O0067](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6671) Non-CE5: Modified coding method for ALF clipping parameters [L. Zhang, K. Zhang, H. Liu, J. Xu, Y. Wang (Bytedance)]

This is identical with JVET-O0064, and a superset of JVET-O0047, JVET-O0058, JVET-O0301 and JVET-O0430.

Decision: Adopt JVET-O0067.

[JVET-O0892](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7514) Crosscheck of JVET-O0067 (Non-CE5: Modified coding method for ALF clipping parameters) [N. Hu (Qualcomm)]

[JVET-O0158](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6762) Non-CE5: Deblocking based on DMVR refined motion [K. Andersson, J. Enhorn]

VTM-5.0 use the motion information before DMVR refinement which make deblocking unaware of differences in motion information that can cause blocking artefacts. Since DMVR refinement is performed on a sub-block size of 16x16 inside a coding unit using DMVR this can also introduce blocking artefacts inside DMVR coding blocks.

This contribution proposes to use DVMR refined motion for deblocking. This gives a significant benefit in subjective quality for some sequences.

Objective results are only tested for random access since DMVR is not used for other coding configurations.

BDR results of -0.03% for RA with ALF on and -0.07% for RA with ALF off are reported.

Encoding time of 100% for RA with ALF on and 103% for RA with ALF off are reported.

Decoding time of 102% for RA with ALF on and 102% for RA with ALF off are reported.

It is pointed out that this would require at least one additional line buffer for refined motion vectors which was discussed before that it is unacceptable.

During the discussion, other experts suggested that one possibility to reduce the memory would be storing the difference of DMVR rather than the actual MV. Another option would be not doing it across CTU boundary.

The contribution points out that there are cases with problems of subjective quality.

Study in CE, including subjective comparison (at least with ALF on). At minimum, the following cases should be tested:

* Current
* Current with DMVR refinement in deblocking
* Same only within CTU, not across boundary
* Current with DMVR off

Also analysis about buffer requirement should be performed.

[JVET-O1125](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7762) Crosscheck of JVET-O0158 (Non-CE5: Deblocking based on DMVR refined motion) [C.-M. Tsai (MediaTek)]

[JVET-O0159](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6763) Non-CE5: Deblocking tC table defined for 10-bit video [K. Andersson, J. Enhorn]

VTM-5.0 uses a tC table defined for 8-bit video which then is upscaled to the bit-depth a video is encoded at.

This contribution proposes to instead define the tC table for 10-bit video to get a better linear dependency between quantization step size and tC for 10-bit video and higher.

BDR results of 0.07%/-0.03%/-0.09%/-0.07% for AI/RA/LDB/LDP with ALF on and 0.06%/-0.03%/-0.04%/-0.04% for AI/RA/LDB/LDP with ALF off are reported.

Encoding time and decoding time unchanged

Currently, the 8-bit tc table is upscaled from 8 bit. The proposal suggests to define a new more granular tc table for 10 bit and downscale it for the case of 8 bit, and upscale for higher bit depth. However, with the current proposal the table for 8 bit becomes slightly different.

Generally agreed that the motivation of redefining the table for 10 bit is a resonable move, as 8 bit video has become less relevant.

The proponents are asked to modify the entries of the 10-bit table such that the downscaling operation would exactly reproduce the current 8 bit table.

Decision: Adopt JVET-O0159 with the modification in the entries of the 10-bit table such that the downscaling operation would exactly reproduce the current 8 bit table.

[JVET-O0188](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6792) Non-CE5: Non-linear ALF simplification [S. Ikonin, V. Stepin, E. Alshina (Huawei)]

This contribution proposes a simplifications of the non-linear adaptive loop filter adopted to VTM5.0 where adaptive clipping operation is applied during the filtering process. For the worst case scenario non-linear adaptive loop filter requires 12 multiplications of 8-bit filter coefficient by (BitDepth+3)-bit value equals to sum of clipped difference between filtering sample and neighboring sample. The proposed method modifies formula of clipping value calculation and applies secondary clipping to guarantee bit depth of multiplication operand after summation. The method allows to save 2 bits of multiplication bit depth from 8x(BitDepth+3) to 8x(BitDepth+1) for each of 12 multiplications in the worst case scenario. Additionally using the same clipping level equation for luma and chroma components is proposed to unify the calculation. The proposed simplifications demonstrate negligible performance change, namely: 0.00%/-0.02% /-0.01% and 0.02%/-0.04%/-0.04% (Y/Cb/Cr) in AI and RA configurations correspondingly.

Aspect 2 (11 bit mult) is not asserted to be of high benefit for hardware complexity, and no problem for software.

Aspect 3 (luma/chroma harmonization) – this is agreed, but using a table instead the formula (see notes under 0532). This also resolves Aspect 1 (10 bit bit depth in clipping formula) in a different way.

JVET-O0437 is also the same as aspect 3.

Other proposals on clipping value calculation: JVET-O0386, JVET-O0532

[JVET-O1027](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7664) Crosscheck of JVET-O0188 (Non-CE5: Non-linear ALF simplifications) [I. Zupancic (HHI)]

[JVET-O0216](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6821) Non-CE5: Modification of ALF coefficient signalling [A. M. Kotra, S. Esenlik, B. Wang, H. Gao, E. Alshina (Huawei)]

The current contribution proposes fixed 3rd order Exponential golomb codes for signalling ALF filter coefficients. VTM-5.0 uses filter merging process wherein the filter coefficient of filter N are predicted from filter N-1 and furthermore the signalled filter coefficients can further be predicted from the fixed filters which are newly introduced in VTM-5.0. The “delta (residual)” is then transmitted using Kth order exponential golomb codes. Reportedly the range of filter coefficient “delta” values can be signalled with fixed 3rd order Exponential golomb codes instead of adaptive Kth Order exponential golomb codes without any coding efficiency impact.

The objective results with “fixed 3rd order Exp. golomb” signalling scheme are as follows: Over VTM5.0 Anchor (AI, RA, LDB, LDP) with “CTC” QP: Luma BD-Rate of 0.00%, 0.01%, 0.02%, -0.01% is achieved.

The objective results with “fixed 3rd order Exp. golomb” signalling scheme are as follows: Over VTM5.0 Anchor (AI, RA, LDB, LDP) with “low” QP values (12, 27, 22, 27): Luma BD-Rate of 0.01%, 0.00%, 0.02%, 0.02% is achieved.

The objective results with “fixed 3rd order Exp. golomb” signalling scheme are as follows: Over VTM5.0 Anchor (AI, RA, LDB, LDP) with “high” QP values (32, 37, 42, 47): Luma BD-Rate of -0.01%, 0.01%, -0.01%, -0.02% is achieved.

JVET-O0302, JVET-O0648 are similar

JVET-O0302 is doing fixed order 3 for chroma, and position dependent for luma

JVET-O0648 has different variants, either position dependent K, or same K for all positions with adaptation of K

It is desirable to not have position dependency for simplicity of decoding.

As detailed results of JVET-O0648 show, the benefit of making K adaptive is negligible compared to fixed K=3.

Note that this is identical with one of the methods in JVET-O0648, and the chroma coding is identical with JVET-O0302

Decision: Adopt JVET-O0216

[JVET-O0786](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7407) Crosscheck of JVET-O0216 (Non-CE5: Modification of ALF coefficient signalling) [C.-Y. Lai (MediaTek)]

[JVET-O0247](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6852) AHG17: Multiple ALF APS for chroma [V. Seregin, N. Hu, M. Coban, M. Karczewicz (Qualcomm)]

In the current VVC, only one ALF APS can be used for chroma in a slice, while luma component may use multiple APS and an APS index is signaled in CTB to indicate the utilized filter coefficients. This contribution proposes to enable the same functionality for chroma ALF, i.e. to signal APS Ids for chroma in a slice header and to signal a chroma APS id per CTB when ALF is applied. The second aspect of the contribution is to remove redundant APS index signaling in a CTU when only 2 APS are used.

It is agreed that switching between several chroma filters is desirable (results of CE5 indicate that up to 8 are beneficial)

Following options:

* Stay with current APS (luma set + 1 chroma), but allow several APS in slice and select at CTU which one is best for luma and which one is best for chroma
* Extend current APS such that several chroma filters are in, but if at CTU level different luma filter sets shall be selected, it may mean that chroma filters need to be sent in several APS
* Have separate APS for chroma, either 1 per filter, or 1 with multiple filters

The most flexible solution would be to have an APS that contains 0…25 luma filters and 0..8(or more?) for chroma. This would allow most flexibility in usage, including the case where an APS just carries a collection of chroma filters.

See further discussion in Monday plenary

JVET-O0246 is also related but proposes separate ALF APS for luma and chroma. It is noted that this might provide more flexibility in inheriting filters from other pictures, but would also make the signalling for selection more complicated.

If only 1 chroma filter is in the APS, would it be a disadvantage to send a set of chroma filters in separate NALU?

The second aspect of the contribution suggests to save the signalling of the APS index in cases where the number is <= 2. This is a minor cleanup. Decision: Adopt this aspect.

[JVET-O0287](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6892) CE5-related: Simplification of subblock deblocking [C.-M. Tsai, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek), A. M. Kotra, S. Esenlik, B. Wang, H. Gao, E. Alshina (Huawei)]

This contribution proposes to simplify the subblock deblocking conditions by using the method proposed in JVET-M0187. In JVET-M0187, to better support parallel deblocking at multiple parallel subblock boundaries on 8x8 grids, if a subblock coding mode is chosen on one side of the subblock boundary, then the maximum allowed filtered samples for the side is set to 3. It is reported that the proposed deblocking results in negligible changes in BD-rate and encoding/decoding time for VTM5.0 common test conditions (CTC) and for VTM5.0 CTC with adaptive loop filter (ALF) off.

Question: Would it be compatible with a possible move to 4x4 grid? Answer: Likely yes, as the 4x4 blocks would use other filters.

Since the choice of filters is reduced, the complexity of decisions becomes simpler.

Some concern was raised that the removal of the 5 tap filters might introduce artifacts in case of large transforms.

No urgent need to solve a problem here. Though simplification is generally desirable, in deblocking subjective quality is of highest importance, and care should be taken not to remove elements that have been introduced for good reasons to reduce artifacts.

[JVET-O1078](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7715) Crosscheck report of JVET-O0287 (CE5-related: Simplification of subblock deblocking) [H. Jang (??)]

[JVET-O0288](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6893) CE5-related: On the syntax constraints of ALF APS [O. Chubach, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

This contribution proposes four cleanups for the adaptive loop filter (ALF) syntax in slice header and adaptive parameter set (APS). The first cleanup is removing the constraints for a number of APSs referenced in one slices. In the current VVC, the maximum number of APSs referenced in one slice depends on slice type, and this contribution proposes to use the same maximum value for all slice types. The second cleanup is removing the inference of APS ID referenced in one slice for chroma (slice\_alf\_aps\_id\_chroma) when only one APS is referenced for luma ALF and the slice type is I slice. The third cleanup is adding one encoder normative constraint that the APS referenced in one slice for luma/chroma shall contain the luma/chroma filter parameters at least. The last cleanup is inferring the flag specifying whether a chroma filter is signalled (alf\_chroma\_filter\_signal\_flag) to be true, when luma filter parameters are not signalled (alf\_luma\_filter\_signal\_flag=0) in the same APS, in order to avoid signalling one ALF-type APS without any ALF parameters. The proposed modifications are implemented on top of VTM5.0. It is reported that the four cleanups together achieves 0.00%/0.00%/0.00%, 0.00%/0.00%/0.00%, and 0.00%/0.00%/0.00% Y/Cb/Cr BD-rates for AI, RA, and LB, respectively.

The first aspect is unifying the max number of ALF APS for inter and intra (currently, it is 1 for intra and 6 for inter). Agreed.

It is discussed that a practical max number is still to be decided.

The second aspect is to remove the inference of chroma APS ID from luma. Following the discussion under JVET-O0247, this is agreed to be useful. Agreed Decision: Adopt JVET-O0288 aspects 1 and 2

The third aspect suggests that if an ALF APS is referenced in the slice header, it should at least contain filter coefficients for at least one filter (encoder / bitstream constraint to be formulated both for luma and chroma). It is noted that the spec already specifies that in this case the filter coefficients are inferred as zero. No action necessary.

The fourth aspect suggests that in an APS at least either luma or chroma shall be non-zero. There is however no problem with the current design, it is up to the encoder not to do that, decoder behaviour is still well defined.

(The following statement does not apply to this specific contribution)

It is noted that, as a side activity to update the ALF APS, plus correspnding slice level and CTU level aspects, the different proponents have circulated their text pieces and coordinated with B. Bross.

[JVET-O0831](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7452) Crosscheck of JVET-O0288 (CE5-related: On the syntax constraints of ALF APS) [S.-C. Lim, J. Kang, H. Lee, J. Lee (ETRI)]

[JVET-O0289](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6894) CE5-related: Redundancy removal in ALF coefficient coding [O. Chubach, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

This contribution is related to redundancy removal in adaptive loop filter (ALF) signalling. It proposes two cleanups for coding filter coefficients in ALF. The first cleanup is to signal alf\_luma\_coeff\_delta\_flag when there are two or more filters in one filter set. The second cleanup is to avoid signalling alf\_luma\_eg\_order\_increase\_flag[ i ] and alf\_chroma\_eg\_order\_increase\_flag[ i ] for i=0. It is reported that the two cleanups result in luma BD-rates as 0.00%, 0.00%, and -0.02% for AI, RA, and LB, respectively, without noticeable runtime changes.

The first aspect is not needed, as a decoder does not have a problem when receiving a filter with zero coefficients.

The second aspect is not relevant due to various adoptions of simplification of filter coefficient coding.

[JVET-O1019](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7656) Crosscheck of JVET-O0289 (CE5-related: Redundancy removal in ALF coefficient coding) [A. M. Kotra (Huawei)]

[JVET-O0290](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6895) CE5-related: Modified syntax design of ALF clipping parameters signalling [O. Chubach, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

This contribution is related to adaptive loop filter (ALF) clipping parameters signalling in VVC. In this contribution, it is proposed to replace Kth order Exponential-Golomb code used for coding clipping parameters with either fixed length code or truncated unary code. It is also proposed to remove the filter coefficient dependency when signalling clipping parameters and signal clipping parameters no matter if the coefficients are equal to zero or not. In addition, it is proposed not to signal the flag, alf\_luma\_use\_fixed\_filter\_flag, used to indicate the fixed filter sets are used for predicting ALF coefficients and infer its value to be equal to zero, when clipping operation is enabled in luma ALF (alf\_luma\_clip\_idx=1). It is reported that all the above proposed changes result in tiny BD-rate changes in the range of -0.02% to +0.02%. It is claimed that these changes avoid unnecessary signalling of flags and remove parsing dependency.

Aspect that is different from the other proposals (see under JVET-O0047, JVET-O0064): Yellow highlight.

It is noted that there are other contribution (JVET-O0669, JVET-O0425) which completely disable the prediction such that this additional modification would not be necessary

[JVET-O0832](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7453) Crosscheck of JVET-O0290 (CE5-related: Modified syntax design of ALF clipping parameters signalling) [S.-C. Lim, J. Kang, H. Lee, J. Lee (ETRI)]

[JVET-O0374](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6979) CE5-related: Context reduction for ALF enable flag syntax element [L. Xu, X. Cao, F. Chen, L. Wang (Hikvision)]

This contribution proposed to simplify the context modelling and reduces the number of contexts for CABAC. The CABAC context modelling for alf\_ctb\_flag is investigated. With the contexts reduction, the BD-Rate increase for method 1 is reported as 0.00% 0.00% and 0.03% for AI, RA and LDB configuration, the BD-Rate increase for method 2 is reported as 0.00% 0.05% and 0.05% for AI, RA and LDB configuration, and the BD-Rate increase for method 3 is reported as 0.00% 0.06% and 0.00% for AI, RA and LDB configuration.

Question is raised where these claimed gains in chroma come from? Furthermore, it is observed that the UHD classes by tendency have losses (0.07%) in luma in RA, which is not compensated by the chroma gains.

Complexity-wise, it is not an issue. No need for action.

[JVET-O1057](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7694) Cross-check of JVET-O0374 (CE5-related: Context Reduction for Syntax Element ALF Enable Flag) [Y. Chen, F. Le Léannec (InterDigital)]

[JVET-O0386](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6991) Non-CE5: A simplification of clipping thresholds for Non-Linear ALF [K. Unno, K. Kawamura, S. Naito (KDDI)]

This contribution proposes new definition of clipping thresholds for Non-Linear ALF. The proposed method changes the definition of the thresholds to keep magnitude relationship of the luma thresholds and the chroma thresholds regardless of internal bit-depth. The proposed method doesn’t have any impact for CTC case, because the thresholds for 10 bits case are not changed from VTM-5.0. It is reported that experimental results when 8 bits case and 12 bits case for both anchor (VTM-5.0) and the proposed method. In the 8 bits case, BD-rates for luma are 0.00%/‑0.05%/‑0.06%/‑0.11% (AI/RA/LDB/LDP) in comparison with VTM-5.0. In the 12 bits case, BD-rates for luma are ‑0.02%/‑0.03%/‑0.03%/‑0.05% (AI/RA/LDB/LDP) in comparison with VTM-5.0.

The contribution points out some inconsistency about handling the thresholds for luma and chroma. This aspect is resolved by the unification of luma and chroma thresholds (see under JVET-O0188, JVET-O0532)

[JVET-O0998](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7634) Crosscheck of JVET-O0386 on a simplification of clipping thresholds for Non-Linear ALF [P. Onno (Canon)]

[JVET-O0413](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7018) Non-CE5: Chroma deblocking filter adjustments for 4:4:4 and 4:2:2 [M. Ikeda, T. Suzuki (Sony)]

No need to present – subsumed in JVET-O0637.

[JVET-O0751](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7372) Crosscheck of JVET-O0413 (Chroma deblocking filter adjustments for 4:4:4 and 4:2:2) [T. Chujoh (Sharp)]

[JVET-O0425](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7030) Non-CE5: Supplementary results on alternative filter sets for Adaptive Loop Filter (JVET-O0090) [J. Taquet, P. Onno, C. Gisquet, G. Laroche (Canon)]

This contribution proposes to extend CE5-4 contribution by adding some limitations on the number of filters signaled by alternative luma filter sets, and by not using ALF Luma filters prediction from static filter sets. These limitations enables to reduce the amount of memory that a decoder should use to store the ALF filters coming from multiple APS.

In Test 1, the use of ALF Luma filters derivation from static filter sets is removed from VTM5.0.

In Test 2 to Test 5, the use of ALF filters derivation from static filter sets is removed from C5-4.3 test, and the maximum number of filters for each filter set is limited. In Test 2 and Test 4 the first filter set is limited to 7 filters, while in Test 3 and Test 5 it is limited to the maximum number of filters in VTM-5.0’s Luma filter set (i.e. 25 filters). The second filter set is limited to 3 filters in Test 2 and Test 3, and it is limited to 1 filter in Test 4 and Test 5.

The average Y/Cb/Cr BDR gains of Test 2 over VTM-5.0 are 0.10%/-0.91%/-1.27% for the AI configuration, 0.03%/-1.90%/-2.28% for the RA configuration, -0.11%/-2.38%/-2.66% for the Low Delay B configuration, and -0.22%/-2.53%/-2.67% for the Low Delay P configuration.

The average Y/Cb/Cr BDR gains of Test 4 over VTM-5.0 are 0.10%/-0.91%/-1.27% for the AI configuration, 0.05%/-1.92%/-2.28% for the RA configuration, -0.08%/-2.40%/-2.69% for the Low Delay B configuration, and -0.17%/-2.47%/-2.32% for the Low Delay P configuration.

The average Y/Cb/Cr BDR gains of Test 3 over VTM-5.0 are respectively 0.08%/-0.88%/-1.23% for the AI configuration, 0.03%/-1.90%/-2.29% for the RA configuration, -0.13%/-2.31%/-2.51% for the Low Delay B configuration, and -0.20%/-2.53%/-2.60% for the Low Delay P configuration.

The average Y/Cb/Cr BDR gains of Test 5 over VTM-5.0 are respectively 0.08%/-0.88%/-1.23% for the AI configuration, 0.05%/-1.92%/-2.29% for the RA configuration, -0.12%/-2.37%/-2.62% for the Low Delay B configuration, and -0.18%/-2.49%/-2.54% for the Low Delay P configuration.

In Test 2, Test 3, Test 4 and Test 5, compared to CE5-4.3 test, the memory for storing ALF Luma filters can be reduced by 80%, 44%, 84% and 48%, respectively. Compared to VTM5.0 considering all ALF filters, including Chroma, Test 2 and Test 4 enables to reduce the ALF filters’ memory by 45% and 53%, respectively, while Test 3 and Test 5 increases the ALF filters’ memory by 12% and 18% respectively.

One aspect (remove prediction from fixed filter set, Test 1) is subset of JVET-O0669

Other aspect was presented Sunday 1330

Tests 2-5 indicate that the results in CTC can be almost retained when reducing the number of filters. Different variants are tested.

Interesting information to assess the amount of storage necessary for storage of filter parameters.

Results also indicate that up to 25 filters may not always be needed.

Reasonable constraints for number per picture still need to be identified.

One possibility could be to constrain the amount of memory needed for decoded APS parameters per picture. See further discussion in plenary.

[JVET-O0985](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7621) Crosscheck of JVET-O0425 (Non-CE5: Supplementary results on alternative filter sets for Adaptive Loop Filter) [K. Unno (KDDI)]

[JVET-O0427](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7032) Non-CE5: Remove differential coding for ALF coefficients [X. W. Meng (PKU), X. Zheng (DJI), S. S. Wang, S. W. Ma (PKU)]

Subset of JVET-O0669

[JVET-O0895](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7517) Crosscheck of JVET-O0427 (Non-CE5: Remove differential coding for ALF coefficients) [N. Hu (Qualcomm)]

[JVET-O0430](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7035) Non-CE5: Modification of clipping value signalling for ALF [X. W. Meng (PKU), X. Zheng (DJI), S. S. Wang, S. W. Ma (PKU)]

See under JVET-O0047

[JVET-O0896](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7518) Crosscheck of JVET-O0430 (Non-CE5: Modification of clipping value signalling for ALF) [N. Hu (Qualcomm)]

[JVET-O0437](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7042) Non-CE5: Unification of non-linear ALF luma/chroma clipping parameters [X. W. Meng (PKU), X. Zheng (DJI), S. S. Wang, S. W. Ma (PKU)]

See notes under JVET-O0188

Furthermore, it is suggested to unify the clipping between luma and chroma.

[JVET-O0897](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7519) Crosscheck of JVET-O0437 (Non-CE5: Unification of non-linear ALF luma/chroma clipping parameters) [N. Hu (Qualcomm)]

[JVET-O0499](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7106) Non-CE5: Parameter alignment for pipelined ALF [A. Wieckowski, K. Sühring, R. Skupin, B. Bross, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

In the last meeting in Geneva, the concept of ALF virtual boundaries was adopted. It introduces a sample dependency boundary 4 sample lines above the bottom of the CTU, so that the first N-4 sample lines can be processed, while the filtering of the last four lines is delayed until the next CTU line is processed (as the content might be changed during the application of deblocking filter in the following CTU line). This concept encourages the implementation of ALF working between the virtual boundaries. With the current implementation, this introduces a parameter dependency, which requires an additional parameter line buffer. In the current implementation, processing of an ALF block requires application of two separate parameter sets (from previous and current line). We propose to move the scope of ALF per-CTU parameters from between CTU boundaries to between ALF virtual boundaries. The proposed change has a negligible impact on coding performance and both encoder and decoder complexity.

The benefits claimed are that 1) it saves storing filter parameters, and 2) to avoid switching to another set at the virtual boundary for the case of optimized pipelining.

As the filter parameters are relatively few, and there is need to frequently switch at much finer granularity (4x4) anywhere, this benefit seems not large.

Might be beneficial for software pipeline, but not necessarily for hardware.

The specification text would need to redefine ALF, such that the area where a filter is valid would need to be newly defined (shifted CTU boundary).

Benefit not overly obvious – no action.

[JVET-O0894](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7516) Crosscheck of JVET-O0499 (Non-CE5: Parameter alignment for pipelined ALF) [N. Hu (Qualcomm)]

[JVET-O0532](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7139) Non-CE5: Simplification on clipping value calculation for adaptive loop filter [N. Hu, V. Seregin, M. Karczewicz (Qualcomm)]

In VTM-5.0, clipping values of adaptive loop filter are calculated with floating-point arithmetic operations. In this proposal, the calculation of clipping values is simplified by using integer operations. Compared to VTM-5.0, the proposed methods achieve similar coding efficiency and encoding/decoding time under common test conditions.

In the discussion, it is agreed that the definition that requires a floating point operation is not desirable and may be ambiguous. It is suggested to use a table definition instead, which for bit depths 8,9,10,…16 times the 4 clipping indices specifies the rounded integer output (4x9=36 entries). Same table should be used for luma and chroma, and this would be the luma formula

filterClips[ sfIdx ][ j ] = Round( 2( BitDepthY \* ( 4 − alf\_luma\_clip\_idx[ sfIdx ][ j ] ) / 4 ) ).

[JVET-O0983](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7619) Crosscheck of JVET-O0532 (Non-CE5: Simplification on clipping value calculation for adaptive loop filter) [K. Unno (KDDI)]

[JVET-O0566](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7181) Non-CE5: Consistent Deblocking for Chroma Components [J. Xu, J. Wang, L. Zhang, W. Zhu, Y. Wang (Bytedance)]

In the current VVC design, different on/off control and different deblocking filters can be applied to Cb and Cr components. Such an inconsistency makes parallel processing for Cb/Cr difficult when they are stored in an interleaved way. This document proposes to unify Cb/Cr deblocking filter. Luma BD-rate, encoding time and decoding time are summarized as follows:

CTC: AI: 0.00%, 100%, 99%; RA: 0.00%, 100%, 100%; LDB: -0.08%, 101%, 93%;

ALF off: AI: 0.00%, 100%, 100%; RA: 0.00%, 100%, 100%; LDB: 0.02%, 100%, 99%.

It is asserted that no obvious visual differences are found.

The motivation is simplification of SIMD implementation.

Some loss in U component in class A1 (could be Campfire?)

Some concern is expressed that in case where Cb and Cr have different characteristics different filters should be used. This could be more extreme for HDR content.

By how much would the SIMD runtime be reduced? Not known. As chroma deblocking is only a small part of the overall deblocking, the benefit may not be too large.

More evidence is requested that it would not be a problem with sequences that have largely different characteristics in Cb and Cr.

Investigate in CE, also include HDR sequences. Results should be reported per sequence, and subjective be arranged with sequences that show strange behaviour in terms of chroma PSNR. Better also test ALF off, as the ALF may hide some effects.

[JVET-O0846](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7467) Crosscheck of JVET-O0566 (Non-CE5: Consistent Deblocking for Chroma Components) [M. Ikeda (Sony)]

[JVET-O0578](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7193) Non-CE5: Long-tap deblocking filter on vertical tile boundary [H. Jang, S. Lee, N. Park, J. Nam, S. Kim, J. Lim (LGE)]

In VTM-5.0, long-tap deblock filtering is disabled on horizontal CTU boundary to reduce line buffer size. Hence, 4-row samples need to be stored in line buffer as the same with HEVC. However, 8-coloumn samples are still required to be stored in vertical line buffer when a picture is sliced to multiple tiles and long-tap deblocking filter is enabled for the vertical edge. In order to prevent vertical line buffer increasing over HEVC, the proposed method disallows the long-tap deblock filtering when in-loop filter is enabled across the vertical tile boundary. From viewing test results, any subjective quality change is not observed at the tile boundary.

It is pointed out that in a real-world implementation it would not be necessary to store entire column.Not important problem.

[JVET-O0950](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7579) Crosscheck of JVET-O0578 Non-CE5: Long-tap deblocking filter on vertical tile boundary [J. Ye, X. Li (Tencent)]

[JVET-O0582](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7197) Non-CE5: Deblock filtering process for BDPCM block [H. Jang, J. Nam, S. Kim, J. Lim (LGE)]

De-block filtering process for BDPCM is proposed in this contribution. In VTM-5.0, boundary strength is set equal to 0 only when both blocks across an edge are coded as BDPCM so that filtering is disabled. Considering that BDPCM is applied for transform skip mode and residual pixels are predicted by sample unit based on DPCM, the deblocking process for BDPCM needs to be considered as PCM block rather than intra coded block where boundary strength equal 2 is applied. Therefore, in this proposal, no deblocking filtering for BDPCM block is suggested so that DPCM coded transform skip block is not to be deblocked as normal intra block. It is reported that BD-rate changes of the proposed scheme 2 is observed to be 0.01% / -0.02% in Class F and TGM in AI, 0.01 / -0.04% in Class F and TGM in RA, and 0.01% / -0.04% in Class F and TGM in LDB , respectively.

The mismatch between text and software has to be resolved -> This aspect to be included in the new AHG to align TS, BDPCM, lossless, etc.

[JVET-O0807](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7428) Crosscheck of JVET-O0582 (Non-CE5: Deblock filtering process for BDPCM block) [C.-M. Tsai (MediaTek)]

[JVET-O0625](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7240) Non-CE5: Unified padding method for samples at variant boundaries in ALF [H. Liu, L. Zhang, K. Zhang, Z. Deng, N. Zhang, J. Xu (Bytedance)]

In current VVC, ALF virtual boundary is not applied to CTUs with their bottom boundary are slice/brick boundaries. Disabling the application of ALF virtual boundary may create pipeline bubble or require processing more lines. In addition, no padding is performed for samples at the slice/brick boundaries even if the ALF operations are disallowed to across the slice/brick boundaries. Moreover, there are variant boundaries (including ALF virtual boundaries, slice/brick boundaries, 360-degree video virtual boundaries) defined and multiple padding methods are employed for handling those boundaries. This contribution proposes to two aspects. Firstly, the ALF virtual boundary is applicable to CTUs with bottom boundaries are slice/brick/virtual boundaries regardless the usage of filtering crossing boundaries. Secondly, on top of the first aspect, it is further proposed to use the symmetric 2-side padding method used by ALF virtual boundaries to pad samples outside those horizontal boundaries in the ALF process.

From the discussion in track B Sunday:

The current virtual boundary concept only applies at horizontal boundaries. Slice/tile/brick boundaries can also be vertical and always coincide with CTU boundaries.

The critical case is what to do if filtering is disabled across the boundaries (regardless if they are horizontal or vertical). The deblocking is turned off at the boundary, whereas SAO and ALF still are operated but require some padding. For SAO, a simple repetition is used The question is which padding method to use for the ALF within the current slice/tile/brick.

* At the horizontal boundary (except picture boundary), the virtual boundary concept is applied anyway
* At the vertical boundary, something must be defined. This could be virtual boundary concept or a more simple padding method. As the content could be continuous across the vertical boundary, the simple padding method might cause some artifacts. Complexity-wise, extending the VB concept to vertical boundaries that shall not be filtered across boundary does not seem critical.

It is discussed if it would be reasonable to apply the virtual boundary concept to picture boundaries as well. However, since this is defined as simple coordinate clipping, it would not be a text simplification, as for the case where the picture boundary is not aligned with CTU boundary the virtual boundary position needs to be defined differently.#

It is agreed that the best solution for this case is applying the VB concept at vertical CTU boundaries. See further discussion and decision in plenary.

In 360 degree video, it is reported that virtual boundaries could be at any multiple of eight, and not aligned with CTU boundaries. This would rather require a mechanism where any filtering is disabled at some predefined sample positions, and invoke some other mechanism such as padding. See further notes under Monday plenary.

Regarding the proposal:

* The first aspect points out that the spec inhibits the ALF VB concept when the bottom CTU boundary is a slice/tile/brick or “360 virtual” boundary. Decision (BF): This should be corrected (align text with software). To further clarify, the ALF virtual boundary starts always 4 lines above the bottom CTU boundary, except if that is the bottom picture boundary. For the “360 virtual boundary”, this also applies if it coincides with a CTU boundary, otherwise a simple padding is applied (as per decision of Monday plenary).

[JVET-O0865](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7486) Crosscheck of JVET-O0625: "Non-CE5: Unified padding method for samples at variant boundaries in ALF" [F. Le Léannec (Interdigital)]

[JVET-O0636](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7252) Cross-Component Adaptive Loop Filter for chroma [K. Misra, F. Bossen, A. Segall (Sharp Labs of America)]

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. The tool is controlled by information in the bit-stream, and this information includes both (a) filter coefficients for each chroma component and (b) a mask controlling the application of the filter for blocks of samples. The filter coefficients are signalled in the APS, while block sizes and mask are signalled at the slice-level.

The proposed approach was evaluated using the CTC and resulted in the average BD rate improvement:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Y** | **U** | **V** | **EncT** | **DecT** |
| **All-Intra** | 0.13% | -8.54% | -6.65% | 102% | 105% |
| **Random Access** | 0.16% | -14.36% | -13.16% | 103% | 105% |
| **Low Delay B** | 0.21% | -20.11% | -15.39% | 104% | 109% |

Furthermore, initial experiments to shift the gains from chroma to luma were also performed and resulted in the average BD rate improvement:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Y** | **U** | **V** | **EncT** | **DecT** |
| **All-Intra** | -0.93% | 0.82% | 2.55% | 102% | 104% |
| **Random Access** | -0.95% | -5.07% | -3.82% | 102% | 105% |
| **Low Delay B** | -0.12% | -14.81% | -9.24% | 103% | 110% |

Revision 1 of the document provides updates the experimental results and provides more signaling details in the appendix

Question: Is downsampling done? No.

Virtual boundary concept also included.

Investigate in CE

Also test configuration as post filter.

Investigate latency aspects.

[JVET-O1149](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7786) Crosscheck of JVET-O0636 on Cross-Component Adaptive Loop Filter for chroma [?? (??)]

[JVET-O0637](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7253) Non-CE5: On chroma line selection for gradient computation in deblocking [K. Misra, P. Cowan, A. Segall (Sharp Labs of America), Y. Morigami, M. Ikeda, T. Suzuki (Sony)]

It is asserted that in VVC WD5, in the worst-case, gradients are computed for every chroma line during deblocking. This is more than for luma, where in the worst-case, gradients are computed for two out of four lines. Also, when the luma and chroma dimensions are same in a direction the lines chosen for gradient computations for luma and chroma are not the same, this is asserted to be undesirable. The contribution proposes a reduction in the number of chroma gradient computations to one out of two lines, for the worst-case, and to align chroma line selection for gradient computation with luma, when luma and chroma dimensions are same in a direction. Specifically:

1. When SubWidthC is 2 only compute gradient for line 0 for horizontal chroma boundary deblocking
2. When SubHeightC is 2 only compute gradient for line 0 for vertical chroma boundary deblocking
3. When SubWidthC is 1 compute gradient for line 0 and line 3 for horizontal chroma boundary deblocking
4. When SubHeightC is 1 compute gradient for line 0 and line 3 for vertical chroma boundary deblocking

The average BD Rate for CTC, for the proposed change, is listed below:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **ALF ON** | | | **ALF OFF** | | |
|  | **Y** | **U** | **V** | **Y** | **U** | **V** |
| **All-Intra** | 0.00% | 0.09% | 0.10% | -0.01% | 0.06% | 0.06% |
| **Random Access** | 0.00% | 0.11% | 0.12% | -0.01% | 0.14% | 0.14% |
| **Low Delay B** | 0.00% | 0.18% | -0.03% | 0.01% | -0.02% | -0.33% |
| **Low Delay P** | 0.01% | 0.15% | 0.03% | 0.02% | -0.14% | -0.13% |

The average BD Rate for JCT-VC RExt CTC test set (4:4:4 YUV, 4:4:4 RGB and 4:2:2 YUV content), is also listed below:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **RGB 4:4:4** | | | **YUV 4:4:4** | | | **YUV 4:2:2** | | |
|  | **Y** | **U** | **V** | **Y** | **U** | **V** | **Y** | **U** | **V** |
| **All-Intra** | 0.00% | 0.00% | 0.00% | 0.00% | -0.04% | -0.05% | 0.00% | 0.02% | 0.01% |
| **Random Access** |  |  |  | -0.01% | -0.02% | -0.03% | 0.01% | 0.01% | 0.01% |
| **Low Delay B** |  |  |  |  |  |  |  |  |  |

It is agreed that there is a problem to be solved.

Decision (BF): Adopt JVET-O0637, Method 1:

1. When SubWidthC is 2 compute gradient for line 0 and 1 for horizontal chroma boundary deblocking
2. When SubHeightC is 2 compute gradient for line 0 and 1 for vertical chroma boundary deblocking
3. When SubWidthC is 1 compute gradient for line 0 and line 3 for horizontal chroma boundary deblocking
4. When SubHeightC is 1 compute gradient for line 0 and line 3 for vertical chroma boundary deblocking

[JVET-O1129](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7766) Crosscheck report of JVET-O0637 (Non-CE5: On chroma line selection for gradient computation in deblocking) [A. Filippov, V. Rufitskiy (Huawei)]

[JVET-O1121](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7758) Crosscheck report of JVET-O0637 (Non-CE5: On chroma line selection for gradient computation in deblocking) [H. Jang (LGE)]

[JVET-O0648](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7264) Non-CE5: On Exp-Golomb Coding of ALF Filter Coefficients and Clip Values [H. E. Egilmez, N. Hu, V. Seregin, M. Karczewicz (Qualcomm)]

This document presents various simplifications for signaling of Exp-Golomb order (EGk) used to build codes for signalling ALF filter coefficients and clip values. In VTM-5.0, the EGk signalling involves a recursive prediction among neighboring EGks and an additional flag used as an offset for the prediction. In this contribution, all presented simplifications remove the recursive prediction and the offset flag. Further tested simplifications include (i) signalling a single EGk for all positions instead of signalling separate EGks for different groups of positions, (ii) and using a fixed EGk without signalling.

The experimental results under common test conditions show that the proposed simplifications lead to almost no performance change.

The results demonstrate (see slide 7 in ppt of upload v4) that along with the adoption of JVET-O0064 for fixed length coding of clip values the version with EG3 for coefficient coding (and without prediction as per adoption of JVET-O0669) has almost identical results as EGk, but is simpler.

[JVET-O1146](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7783) Crosscheck of JVET-O0648 (Non-CE5: On Exp-Golomb Coding of ALF Filter Coefficients and Clip Values) [X. W. Meng (PKU)]

[JVET-O1165](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7802) Crosscheck of JVET-O0648: Non-CE5: On Exp-Golomb Coding of ALF Filter Coefficients and Clip Values [W. Chen (InterDigital)]

[JVET-O0142](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6746) AHG12: On turning off ALF filtering at brick and slice boundaries [Y.-K. Wang, J. Chen, Hendry (Futurewei)]

Also included in the agenda item 6.17.6.

See discussion under JVET-O0625.

[JVET-O0494](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7101) AHG12: On filtering of independently coded region [R. Skupin, Y. Sanchez, K. Sühring, T. Schierl (HHI)]

Also included in the agenda item 6.17.6.

This contribution proposes to changes to the filtering of independently coded regions in order to allow drift free filtering and is twofold:

The first aspect is to reduce the number of in-loop filter affected samples at boundaries of independently coded regions by disabling certain in-loop filters. Two options are given to reduce the filter reach, i.e. the in-loop filter affected samples, to either 7 or 3 samples.

The second aspect is to apply padding in order to replace in-loop filter affected samples at the boundaries of independent regions for inter-prediction.

Revision 1 of the document adds the accumulated filter reach.

Revision 2 of the document adds specification text.

The independent coded regions are processed at the encoder such that loop filtering is applied across region boundaries, whereas a decoder would pad in case when it decodes an independent region but the neighbor region is not decoded. This may cause drift, which may be acceptable for an application.

This corresponds to MCTS of HEVC, where however the problem is less severe because

1. No ALF exists
2. No long deblocking filter exists
3. No padding is performed in MC, whereas the corresponding concept investigated in CE12 of Marrakesh pads samples to outside of the region, and these padded samples could already be wrong as they were generated by loop filters.

More study necessary to see how these problems can be resolved. There is a penalty in compression performance for this functionality. Therefore, the padding in MC which seems part of the problem might need to be re-considered (and simply disallow MV that point outside as in HEVC MCTS). Another aspect might be disallowing long deblocking filters (could this be done as encoder constraint?). For ALF, needs to be clarified if the virtual boundary concept helps.

Further study recommended.

[JVET-O0654](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7270) AHG12/Non-CE5: Unification of boundary handling for adaptive loop filter [N. Hu, V. Seregin, M. Karczewicz (Qualcomm)]

Also included in the agenda item 6.17.6.

See discussion under JVET-O0625.

[JVET-O0939](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7564) Crosscheck of JVET-O0654 (AHG12/Non-CE5: Unification of boundary handling for adaptive loop filter) [S. Paluri (LGE)]

[JVET-O1119](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7756) Cross-Check of JVET-O0654 (AHG12/Non-CE5: Unification of boundary handling for adaptive loop filter) [A. Wieckowski (HHI)]

[JVET-O0662](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7279) Non-CE5: Modified ALF filtering for Slice, Brick and Virtual boundaries [A. M. Kotra, S. Esenlik, B. Wang, H. Gao, E. Alshina (Huawei)]

Also included in the agenda item 6.17.6.

See discussion under JVET-O0625.

In Track B Tuesday afternoon it was further clarified that this proposal contains part of the agreement reached in Monday plenary, specifically applying the ALF virtual boundary padding method also at vertical CTU boundaries, if they coincide with slice/tile/brick boundary.

Decision: Adopt JVET-O0662 except that it shall not be applied for “360 VB” unless that is a CTU boundary

Proponents of JVET-O0625, JVET-O0654 and JVET-O0662 were asked to prepare a combined text that reflects the Monday plenary decision on the processing of slice/tile/brick boundaries. In this context it should be checked if the current VVC text needs update such that the “360 VB” is handled the same way if it is a CTU boundary. This is included in JVET-O0662v4. Text was inspected in Track B Thur 11 July 1315, and seems to include all adopted changes. Further improvement left to editor.

[JVET-O0656](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7273) Non-CE5: Boundary strength derivation for transform skipped block [S. Iwamura, S. Nemoto, A. Ichigaya (NHK)]

This contribution proposes modification of the boundary strength derivation of deblocking filter for transform-skipped block. In the current VTM, boundary strength is set equal to 1 when one of the adjacent blocks has non-zero transform coefficients. This process is based on the assumption that the energy distribution of the residual signal spreads in a whole block if a given block has non-zero transform coefficients. However, considering the transform-skipped case, the energy distribution may not spread in a whole block since inverse transform is not applied to the transform-skipped block. The proposed modification adds one condition to the boundary strength derivation to check whether the block is transform-skipped or not. The experimental results show that the proposed modification reduce the over-smoothing on the reconstructed picture.

In HEVC, deblocking in case of TS is unchanged. Different from that, as VVC uses TS also for larger blocks, the characteristics are becoming more different from transform coded blocks.

It is definitely necessary to take some action here

Question: How is it done in HEVC RExt and SCM?

Relation with JVET-O0405 and JVET-O0919 which point out that the QP in TS should be interpreted differently – this might also have impact on the filter rules.

Further Study – establish AHG (T. Nguyen, S. Iwamura) to study these issues in a larger context of TS, lossless, BDPCM, QP alignment, deblocking alignment, etc.

[JVET-O0847](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7468) Crosscheck of JVET-O0656 (Non-CE5: Boundary strength derivation for transform skipped block) [[K. Kondo](mailto:Kenji.Kondo@sony.com), M. Ikeda (Sony)]

[JVET-O0665](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7282) Non-CE5: Syntax redundancy removal in adaptive loop filter [X. W. Meng (PKU), X. Zheng (DJI), S. S. Wang, S. W. Ma (PKU)]

This contribution proposes to remove syntax redundancy for adaptive loop in VTM-5.0. The proposed method removes the **alf\_luma\_coeff\_delta\_idx** when the number of alf filters equals to NumAlfFilters-1 and remove the **alf\_luma\_coeff\_delta\_flag** when the number of ALF filters equals to 1.

In test1, **alf\_luma\_coeff\_delta\_idx** is removed when the number of alf filters equals to NumAlfFilters-1. In this test, there is no BD-rate change in AI and LDB and minor bitrate reduction in some cases. For LDB, there is minor coding gain in Class E, 0.00%, 0.01%, 0.04% coding gain for Y, Cb and Cr, respectively.

In test 3, alf\_luma\_min\_eg\_order\_minus1, alf\_luma\_eg\_order\_increase\_flag, alf\_luma\_coeff\_flag, alf\_luma\_coeff\_delta\_abs, alf\_luma\_coeff\_delta\_sign, alf\_luma\_clip\_min\_eg\_order\_minus1, alf\_luma\_clip\_eg\_order\_increase\_flag and alf\_luma\_clip\_idx are all removed when the number of ALF filters and **alf\_luma\_coeff\_delta\_flag** both equal to 1. In this test, there is no BD-rate change and minor bitrate reduction in some cases for AI, RA and LDB, respectively.

Test2 is the combination of Test1 and Test3. In this test, there is no BD-rate change in AI and LDB and minor bitrate reduction. For LDB, there is minor coding gain in Class E, 0.00%, 0.01%, 0.04% coding gain for Y, Cb and Cr.

Test3 irrelevant due to adoption of O0669.

Test1: The benefit in bit rate is very small, and the syntax becomes less clear.

No action.

[JVET-O0923](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7548) Crosscheck of JVET-O0665 (Non-CE5: Syntax redundancy removal in adaptive loop filter) [S. Ye (Hikvision)]

[JVET-O0669](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7286) Non-CE5: A Simplification of ALF Coefficient Signalling [H. E. Egilmez, N. Hu, V. Seregin, M. Karczewicz (Qualcomm)]

This document proposes a simplification by removing the coefficient predictions in ALF signaling. In VTM-5.0, ALF signaling may involve (i) recursive prediction of ALF coefficients and (ii) prediction using fixed filters. It is proposed to remove both prediction steps and relevant syntax elements. The experimental results show that the proposed changes lead to negligible coding losses over VTM-5.0 under CTC.

Fixed filters would still be existing, but not for prediction. It is reported that the fixed filters are sometimes used at CTU level adaptation.

Decision: Adopt JVET-O0669 both aspects

Note that JVET-O0427 is identical with the first aspect (remove recursive prediction)

and JVET-O0425 is identical with the second part.

[JVET-O1145](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7782) Crosscheck of JVET-O0669 (Non-CE5: A Simplification of ALF Coefficient Signalling) [X. W. Meng (PKU)]

[JVET-O0803](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7424) Non-CE5: Unified design for longer tap deblocking line buffer reduction [A. M. Kotra, S. Esenlik, B. Wang, H. Gao, E. Alshina (Huawei)] [late]

In VTM-5.0, to reduce line buffer requirement for the longer tap filter at horizontal CTU boundaries, for the Luma component an asymmetric filter which only modifies 3 samples from the top CU, and 7 samples from the bottom CU is employed, whereas for the Chroma deblocking, the longer tap filter is completely switched off at the CTU boundaries. Since a potential “large block” blocking artifact could occur at the horizontal Chroma CTU boundary, the current proposal reportedly employs a longer tap asymmetric filter which modifies 1 sample from the top CTU but can still modify up to 3 samples from the bottom CTU to more effectively remove the blocking artifact.

The objective results, over VTM5.0 Anchor for CTC configuration are as follows

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Config. | Y | U | V | EncT | DecT |
| AI | 0.00% | 0.00% | 0.00% | 101% | 101% |
| RA | 0.00% | -0.06% | -0.04% | 101% | 102% |
| LDB | 0.02% | 0.00% | -0.10% | 101% | 102% |
| LDP | 0.00% | 0.18% | -0.05% | 101% | 102% |

Subjective evaluation showed that the quality is slightly better when compared to the Anchor and reportedly the subjective benefits are better for 4:2:2 and 4:4:4 content.

Further study in CE. Unification is not necessary an argument, as there is a slight complexity increase, and should be justified by evidence that artifacts are avoided.

[JVET-O0809](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7430) Crosscheck of JVET-O0803 (Non-CE5: Unified design for longer tap deblocking line buffer reduction) [C.-M. Tsai (MediaTek)]

[JVET-O0300](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6905) AHG17: Clean-up of ALF Syntax Parameters [S. Paluri, J. Lim, S. Kim (LGE)]

This document proposes clean-ups of two Adaptive Loop Filter (ALF) Parameters, namely, **alf\_luma\_fixed\_filter\_idx** and **alf\_luma\_fixed\_filter\_set\_idx**. Currently, both parameters use truncated binary (tb) binarizations. However, these two syntax elements have a maximum value of 15. Hence, there is no coding benefit obtained from TB binarization compared to fixed length coding (FLC). Using Truncated Binary binarization introduces more complexity than fixed length coding. Additionally FLC is especially useful for representing numbers when they are a power of two.

In the discussion, several experts expressed that the decoding of TB is so simple that there is no need to change.

[JVET-O0301](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6906) AHG17: Simplification of ALF Clipping Coefficients in the APS [S. Paluri, J. Lim, S. Kim (LGE)]

See under JVET-O0047

[JVET-O0302](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6907) AHG17: Simplification of ALF Coefficients in the APS [S. Paluri, J. Lim, S. Kim (LGE)]

See under JVET-O0216

[JVET-O1120](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7757) Non-CE5: Hadamard transform domain in-loop filter [S. Ikonin, V. Stepin, A. Karabutov (Huawei)] [late]

This contribution reports performance of Hadamard transform domain filter from JVET-N0479 on top of VTM5.0 and with deblocking RDO option enabled option as well combination of the filter with SAO.

Being applied as conventional in-loop the filter provides -0.39%/-0.45% of the luma BD-rate change with 107%/103% of encoding time and 107%/102% of decoding time for AI/RA configurations correspondingly.

Additionally it is proposed to apply the filter in parallel with SAO using output of deblocking filter is an input with following averaging of filter and SAO outputs. In this mode the filter provides --0.36%/-0.44% of the luma BD-rate change with 107%/110% of encoding time and 107%/105% of decoding time for AI/RA configurations correspondingly.

Presented Thursday 11 July morning in Track B.

The proponents request to be included in CE along with the bilateral filter.

The RDO optimization in mode decision tests on the reconstruction including this filter and the deblocking filter.

The proponents report that they saw subjective benefit (e.g. Cactus, ArenaOfValor).

The crosschecker (JVET-O1174) reports some mismatch of results in LDB case.

Investigate in the CE along with JVET-O0548. As said there, subjective benefit is of highest priority. To be tested with similar conditions, i.e. also as potential replacement of SAO, and also without testing the filter in RDO stage, and also tested as a post filter.

[JVET-O1174](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7811) Crosscheck of JVET-O1120: Non-CE5: Hadamard transform domain in-loop filter [J. Ström (Ericsson)]

## CE6 related – Transforms and transform signalling (50)

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

[JVET-O0195](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6800) Non-CE6: Simplification on LFNST [Y. Zhao, H. Yang (Huawei)]

[JVET-O0953](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7583) Crosscheck of JVET-O0195 (Non-CE6: Simplification on LFNST) [M. Koo (LGE)]

[JVET-O0209](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6814) Non-CE6: LFNST simplification based on the methods proposed in CE6-2.1a [M. Koo, J. Nam, J. Lim, M. Salehifar, S. Kim (LGE)]

[JVET-O0977](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7612) Crosscheck of JVET-O0209 (Non-CE6: LFNST simplification based on the methods proposed in CE6-2.1a) [Y. Kidani, S. Naito (KDDI)]

[JVET-O1107](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7744) Crosscheck of JVET-O0209 (Non-CE6: LFNST simplification based on the methods proposed in CE6-2.1a: Test 3, 4 and 5) [K. Naser (InterDigital)]

[JVET-O0213](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6818) Non-CE6: Block size restriction of LFNST [M. Koo, J. Nam, J. Lim, M. Salehifar, S. Kim (LGE)]

[JVET-O0884](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7506) Crosscheck of JVET-O0213 (Non-CE6: Block size restriction of LFNST) [Z. Zhang (Ericsson)]

[JVET-O0214](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6819) Non-CE6: Harmonization of implicit MTS and LFNST [T. Ikai (Sharp)]

[JVET-O1045](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7682) Crosscheck of JVET-O0214 (Non-CE6: Harmonization of implicit MTS and LFNST) [X. Chen (Huawei)]

[JVET-O0219](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6824) Non-CE6: On LFNST transform set selection for a CCLM coded block [Z. Zhang, R. Sjöberg, R. Yu (Ericsson)]

[JVET-O0954](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7584) Crosscheck of JVET-O0219 (Non-CE6: On LFNST transform set selection for a CCLM coded block) [M. Koo (LGE)]

[JVET-O0264](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6869) CE6-related: On DCT-8 in VVC [K. Zhang, L. Zhang, Z. Deng, H. Liu, N. Zhang (Bytedance)]

[JVET-O0916](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7538) Crosscheck of JVET-O0264: CE6-related: On DCT-8 in VVC [C. Hollmann (Ericsson)]

[JVET-O0876](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7497) Crosscheck of JVET-O0266 (Non-CE6: Simplifications on LFNST) [T. Tsukuba (Sony)]

[JVET-O0266](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6871) Non-CE6: Simplifications on LFNST [K. Zhang, L. Zhang, Z. Deng, H. Liu, N. Zhang (Bytedance)]

[JVET-O0291](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6896) CE6-related: Constraint and simplification for LFNST signalling [M.-S. Chiang, C.-W. Hsu, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O1090](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7727) Crosscheck of JVET-O0291 (CE6-related: Constraint and simplification for LFNST signalling) [X. Cao (Hikvision)]

[JVET-O0292](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6897) CE6-related: Simplifications for LFNST [M.-S. Chiang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O1074](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7711) Crosscheck report of JVET-O0292: CE6-related: Simplifications for LFNST [[X. Xu (Tencent)](mailto:xiaozhongxu@tencent.com)]

[JVET-O1162](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7799) Crosscheck report of JVET-O0292 [J. Nam (LGE)]

[JVET-O0293](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6898) CE6-related: Latency reduction for LFNST signalling [M.-S. Chiang, C.-W. Hsu, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O1002](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7638) Crosscheck of JVET-O0293 (CE6-related: Latency reduction for LFNST signalling) [B.-J. Fuh, C.-H. Yau, C.-C. Lin, C.-L. Lin (ITRI)]

[JVET-O1167](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7804) Crosscheck of JVET-O0293 (CE6-related: Latency reduction for LFNST signaling) [T.-C. Ma (Kwai Inc.)]

[JVET-O0294](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6899) CE6-related: Context modelling for signalling MTS index [O. Chubach, M.-S. Chiang, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0917](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7539) Crosscheck of JVET-O0294: CE6-related: Context modelling for signalling MTS index [C.-H. Hung (Qualcomm)]

[JVET-O0349](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6954) CE6-related: Simplified LFNST [J. Lainema (Nokia)]

[JVET-O0350](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6955) CE6-related: LFNST with one mode [J. Lainema (Nokia)]

[JVET-O0352](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6957) Non-CE6: TU/TB-level LFNST index coding [T. Tsukuba, M. Ikeda, Y. Yagasaki, T. Suzuki (Sony)]

[JVET-O0743](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7364) Crosscheck of JVET-O0352 (Non-CE6: TU/TB-level LFNST index coding) [K. Zhang (Bytedance)]

[JVET-O0354](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6959) Non-CE6: Context modeling for MTS index coding [T. Tsukuba, M. Ikeda, Y. Yagasaki, T. Suzuki (Sony)]

[JVET-O0711](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7331) Crosscheck of JVET-O0354 (Non-CE6: Context modeling for MTS index coding) [J. Nam (LGE)]

[JVET-O0357](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6962) Non-CE6: Maximum TU size for chroma format 4:2:2 and 4:4:4 [L. Li, J. Nam, J. Lim, S. Kim (LGE)]

[JVET-O0368](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6973) Non-CE6: An MTS-based Restriction for LFNST beyond Transform Skip [H. E. Egilmez, A. K. Ramasubramonian, A. Said, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-O0863](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7484) Crosscheck of JVET-O0368: "Non-CE6: An MTS-based Restriction for LFNST beyond Transform Skip" [F. Le Léannec (Interdigital)]

[JVET-O0370](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6975) CE6-related: Applying LFNST Only for Top-Left Subblocks [H. E. Egilmez, A. Nalci, A. Said, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-O0372](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6977) Non-CE6: A Simplification for MTS Index Signaling [A. Nalci, H. E. Egilmez, A. Said, M. Coban, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-O1062](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7699) Cross-check of JVET-O0372 (Non-CE6: A Simplification for MTS Index Signaling) [A. Tamse (Samsung)]

[JVET-O0373](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6978) Non-CE6: An Improved Context Modeling for LFNST [A. Nalci, H. E. Egilmez, A. Said, M. Coban, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-O1063](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7700) Cross-check of JVET-O0373 (Non-CE6: An Improved Context Modeling for LFNST) [A. Tamse (Samsung)]

[JVET-O0380](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6985) Non-CE6: Simplification on MTS index coding [X. Cao, F. Chen, L. Wang (Hikvision)]

[JVET-O1058](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7695) Cross-check of JVET-O0380 (Non-CE6: Simplification on MTS index coding) [Y. Chen, F. Le Léannec (InterDigital)]

[JVET-O0381](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6986) Non-CE6: Simplification on SBT coding [X. Cao, F. Chen, L. Wang (Hikvision)]

[JVET-O0752](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7373) Crosscheck of JVET-O0381 (Non-CE6: Simplification on SBT coding) [Y. Zhao (Huawei)]

[JVET-O0382](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6987) Non-CE6: Unification between implicit MTS and ISP [X. Cao, F. Chen, L. Wang (Hikvision)]

[JVET-O0972](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7604) Crosscheck of JVET-O0382 (Non-CE6: Unification between implicit MTS and ISP) [M.-S. Chiang (MediaTek)]

[JVET-O0387](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6992) Non-CE6: MTS Index Signaling Simplification [A. Tamse, M. W. Park, K. Choi (Samsung)]

[JVET-O0852](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7473) Crosscheck of JVET-O0387 (Non-CE6: MTS Index Signaling Simplification) [Z. Deng (Bytedance)]

[JVET-O0402](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7007) Non-CE6: Simplification of context modeling on MTS index [J. Nam, M. Koo, J. Lim, S. Kim (LGE)]

[JVET-O0877](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7498) Crosscheck of JVET-O0402 (Non-CE6: Simplification of context modeling on MTS index) [T. Tsukuba (Sony)]

[JVET-O0410](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7015) CE6-related: Signalling of Low Frequency Non-Separable Transform [Y. Kidani, K. Unno, K. Kawamura, S. Naito (KDDI)]

[JVET-O0955](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7585) Crosscheck of JVET-O0410 (CE6-related: Signalling of Low Frequency Non-Separable Transform) [M. Koo (LGE)]

[JVET-O0444](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7049) Non-CE6: On LFNST index coding [C. Hollmann, D. Saffar, P. Wennersten, J. Ström (Ericsson)]

[JVET-O0873](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7494) Crosscheck of JVET-O0444 (Non-CE6: On LFNST index coding) [J. Lainema (Nokia)]

[JVET-O0446](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7051) Non-CE6: Reduced MTS [C. Hollmann, D. Saffar, P. Wennersten, J. Ström (Ericsson)]

[JVET-O0808](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7429) Crosscheck of JVET-O0446 (Non-CE6: Reduced MTS) [[C.-H. Hung](mailto:chaohsiu@qti.qualcomm.com) (Qualcomm)]

[JVET-O0465](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7072) Non-CE6: simplified SBT mode coding [F. Le Léannec, Y. Chen, T. Poirier (InterDigital)]

[JVET-O0853](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7474) Crosscheck of JVET-O0465 (Non-CE6: Simplified SBT mode coding) [Z. Deng (Bytedance)]

[JVET-O0466](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7073) Non-CE6: interaction between MTS and LFNST [F. Le Léannec, F. Urban, K. Naser, T. Poirier (InterDigital)]

[JVET-O0915](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7537) Crosscheck of JVET-O0466: Non-CE6: interaction between MTS and LFNST [C. Hollmann (Ericsson)]

[JVET-O0472](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7079) Non-CE6: Simplified LFNST signalling [J. Jung, D. Kim, G. Ko, J. Son, J. Kwak (WILUS)]

[JVET-O1135](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7772) Crosscheck of JVET-O0472 (Non-CE6: Simplified LFNST signalling) [?? (??)]

[JVET-O1144](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7781) Crosscheck of JVET-O0472 "Non-CE6: Simplified LFNST signalling" on top of CE6-2.1a [M. Siekmann (HHI)]

[JVET-O0474](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7081) Non-CE6: Mismatch between text specification and reference software on MTS for IBC-coded block [J. Jung, D. Kim, G Ko, J. Son, J. Kwak (WILUS)]

[JVET-O1012](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7648) Crosscheck of JVET-O0474 (Non-CE6: Mismatch between text specification and reference software on MTS for IBC-coded block) [J. Kim (SK Telecom), K. Ko, A. Baek, S. Lee, S. Son (PIXTREE)]

[JVET-O0475](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7082) Non-CE6: Context Simplification for Subblock Transform (SBT) [J. Park, B. Jeon (SKKU)]

[JVET-O0764](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7385) Crosscheck of JVET-O0475: Non-CE6: Context Simplification for Subblock Transform (SBT) [L. Pham Van, G. Van der Auwera, M. Karczewicz (Qualcomm)]

[JVET-O0476](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7083) Non-CE6: Syntax change for LFNST [D. Park, Y.-U. Yoon, J.-G. Kim (KAU), J. Lee, J. Kang (ETRI)]

[JVET-O1151](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7788) Crosscheck of JVET-O0476 (Non-CE6: Syntax change for LFNST) [A. Nalci (Qualcomm)]

[JVET-O0521](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7128) Non-CE6: Removing LFNST when MTS larger than zero [G. Kulupana, S. Blasi, A. Seixas Dias (BBC)]

[JVET-O1091](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7728) Crosscheck of JVET-O0521 Non-CE6: Removing LFNST when MTS larger than zero [M. Abdoli, T. Guionnet (ATEME)]

[JVET-O0528](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7135) Non-CE6: Simplified Transform Selection For ISP [K. Naser, F. Le Léannec, T. Poirier, P. de Lagrange (InterDigital)]

[JVET-O0965](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7595) Crosscheck of JVET-O0528 (Non-CE6: Simplified Transform Selection For ISP) [S. De-Luxán-Hernández (HHI)]

[JVET-O0529](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7136) Non-CE6 Interaction between Implicit MTS and LFNST and MIP [K. Naser, F. Le Léannec, T. Poirier (InterDigital)]

[JVET-O0538](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7145) Non-CE6: An SPS Control of ISP and SBT Transform Selection [[K. Naser](mailto:karam.naser@interdigital.com), F. Le Léannec, M. Kerdranvat (InterDigital)]

[JVET-O1067](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7704) Crosscheck of JVET-O0538 (Non-CE6: An SPS Control of ISP and SBT Transform Selection) [[H. E. Egilmez (Qualcomm)](mailto:hegilmez@qti.qualcomm.com)]

[JVET-O0539](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7146) CE6-related: Unified LFNST using block size independent kernel [X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-O0899](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7521) Crosscheck of JVET-O0539 (CE6-related: Unified LFNST using block size independent kernel) [M. Siekmann (HHI)]

[JVET-O0934](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7559) Crosscheck of JVET-O0539: CE6-related: Unified LFNST using block size independent kernel [C. Hollmann (Ericsson)]

[JVET-O0540](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7147) Non-CE6: Harmonization of LFNST, MIP and implicit MTS [X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-O0541](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7148) Non-CE6: Modified high-level syntax control on implicit transform [S. Liu, X. Zhao, X. Li (Tencent)]

[JVET-O0544](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7154) Non-CE6: Modified LFNST Transform Matrices for Fast Implementation [K. Naser, L. Kerofsky, F. Le Léannec, T. Poirier (InterDigital)]

[JVET-O0956](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7586) Crosscheck of JVET-O0544 (Non-CE6: Modified LFNST Transform Matrices for Fast Implementation) [M. Koo (LGE)]

[JVET-O0545](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7156) Non-CE6: Configurable maximum transform size in VVC [X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-O0941](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7568) Crosscheck of JVET-O0545 (Non-CE6: Configurable maximum transform size in VVC) [T.-C. Ma (Kwai Inc.)]

[JVET-O0546](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7157) Non-CE3/6: Transform selection for MRL [L. Zhao, X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-O0680](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7299) Crosscheck of JVET-O0546 (Non-CE3/6: Transform selection for MRL) [J. Jung, D. Kim, G. Ko, J. Son, J. Kwak (WILUS)]

[JVET-O0569](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7184) Non-CE6: LFNST Signalling at the TU Level [A. Nalci, H. E. Egilmez, A. Said, M. Coban, V. Seregin, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-O1111](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7748) Crosscheck of JVET-O0569 (Non-CE6: LFNST Signalling at the TU Level) [T. Hashimoto, Y. Yasugi, T. Ikai (Sharp)]

[JVET-O1154](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7791) Crosscheck of JVET-O0569 (Non-CE6: LFNST Signaling at the TU Level) CTC tests [M. Siekmann (HHI)]

[JVET-O0576](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7191) Non-CE6: Reduced contexts and context coded bins for MTS index coding [Z. Deng, L. Zhang, H. Liu, K. Zhang, Y. Wang (Bytedance)]

[JVET-O0837](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7458) Crosscheck of JVET-O0576 (Non-CE6: Reduced contexts and context coded bins for MTS index coding) [A. Tamse (Samsung)]

[JVET-O0620](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7235) Non-CE6: Simplification with new LFNST transform basis [T. Zhou, T. Hashimoto, T. Ikai (Sharp)] [late]

[JVET-O0719](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7339) Crosscheck of JVET-O0620 (Non-CE6: Simplification with new LFNST transform basis) [L. Xu, F. Chen, L. Wang (Hikvision)]

[JVET-O0642](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7258) Non-CE6: Reducing secondary transform kernel for specific residual block size [S. Shrestha, A. Kumar, B. Lee (Chosun Univ.), Y. Lee, J. Park (Humax)]

[JVET-O1108](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7745) Crosscheck of JVET-O0642 (Non-CE6: Reducing secondary transform kernel for specific residual block size) [[J. Park](mailto:jiyoonpark@skku.edu), B. Jeon (SKKU)]

[JVET-O0699](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7319) Non-CE6: Modified DCT8/DST7 Transform Matrices for Faster Implementation [K. Naser, L. Kerofsky, F. Le Léannec, T. Poirier (InterDigital)] [late]

[JVET-O0986](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7622) Crosscheck of JVET-O0699: Non-CE6: Modified DCT8/DST7 Transform Matrices for Faster Implementation [X. Zhao (Tencent)]

[JVET-O0963](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7593) Non-CE6: LFNST Signalling at the TU Level with Last Position Constraints [A. Nalci, H. E. Egilmez, A. Said, M. Coban, V. Seregin, M. Karczewicz (Qualcomm)] [late]

[JVET-O1155](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7792) Crosscheck of JVET-O0963 (Non-CE6: Combination of JVET-O0472 and JVET-O0569 for TU-level LFNST Signaling with Last Position Constraints) [M. Siekmann (HHI)]

## CE7 related – Quantization and coefficient coding (26)

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

[JVET-O0068](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6672) AHG16/Non-CE7: A study of bin to bit ratio for VTM5.0 [M. Zhou (Broadcom)]

[JVET-O0193](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6798) CE7-related: Remove transform depth in cbf coding [Y. Zhao, H. Yang (Huawei)]

[JVET-O0773](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7394) Crosscheck of JVET-O0193 (CE7-related: Remove transform depth in cbf coding) [Y.-W. Chen (Kwai Inc.)]

[JVET-O0231](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6836) Non-CE7: Modified chroma coded block flag signalling [S. Esenlik, Y. Zhao, A. M. Kotra, H. Gao, B. Wang, E. Alshina (Huawei)]

[JVET-O0872](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7493) Crosscheck of JVET-O0231 (Non-CE7: Modified chroma coded block flag signalling) [J. Lainema (Nokia)]

[JVET-O0295](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6900) CE7-related: Modified subblock coding passes for coding TS residual [S.-T. Hsiang, S.-M. Lei (MediaTek)]

[JVET-O0937](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7562) Crosscheck of JVET-O0295 (CE7-related: Modified subblock coding passes for coding TS residual) [M. Salehifar (LGE)]

[JVET-O0376](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6981) CE8-related: A SPS level flag for BDPCM and JCCR [L. Xu, X. Cao, F. Chen (Hikvision)]

The JCCR flag to be discussed in CE7 context. Proponents asked to manage that. BDPCM part was discussed in CE8 related.

[JVET-O0375](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6980) Non-CE7: A Simplified CBF Coding for Luma and Chroma [A. Nalci, H. E. Egilmez, A. Said, M. Coban, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-O1070](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7707) Crosscheck of JVET-O0375 (Non-CE7: A Simplified CBF Coding for Luma and Chroma) [H.-J. Jhu (Kwai Inc.)]

[JVET-O0383](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6988) Non-CE7: Harmonization of scaling matrix and LFNST [T. Hashimoto, E. Sasaki, T. Chujoh, T. Ikai (Sharp)]

[JVET-O0791](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7412) Crosscheck of JVET-O0383 (Non-CE7: Harmonization of scaling matrix and LFNST) [Y.-L. Hsiao (MediaTek)]

[JVET-O0400](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7005) CE7-related: Context-coded bin restriction [J. Choi, S. Yoo, J. Heo, J. Choi, J. Lim, S. Kim (LGE)]

[JVET-O0909](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7531) Crosscheck of JVET-O0400: CE7-related: Context-coded bin restriction [W. Zhu (Bytedance)]

[JVET-O0405](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7010) Non-CE8: Minimum Allowed QP for Transform Skip Mode [T. Nguyen, B. Bross, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

Was moved from CE8 to CE7 related

[JVET-O1068](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7705) Crosscheck of JVET-O0405 (Non-CE8: Minimum Allowed QP for Transform Skip Mode) [M Coban (Qualcomm)]

[JVET-O0406](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7011) Non-CE7: Unification of syntaxes after CCB count exceeds the maximum number between transform residual and transform skip residual [Y. Kato, K. Abe, T.Toma (Panasonic)]

[JVET-O0788](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7409) Crosscheck of JVET-O0406 (Non-CE7: Unification of syntaxes after CCB count exceeds the maximum number between transform residual and transform skip residual) [C.-Y. Lai (MediaTek)]

[JVET-O0409](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7014) Non-CE7: Unification of CCB count method between transform residual and transform skip residual [Y. Kato, K. Abe, T. Toma (Panasonic)]

[JVET-O1054](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7691) Crosscheck of JVET-O0409 (Non-CE7: Unification of CCB count method between transform residual and transform skip residual) [J. Choi, J. Lim (LGE)]

[JVET-O0543](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7151) CE7-related: Alternative configuration for joint chroma residual coding [C. Helmrich, H. Schwarz, T. Nguyen, C. Rudat, D. Marpe, T. Wiegand (Fraunhofer HHI)]

[JVET-O0874](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7495) Crosscheck of JVET-O0543 (CE7-related: Alternative configuration for joint chroma residual coding) [J. Lainema (Nokia)]

[JVET-O0556](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7170) CE7-related: Alternative method to RDPCM with TS level mapping [M. Karczewicz, Y. Han, Y.-H. Chao, M. Coban (Qualcomm)]

[JVET-O0774](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7395) Crosscheck of JVET-O0556 (CE7-related: Alternative method to RDPCM with TS level mapping) [Y.-W. Chen (Kwai Inc.)]

[JVET-O0557](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7171) Non-CE7: Context modeling unification in significant flag of coefficient group [Y.-H. Chao, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-O0777](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7398) Crosscheck of JVET-O0557 (Non-CE7: Context modeling unification in significant flag of coefficient group) [Y.-W. Chen (Kwai Inc.)]

[JVET-O0558](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7172) CE7-related: Reduction of Gtx passes in transform skip residual coding [M. Karczewicz, Y.-H. Chao, H. Wang, M. Coban (Qualcomm)]

[JVET-O0775](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7396) Crosscheck of JVET-O0558 (CE7-related: Reduction of Gtx passes in transform skip residual coding) [Y.-W. Chen (Kwai Inc.)]

[JVET-O0559](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7173) CE7-related: QP dependent binarization in TS residual coding [M. Karczewicz, Y.-H. Chao, M. Coban (Qualcomm)]

[JVET-O0776](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7397) Crosscheck of JVET-O0559 (CE7-related: QP dependent binarization in TS residual coding) [Y.-W. Chen (Kwai Inc.)]

[JVET-O0575](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7190) CE7-related: Reduction for Context Coded Bins in Transform Skip Mode [W. Zhu, L. Zhang, J. Xu, K. Zhang, H. Liu (Bytedance)]

[JVET-O0596](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7211) CE7-related: On chroma CBF signaling of subblock transform mode [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-O0753](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7374) Crosscheck of JVET-O0596 (CE7-related: On chroma CBF signaling of subblock transform mode) [Y. Zhao (Huawei)]

[JVET-O0613](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7228) CE7-related: Unification of Rice parameter tables in residual coding [C. Auyeung, X. Li, S. Liu (Tencent)]

[JVET-O0758](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7379) Crosscheck of JVET-O0613 (CE7-related: Unification of Rice parameter tables in residual coding) [H.-J. Jhu (Kwai Inc.)]

[JVET-O0617](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7232) CE7-related: Context reduction of transform coefficient significance flag [C. Auyeung, X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-O0936](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7561) Crosscheck of JVET-O0617 (CE7-related: Context reduction of transform coefficient significance flag) [H. Schwarz (Fraunhofer HHI)]

[JVET-O0619](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7234) Non-CE7: Simplification of transform skip residual coding [M. G. Sarwer, Y. Ye (Alibaba)]

[JVET-O0878](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7499) Crosscheck of JVET-O0619 (Non-CE7: Simplification of transform skip residual coding) [T. Tsukuba (Sony)]

[JVET-O0623](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7238) CE7-related: Interleaved coefficient coding for transform-skip mode [M. Karczewicz, H. Wang, M. Coban, Y.-H. Chao (Qualcomm)]

[JVET-O0690](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7310) Crosscheck of JVET-O0623: Interleaved coefficient coding for transform-skip mode [T. Nguyen (HHI)]

[JVET-O0670](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7287) CE7-related: Alternative joint coding of chroma residuals [B. Ray, G. Van der Auwera, M. Karczewicz (Qualcomm)]

[JVET-O0875](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7496) Crosscheck of JVET-O0670 (CE7-related: Alternative joint coding of chroma residuals) [J. Lainema (Nokia)]

[JVET-O0783](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7404) AHG17: Control of transform skip residual coding [L Chen, Y.-W. Huang, S.-M. Lei (MediaTek)] [late]

Was moved to CE7

[JVET-O0919](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7541) Non-CE8: Minimum QP for Transform Skip Mode [M. Karczewicz, Y.-H. Chao, H. Wang, M. Coban (Qualcomm)] [late]

Was moved from CE8 to CE7 related

[JVET-O1017](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7654) Crosscheck of JVET-O0919: Minimum QP for Transform Skip Mode [T. Nguyen (HHI)]

[JVET-O0928](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7553) CE7-related: Context reduction for entropy coding sig\_coeff\_flag [S.-T. Hsiang, S.-M. Lei (MediaTek)] [late]

[JVET-O1134](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7771) Crosscheck of JVET-O0928 (CE7-related: Context reduction for entropy coding sig\_coeff\_flag) [M. Sychev (Huawei)]

[JVET-O0935](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7560) CE7-related: Alternative configuration of CE7-2.2 joint chroma residual coding [C. Helmrich, H. Schwarz, T. Nguyen, C. Rudat, D. Marpe, T. Wiegand (Fraunhofer HHI, B. Ray, G. Van der Auwera, A. K. Ramasubramonian, M. Coban, M. Karczewicz (Qualcomm)] [late]

[JVET-O1098](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7735) Non-CE7: Context reduction in residual coding [Y. Chen, F. Le Léannec, T. Poirier (InterDigital)] [late]

[JVET-O1169](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7806) CE8(7)-related: Alignment of number of context coded bins per coefficients for TS residual coding and transform coefficient coding [M. Coban, M. Karczewicz (Qualcomm)] [late]

[JVET-O1173](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7810) Crosscheck of JVET-O1169: Alignment of number of context coded bins per coefficients for TS residual coding and transform coefficient coding [T. Nguyen (HHI)]

## CE8 related – Screen content coding tools (46)

Contributions in this category were discussed Friday 5 July 0900–1330 and 1430-1755 in Track B (chaired by JRO). Some documents as noted below were assigned for review in BoG (X. Xu)

[JVET-O0074](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6678) CE8-1.6-related: IBC Dedicated Buffer with 120x128 8-bit Setting [J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)]

This document proposes the dedicated IBC buffer design, i.e. CE8-1.6 with 120x128 samples in 8-bit precision setting. LowQP (QP=2, 7, 12, 17) results are also shown, in addition to results under CE8 test conditions. Software and text are the same as in the CE8-1.6 except for a parameter changed.

The summary results for normal QPs are shown below:

Class F/4:2:0 TGM – AI: -0.86%/-2.13%; -0.66%/-1.17%; LDB: -0.25%/-0.50%.

The summary results for low QPs are shown below:

Class F/4:2:0 TGM – AI: 0.26%/-2.42%; RA: 0.35%/-3.49%; LDB: 0.64%/3.10%.

In addition, for low QPs, summary results are shown for LMCS off cases:

Class F/4:2:0 TGM – AI: -0.88%/-2.42%; RA: -1.94%/-4.16%; LDB: -1.27%/-0.81%.

Comments of crosschecker:

* Is the case covered that the prediction comes partially from the current and partially from previous CTU? Yes
* Addressing where the current reference block is coming from is new. It is however not complicated (modulo operation)
* At the software encoder, the buffer is not used.
* The storage in 8 bit precision requires conversion both when writing as well as reading the buffer.

It is commented that a drawback of the method is due to the fact that each CU needs to be copied individually to the virtual buffer, so the data flow is increased.

The method simplifies the availability, but this comes at the expense of more complicated memory transfer.

[JVET-O1073](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7710) Crosscheck report of JVET-O0074: CE8-1.6-related: IBC Dedicated Buffer with 120x128 8-bit Setting [X. Xu (Tencent)]

[JVET-O0127](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6731) CE8-related: IBC modifications [J. Li, C. S. Lim (Panasonic)]

This proposal is a further improvement over JVET-N0201/N0316 that reduces the complexity of IBC block vector validation check for decoder. While using same amount of additional buffer as VTM5.0, worst-case complexity of IBC vector validation check is greatly reduced.

Simulation results of 2 tests are reported, the 1st test uses proposed method for reconstruction process of IBC block. The 2nd test applies proposed method to block vector search in encoding process on top of first test. Average results of luma BD rate difference for CTC, classF, and TGM compared with VTM5.0 (IBC enabled) are as below:

Test1 (proposed method used for recon process): All Intra: 0.00%, 0.00%, 0.00%

RA: 0.00%, 0.00%, 0.00%

LDB: 0.00%, 0.00%, 0,00%

Test2 (test 1+ proposed method applied to block vector search): All Intra: -0.01%, -0.03%, -0.18%

RA: 0.00%, -0.02%, -0.18%

LDB: 0.01%, 0.01%, -0.02%

Presentation deck not included.

The method introduces an additional “isDecoded” buffer (1 bit flag for each 4x4). It is suggested that different from the proposal, this is necessary only for the current 64x64 VPDU area. The scheme is simle and straightforward, but still needs some checks and a fallback if unavailability is determined (which is suggested to be the mid gray value). This also indicates that an encoder could simply check as well to obey the bitstream constraint.

Significantly simpler than current design. Requires a maximum of 5 comparisons, 11 additions and 6 bitwise-and operations and a 1024-bit buffer. For dual-tree case, this would be doubled.

Test 2 shows that the proposed availability check is less conservative than the current method, as it seems to allow cases that are improving the results.

Could this method be used to express the bitstream constraint? Not necessary -> new document O1170

[JVET-O0738](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7359) Crosscheck of JVET-O0127 (CE8-related: IBC modifications) [J. Xu (Bytedance)]

[JVET-O0162](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6766) Non-CE8: On IBC motion vector list construction [H. Chen, H. Yang (Huawei)]

In current VTM, a unified motion vector candidate list is used for IBC merge and MVP mode. According to the working draft JVET-N1001, when MaxNumMergeCand is set equal to 1, the length of MVP candidate list may be equal to 1 or 2, depending on the number of available spatial motion vector candidates. If mvp\_l0\_flag for the decoded IBC block is equal to 1, the motion vector for the IBC block may be undefined. Therefore, this contribution presents 3 methods to solve this issue. First method is to set the second candidate to be zero motion vector when MaxNumMergeCand is 1, which is aligned with the software. Second method is to infer mvp\_l0\_flag to 0 for IBC mode. Third method is to derive max(2, MaxNumMergeCand) candidates for IBC motion vector prediction.

The proposed method 2 reportedly shows 0.64%, 0.49% luma BD-rates for Class F in AI and RA settings, respectively, and shows 0.15%, 0.11% luma BD-rates for Class SCC in AI and RA settings, respectively.

The proposed method 3 reportedly shows -0.91%, -0.46% luma BD-rates for Class F in AI and RA settings, respectively, and shows -0.32%, -0.20% luma BD-rates for Class SCC in AI and RA settings, respectively, for Class SCC.

Currently, the software fills a zero vector as second candidate (which is then used as predictor), whereas the spec does not specify anything. Beyond the fact that the mismatch has to be resolved, this contribution indicates that the current SW approach may not be optimum.

Contributions 0331, 0480, 0574 also relate to this issue -> BoG.

[JVET-O1104](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7741) Crosscheck report of JVET-O0162: Non-CE8: On IBC motion vector list construction [X. Xu (Tencent)]

[JVET-O0165](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6769) CE8-related: SPS flag for BDPCM [F. Henry (Orange)]

In the current design of the VVC specification and reference software, there is no High Level Syntax flag to activate BDPCM (unlike other Screen Content Coding tools). This contribution proposes to add a sps\_bdpcm\_enable\_flag at SPS level. It is also proposed that this flag follows the behaviours of sps\_ibc\_enabled\_flagforCommon Testing Conditions.

The introduction of the SPS flag gives also BR reduction for natural content under CTC.

Obviously, introduction of a high-level flag was forgotten when BDPCM was adopted. Currently, it can only be disabled at block level.

JVET-O0376 method 1 has the same aspect.

Decision (BF): Adopt JVET-O0165.

[JVET-O0166](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6770) CE8-related: BDPCM for chroma [F. Henry (Orange), G. Clare (bcom)]

In the current design of the VVC specification, BDPCM is applied on the luma component only. This contribution proposes to apply it also to the chroma components. A single additional flag is used to signal the use of BDPCM on chroma components. When BDPCM is used on chroma components, a single direction flag is sent for all chroma components at block level.

The proponents report the following BD-rate change on TGM444 1080p formats in single tree configuration:

All Intra:

Luma Chroma1 Chroma2 EncT DecT

YUV -0,48% -2,91% -3,05% 102% 97%

RGB -3,55% -5,57% -5,93% 103% 96%

Random Access:

Luma Chroma1 Chroma2 EncT DecT

YUV -0,46% -2,04% -2,08% 100% 102%

RGB -2,49% -3,83% -4,05% 101% 100%

It is suggested to do this only for the 444 case.

For other classes, there is loss in luma (e.g. mixed content 0.6% loss in AI).

Further study (CE): Relation with TS for chroma and palette should be further investigated.

[JVET-O1088](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7725) Crosscheck report of JVET-O0166 (CE8-related: BDPCM for chroma) [V. Rufitskiy, A. Filippov (Huawei)]

[JVET-O0696](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7316) Crosscheck of JVET-O0166 (CE8-related: BDPCM for chroma) [Y.-H. Chao (Qualcomm)]

[JVET-O0200](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6805) CE8-related: RDPCM intra mode mapping, maximum RDPCM block size [M. Coban, Y. Han, M. Karczewicz (Qualcomm)]

This contribution proposes to assign horizontal/vertical RDPCM directions to horizontal/vertical intra prediction modes instead of planar intra mode. The simulations results show Class F: -0.12% AI, -0.09% RA, 0.02% LB BD-Rate, and Class TGM: -0.18% AI, -0.18% RA, -0.04% LB BD-Rate, versus the VTM-5.0 anchor under common test conditions. The maximum coding block width/height that supports RDPCM is aligned to maximum transform skip size signalled in PPS instead of fixed 32 maximum dimension.

Other contributions that have the same aspect of Part 1 (hor/vert direction): 205, 296, 315, 342, 463, 542. See further notes under JVET-O0315.

Part 2 suggests to inherit the maximum size of BDPCM (hard coded with 32) with the maximum size of TS (signalled). The rationale behind limiting the size of BDPCM was motivated by a throughput issue, which is no longer existing since BDPCM is applied in the coefficient domain.

In the current syntax, TS is always inferred when BDPCM is enabled. Therefore, coupling the two max sizes is logical.

JVET-O0206 also proposes this aspect, but raises another issue that there would be an ill-posed condition if TS was disabled and BDPCM was enabled. It therefore suggests another condition at low level to resolve this issue.

During the discussion it is agreed to better resolve this at a high level, defining that the BDPCM flag can only be set if TS is set. As the BDPCM flag is agreed to be introduced in SPS (as per adoption of JVET-O0165), the appropriate solution would be to also move the TS flag to SPS (suggested in JVET-O0783 option 2). The PPS flag should be removed. Max TS size should stay at PPS

Decision: Adopt JVET-O0200 “Part 2” (align max size of BDPCM and TS)

Proponents of JVET-O0165, JVET-O0200, JVET-O0783 were asked to work on unified syntax of those aspects.

[JVET-O1136](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7773) Unified syntax for JVET-O0165/O0200/O0783 on TS and BDPCM signalling [M. Coban, Y. Han, M. Karczewicz (Qualcomm), F. Henry (Orange), G. Clare (bcom), L. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)] [late]

This contribution provided unified syntax for JVET-O0165, JVET-O0200, JVET-O0783 on TS and BDPCM signalling in SPS and PPS, maximum coding block size that supports BDPCM is aligned with maximum transform skip size

Text was presented Wed 10 July 1120.

Question: Is the usage of TS implicit when BDPCM is turned on at block level? Yes

Question: Can TS be used at block level without BDPCM? Yes

Text was inspected and found to be matching the desired behaviour.

Decision: Adopt JVET-O1136

(remove adoption decisions from meeting notes under O0165/O0200/O0783)

[JVET-O0205](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6810) CE8-related: Improvements on BDPCM [S. Yoo, J. Choi, J. Nam, J. Heo, J. Lim, S. Kim (LGE)]

Two methods for improving BDPCM are proposed in this contribution as follows.

* Intra mode derivation for BDPCM
* Line-shaped CG for BDPCM block

In the current VVC, when the BDPCM mode is enabled for a block, its prediction mode is set to MODE\_INTRA and its intra mode is inferred to be the first candidate in the MPM list, which is planar mode. Considering that BDPCM actually uses one of intra prediction between horizontal and vertical modes, this proposal suggests to derive the BDPCM prediction mode based on actual prediction mode. Another aspect is to use line-shaped CG for BDPCM. In the BDPCM process, once the DPCM direction is indicated to a CU, the transform skipped residuals are processed/predicted by the line. Therefore, combining the residuals with a line CG seems to be desirable and it also provides coding performance. As a result, coding gains of the proposed scheme is observed to be -0.18% / -0.28% in Class F and TGM in AI, -0.12% / 0.00% in Class F and TGM in RA, and -0.24% / -0.23% in Class F and TGM in LDB, respectively.

First aspect: See under JVET-O0315

Second aspect: Results are presented only for combination with the first aspect. Though it gives some additional gain for AI in TGM, the gain that the first method gives in RA is going to zero in the combination. Furthermore, decoder run time increases. No action.

[JVET-O0705](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7325) Crosscheck of JVET-O0205: CE8-related: Improvements on BDPCM [X. Zhao (Tencent)]

[JVET-O0969](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7601) Crosscheck of method 2 in JVET-O0205 (CE8-related: Improvements on BDPCM) [M.-S. Chiang (MediaTek)]

[JVET-O0206](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6811) CE8-related: Unified condition between BDPCM and transform skip [S. Yoo, J. Nam, J. Choi, J. Lim, S. Kim (LGE)]

(include abstract)

See notes under JVET-O0200 that the problem raised in this contribution can better be resolved at a high level.

[JVET-O0689](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7309) Crosscheck of JVET-O0206: Unified condition between BDPCM and transform skip [T. Nguyen (HHI)]

[JVET-O0248](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6853) CE8-related: Dedicated IBC reference buffer without bitstream restrictions [H. Gao, A.Karabutov, S. Esenlik, S. Ikonin, B. Wang, A. M. Kotra, E. Alshina (Huawei)]

In the current VVC Draft 5, IBC mode reference area comprises 3 VPDUs from left CTU and the current VPDU in current CTU. However, many bitstream restrictions are necessary to make sure the block vector (BV) points to a valid area. In the CE test CE8-1.6, the concept of dedicated IBC reference buffer is introduced which reduce the number of the block vector restrictions (i.e. necessary conformance checks in the encoder). This proposal is based on CE8-1.6 and provides a simple IBC buffer concept that remove all of the BV bitstream restrictions. It is asserted that considerable simplification in draft text is achieved with no impact on coding performance. Furthermore the additional memory requirement for IBC mode (3 VPDUs) is not changed.

Results are unchanged with current encoder. When releasing the current encoder constraint, the results are slightly improved (as apparently the current method of encoder is too restrictive).

The approach is filling the current dedicated area with average grey value. For example, in case where the current CU would be addressed, a grey value would be used for prediction.

The cost is an additional memory initialization once per 64x64 VPDU.

[JVET-O0739](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7360) Crosscheck of JVET-O0248 (CE8-related: Dedicated IBC reference buffer without bitstream restrictions) [J. Xu (Bytedance)]

[JVET-O0258](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6863) Non-CE8: Adaptive single/dual tree with IBC simplification [W. Zhu, J. Xu, L. Zhang (Bytedance)]

It was verified that dual tree is efficient in general, especially for chroma components. However, it may not be the case for screen content coding and for 4:4:4 format. Thus, it is proposed to adaptively switch between dual tree and single tree at CTU-level and disable chroma IBC in the dual tree coding structure. Simulation results show that the proposed scheme achieves coding gains over both single tree and dual tree anchors. Furthermore, it removes IBC for chroma CU, which simplify both the implementation and the text. Results (BD-rate for luma, encoding time change and decoding time change) are summarized as follows:

On 4:2:0 sequences (versus VTM-5.0 with dual tree on, i.e. VTM-5.0 anchor),

Class F: AI: -0.01%, 126%, 100%; RA: -0.20%, 110%, 101%; LDB: 0.05%, 104%, 98%;

Class TGM: AI: -1.31%, 143%, 98%; RA: -0.10%, 108%, 100%; LDB: -0.02%, 103%, 99%.

On 4:2:0 sequences (versus VTM-5.0 with dual tree off),

Class F: AI: -0.80%, 89%, 101%; RA: -0.59%, 102%, 107%; LDB: -0.08%, 102%, 104%;

Class TGM: AI: -0.54%, 105%, 99%; RA: -0.24%, 104%, 104%; LDB: -0.03%, 103%, 103%.

On 4:4:4 sequences (versus VTM5 with dual tree on),

Class TGM 1080p: AI: -6.35%, 150%, 88%; RA: -2.06%, 108%, 106%; LDB: -0.32%,1 05%, 101%;

Class TGM 720p: AI: -3.33%, 161%, 99%; RA: -2.34%, 114%, 111%; LDB: -0.38%, 106%, 111%;

Animation: AI: 0.17%, 102%, 102%; RA: 0.08%, 103%, 107%; LDB: 0.03, 103%, 102%;

Mixed content: AI: -1.75%, 160%, 95%; -1.24%, 112%, 104%; -0.16%, 106%, 101%;

Camera-captured content: AI: 0.02, 103%, 103%; -0.02%, 103%, 104%; 0.01%, 104%, 103%.

On 4:4:4 sequences (versus VTM5 with dual tree off)

Class TGM 1080p: AI: -0.17%,101%, 102%; RA: 0.00%, 104%, 106%; LDB: 0.00%, 105%, 103%;

Class TGM 720p: AI: -0.45%,105%,107%; RA: -0.52%,103%, 112%; LDB: -0.04%,104%,112%.

Animation: AI: 0.21%, 62%, 107%; RA: -0.17%, 97%, 108%; 0.02%, 102%, 103%;

Mixed content: AI: -0.05%, 109%, 103%; RA: -0.12%, 106%, 104%; -0.10%, 107%, 101%;

Camera-captured content: AI: -1.58%, 57%, 106%; -1.57%, 98%, 105%; -0.15%, 105%, 105%.

The aspect of disabling chroma IBC in case of dual tree is of interest according to the opinion of several experts, as the inheritance of BV is complicated and it does not result in significant loss (1.7% in TGM is asserted not to be much, loss for class F is 0.05%).

The aspect of switching at CTU level does not seem to provide gain. This had been investigated before (Ljubljana) and the situation seems to be the same for screen content – almost same results as switching at picture level as per CE8-4.

Decision: Adopt JVET-O0258, only the aspect of disabling IBC for chroma in case of dual tree.

[JVET-O0695](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7315) Crosscheck of JVET-O0258 (Non-CE8: Adaptive single/dual tree with IBC simplification) [C.-H. Hung, Y.-H. Chao (Qualcomm)]

[JVET-O0259](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6864) CE8-related: Palette mode with 8 bits entries [W. Zhu, J. Xu, L. Zhang, H.-C. Chuang (Bytedance)]

In the palette design of CE8-2.1, 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 to reduce the memory cost. The proposed method is implemented on top of CE8-2.1 base software and compared with VTM-5.0. Simulation results (BD-rate, encoding time, decoding time) are reported as below:

On 420 sequences,

Class F: AI: -0.69%, 105%, 102%; RA: -0.56%, 105%, 98%; LDB: -0.11%, 108%, 98%.

Class TGM: AI: -4.11%, 101%, 97%; RA: -1.54%, 100%, 98%; LDB: -0.31%, 102%, 99%.

On 444 sequences (Dual tree on),

Class TGM 1080p: -6.51%, 109%, 94%; RA: -5.28%, 96%, 99%; LDB: -5.05%, 103%, 99%.

Class TGM 720p: -1.42%, 107%, 103%; RA: -0.60%, 103%, 106%; LDB: -1.07%, 105%, 103%.

On 444 sequences (Dual tree off),

Class TGM 1080p: -16.07%, 100%, 91%; RA: -10.53%, 94%, 97%; LDB: -6.31%, 104%, 98%.

Class TGM 720p: -4.09%, 104%, 102%; RA: -4.31%, 103%, 108%; LDB: -1.75%, 105%,102%.

In CE8-2.1, the bit depth of palette entries is same with the internal bit depth, which may be unnecessarily large. A palette prediction table with size 63 is used to predict the palette of every CU, which increases the on-chip memory cost. This document proposes to set the bit depth of palette entries to a constant, e.g. 8, to reduce the on-chip memory cost and align to the bit depth of input video. By using the proposed method, the on-chip memory cost of the palette prediction table can be reduced from 14\*63\*3 = 2646 bits to 8\*63\*3 = 1512 bits.

Presentation deck not uploaded.

Loss compared to base palette is approx. 0.03% for class F, 0.17% for TGM.

Question: The current test sequences are 8 bit – further study should include 10 bit data and 4:4:4. In the new sequences, at least one sequence (glass half) is 10 bit.

Future developments could even have higher bit depth in animation sequences. The 14 bit was inherited from HEVC, which obviously was put there for range extension purpose.

No need for action currently. For further study.

[JVET-O0889](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7511) Crosscheck of JVET-O0259 (CE8-related: Palette mode with 8 bits entries) [F. Henry (Orange), G. Clare (bcom)]

[JVET-O0282](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6887) CE8-releated: Bug Fix in CE8-2.1 [C.-H. Hung, Y.-H. Chao, W.-J. Chien, V. Seregin, M. Karczewicz (Qualcomm)]

This document reports a bug fix in CE test 8-2.1 [1] on palette mode tested on top of VTM-5.0. The original CE8-2.1. will crash for some 4:4:4 test sequences under low QP conditions. The CE results after bug fixing show that:4:2:0 test sequences,

1. Under CTC conditions, the BD-rate and PSNR after bug fixing are the same as original ones.
2. Under low QP conditions, including DualITree turned on and off, the BD-rate and PSNR after bug fixing are the same as original ones.

For 4:4:4 test sequences,

1. Under CTC conditions, the BD-rate and PSNR after bug fixing are the same as original ones.
2. Under low QP conditions, including DualITree turned on and off, the BD-rate and PSNR after bug fixing are slightly different from original ones.

The encoder crashes at low QP for some 4:4:4 sequences. This occurs since palette is used more frequently here, and there is a problem with a temporary buffer.

Decision (SW/BF): Adopt JVET-O0282. Palette software to be updated.

[JVET-O0787](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7408) Crosscheck of JVET-O0282 (CE8-related: Bug fix in CE8-2.1) [C.-Y. Lai (MediaTek)]

[JVET-O0296](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6901) CE8-related: Intra prediction mode for BDPCM [M.-S. Chiang, O. Chubach, C.-W. Hsu, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

(include abstract)

See notes under JVET-O0315

[JVET-O0913](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7535) Crosscheck of JVET-O0296: CE8-related: Intra prediction mode for BDPCM [W. Zhu (Bytedance)]

[JVET-O0315](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6920) CE8-related: Intra prediction mode alignment for BDPCM [W. Zhu, L. Zhang, J. Xu (Bytedance)]

In the current design, Block-based quantized residual domain DPCM uses a special MPM (Planar mode in VVC draft 5) as the stored intra prediction mode, although it is performed horizontally or vertically. It is proposed to align its stored intra mode with the actual intra mode employed in BDPCM. It is asserted that with the proposed method, the MPM list construction process could be simplified since the checking of BDPCM mode of neighboring blocks is avoided. The simulations result reports that the proposed modification can achieve -0.18%/-0.18%/-0.04% BD-Rate changes under AI/RA/LDB configurations versus the VTM-5.0 anchor on class TGM. It is also reported that the proposed modification can achieve -0.34%/-0.26%/0.00% BD-Rate changes under AI/RA/LDB configurations versus the VTM-5.0 anchor on class TGM1080p 444 sequences.

The additional results in the contribution indicate that the suggested change (hor/ver intra mode alignment with BDPCM direction) is giving minor gain or unchanged performance also in other classes of natural content.

Exactly the same approach is proposed in 200, 205, 296, 342, 463, 542, also with identical results at least for the TGM class.

Decision: Adopt JVET-O0315

[JVET-O0970](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7602) Crosscheck of JVET-O0315 (CE8-related: Intra prediction mode alignment for BDPCM) [M.-S. Chiang (MediaTek)]

[JVET-O0325](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6930) CE8-related: Simple BVD coding scheme without adding more context [Y. Sun, F. Chen, L. Wang (Hikvision)]

BoG

[JVET-O0709](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7329) Crosscheck of JVET-O0325 (CE8-related: Simple BVD coding scheme without adding more context) [J. Nam (LGE)]

[JVET-O0326](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6931) CE8-related: JVET-O0325 combined with CE8 BVD coding scheme [Y. Sun, F. Chen, L. Wang (Hikvision)]

BoG

[JVET-O0710](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7330) Crosscheck of JVET-O0326 (CE8-related: JVET-O0325 combined with CE8 BVD coding scheme) [J. Nam (LGE)]

[JVET-O0327](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6932) CE8-related: Default filling method for IBC mode [S. Ye, Y. Sun, F. Chen, L. Wang (Hikvision)]

BoG

[JVET-O0840](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7461) Crosscheck of JVET-O0327: CE8-related: Default filling method for IBC mode [J. Chen (Alibaba)]

[JVET-O0908](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7530) Crosscheck of JVET-O0327: CE8-related: Default filling method for IBC mode [W. Zhu (Bytedance)]

[JVET-O0331](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6936) Non-CE8: On IBC BVP Candidate List Derivation [H. Lee, S.-C. Lim, J. Lee, J. Kang, H. Y. Kim (ETRI)]

BoG

[JVET-O1105](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7742) Crosscheck report of JVET-O0331: Non-CE8: On IBC BVP Candidate List Derivation [X. Xu (Tencent)]

[JVET-O0342](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6947) Non-CE8: Unification of intra prediction mode of BDPCM block [J. Lee, J. Kang, H. Lee, S.-C. Lim, H. Y. Kim (ETRI)]

(include abstract)

See notes under JVET-O0315

[JVET-O0683](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7302) Crosscheck of JVET-O0342: Non-CE8: Unification of intra prediction mode of BDPCM block [X. Zhao (Tencent)]

[JVET-O0376](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6981) CE8-related: A SPS level flag for BDPCM and JCCR [L. Xu, X. Cao, F. Chen (Hikvision)]

(include abstract)

For BDPCM flag: See under JVET-O0165

The JCCR flag was further discussed in CE7 context

[JVET-O0772](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7393) Crosscheck of JVET-O0376 (CE8-related: A SPS level flag for BDPCM and JCCR) [Y.-W. Chen (Kwai Inc.)]

[JVET-O0442](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7047) [Non-CE8] IBC prediction improvement [A. Singh, A. Konda (Samsung)] [late]

Current IBC design in VVC considers only left CTU as a reference for prediction. There can be cases where other neighbours like top or top left CTUs may be better as compared to the left CTU. In this proposal we decide on to use left or top CTU as a reference based on hash based match. We use the same hash mechanism which was used in IBC. Average BD-BR gain of {-0.79%, -0.79%, -0.8%} and { -4.41%, -4.23%, -4.27%} is observed for Class F and Class SCC sequences respectively for AI case and {-0.52%, -0.65%, -0.42%} and {-1.91%, -1.84%, -1.90%} for RA case.

Powerpoint deck in upload is corrupt.

This would require additional external memory read to the dedicated buffer. It might further require an additional buffer for the CTU row above (or yet more memory accesses for deblocking), depending on whether an implementation is performing deblocking and loop filtering at the time of external memory write.

This additional complexity impact would not be justified by the gain.

[JVET-O1138](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7775) Crosscheck of JVET-O0442 (Non-CE8: IBC prediction improvement) [J. Heo, L. Li (LGE)]

[JVET-O0443](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7048) [Non-CE8] Flipping of reference blocks for Intra Block Copy (IBC) [A. Singh, A. Konda (Samsung)] [late]

In the VVC pipeline [1], Intra Block Copy (IBC) gives a considerable gain for Class F and Class SCC sequences. IBC, uses references from the current picture for prediction of a particular block. The current implementation of IBC uses matching of blocks in their original orientation, which sometimes may not result in optimum match. There are some patterns and shapes (especially in SCC/ Class F) which differ only in orientation. To efficiently match these shapes, this contribution proposes to use original reference blocks as well as three flipped versions of the blocks for matching, viz. flipping along vertical axis, along horizontal axis and along both the axes. Furthermore the contribution also proposes an efficient signalling of orientation. The Luma gains observed in class F and Class SCC sequences are -1.13% and -1.41% respectively for AI.

Interesting idea and also gain, but the encoder run time is too large (>40% increase). Also complexity / memory copy impact at decoder. Decoder runtime increases 2-3%.

Currently, not a good tradeoff complexity vs. benefit. Further study recommended.

[JVET-O1139](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7776) Crosscheck of JVET-O0443 (Non-CE8: Flipping of reference blocks for Intra Block Copy (IBC)) [J. Heo, L. Li (LGE)]

[JVET-O0455](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7061) Non-CE8: On IBC merge mode [Y.-J. Chang, Y. Zhang, C.-C. Chen, W.-J. Chien, M. Karczewicz (Qualcomm)]

BoG

[JVET-O1089](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7726) Crosscheck of JVET-O0455 (Non-CE8: On IBC merge mode) [A. Browne (Sony)]

[JVET-O0463](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7070) Non-CE8: Intra prediction mode of BDPCM [D. Kim, G. Ko, J. Son, J. Kwak (WILUS), J. Jung (Gaudio Lab)]

(include abstract)

See notes under JVET-O0315

[JVET-O0822](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7443) Crosscheck of JVET-O0463 (Non-CE8: Intra prediction mode of BDPCM) [S. Yoo, J. Lim (LGE)]

[JVET-O0480](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7087) Non-CE8: On signaling of IBC block vector predictor list size [X. Xu, X. Li, S. Liu (Tencent)]

BoG

[JVET-O0860](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7481) Crosscheck of JVET-O0480: Non-CE8: On signaling of IBC block vector predictor list size [X. Xiu (Kwai Inc.)]

[JVET-O0482](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7089) CE8-related: Modulo operations for IBC block vectors [X. Xu, X. Li, S. Liu (Tencent)]

In this contribution, a modulo operation is performed on the decoded IBC block vector, such that after the operation, the reference block indicated by the modified block vector falls into the potentially available reference area (e.g. in current CTU or left CTU), which are the allowed search range for IBC compensation.

It is reported that the proposed modification converts some of the bitstream conformance constraints for IBC into operations in the decoding process. It is asserted to be easier for the encoders to generate compliant bitstreams by using the proposed conversions.

Simulation results reportedly show that no RD performance or runtime impact were observed with the proposed modification.

From the discussion, it is noted that some additional checks are necessary at the picture boundary.

Only the range is tested at the decoder, and then the vector is truncated into the valid range.

Availability constraints would still be necessary in the bitstream, and availability checks at the encoder.

It is pointed out that the modulo value might also be variable depending on position.

It is requested to provide data about the maximum number of operations per 4x4 block.

[JVET-O0513](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7120) Non-CE4: Adaptive blending filtering for TPM [S. Esenlik, H. Gao, B. Wang, A. Kotra, Z. Zhao, E. Alshina (Huawei), M. Bläser, J. Sauer (RWTH Aachen)]

BoG

[JVET-O0921](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7545) Crosscheck of JVET-O0513: Non-CE4: Adaptive blending filtering for TPM [X. Xiu (Kwai Inc.)]

[JVET-O0542](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7150) Non-CE8: Modified intra mode associated with BPDCM [X. Zhao, X. Li, X. Xu, S. Liu (Tencent)]

(include abstract)

See notes under JVET-O0315

[JVET-O1032](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7669) Crosscheck of JVET-O0542 (Non-CE8: Modified intra mode associated with BDPCM) [J. Lee, S.-C. Lim, H. Lee, J. Kang (ETRI)]

[JVET-O0563](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7177) Non-CE8: disabling TPM blending [W. Zhu, L. Zhang, J. Xu, K. Zhang (Bytedance)]

BoG

[JVET-O0922](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7547) Crosscheck of JVET-O0563 (Non-CE8: disabling TPM blending) [S. Ye (Hikvision)]

[JVET-O0564](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7178) CE8-related: Signalling of chroma IBC prediction modes [W. Zhu, L. Zhang, J. Xu, K. Zhang (Bytedance)]

(include abstract)

Due to the decision of not using IBC for chroma in case of dual tree, no further review necessary.

[JVET-O0565](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7179) CE8-related: Default chroma IBC mode with vertical/ horizontal copying [W. Zhu, J. Xu, L. Zhang (Bytedance)]

It is proposed to apply vertical/horizontal copying when sub-block based chroma IBC is used and the corresponding block vector is invalid. In the proposed method, the vertical or horizontal samples are employed to fill up invalid sub-blocks in the chroma IBC mode. Simulation results reports that the proposed method can achieve -0.57%/-0.19%/-0.04% BD bitrate changes on TGM sequences under AI/RA/LDB configurations. For 4:4:4 sequences, the proposed method can achieve -1.13%/-0.39%/-0.01% BD bitrate changes under AI/RA/LDB configurations on class TGM 1080p.

For dual tree, not needed as per decision on not using the chroma IBC for dual tree.

For single tree, if no invalid luma vectors are allowed, this does not apply.

No need to be considered, unless bitstream constraints of not sending invalid vectors would be removed.

[JVET-O1072](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7709) Crosscheck report of JVET-O0565: CE8-related: Default chroma IBC mode with vertical/ horizontal copying [X. Xu (Tencent)]

[JVET-O0568](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7183) Non-CE8: An Alternative VPDU Memory Reuse for IBC [J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)]

This proposal presents an alternative way to reuse on-chip VPDU memory for IBC. When CTU size is 128x128, two most recently coded VPDUs in the even-number VPDU row and one most recently coded VPDU in the odd-number VPDU row are kept as reference for IBC. Compared with VTM-5.0, BD-rate changes for class F and 4:2:0 TGM are: AI: -0.78%/-1.82%; RA: -0.55%/-1.09%; LDB: -0.32%/-0.71% with almost the same running time.

The impact on implementation seems to be low. The occupancy of the dedicated buffer would need to switched between 64x64 VPDUs. It should be further clarified how complicated the addressing would be, and if this would be different in cases of 128x64 or 64x128 PUs. (note that perhaps 128x64 and 64x128 PUs are not realistc, as those could hardly find a full coverage in the dedicated buffer).

It is asked how this would be compatible with methods that simplify the availability check in particular JVET-O0127.

Further evidence had been asked to be brought on these aspects.

Interesting gain that comes almost for free.

[JVET-O1161](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7798) An implementation of JVET-O0568 based on the IBC buffer design of JVET-O0127 [J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance), J. Li, C.S. Lim (Panasonic)] [late]

JVET-O0127 presents an IBC reference buffer design that reduces the number of operations for block vector checking; and JVET-O0568 proposes an alternative VPDU memory reuse scheme that shows bitrate saving compared with the current design. This document presents an implementation of the alternative VPDU memory reuse scheme using the IBC reference buffer design in JVET-O0127. The implementation is compatible to JVET-O0568, so that it preservs the advantages of both JVET-O0127 and JVET-O0568. Compared with the VTM-5.0 design, the BD-rate changes for class F and 4:2:0 TGM are: AI: -0.78%/-1.82%; RA: -0.55%/-1.10% and the number of operations to check a block vector for a 4x4 block can be reduced from 44 to 22.

In addition, during the discussion of JVET-O0568, IBC with 64x128/128x64 block size was mentioned. This document also reports the performance change when 64x128/128x64 IBC blocks are disabled at both the encoder and decoder. The BD-rate numbers for classF and 4:2:0 TGM are: AI: 0.00%/0.00%; RA: 0.00%/0.00%.

Was presented Tuesday 9 July afternoon, Track B.

The new figures indicate that cycling over 8 buffer states is performed.

Performance is not significantly changed due to the somewhat different availability check.

It is further shown that 128x64 and 64x128 PU is imposing some difficulty in context with the 64x64 VPDU (which would also apply to current VTM -> agreed to disable.

The implementation method 2 (only in the slide deck of v1 upload) is the variant with bitstream constraint and without check at the decoder side, but its formulation appears more complicated than the current constraint – question is raised if the bitstream constraint could be formulated by a function?

The WD text attached to the contribution formulates the constraint as a function, and the conformance to that function as a bitstream constraint. Though simpler than the current constraint formulation, it may be difficult to understand and seems somewhat disconnected from the sequence of decoding of blocks.

Generally,

* It is agreed that it is better targeting a bitstream constraint without imposing a mandatory check at the decoder. If the latter was imposed, decoder conformance checking could become quite complicated.
* Further study is necessary to identify the best way of expressing the bitstream constraint – perhaps the current way of expressing by a formula is not necessary (and the current text also has redundancy here) – as long as it would be possible to declare that a) the BV shall only refer to previously decoded samples and b) to samples within the local dedicated buffer

A new document JVET-O1170 was being prepared that tries to simplify the text as an encoder constraint. See notes for that contribution.

[JVET-O0993](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7629) Crosscheck of JVET-O0568 (Non-CE8: An Alternative VPDU Memory Reuse for IBC) [J. Li (Panasonic)]

[JVET-O0574](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7189) Non-CE8: Fixes of IBC BV candidate list [L. Zhang, J. Xu, K. Zhang, H. Liu, W. Zhu (Bytedance)]

BoG

[JVET-O0597](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7212) CE3/8-related: On signaling of PDPC enabling/disabling flag in SPS [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

This contribution proposes to introduce one control flag in sequence parameter set (SPS) to adaptively enable/disable position dependent intra prediction combination (PDPC). When the flag is off, all the decoding process of the PDPC are bypassed. Experimental results show that sequence-level adaptive enabling/disabling of the PDPC provides 0.27% and 1.2% BD-rate savings for Class F and TGM test sequences for AI configuration.

The comparison is made against a configuration with IBC disabled. As IBC would typically be enabled for SCC classes, it is likely that conventional intra prediction would be less used, and the gain by disabling PDPC could be much less.

From the perspective of CE8, proponents are asked to bring evidence under CE8 testing conditions.

No action.

[JVET-O0929](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7554) Crosscheck of JVET-O0597 (CE3/8-related: On signaling of PDPC enabling/disabling flag in SPS) [Y.-H. Chao (Qualcomm)]

[JVET-O0600](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7215) CE8-related: Palette mode excluding small blocks [H.-J. Jhu, X. Xiu, Y.-W. Chen, T.-C. Ma, X. Wang (Kwai Inc.)]

It is observed that applying palette mode on small CUs introduces insignificant coding gain and brings extra complexity on the small blocks. This contribution proposes to disable palette mode for CU that are smaller or equal to 16 pixels. The proposed method reports negligible BD-rate changes compared to CE8-2.1 and reduces complexity.

Presentation deck to be uploaded.

Decoder complexity advantage is not obvious, as 1) the complexity of palette is linear with the number of samples and therefore not block size dependent, and 2) palette is less complex than residual coding. This is also somewhat reflected in the slightly increased decoder run time.

Encoder complexity could be reduced by not checking palette against residual coding for small blocks. However, a tendency of encoder runtime cannot be detected from the results.

The current test set likely is not fully representative, there might be screen content that has benefit from using palette in small blocks.

No action on the proposal.

[JVET-O0821](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7442) Crosscheck of JVET-O0600 (CE8-related: Palette mode excluding small blocks) [T.-S Chang (Alibaba)]

[JVET-O0602](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7217) Non-CE3/Non-CE8: Remove MIP/IBC mode storage from line buffer [H.-J. Jhu, Y.-W. Chen, X. Xiu, T.-C. Ma, X. Wang (Kwai Inc.)]

To be discussed in CE3 BoG.

[JVET-O0813](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7434) Crosscheck of JVET-O0602 (Non-CE3/Non-CE8: Remove MIP/IBC mode storage from line buffer) [[T.-H. Li](mailto:thli@fginnov.com), J.-Y. Deng (Foxconn)]

[JVET-O0614](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7229) CE8-related: Combination of a simplified IBC mode and the palette mode in CE8-2.5 [Y.-C. Sun, X. Zuo, T.-S. Chang, J. Lou (Alibaba)]

This document proposed to simplify IBC mode. In VTM-5.0, residual decoding module is applied to refine IBC prediction. This proposal proposed to simplify IBC by forcing IBC CU to be transform skip mode. In other word, the transform module can be removed from IBC decoding path. An IBC CU is forced to be transform skip mode if the transform skip mode is supported for the size of the CU. For other CUs without transform skip mode support, IBC mode is disallowed. For 4:2:0 test sequences, the proposed simplification shows:

1. 0.6%, 0.4%, and 0.3% BD-rate losses for luma in TGM sequences, with 96%, 97% and 98% in encoding time, and 102%, 101% and 105% in decoding time under AI, RA, and LD configurations, respectively.
2. 1.3%, 1.0%, and 0.5% BD-rate losses for luma in class F sequences, with 97%, 98% and 98% for encoding time, and 97%, 101% and 104% in decoding time under AI, RA, and LD configurations, respectively.

The combination of the proposed simplified IBC mode and the palette mode in CE8-2.5 is also tested. For 4:2:0 test sequences, the combination shows:

1. -4.7%, -1.6%, and -0.3% BD-rate gains for luma in TGM sequences, with 99%, 96% and 102% in encoding time, and 95%, 98% and 104% in decoding time under AI, RA, and LD configurations, respectively.
2. 0.4%, 0.2%, and 0.1% BD-rate losses for luma in class F sequences, with 102%, 102% and 103% for encoding time, and 103%, 101% and 103% in decoding time under AI, RA, and LD configurations, respectively.

The simplification of IBC is that TS is always used for residual coding in the combination with palette. The method shows losses. No action.

[JVET-O0769](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7390) Crosscheck of JVET-O0614 (CE8-related: Combination of a simplified IBC mode and the palette mode in CE8-2.5) [Y.-W. Chen (Kwai Inc.)]

[JVET-O0626](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7241) Non-CE8: Simplified IBC BV candidate list construction process [L. Zhang, K. Zhang, H. Liu, J. Xu, Z. Deng, N. Zhang (Bytedance)]

BoG

[JVET-O1080](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7717) Crosscheck report of JVET-O0626: Non-CE8: Simplified IBC BV candidate list construction process [Y. Wang, X. Zheng (DJI)]

[JVET-O0645](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7261) Non-CE4/8: Blending-off Switch for TPM Mode [C.-C. Chen, Y. Zhang, K. Reuze, Y.-J. Chang, W.-J. Chien, M. Karczewicz (Qualcomm)]

BoG

[JVET-O0912](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7534) Crosscheck of JVET-O0645: Non-CE4/8: Blending-off Switch for TPM Mode [W. Zhu (Bytedance)]

[JVET-O0646](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7262) Non-CE4/8: Combination of Blending-off Switch (JVET-O0645) and Simplified Motion Storage (JVET-O0411) for TPM Mode [C.-C. Chen, K. Reuze, Y. Zhang, W.-J. Chien, M. Karczewicz (Qualcomm)]

BoG

[JVET-O0763](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7384) Crosscheck of JVET-O0646 (Non-CE4/8: Combination of Blending-off Switch (JVET-O0645) and Simplified Motion Storage (JVET-O0411) for TPM Mode) [H. Yang (InterDigital)]

[JVET-O0651](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7267) Non-CE8: Intra prediction mode derivation for DM chroma block with corresponding IBC/PCM luma [L. Pham Van, G. Van der Auwera, A. K. Ramasubramonian, V. Seregin, M. Karczewicz (Qualcomm)]

To be discussed in CE3 BoG.

[JVET-O0694](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7314) Crosscheck of JVET-O0651 (Non-CE8: Intra prediction mode derivation for DM chroma block with corresponding IBC/PCM luma) [L. Zhao (Tencent)]

[JVET-O0682](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7301) CE8-related: An Intra-Affine mode for screen content coding [J. Cao, Z.-R. Li, J. Wang, F. Liang (SYSU), Y.-F. Yu, Y. Liu (OPPO)] [late]

In this contribution, a new intra-affine mode is proposed. In this new mode, affine model is introduced to intra prediction for SCC. The current partially encoded picture is considered as the only reference picture. The use of intra-affine mode is signaled by using the IBC mode flag [1] and the Affine flag. These two flags are both true when the proposed mode is used. The proposed intra-affine mode is implemented on VTM-5.0. The simulations show BD-rate gains for VTM-5.0 anchor (IBC mode enabled) are:

* In AI, -2.03% / -1.99% / -2.03% for Y, U, V component of SCC 1080p, separately.
* In AI, -0.19% / -0.24% / -0.18% for Y, U, V component of Class F, separately.
* In RA, -0.61% / -0.61% / -0.67% for Y, U, V component of SCC 1080p, separately.
* In RA, -0.17% / -0.15% / -0.23% for Y, U, V component of Class F, separately.

Questions to be answered (these are included in v4 upload, see below)

* Is the proposal using subpel interpolation?
* How are to CPMV derived and coded?
* What is the impact on memory access and computation compared to current IBC?
* How complicated is the availability check compared to the current scheme?

1. **Is the proposal using subpel interpolation?**

Subpel interpolation is not used in the proposed intra-affine mode. A 4x4 subblock MV is adjusted to an integral multiple of 16 to indicate a location of a reference subblock.

1. **How are to CPMV derived and coded?**

Decoding:

4-parameter affine model is used in intra-affine mode. MVD of the two control points is signalled in CU (i.e. in MODE\_IBC branch after a flag indicating intra-affine mode). MVPcand for intra-affine is established in a similar way to that for inter affine mode. MVP of the two control points are obtained using MVP\_index. CPMV is calculated using MVP and MVD.

Encoding:

The process has two main steps: 1) selecting initial BVAffis (block-affine vectors, consist of BV of two control points) and 2) iterative searching for the best BVAffi.

* 1) Initial BVAffis can be obtained by inheritance and local search. Inheritance means that initial BVAffis can be obtained by reusing the motion information of encoded spatial neighboring blocks (BV in IBC mode and BVAffi in proposed mode).
* The local search way means that initial BVAffis are obtained by searching in the encoded area. The way of searching is similar to the traditional inter prediction. Searching area is limited to the current CTU and searching step length is set to 8 pixels.

2) The way of iterative searching is similar to the affine motion inter prediction. The major differences are that the reference picture is the current picture itself and boundary checking (for reconstructed region in the current picture) is applied in the proposed mode.

1. **What is the impact on memory access and computation compared to current IBC?**

We did not considered much on hardware implementation at the moment. We would like to present some preliminary analyses as follows:

1) Memory size:

For the proposed intra-affine mode, there are 2 BVAffi search methods, i.e., inheritance and local search.

For BV local search, the search area is restricted within the current CTU, and thus the reference memory size is not larger than that of the current IBC implementation in VTM.

For BV inheritance search, there is not special search restriction applied in the current intra-affine implementation. The size of search area depends on its neighbor's BVAffi or BV. Thus, the reference memory size is not fully determined compared to IBC, and further study on this issue is recommended.

2) Memory access:

BV checking is performed for all 4x4 subblocks in the current implementation. Therefore, it takes more memory access operations than that of IBC. However, this could be further optimized during further study. For example, early termination of BV searching would help to save memory access operations.

3) Computation:

As shown in experimental results, the fluctuation of running time is 1% or 2% in AI decoding and RA compared with VTM anchor except AI encoding. Although the running time is rough indication of computation burden, a conclusion is that computation burden of intra-affine would be acceptable. The reasons would include 1) BV searching step for IBC is 1 pixel while for intra-affine is 8 pixels, and 2) intra-affine does not have subpel interpolation.

1. **How complicated is the availability check compared to the current scheme?**

An additional check is performed to determine whether a reference subblock indicated by a 4x4 subblock MV (adjusted to integer pel precision) is in a reconstructed area of the current picture or not. If not, MV of control point is invalid. The 4x4 subblock MV is derived based on MV of two control points and the location of the subblock, which is the same as the process for inter affine mode.

In JVET-O0628 implementation of intra-affine mode, the above mentioned checking is used in both encoding and decoding processes. However, further study is recommended as such checking operation could be eliminated in decoding process considering that encoding process could be made always guarantee the finally selected subblock BV is valid.

Generally, the approach appears to be similar to inter affine, where 4x4 subblocks are shifted using an integer vector that is determined from the CPMV (only 4-parameter model is used)

Another follow-up question is asked what would be the minimum block size for the IBC affine mode?

The pixel processing in IBC is unchanged. It requires additional logic for implementing the affine mode decoding, local storage of CPMV, and line buffer for the CPMV. Further, the availability check at the encoder could be more complicated, in particular it is necessary to check for all subblocks if they are pointing to an available decoded area.

Not coming for free in terms of complexity, and the gain in TGM is not large, even less in class F.

No action.

[JVET-O0996](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7632) Crosscheck of JVET-O0682 (CE8-related: An Intra-Affine mode for screen content coding) [?? (??)]

[JVET-O1081](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7718) Crosscheck report of JVET-O0682: CE8-related: An Intra-Affine mode for screen content coding [Y. Wang, X. Zheng (DJI)]

[JVET-O0706](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7326) CE8-related: 4x4 sub-block based dual-tree chroma IBC block-vector derivation [H. Yang, Y. He (InterDigital)] [late]

(include abstract)

No need to discuss, as IBC is not used for chroma in dual-tree any more.

[JVET-O0740](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7361) Crosscheck of JVET-O0706 (CE8-related: 4x4 sub-block based dual-tree chroma IBC block-vector derivation) [J. Xu (Bytedance)]

[JVET-O0914](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7536) CE8-related: Improved color generation method for palette mode [C.-H. Hung, Y.-H. Chao, V. Seregin, M. Karczewicz (Qualcomm)] [late]

This document proposes an improved color generation method based on CE test 8-2.1 [1] on palette mode tested on top of VTM-5.0. The results show that:

For 4:2:0 test sequences,

1. the proposed method provides 4.41%, 2.12%, and 0.71% BD-rate gains for luma in TGM sequences, with 102%, 104% and 107 % in encoding time, and 102%, 102% and 104% in decoding time under AI, RA, and LD configurations, respectively.
2. the proposed method provides 0.74%, 0.75%, and x.xx % BD-rate gains for luma in class F sequences, with 108%, 117% and xxx % in encoding time, and 107%, 108% and xxx % in decoding time under AI, RA, and LD configurations, respectively.

For 4:4:4 test sequences,

1. when DualITree turned off, the proposed method achieves 16.34%, 10.76%, and 6.34% BD-rate gain in TGM 1080p sequences, and 5.79%, 4.21%, and x.xx % BD-rate gains overall for luma, with 103%, 103% and xxx % in encoding time, and 99%, 99% and xxx % in decoding time under AI, RA, and LD configurations, respectively.
2. when DualITree turned on, the proposed method achieves 7.17%, 6.12%, and 5.31% BD-rate gain in TGM 1080p sequences, and 2.55%, 2.31%, and x.xx % BD-rate gains overall for luma with 111%, 104% and xxx % in encoding time, and 104%, 100% and xxx % in decoding time under AI, RA, and LD configurations, respectively.

An adaptive selection algorithm is also proposed. If the check condition is satisfied, the proposed generation method is used. Otherwise the original color generation method in CE test 8-2.1 is used. The results with the adaptive selection algorithm show that:

For 4:2:0 test sequences,

1. the proposed method provides 4.50%, 2.14%, and 0.57% BD-rate gains for luma in TGM sequences, with 104%, 106% and 107% in encoding time, and 103%, 103% and 103% in decoding time under AI, RA, and LD configurations, respectively.
2. the proposed method provides 0.73%, 0.69%, and x.xx % BD-rate gains for luma in class F sequences, with 109%, 115% and xxx % in encoding time, and 108%, 110% and xxx % in decoding time under AI, RA, and LD configurations, respectively.

For 4:4:4 test sequences,

1. when DualITree turned off, the proposed method achieves 16.45%, 10.77%, and 6.29% BD-rate gain in TGM 1080p sequences, and 5.80%, 4.22%, and x.xx % BD-rate gains overall for luma, with 103%, 102% and xxx % in encoding time, and 100%, 99% and xxx % in decoding time under AI, RA, and LD configurations, respectively.
2. when DualITree turned on, the proposed method achieves 7.14%, 5.93%, and 5.08% BD-rate gain in TGM 1080p sequences, and 2.48%, 2.07%, and x.xx % BD-rate gains overall for luma with 109%, 104% and xxx % in encoding time, and 103%, 100% and xxx % in decoding time under AI, RA, and LD configurations, respectively.

Presentation deck to be uploaded.

Benefit over current method of palette construction is about 0.2% for TGM in RA for 4:2:0, and 0.1% for 4:4:4.

The method uses a k-means method (1 iteration) at the encoder to generate the palette.

The gain is not substantial enough to take action for reference SW.

[JVET-O1170](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7807) Bitstream conformance with a virtual IBC buffer concept [J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance), J. Li, C.S. Lim (Panasonic), X. Xu, X. Li, S. Liu (Tencent)] [late]

Presented Wed 10 July afternoon Track B

During discussion of IBC conformance, it is agreed that it is better targeting a bitstream constraint without imposing a mandatory check at the decoder and a simple solution is preferred to define the IBC bitstream constrains. This document presents a simple design of bitstream constrains based on a virtual IBC buffer concept.

It is generally agreed that the concept goes into the right direction and largely simplifies the definition of the bitstream constraint. The current version still requires improvements, e.g.

* definition of variables
* it is inconsistent that the changing of the state of ibcbuf is part of the decoding process in clause 8.7.5.1, whereas it is not mandatory for a decoder. This should be clarified and better referred to the bitstream restriction in clause 8.6.2.1 (perhaps just adding notes)

It is noted that JVET-O1171 is identical.

Decision: Adopt JVET-O1170 – remaining issues to be sorted out with editor.

It is further noted that the improved text should also include one more restrictions on IBC that was agreed in context with JVET-O1161 discussion: Limit largest IBC luma CU size to 64x64.

Furthermore, the text already includes disabling IBC for chroma in case of dual tree (as adopted from JVET-O0258).

[JVET-O1171](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7808) Bitstream conformance with a virtual IBC buffer concept [H. Gao, S. Esenlik, E. Alshina, A.Karabutov, S. Ikonin, B. Wang, A. M. Kotra (Huawei)] [late]

[JVET-O1172](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7809) Non-CE4/8: On disabling blending process in TPM [C.-C. Chen, K. Reuze, W.-J. Chien, M. Karczewicz (Qualcomm), W. Zhu, L. Zhang, J. Xu, K. Zhang (Bytedance), M. Bläser, J. Sauer (RWTH Aachen University)] [late]

Chaired by Y. Ye July 11 1000

The contribution proposes solutions to disable the blending process in the Triangle Prediction Merge (TPM) mode. In common, these solutions introduce a sps- and a slice-level flag to indicate the whether the blending process of TPM is disabled or not. According to flag values, if the blending process is not indicated to be disabled, the blending process as for the current TPM is not changed; otherwise, this blending process is disabled. On top of the introduced flags, this proposal suggests two methods to fill the prediction samples for each triangle partition based on the respective motion-compensated blocks of the two TPM motion vectors. In suggested method 1 (JVET-O0645), the weighting values in the blending area are all clipped to be either 0/8 or 8/8, depending on whether they are closer to 0/8 or 8/8. In suggested method 2 (JVET-O0563), the samples located on the diagonal or anti-diagonal line will be determined by using the motion-compensated samples of the shorter MV. In suggested method 3 (JVET-O0513) the weighting values in the blending area are all clipped to be either 0/8 or 8/8, and so that both partition contain the same number of samples.

For each of these methods, two methods for motion vector storage are tested. In suggested method 1, when both motion vector used for triangle are identical, the motion vector from the bottom partition (Mv2) is stored. This is the method that was adopted during the Göteborg meeting. In suggested method 2, motion storage for TPM is modified so that the shorter Mv is stored, following the motion vector storage proposed in JVET-O0563.

Simulation results report that when compared with VTM-5.0 anchor,

Method A1 (adopted storage + JVET-O0645 blending off)

Class TGM1080p420: -0.51% (RA) / -0.78% (LDB)

Class TGM1080p444: -0.53% (RA) / -1.01% (LDB).

Method A2 (adopted storage + JVET-O0563 blending off)

Class TGM1080p420: -0.56% (RA) / -0.82% (LDB)

Class TGM1080p444: -0.73% (RA) / -1.09% (LDB).

Method A3 (adopted storage + JVET-O0513 blending off)

Class TGM1080p420: -0.61% (RA) / -0.71% (LDB)

Class TGM1080p444: -0.68% (RA) / -1.09% (LDB).

Method B1 (JVET-O0563 storage + JVET-O0645 blending off)

Class TGM1080p420: -0.72% (RA) / -0.71% (LDB)

Class TGM1080p444: -0.80% (RA) / -0.98% (LDB).

Method B2 (JVET-O0563 storage + JVET-O0563 blending off)

Class TGM1080p420: -0.83% (RA) / -0.84% (LDB)

Class TGM1080p444: -0.85% (RA) / -1.11% (LDB).

Method B3 (JVET-O0563 storage + JVET-O0513 blending off)

Class TGM1080p420: -0.81% (RA) / -0.85% (LDB)

Class TGM1080p444: -0.94% (RA) / -1.05% (LDB).

Three contributions O0645, O0563, O0513 had a common aspect of SPS flag and slice level flag, but the blending off processes were different. In earlier discussion, it was suggested to test the three different blending off methods using the same encoder.

It was suggested by the proponents to turn this mode off for camera content.

It was commented that the gain on 420 screen content is small, and that in general we have not adopted tools that have only small gains for screen content.

The proponents said that the main motivation of turning off the blending is to preserve the edges in screen content, which generally are sharper. And a side effect of this is that there is some objective coding gain in the low delay case for 420 screen content.

It was commented that some subjective quality improvement has been observed in still images, but no visual tests in the video mode had been performed.

It was commented that the BD rate performance does not justify the change, but visual quality improvement in the video mode might.

It was suggested to take just one method of blending off, and perform a CE test with visual testing. Method 1 and method 3 only change the weights, method 2 also needs to check motion vectors. Between methods 1 and 3, method 3 is reported to keep the number of samples equal between the two partitions, and has slightly better RD performance.

It was suggested by a non proponent of method 2 that it could provide additinoal visual benefits, but another non proponent pointed out that the current method 2 does not cover a corner case.

Method 3 has the same complexity as method 1, and was recommended by several experts to be the one tested in the CE.

Test the blending off process in method 3 in screen content CE with visual testing at next meeting.

Proposed changes to motion vector storage will not be tested in CE.

## CE9 related – Decoder motion vector derivation (26)

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

[JVET-O0207](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6812) Non-CE9: A bug fix of BDOF specification [T. Chujoh, E. Sasaki, T. Ikai (Sharp)]

[JVET-O0208](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6813) Non-CE9: An improvement of early termination for BDOF [T. Chujoh, E. Sasaki, T. Ikai (Sharp)]

[JVET-O0987](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7623) Crosscheck of JVET-O0208: Non-CE9: An improvement of early termination for BDOF [K. Kondo, M. Ikeda (Sony)]

[JVET-O0210](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6815) Non-CE9: BDOF for chroma components [T. Chujoh, E. Sasaki, T. Ikai (Sharp)]

[JVET-O0679](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7298) Crosscheck of JVET-O0210 on BDOF for chroma components [[S. Iwamura (NHK)](mailto:iwamura.s-gc@nhk.or.jp)]

[JVET-O0702](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7322) Crosscheck of JVET-O0210 (Non-CE9: BDOF for chroma components) [N. Park (LGE)]

[JVET-O0211](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6816) Non-CE9: A speed up method of BDOF [T. Chujoh, T. Ikai (Sharp)]

[JVET-O0982](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7618) Crosscheck of JVET-O0211 (Non-CE9: A speed up method of BDOF) [K. Unno (KDDI)]

[JVET-O0250](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6855) DMVR and BDOF on/off control [H. Huang, W.-J. Chien, V. Seregin, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-O0684](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7303) Crosscheck of JVET-O0250 (DMVR and BDOF on/off control) [T. Chujoh (Sharp)]

[JVET-O0297](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6902) CE9-related: Simplification for DMVR padding process [Y.-C. Lin, C.-C. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0902](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7524) Crosscheck of JVET-O0297 (CE9-related: Simplification for DMVR padding process) [H. Huang (Qualcomm)]

[JVET-O0304](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6909) Non-CE9: Simplification of BDOF [Y. Kato, T. Toma, K. Abe (Panasonic)]

[JVET-O0861](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7482) Crosscheck of JVET-O0304 (Non-CE9: Simplification of BDOF) [S. Sethuraman (Ittiam)]

[JVET-O0307](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6912) Non-CE9/3: Unification of division processing [K. Abe, Y. Kato, T. Toma (Panasonic)]

[JVET-O0981](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7617) Crosscheck of JVET-O0307 (Non-CE9/3: Unification of division processing) [K. Unno, K. Kawamura (KDDI)]

[JVET-O0385](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6990) Non-CE9: An applying condition considering temporal correlation for DMVR [K. Unno, K. Kawamura, S. Naito (KDDI)]

[JVET-O0659](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7276) Crosscheck of JVET-O0385 on DMVR applying condition [S. Iwamura (NHK)]

[JVET-O0503](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7110) Non-CE9: Modifications to MMVD for CUs eligible for DMVR [S. Sethuraman (Ittiam)]

[JVET-O0810](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7431) Crosscheck of JVET-O0503 (Non-CE9: Modifications to MMVD for CUs eligible for DMVR test3) [E. Sasaki (Sharp)]

[JVET-O0504](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7111) Non-CE9: Header flags to disable DMVR and BDOF at finer granularities [S. Sethuraman (Ittiam)]

[JVET-O0505](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7112) Non-CE9: Simplifying BDOF early termination related cost calculations [S. Sethuraman (Ittiam)]

[JVET-O0984](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7620) Crosscheck of JVET-O0505 (Non-CE9: Simplifying BDOF early termination related cost calculations) [K. Unno (KDDI)]

[JVET-O0506](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7113) Non-CE9: An improvement to extended predicted sample value derivation in BDOF [S. Sethuraman (Ittiam)]

[JVET-O0871](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7492) Crosscheck of JVET-O0506 (Non-CE9: An improvement to extended predicted sample value derivation in BDOF) [C.-C. Chen, W.-J. Chien (Qualcomm)]

[JVET-O0508](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7115) Non-CE9: Refinement of optical flow estimates in BDOF [S. Sethuraman (Ittiam)]

[JVET-O0782](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7403) Crosscheck of JVET-O0508: Non-CE9: Refinement of optical flow estimates in BDOF [X. Xiu (Kwai Inc.)]

[JVET-O0570](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7185) Non-CE9: Unified gradient calculations in BDOF [H. Liu, L. Zhang, K. Zhang, Z. Deng, N. Zhang (Bytedance)]

[JVET-O0731](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7352) Crosscheck of JVET-O0570: Non-CE9: Unified gradient calculations in BDOF [[Y. He (InterDigital)](mailto:yuwen.he@interdigital.com)]

[JVET-O1131](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7768) Crosscheck of JVET-O0570 (Non-CE9: Unified gradient calculations in BDOF, additional test for gradient calculation in PROF) [T. Chujoh (Sharp)]

[JVET-O0573](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7188) Non-CE9: Restriction on motion vector refinement in BDOF [H. Liu, L. Zhang, K. Zhang, H.-C. Chuang, J. Xu (Bytedance)]

[JVET-O0819](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7440) Crosscheck of JVET-O0573 (Non-CE9: Restriction on motion vector refinement in BDOF) [T. Ikai (Sharp)]

[JVET-O0577](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7192) Non-CE9: Bi-directional optical flow (BDOF) for chroma components [W. Chen, Y. He (InterDigital)]

[JVET-O0857](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7478) Crosscheck of JVET-O0577 (Non-CE9: Bi-directional optical flow (BDOF) for chroma components) [H. Liu (Bytedance)]

[JVET-O0581](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7196) Non-CE9: Block Boundary Prediction Refinement with Optical Flow for DMVR [W. Chen, Y. He (InterDigital)]

[JVET-O0729](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7350) Crosscheck of JVET-O0581: Non-CE9: Block Boundary Prediction Refinement with Optical Flow for DMVR [[X. Xiu (Kwai Inc.)](mailto:xiaoyuxiu@kwai.com)]

[JVET-O0590](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7205) Non-CE9: Improvement of DMVR [Y.-W. Chen, X. Xiu, X. Wang (Kwai Inc.)]

[JVET-O0799](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7420) Crosscheck of JVET-O0590 on Non-CE9: Improvement of DMVR [X. Li (Tencent)]

[JVET-O0609](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7224) CE9-related: On BDOF precision alignment for high internal bit-depth [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-O0612](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7227) CE9-related: Complexity reduction for BDOF parameters calculation [K. Panusopone (Nokia)]

[JVET-O0615](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7230) Non-CE9: Derivation of extended prediction samples for BDOF gradient calculation [Y. He, W. Chen (InterDigital)]

[JVET-O0994](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7630) Crosscheck of JVET-O0615 (Non-CE9: Derivation of extended prediction samples for BDOF gradient calculation) [J. Li (Panasonic)]

[JVET-O0628](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7243) Non-CE9: SATD based DMVR [J. Chen, R.-L. Liao, Y. Ye, J. Luo (Alibaba)]

[JVET-O0703](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7323) Crosscheck of JVET-O0628: Non-CE9: SATD based DMVR [X. Xiu (Kwai Inc.)]

[JVET-O0634](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7249) Non-CE9: BDOF simplifications [X. Chen, H. Yang (Huawei)]

[JVET-O0940](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7566) Crosscheck of JVET-O0634: Non-CE9: BDOF simplifications [X. Xiu (Kwai Inc.)]

[JVET-O0975](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7608) Crosscheck of JVET-O0634 (Non-CE9: BDOF simplifications) [T. Zhou (Sharp)]

[JVET-O1060](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7697) Cross-check of JVET-O0364 (On general intra sample prediction) [A. K. Ramasubramonian (Qualcomm)]

[JVET-O0644](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7260) Non-CE9: Evaluation of Threshold Value Applied to SAD-based Early Termination in DMVR [C.-C. Chen, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-O0866](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7487) Crosscheck of JVET-O0644 (Non-CE9: Evaluation of Threshold Value Applied to SAD-based Early Termination in DMVR) [S. Sethuraman (Ittiam)]

[JVET-O1082](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7719) Crosscheck report of JVET-O0644: Non-CE9: Evaluation of Threshold Value Applied to SAD-based Early Termination in DMVR (TH=12 and TH=16 cases) [Y. Wang, X. Zheng (DJI)]

[JVET-O0681](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7300) CE9-related: Disabled DMVR, BDOF and BCW for CIIP [H. Huang, W.-J. Chien, M. Karczewicz (Qualcomm)] [late]

[JVET-O0952](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7582) Crosscheck of JVET-O0681 (CE9-related: Disabled DMVR, BDOF and BCW for CIIP) [Y.-W. Chen (Kwai Inc.)]

[JVET-O1140](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7777) Unified syntax for JVET-O0184/O0250/O0504 on DMVR and BDOF flag [Y. He, A. Hamza (InterDigital), H. Huang, W.J. Chien, V. Seregin, M. Coban, M. Karczewicz (Qualcomm), S. Sethuraman (Ittiam)] [late]

Text was reviewed Thu July 11 morning in Track B, seems OK.

Any further improvement left to editor.

Decision: Adopt JVET-O1140

(Decisions on the 3 contributions to remove from meting notes, are subsumed here)

[JVET-O1142](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7779) CE4/9-related: Combined Test of JVET-O0593/JVET-O0252/JVET-O0281/JVET-O0615 on harmonization on BDOF and PROF [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)] [late]

Was already presented, will be studied in CE (see under BoG JVET-O1133)

## CE10 related – Neural network based loop filtering (2)

Contributions in this category were discussed Thursday 4 July 2020–XXXX in Track B (chaired by JRO).

[JVET-O0157](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6761) Non-CE10: A CNN based in-loop filter for intra frame [L. Xu, J. Zhu, K. Kazui (Fujitsu)]

A sub-sampled Convolution Neural Network filter is proposed to replace the de-blocking filter (DBF) in VVC. This CNN based in-loop filter is trying to reduce neural network complexity while keeping coding efficiency. It is a light weight CNN and with an effective way to control the CNN filtering strength for processing in different quantization condition. It is only for intra frames. On top of VTM-5.0, simulation results reportedly show 1.44%/2.51%/3.39% BD-rate saving for Y, Cb and Cr components respectively in AI configuration. The decoding time is 1040%. Subjective quality improvement can also be observed.

Presentation deck to be uploaded.

It is commented that the division by QSTEP is not exactly approximating the coding errors that VVC produces, since quantization is performed in the residual transform domain. Might be better to condsider the characteristics of transform basis functions and block structure additionally.

From the example given, the method seems to have some smoothing but also some sharpening effects, depending on local content.

ALF and SAO are still operated.

Only intra is tested – would it work for inter coded pictures?

In terms of performance, it is better than the simplest AI solution from CE10 (CE10-2.8c). Complexity-wise, it shows approx. 10x higher run time, but this was measured on CPU, whereas the CE proposal used GPU, so the complexity may be in a comparable range. Performance-wise, it is worse (but significantly less complex) than other such as CE10-2.2a.

Further study recommended along with other NN technology.

## CE11 related – Gradual random access (2)

[JVET-O0976](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7611) CE11-related: Wavefront-based GRA and Related Syntax [L. Wang, M. M. Hannuksela (Nokia)] [late]

This contribution was discussed Thursday 4 July 1800 (chaired by GJS).

This contribution contains the following proposed items:

* It is proposed to indicate a virtual boundary type in PPS. Type 0 would be the same as currently in VVC Draft 5, and types 1 to 3 would be specified for vertical, horizontal, and wavefront-based (i.e., diagonal) virtual boundaries specified with syntax elements in the slice header. Types 1 to 3 are asserted to avoid the need for updating PPSs for turning off loop filtering.
* The contribution proposes a special syntax for a wavefront-based GRA (Gradual Random Access) and proposes related syntax to turn off loop filtering across a wavefront boundary. A GRA picture, in general, consists of three areas; clean, intra coded and dirty. With the wavefront-based GRA, all the reference pixels for the blocks in intra coded area are in clean and/or intra coded area. Hence, no restriction would be imposed on intra prediction for the blocks in the intra coded area.

It was noted that some form of diagonal refresh would be possible without special syntax support. Note that JVET-O0979 considers this.

It is proposed that the block granularity of the diagonal boundary could be smaller than a CTU.

Reviewing the proposed syntax, it seemed clear that some aspects had not been fully thought out yet.

See also the notes for JVET-O0979.

[JVET-O0979](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7614) CE11-related: Wavefront-based GRA Method [L. Wang (Nokia)] [late]

This contribution was discussed Thursday 4 July 1820 (chaired by GJS).

This contribution describes a gradual random access (GRA) method using a GRA block size which could be smaller than a CTU. This could be done without any special support in the syntax or decoding process to some degree, but the contribution proposes having a special treatment for in-loop filtering.

It was commented that this could avoid the need for CIP because “dirty” above-right data is never used. However, if CIP is not used (and nothing else special is done about intra prediction), the refresh could only start when the encoder starts over at the upper-left corner; it cannot jump in at any arbitrary picture.

Syntax was proposed but full spec text and software were not.

Further study of this and JVET-O0976 was encouraged.

[JVET-O1048](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7685) Non-CE11: Non-CIP normative Gradual Random Access [D. Gommelet, J.-M. Thiesse, D. Nicholson (VITEC)] [late]

Discussed Thursday 2100 (GJS & JRO)

This contribution proposes something related to CE 11 Test 2.2 to support Gradual Random Access. Instead of using a full CIP-like constraint on all intra CUs of the refreshed region, this contribution only take care of not using reference samples from the non-refresh area. There is reported to be no impact on bitrates fluctuations which are keeping smooth as in CE 11 Test 2.2. The resulting BD rate impact over CE11 test 2.2 is reported of -3.41% in class E, -1.05% in class C and -1.22% in class D.

The contribution also proposes a less-intrusive option leveraging the same principle: virtual boundaries brought at slice level are proposed to be used for disabling intra prediction across the virtual boundary. This option is intended to be less complex to support than CIP since the resulting impact on intra reference pixels filling is kept similar as for picture boundaries.

Proposes having a virtual boundary syntax at the slice level with intra prediction disabling.

This is targeted for AU-based delay minimization.

As a proposed example, the picture would contain only one slice.

It was commented that DU-based operation can provide more delay reduction than AU-based GDR (see prior JVET-N0114). It would use multiple slices per picture.

Is the target application for ultra-low delay? Not necessarily. The proponent said that an example implemation is game streaming (e.g., per the Amazon Twitch service). The proposed operation would be for both random access and low delay.

There are three aspects: 1) disabling in-loop filters, 2) disabling intra prediction, 3) disabling MC references, 4) not using temporal MVP in “dirty” reference picture areas. We only currently do aspect 1 for picture level or at slice/tile/brick boundaries. We currently do aspect 2 only at slice/tile/brick boundaries. We currently support aspect 3 as encoder-only or newly-adopted subpicture boundary.

This proposal uses encoder-only for aspects 3 and 4.

As proposed, there could be a restriction that the virtual boundary position would not be able to change within a picture. This is just a way to not need to send a new PPS. This should not present a problem from a decoder perspective since the PPS can change on every picture anyway.

It was commented that the boundary syntax could be in the AUD.

For aspect 2, the enhanced functionality of the proposal is to be able to do this on a granularity of 8 lines/columns rather that CTU rows/columns. It was commented that this could also be somewhat helpful for cubemap video, but is not so important for that.

This was reported to have 5% BD rate loss relative to no GDR with and intra refresh period that is the same as the GDR picture (1 second). This can compare to a roughly 20% loss for an encoder-only method (without aspect #1).

It was commented that this should be cross-checked.

It was commented that the same functionality is provided by having two tiles in a picture; the differences being the granularity and the cutting off of MV prediction and CABAC adaptation at the tile boundary. CE11-3.2 was similar to this.

It was commented that it would also not be a big problem to move some slice/tile structure partitioning from the PPS to a lower level like AUD or SH.

It seemed that:

* It would not be especially difficult to implement the proposed intra prediction disabling.
* But we don’t really know how important it would be to have that. One participant estimated that benefit to be 2-3%. Some thought it would be less.
* Plan a CE to test this benefit. Test two-slice/tile approach (assuming an efficient picture-level tile syntax) versus the 8-granularity intra prediction disabling. Also test combinations with treating slice/tile boundary as picture boundary for MC. Tests will assume that loop filter disabling virtual boundary support is usable (in both anchor and test configs).

## Quantization parameter signalling (8)

[JVET-O0046](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6650) AHG16: Changing cu\_qp\_delta signalling to facilitate VDPU-level processing [B. Heng, M. Zhou, T. Hellman (Broadcom)]

This contribution was discussed 4 July 1900 (GJS).

This contribution claims that the existing syntax definition for cu\_qp\_delta, in which QP delta transmission is delayed until the first transform unit with coded coefficients, inhibits VDPU-level decode processing (64x64 decoder pipeline). It notes that a QP value is necessary for filtering operations, and therefore, for CU sizes larger than 64x64, earlier VDPUs cannot be filtered until cu\_qp\_delta is received. It claims that this is the only syntax element in the entire standard that introduces such a delay.

The contribution recommends changing the delta QP syntax as follows:

* For any CU larger than 64x64, send the cu\_qp\_delta syntax with the first transform unit, regardless of whether that first TU has any non-zero CBF or not.

In this way, QP can be determined when a VDPU is parsed, rather than depending on delta QP information carried in future VDPUs. The experimental results revealed that the proposed delta QP signalling method is equally efficient when compared to the current method implemented in VTM5.0.

It was noted that this would send delta QP in a rare case when it otherwise would not be sent: in a very large intra CU when all CBFs are zero. This has no effect on CTC, since CTC does not use delta QP. An experiment found no practical effect from this.

See also JVET-O0643.

It was commented that this approach seems simpler, at least from a spec text impact perspective, than the one proposed in JVET-O0643.

Decision (bug fix): Adopt JVET-O0046.

[JVET-O0838](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7459) Crosscheck of JVET-O0046: AHG16: Changing cu\_qp\_delta signalling to facilitate VDPU-level processing [L. Zhang (Bytedance)]

[JVET-O0643](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7259) Modification on Delta QP for Deblocking [Y. Han, G. Van Der Auwera, M. Coban, M. Karczewicz (Qualcomm)]

This contribution was discussed 4 July at 1910 (GJS).

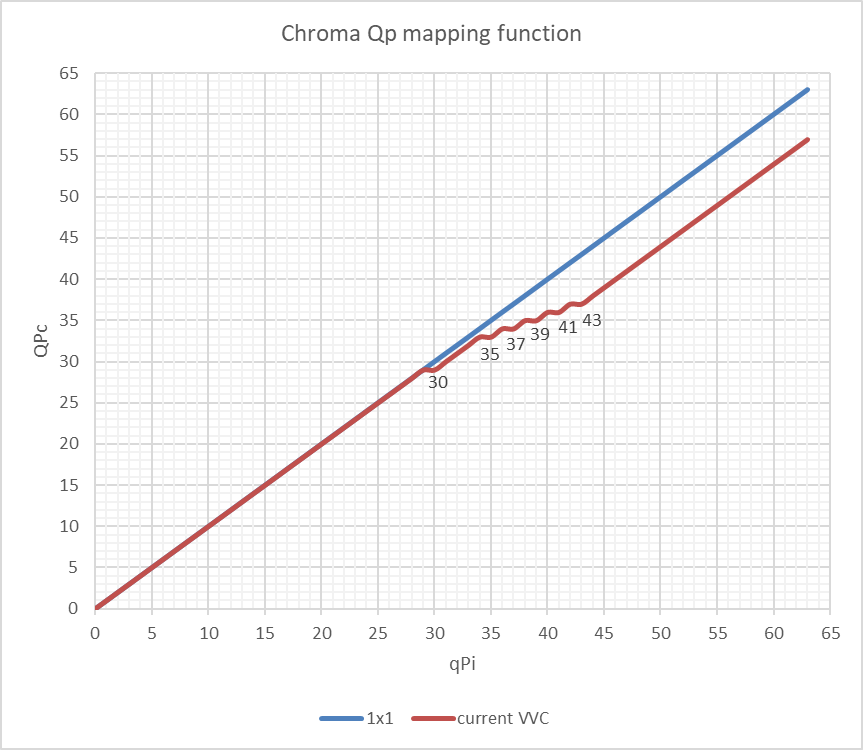
This is similar in concept to JVET-O0046, but has a different proposed approach, which is to not change the signalling, but apply the delta QP only to the VDPUs that follow the first one that has nonzero transform coefficients – i.e., there would be different QP values for different areas within a large CU. Complete spec text was not provided. See the notes for JVET-O0046.

[JVET-O0186](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6790) AHG15: Signalling of chroma Qp mapping table [S. Ikonin, R. Chernyak, E. Alshina (Huawei)]

This contribution was discussed 4 July at 1925 (chaired by GJS).

O0186 O0298, O0433, O0562, and O0650 are all related.

This contribution proposes a signalling mechanism for a chroma Qp mapping table. It is also reported that usage of an adjusted mapping table can provide additional benefits in terms of coding performance and coding gain balancing across luma and chroma components. Informal subjective evaluation results are also reported demonstrating no noticeable difference for moving pictures and slight improvement for static pictures. No color issues or artefacts are reportedly detected.



The proponent indicated that the coding of the deltas was proposed to be ue(v).

Experiment results were shown with a different table, with gain shown relative to the anchor. However, it was commented that subjective effects may be different, and one participant remarked that some sample images in the contribution seemed to have lower visual quality.

It was commented that aside from the fact that the default relationship was never optimized to begin with, the desired default relationship might be different for different colour spaces (e.g. PQ).

The current CTC has an offset intended shift some bits from chroma to luma, but at very low QPs it can result in chroma problems. Adjusting the table rather than the offset could prevent.

The syntax proposed here requires the slope of the table to always be less than or equal to 1.

This proposal does not have separate tables for different chroma components (although it’s not difficult to adapt it to do that).

[JVET-O0298](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6903) AHG15: Chroma Quantization Qpc Parameter Signalling [S. Paluri, J. Zhao, J. Lim, S. Kim (LGE)]

This contribution was discussed 4 July at 2010 (chaired by GJS).

O0186 O0298, O0433, O0562, and O0650 are all related.

This document proposes the inclusion of a user defined chroma quantization (QpC) in the VVC specification text. A flag in the sequence parameter set (SPS) is introduced to indicate if the default table in the specification text is to be used or if the contents of the table should be derived from the information signaled in the SPS. In the current draft of VVC, the QpC values are derived using a fixed table given in the specification text. It is asserted that this design enables functionality to accommodate user defined chroma quantization to benefit different content. Additionally, two options are presented in the proposal. Option 1 asserts that only 1 user defined table is sufficient while Option 2 provides added flexibility to have separate user defined tables for Cb and Cr components.

There were comments about the syntax in the very low QP range (for QP <= 0).

[JVET-O0433](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7038) AHG15: Chroma quantization parameters Qpc table [F. Pu, T. Lu, P. Yin, S. McCarthy, W. Husak, T. Chen (Dolby)]

This contribution was discussed 4 July at 2020 (chaired by GJS).

O0186 O0298, O0433, O0562, and O0650 are all related.

This contribution proposes syntax and semantics for signalling user-defined chroma quantization parameter QpC tables for any signal type. The proposed syntax and semantics support signalling of either one QpC table to be shared by both chroma components or a pair of QpC tables, one for each chroma component. The proposed syntax and semantics can be used for any signal type, including SDR and HDR. This contribution additionally proposes that default chroma quantization parameter QpC tables be defined to provide an option to simplify signalling and reduce the number of bits required to signal QpC tables. Three default QpC tables are proposed to support the following use cases: SDR Y'CbCr, HDR PQ Y'CbCr and HDR HLG Y'CbCr. (The proposed syntax and semantics allow additional default QpC tables, for example default tables for ICTCP, to be specified later if desired.)

The maximum number of bits required to signal QpC table(s) for each option is reportedly as follows:

* two QpC tables (one for each chroma component): 170 bits
* one QpC table (shared by both chroma components): 86 bits
* default QpC table (shared by both components): 2 bits for SDR and 4 bits for HDR

[JVET-O0678](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7297) Crosscheck of JVET-O0433 (AHG15: chroma quantization parameters QpC table) [Louis Kerofsky (InterDigital)]

[JVET-O0562](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7176) AHG15: Flexible luma-to-chroma quantization parameter tables [F. Bossen, A. Segall (Sharp)]

This contribution was discussed 4 July at 2030 (chaired by GJS).

O0186 O0298, O0433, O0562, and O0650 are all related.

The current VVC draft defines a table that maps a luma quantization parameter value to a chroma quantization parameter value. The table is substantially the same as what was used in previous standards, and it is the authors understanding that the table was originally developed to manage the bit-allocation between luma and chroma channels at lower rates. However, compared to these previous standards, the VVC draft now contains additional tools that impact the balance of luma and chroma, such as dual tree support and cross-component linear model prediction (CCLM). Furthermore, it is anticipated that the VVC standard will be used to compress a larger amount of content types – including both standard dynamic range and high dynamic range content – that contain different relationships between the luma and chroma channels. As such, it is asserted that the current and fixed table may not be ideal, and it is proposed to have a programmable table to offer encoder flexibility.

The contribution notes that there is something different about QP for joint chroma coding.

The proposed syntax uses a piece-wise linear scheme (with no slope assumption).

The syntax is proposed to be at the PPS level.

Offsets both prior to and after the mapping table are proposed to be used.

Tests with not rounding the lambda value were reported, showing a more linear behaviour with increasing chroma QP.

It was commented that the chroma QP offset as currently used may not be needed if a general table is supported.

[JVET-O0650](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7266) AHG15: On signalling of chroma QP tables [A. K. Ramasubramonian, G. Van der Auwera, D. Rusanovskyy, M. Karczewicz (Qualcomm)]

This contribution was discussed 4 July at 2100 (chaired by GJS).

O0186 O0298, O0433, O0562, and O0650 are all related.

This document proposes a signalling mechanism for chroma QP tables. It is suggested that the mechanism should be flexible to provide encoders the opportunity to optimize the table for SDR and HDR content. It is argued that the signalling mechanism should have support for signalling the tables separately for Cb and Cr components. The proposed mechanism signals the chroma QP table as a piece-wise linear function.

[JVET-O1021](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7658) Crosscheck of JVET-O0186 (AHG15: Signalling of chroma Qp mapping table) [K. Choi (Samsung)]

General consideration of chroma QP mapping

Discussion time Thursday 4 July 2110-2230 (GJS)

Issues:

* Separate mapping tables for Cb and Cr – yes, should support this (also supporting a common table)
* SPS, PPS, or APS – SPS
* Default(s) – no default
* Additional offsets prior to or after the mapping table (currently we have PPS and slice level offsets before the mapping) – PPS and slice level, offsets applied *after* the mapping table (deblocking continues to use only the picture level offset)
* Joint chroma coding handling – use a third table if not using a common table, and support a third offset at PPS and slice level (similar to what we’re doing now at the PPS and slice level)
* Additional issues:
  + Degree of generality needed for the mapping table (slope constraints other than non-negative, and starting point constraints) – it was commented that we seem to have some use for a general non-negative slope, where we want slope of 1 at very low QP, a somewhat higher QP for chroma in some middle range, but then a somewhat lower QP for chroma at very high QP values – we prefer to have a general syntax, O0562 actually supports negative slopes, O0650 supports arbitrary non-negative slopes, so it was suggested to consider that syntax as a candidate for adoption; see further notes after offline study.
  + Syntax & semantics details (amount of bits, number of syntax elements, text description)
  + What to do in CTC

This was further discussed Thursday 1145 at 1245 (GJS).

Text was presented as an additional document in the zip archive for O0650. The tables are also sent for 4:4:4 and 4:2:0. Decision: Adopt as in the new attachment.

For CTC, it was initially agreed to use the new syntax to achieve the chroma QP settings proposed in O0186 for SDR, N0221 for PQ, O0433 for HLG. For the joint table, use the average of the Cb and Cr tables. Below QP = 16, chroma and luma QP should be equal for CEs using low QP.

Decision (CTC): This was further discussed in the closing plenary on Friday. It was suggested to keep the anchor QP settings for PQ and HLG as in CTC of prior meeting cycle. For SDR, see above. Below QP = 16, chroma and luma QP should be equal for CEs using low QP.

Further study of CTC is encouraged.

O1126

This was further discussed Thursday 1145 at 1300 (GJS).

Information document about the bit usage of the draft 5 approach and something similar to the adopted approach. Available for study.

O1166

This was further discussed Thursday 1145 at 1300 (GJS).

A further analysis responding to O1126. Available for study.

[JVET-O0737](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7358) Chroma Delta QP for Separate Tree [Y. Han, G. Van Der Auwera, M. Coban, W.-J. Chien, Y.-H. Chao, A. Nalci, M. Karczewicz (Qualcomm)] [late]

This contribution was discussed Friday 5 July at 0940 (chaired by GJS).

CU level chroma QP control is available in VTM5.0 and the same as in HEVC range extension, but it is not in the draft of VVC. In this contribution CU level chroma QP control is proposed to be included in VVC.

* It was agreed in principle that VVC should have some form of local chroma QP control.
* Currently, chroma QP is predicted from the luma QP of roughly the center of the chroma block and a slice-level delta.
  + The proponent said that in the single-tree case, this makes sense because a chroma quantization group corresponds directly to a luma quantization group, but this is not true in the separate tree case. However, another participant said that there is not such a 1:1 correspondence in HEVC.
  + Hypothetically, we could just basically do what is in HEVC (“variant 0”).
  + Proposal variant 1 is to add a syntax element as a delta from the luma QP to a common reference point for applying component-specific QP deltas. The proponent suggested that perhaps the common reference point could be used for the joint case if that is enabled.
  + Proposal variant 2 is to signal a delta from the luma QP for Cb and another for Cr (and perhaps third for the joint case if that is enabled).
* HEVC has a maximum table size of 6. It was discussed whether we should support more offsets than that.
* Some scheme is needed for joint coding of chrominance residuals (JCCR) mode. A “variant 0” would have three offsets for each entry in the table.
* To address dependency issue when chroma separate tee is enabled, luma deltaQP is proposed to not depend on chroma CBF flags.

Text was not yet available.

See document O1168.

[JVET-O1168](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7805) CU level chroma QP control for VVC [Y. Han, A. Ramasubramonian, A. Nalci, G. Van Der Auwera, M. Coban, W.-J. Chien, Y.-H. Chao, M. Karczewicz (Qualcomm), P. De Lagrange (InterDigital)] [late]

This has text for CU level chroma QP control as described in the discussion of O0737.

Decision: Adopted.

In the closing plenary it was clarified that the O0046 action does not affect chroma.

[JVET-O0267](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6872) AHG15: Cleanups for scaling matrices [O. Chubach, C.-Y. Lai, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

This contribution was discussed Friday 5 July at 0900 (chaired by GJS).

This contribution is related to scaling matrices support and signalling cleanup. It is proposed to remove signalling the flag for the default scaling matrices on top of VTM5.0 and VVC Draft 5, considering the fact that the default scaling matrices are assigned to flat and the same as the case of not signalling scaling matrices. Also, it is proposed to modify the associated scaling matrices for intra block copy mode (IBC) to inter mode, instead of intra mode. The two proposed cleanups do not change results under common test conditions (CTC).

* Default is flat, so why have two ways to signal that – trivial issue. It was agreed to keep this in mind for later work; what we have now is not what we really want in the final spec, but the matter is very minor and can be dealt with in final cleanup later.
* Proposes to use the inter quant matrices for IBC mode – the same as JVET-O0527 (and was also suggested on the reflector previously). Decision: Adopted this aspect.

It was noted that we use the same quantization matrices for DCT and DST blocks, which might seem strange. Another participant commented that transforming a basis function into coefficients of the other transform shows that the frequencies are not so different, and thus it should be OK to share them.

Editorial action item: The contributor also remarked that the spec text is unnecessarily verbose and can be simplified. The editor is requested to consider this.

[JVET-O0527](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7134) Non-CE7: Use INTER quantization matrices for IBC [P. de Lagrange, Y. Chen (InterDigital)]

See also JVET-O0267. This was discussed in the context of that contribution.

[JVET-O0223](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6828) Non-CE7: Quantization matrices with single identifier and prediction from larger ones [P. de Lagrange, F. Le Léannec, E. François, K. Naser (InterDigital)]

This contribution was discussed Friday 5 July at 1145 (chaired by GJS).

This contribution proposes to change quantization matrix (QM) signalling and prediction, and allow any matrix to be predicted from any previously signalled one, by identifying a QM with a single index, transmitting QMs in decreasing block size order, and specifying a prediction process as either a copy or decimation process.

It also describes a QM derivation process that involves selecting a decoded QM for a given transform block, up-sampling for blocks larger that 8x8, and down-sampling for rectangular blocks.

These modifications are said to reduce by half the text needed to support QMs, and to save about 50% of the bits needed to signal example QMs from a provided test set.

It was commented that JVET-O0267 also has a text simplification (without technical change).

Part of the question of the need for efficiency in sending the QMs is a matter of how often they would be sent.

It was commented that the bit efficiency depends on the selected example QMs to encoded.

It was commented that having the ability to do a prediction with a difference would provide more of an assurance that the bits would generally be minimized for more arbitrary selections of QMs to be encoded.

This did not seem to be a high priority or urgent issue and is generally orthogonal to other work.

For further study and potential action at the next meeting.

[JVET-O0924](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7549) Crosscheck of JVET-O0223 (Non-CE7: Quantization matrices with single identifier and prediction from larger ones) [J. Le Tanou (MediaKind)]

[JVET-O1126](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7763) On chroma Qp mapping tables signalling [S. Ikonin, R. Chernyak, A. Karabutov (Huawei), S. McCarthy, F. Pu (Dolby), P. de Lagrange (InterDigital)] [late]

See notes above.

[JVET-O1166](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7803) AHG15: Efficient encoding of chroma QP tables using piecewise linear representations [F. Bossen, A. Segall (Sharp), A. K. Ramasubramonian, G. Van der Auwera (Qualcomm)] [late]

See notes above.

## Entropy coding (6)

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

[JVET-O0308](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6913) CABAC skip mode [K. Abe, T. Toma (Panasonic), D.-Y. Kim (Chips&Media)]

This contribution was discussed Friday 5 July at 1145 (chaired by GJS).

This contribution is a follow-up contribution to JVET-M0089 and JVET-N0207. CABAC throughput depends on the number of binarized bins and it is reportedly difficult to guarantee to complete the processing in the pipeline stage. Some systems introduce a kind of buffer to solve it, but the guarantee of this buffer control strongly depends on CABAC throughput, and this issue will reportedly be more significant for the use case of high bit rate and low delay. This contribution proposes to introduce a CABAC skip mode which directly outputs binarized bins as a bitstream without CABAC processing. This mode decreases the coding efficiency, but it can reportedly avoid a CABAC throughput issue without any additional building blocks. Simulation results reportedly show that the proposed mode can guarantee a fixed processing delay with the cost of 17%, 18%, and 21% bit rate increases for AI, RA, and LDB on VTM-5.0. At low QP, similar but slightly less penalty was reported.

This is proposed for special use cases in which throughput is a higher priority than compression.

As proposed, the entire bitstream would operate in this mode (including all syntax, not just transform coefficients).

For transform coefficients there are two binarizations, and this would also force use of the bypass-type binarizations always.

It was asked whether this would be in a different profile or all decoders would be required to support this type of operation. The proponent said that either approach was possible but that it may not be especially difficult for all decoders to support it. Another participant said it seemed more reasonable to have a separate profile for this.

At the previous meeting it had been remarked that a very high throughput encoder would probably not be able to use all the VVC coding tools (or not use them as effectively) – which would imply a more substantial coding efficiency penalty than what is represented by CTC testing.

This may be largely a profiling question.

It was suggested that this should be considered at the parent body level. Options include a separate profile, adding a requirement to all decoders to support the mode, adding the syntax and deciding profiling questions later, or of course not having this mode in the spec.

[JVET-O1052](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7689) Crosscheck of JVET-O0308 (CABAC skip mode) [C. Rosewarne (Canon)]

[JVET-O0450](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7056) Separating context coded and bypass coded data [A. Hallapuro, J. Lainema (Nokia)]

This contribution was discussed Friday 5 July at 1230 (chaired by GJS).

Currently the VVC draft standard specifies that context coded bins and bypass coded bins are both coded by the arithmetic coder and the resulting data for both are interleaved in the bitstream. The contribution proposes to separate the context coded data from bypass coded data in the bitstream. It is asserted that by separating bypass coded data, the decoding of bypass bins is simplified and the decoding of context coded bins does not depend on bypass bins anymore.

To avoid sending a length field indicating start of the bypass coded part, the bypass part is coded after the context coded part in byte reversed manner.

The average overhead for separating bypass bins is reported to be 4.5 bits on average (3.5 bits on average for additional byte alignment and 1 extra stop bit) if bypass data always exists. The overhead is zero if the bypass data does not exist.

The impact on bit rate for common test conditions is reportedly 0.00%/0.01%/0.03%/0.03% for AI/RA/LB/LP, respectively. There is no impact on PSNR.

As the parsing process proceeds, the decoder reads data from two places in the NAL unit, with one pointer progressing forward from the beginning and the other progressing backward from the end. It would be necessary to have access to the entire NAL unit before any of it could be decoded.

An encoder would have some latency and buffering/reordering delay. It could not start putting out data beyond the context-coded portion until the entire NAL unit is ready to be sent.

A decoder also could not start decoding the NAL unit data until the end of the NAL unit has been read.

There is some extra (relatively minor) byte alignment overhead.

It was commented that it is not clear that there would be a substantial practical benefit for this, since the buffering is somewhat of an extra headache.

No action was taken on this.

[JVET-O0517](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7124) Slice/tile level CABAC zero-word constraints [A. Browne, S. Keating, K. Sharman (Sony)]

This contribution was discussed Friday 5 July at 1255 (chaired by GJS).

This document describes a modified coding method for padding with cabac\_zero\_word. The current coding method adds padding at the end of a slice based upon picture-level information. It is proposed that the padding is moved to the end of each slice/tile (or the appropriate independently decodable region) and base the calculation on the sub-region information. Implementation of this modification would allow any picture created by composition of different slices/tiles/sub-regions from different pictures to meet the specification, removing the need for counting bins in the resulting bitstream.

It was commented that rather than imposing such a sub-region constraint always in the standard, the encoders that are designed for use in a particular application could be designed to operate in this “friendly” way to enable flexibility that might not be guaranteed to be possible for all bitstreams.

In principle, this would result in somewhat more padding data to be added than what would ordinarily be needed.

It seems acceptable that not all encoders would be designed to produce bitstreams that are friendly to “fancy” mix-and-match bitstream repurposing.

However, another participant commented that having the constraint at a lower level could be justified for other reasons as well – e.g., when considering parallel decoders, it might be friendlier to decoders to impose the constraint on a lower level.

It was noted that we do have a measurable percentage CABAC zero words in our low-QP.

A suggestion was to raise the value of the ratio constraint. Doing this could be coupled with changing the place where the constraint is imposed.

It was agreed that this proposal should be further studied along with the formula and threshold value of the constraint.

[JVET-O0519](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7126) Switching between CABAC context coded bins and EP coded bins [A. Browne, S. Keating, K. Sharman (Sony)]

This contribution was discussed Friday 5 July at 1445 (chaired by GJS).

This document describes a modified coding method which would change the entropy coding by modifying the coefficient coding. This change is said to remove the need to use cabac\_zero\_word padding. The modification works by dynamically swapping between bypass and CABAC bin coding. Two different implementations are described, the second of which is designed to limit the number of exchanges between CABAC and bypass bin coding. Results are given which reportedly how gains in low QP conditions (-0.42% for class A1 in All Intra) without harming performance in CTC conditions.

The second variant would avoid switching within a TU. It was commented that it would be important to avoid needing to keep track of the switching possibility all the time.

We currently have limits on the number of context coded bins in a TU (32 for 4x4, 8 for 2x2 sub-TUs). The proposal would remove these limits in favour of switching to bypass coding for the whole TU when the bin-to-bit ratio is becoming excessive. Since these limits on context coded bins per TU is removed, there is some coding efficiency benefit.

In some test results some gain was observed for low QP (0.36% for RA average across classes, 0.81% for AI Class F, 3.41% for RA Class F).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **AI (Low QP)** |  |  |
|  |  |  | **Over VTM** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -0.42% | -0.60% | -0.63% | 102% | 104% |
| Class A2 | -0.39% | -0.58% | -0.58% | 103% | 106% |
| Class B | -0.06% | -0.12% | -0.16% | 102% | 104% |
| Class C | 0.05% | -0.03% | -0.04% | 105% | 101% |
| Class E | 0.02% | -0.12% | -0.14% | 102% | 102% |
| **Overall** | -0.14% | -0.26% | -0.28% | 103% | 103% |
| Class D | 0.03% | -0.05% | -0.03% | 105% | 103% |
| Class F | -0.81% | -0.75% | -0.76% | 104% | 102% |
|  |  |  |  |  |  |
|  |  |  | **RA (Low QP)** |  |  |
|  |  |  | **Over VTM** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -0.39% | -0.59% | -0.57% | 101% | 102% |
| Class A2 | -0.53% | -0.84% | -0.83% | 101% | 103% |
| Class B | -0.35% | -0.53% | -0.59% | 101% | 103% |
| Class C | -0.24% | -0.39% | -0.35% | 101% | 102% |
| Class E |  |  |  |  |  |
| **Overall** | -0.36% | -0.57% | -0.57% | 101% | 102% |
| Class D | -0.25% | -0.34% | -0.35% | 102% | 100% |
| Class F | -3.42% | -0.70% | -0.78% | 101% | 100% |

For this approach, it is necessary to be able to switch the process based on the tracking of the number of bits that have been pushed out of the CABAC engine, and it was commented that the need for this decision path might increase the length of the critical path.

It was also commented that this would embed the bin-to-bit ratio formula into the decoding process, which would affect whether the same CABAC engine might be usable for decoders that support multiple profiles that could have different limits. This contrasts with the current scheme for cabac\_zero\_word, which is just ignored by decoders without being part of the decoding process.

It was also commented that some form of this could make it easier to support the proposed JVET-O0308 CABAC skip mode described above.

There was clear interest in this proposal, and further study was thus encouraged.

[JVET-O1069](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7706) Crosscheck of JVET-O0519 (Switching between CABAC context coded bins and EP coded bins) [M. Coban (Qualcomm)]

[JVET-O0520](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7127) GT1 flag coding [A. Browne, S. Keating, K. Sharman (Sony)]

This contribution was discussed Friday 5 July at 1530 (chaired by GJS).

For some sequences it has been observed that at certain QPs there is a peak in the number of GT1 flags coded but which predominantly indicated a value of 0.

This contribution proposes the introduction of a GT1\_GROUP flag into coefficient coding. This flag would be set to indicate the presence of a value greater than one in a transform unit block. The GT1\_GROUP flag would only be coded if a statistical measure indicates a very high probability that this flag is not set. When this flag is present and not set, there would be no need to code a GT1 flag for each significant coefficient.

For the above cases, it is reported that the introduction of the flag results in a significant reduction (~40%) in the number of GT1 flags that must be coded. This reduces the workload on the entropy decoder, can reduce the amount of cabac\_zero\_word padding, and can result in BD-rate reductions for some sequences.

The presenter said the trellis quantization especially aggravates the situation where the bitstream contains many GT1 flags that are being coded very efficiently with a very skewed probability estimate.

This does not really provide coding gains (even in the low QP case), so it was commented that the issue may not be very severe. If cabac\_zero\_word is being observed in CTC, perhaps the formula for requiring its presence could simply be adjusted.

It was commented that this could reduce the coding efficiency loss of the proposed JVET-O0308 CABAC skip mode described above, since it reduces the use of CABAC to code bins that have a heavily skewed probability.

The grouping proposed here would not be used all the time. The conditions of when it would be used would need to be established.

This does not seem quite mature for a CE. However, the proposal at least points out that we are sometimes encountering situations where CABAC is being operated with a heavily skewed probability within the transform coefficient coding process.

Further study was encouraged.

[JVET-O0554](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7168) Removal of infrequently used context models [A. Alshin, J. Boyce, P. Frolov, V. Aristarkhov (Intel)]

This contribution was discussed Friday 5 July at 1545 (chaired by GJS).

The latest VTM5.0 uses 424 context models which correspond to 65 different types of data starting with SplitFlag and ending with TsResidualSign. However, the frequency of use of context models differs significantly. This contribution proposes to reduce the number of contexts by removing the 100 least frequently used context models for the RA CTC, which together account for only 0.5% of the total context usage. The removed contexts are replaced by bypass or a proposed “generalized bypass”. When bypass is substituted for 100 removed contexts, this contribution shows a 0.32% bitrate increase for RA. When generalized bypass is substituted for 100 removed contexts, the bitrate increase for RA is reduced to 0.19%. When the number of removed contexts is reduced to 90 or 80 contexts and generalized bypass is used, the bitrate increase for RA is reduced to 0.16% or 0.09%, respectively.

The v2 version of this document adds a parsing process section.

It was commented that some of the contexts in the software are not actually used in the spec, and that some contexts. There are some that may not be used in the CTC that could be used when the encoder is operating differently – e.g., there is no use of delta QP in the CTC.

It was commented that the CE1 software outputs an indication of which contexts are not encountered while processing a particular bitstream.

The proposal would introduce additional bypass types in addition to the current 0.5 probability bypass.

It was commented that this analysis can help identify some contexts that could be investigated for elimination or for simplifying their derivation. If we conclude that some context that is difficult to derive is not really used very much, we should question why we are doing the derivation (e.g., for cases that require a line buffer).

We don’t really have a problem of an excessive amount of contexts, and can defer some of cleanup that to later.

We need to be careful about introducing new types of things to deal with in CABAC, so there was some skepticism about adding more types of bypass.

A first step would be to just editorially remove things from the software that are not used at all and are not in the spec. There might be 30 or 40 contexts like that.

Further study was encouraged.

[JVET-O0854](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7475) Crosscheck of JVET-O0554 (Removal of infrequently used context models) [Z. Deng (Bytedance)]

[JVET-O0741](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7362) Context memory reduction via selective adaptation [A. Said, T. Hsieh, J. Dong (Qualcomm)] [late]

This contribution was discussed Friday 5 July at 1645 (chaired by GJS).

This is a proposal reduce the cost of supporting a large number of CABAC contexts by removing the adaptability of the least important contexts. It is reported that this can be done with a minimal change to the context implementation (a single “if” line added), no changes to the CABAC engine, and (unlike converting to bypass) no changes to the any other parts of VTM or the standard’s text. The change can reportedly yield significant savings in memory and hardware implementation costs because it changes the context memory requirement from 28 bits to 6 bits, and a part of the context-state total RAM can be replaced by cheaper ROM. Simulation results show that if the CTC is sufficiently representative of usage, between 40% to 60% percent of the contexts can be converted with very small losses. Under CTC and 4 bits of precision for probabilities, conversion of 100 contexts from adaptive to non-adaptive reportedly results in 0.01% and 0.00% luma losses in AI and RA, and conversion of 200 contexts reportedly results in 0.06% and 0.xx% luma losses in AI and RA CTC conditions.

See also the notes for JVET-O0554. As with that contribution, was noted that not all contexts that are in the software are actually used in the standard, and the CTC does not represent all anticipated usage (e.g., delta QP is not used).

The core engine uses 6 bits for a probability estimate.

A participant said that a typical implementation would not have a benefit from this, since it would have sufficient RAM already, due to more storage being needed for other decoder designs that would be supported in the same implementation. In general it has been agreed that minimizing the number of contexts is not a very high priority currently, as the number of contexts in the design is not very excessive.

The proposal would have a less severe effect on coding efficiency than using bypass coding because this supports skewed (although fixed) probabilities. However, it was noted that the maximum penalty of a mismatch between the estimated and actual probability could be larger in this case if the experienced probability is different from the estimate.

It was commented that it would be undesirable to need to have some “if” condition for whether or not a particular context has probability adaptation. If a particular syntax element would always use an adaptive context or would always use a non-adaptive context, that would be OK, but it would be bad to need a condition check when operating the CABAC process.

If this is done to some degree, selecting which contexts it could apply to would need to be done carefully.

No action was taken on this.

[JVET-O1015](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7652) Crosscheck of JVET-O0741 (Non-CE1: Context memory reduction via selective adaptation) [H. Kirchhoffer (HHI)]

## Chroma sampling and chroma formats (2)

[JVET-O0616](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7231) Non-CE: Various chroma format support in VVC [N. Zhang, L. Zhang, H. Liu, K. Zhang, Y. Wang (Bytedance)]

This contribution was discussed Friday 5 July at 1805 (chaired by GJS).

In the last meeting, it is decided to support 4:0:0 color format in VVC. Several tools related to chroma coding have been modified to be conditionally enabled or signaled. However, it is noticed that some tools still need to be modified under the consideration of different color formats. In this contribution, signalling of a few syntax elements and semantics are further modified based on the condition of ChromaArrayType.

The proposes not sending useless syntax elements in the SPS and slice header. The proponent indicated that this was something agreed in spirit at the previous meeting.

* SPS
  + Chroma bit depth
  + PCM chroma bit depth
* SH
  + Slice ALF chroma indication
  + Slice chroma residue scaling flag
  + ALF chroma filter signal flag

It was noted that in HEVC we don’t do the suggested removals in the SPS, only one bit needs to be wasted for each of these.

Decision (bug fix / cleanup): Adopt the SH aspects only.

[JVET-O0622](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7237) AHG2: Draft text to update BT.2100 references and ICTCP HLG coding equations [S. McCarthy, F. Pu, T. Lu, P. Yin, W. Husak, T. Chen (Dolby)]

This contribution was discussed Friday 5 July at 1800 (chaired by GJS).

This contribution proposes the following changes to the current VVC draft specification:

* Replace all occurences of ITU-R BT.2100-1 with ITU-R BT.2100-2; and,
* Add text and equations to support ICTCP HLG.

This is about an issue already addressed for HEVC and AVC. It was commented that in VVC we may not need to have these details, as we could refer to the CICP text.

Decision (bug fix/update): This proposal is agreed in principle, but may be incorporated by reference rather than directly documented in the VVC text. The form depends on the structuring of the text.

## Other coding tools (13)

Contributions in this category were discussed Friday 5 July 1800–2130 in Track B (chaired by JRO).

[JVET-O0194](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6799) On chroma-CU-related flags and coding information [Y. Zhao, H. Yang (Huawei)]

When separate tree is used, the coding information CuPredMode[x][y], cqtDepth[x][y], CbWidth[x][y], CbHeight[x][y], CbPosX[x][y] and CbPosY[x][y] of location (x,y) may be different for luma and chroma CBs. However, VVC draft 5 does not discern these parameters for luma and chroma. To fix this problem, it is proposed to extend these parameters with channel type in VVC spec, e.g., CuPredMode[chType][x][y]. Besides, the first four of the six parameters are used in the neighbor-based context modeling of pred\_mode\_ibc\_flag, split\_qt\_flag, mtt\_split\_cu\_vertical\_flag and split\_cu\_flag, thus requiring line buffer to store these parameters for luma and chroma separately.

Three tests are made to remove neighbor dependency in context modeling of the four flags for chroma CU, by which the line buffer for storing CuPredMode, cqtDepth and CbWidth for chroma blocks is reduced. Test 1 does not check neighbors for the first two flags for chroma CU. Test 2 does not check neighbors for all the four flags for chroma CU. Test 3 does not check neighbors for the first three flags for chroma CU, and checks only the left neighbor for the split\_cu\_flag. It is reported that Test 1 results in 0.00%/-0.01%/0.02% and 0.02%/-0.03%/0.01% Y/Cb/Cr BD-rates in AI and RA configuration, respectively. Test 2 results in 0.06%/0.23%/0.25% and 0.02%/-0.02%/0.11% Y/Cb/Cr BD-rates in AI and RA configuration, respectively. Test 3 results in 0.02%/0.13%/0.22% and 0.00%/0.00%/-0.03% Y/Cb/Cr BD-rates in AI and RA configuration, respectively, and saves 6 bits/4x4 in line buffer.

The contribution points out some issues for the case of dual tree luma/chroma dependency.

First aspect: CB width/height is purely editorial (no change in software)

Second aspect: remove context modelling from any neighbors for chroma, loss is 0.06% in luma, 0.2% in chroma

Third aspect: remove context modelling only for neighbors above, saves line buffer for context model (about 5 bit per 4x4 block, approx. 5000 bit for case of 4K), loss 0.02% in luma,0.1-0.2% in chroma.

Question is raised: Is this really a problem?

No support by other experts – no action on aspects 2 or 3.

Decision (ed.): Adopt JVET-O0194 first aspect – editorial improvement.

[JVET-O0824](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7445) Crosscheck of JVET-O0194 (On chroma-CU-related flags and coding information) [X. Cao (Hikvision)]

[JVET-O0389](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6994) On Supporting 64x64 Chroma Transform Unit [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 for inter CU to make the maximum chroma TU size for 4:4:4, 4:2:2 and 4:2:0 format identical. When inter CU size in luma sample unit is larger or equal to 128x128, the size of transform unit of chroma components is 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 -0.00%, -0.19%, and -0.15% BD-rates for Y, Cb, and Cr components respectively in RA configuration on top of VTM-5.0. It has no impact on the performance of AI.

This would break the 64x64 VPDU concept in case of 4:2:0.

The gain is low.

For 4:4:4, it would be OK in terms of pipelining in VPDU, but no results.

Further study recommended for 4:4:4, i.e. results should be provided both for RGB and YUV. If it shows benefit, 64x64 transform should be used for chroma in 4:4:4 case.

For 4:2:2, 32x32 should be retained. For the current draft, it should also be retained for 4:4:4, waiting for results as stated above to potentially change it in the future.

[JVET-O0704](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7324) Crosscheck of JVET-O0389: On Supporting 64x64 Chroma Transform Unit [X. Zhao (Tencent)]

[JVET-O0398](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7003) Chroma block size restriction in dual tree intra coding [J. Choi, J. Heo, J. Lim, S. Kim (LGE)]

This contribution proposes to restrict chroma 2xN block in dual tree of intra coding. With this restriction, the width of chroma block becomes always bigger than or equal to 4, and thus 2xN pixel process of chroma coding is removed in the dual tree block structure. This restriction can help hardware implementation in terms of pipeline management and latency.

Experimental results show 0.02%, 0.34%, and 0.38% BD-rates on Y, Cb, and Cr components, respectively in All Intra configuration.

It is commented that this might be desirable in hardware, but disallowing 2xN and Nx2 only for dual tree would not help worst case complexity.

Further study recommended also for case of single tree.

[JVET-O1031](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7668) Crosscheck of JVET-O0398 (Chroma block size restriction in dual tree intra coding) [J. Lee, S.-C. Lim, H. Lee, J. Kang (ETRI)]

[JVET-O0447](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7053) Enabling tools for small blocks in small pictures [P. Bordes, F. Le Léannec, T. Poirier, F. Galpin (InterDigital)]

In VVC, many tools have been disabled for lower block sizes, mainly to prevent the burden worst case of large pictures that could be fully encoded with 8x8 or 4x4 CUs for example. This has a non-desired consequence of degrading the relative coding performance of VVC for sequences with small picture sizes (class D or class C) in comparison with other state-of-art codecs (HEVC, AV1).

It is proposed some means to make the enabling of some coding tools depending not on CU size only but on picture size too.

The concept would not work in case where several low resolution pictures would be combined by bitstream splicing to be decoded by one decoder that is supporting larger resolution.

Otherwise, several experts expressed that targeting for better gain in the low resolution cases is important.

Further thinking recommended.

[JVET-O1101](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7738) Crosscheck of JVET-O0447: Enabling tools for small blocks in small pictures [J. Ström (Ericsson)]

[JVET-O0460](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7067) On lossless coding for VVC [T. Poirier, F. Le Léannec, F. Galpin (InterDigital)]

No need to be presented – There is a joint proposal JVET-O1061 which combines aspects of 0460, 0584, and 0591

[JVET-O0945](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7572) Crosscheck of JVET-O0460 (On lossless coding for VVC) [T.-C. Ma (Kwai Inc.)]

[JVET-O0461](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7068) AHG13: On chroma tool evaluation in Dual Tree [T. Poirier, F. Le Léannec, F. Galpin, E. François (InterDigital)] [late]

This contribution proposes to report separated Y,U and V BD rate numbers by separating luma and chroma rates in addition to numbers computed with global luma and chroma rate when Dual Tree is used.  
CCLM and Joint CB-Cr coding tools are evaluated with this method in All Intra configuration, results are reported as follows: CCLM tool off leads to +1.86% increase in BD-rate for Y, +15.80% for U and 15.73% for V, with the proposed evaluation method CCLM tool off leads to +0.01% for Y, +26.92% for U and 26.95% for V. Joint Cb-Cr coding tool off leads to 0.15% increase in BD-rate for Y, +1.61% for U and +2.01% for V, with the proposed evaluation method Joint Cb-Cr tool off leads to -0.01% decrease in BD-rate for Y, +2.92% increase for U and 3.31% for V.

Having rate separation for separate tree only may not be helping much as

* Single tree is also important
* Also in dual tree case chroma benefits from luma (e.g. CCLM improves chroma quality substantially without spending much rate

Have the proponents identified cases where a wrong decision was taken due to lack of knowledge about the rate spent for chroma

How does it compare with other approaches such as weighting the MSE in some ratio luma vs chroma?

Further study

[JVET-O0525](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7132) AHG16: Removal of PCM mode [T. Hellman (Broadcom)]

This contribution proposes a claimed simplification to VVC by the removal of PCM mode. It contends that PCM mode has been simply carried over since the H.264/AVC standard without any evidence of its benefit. It further claims that PCM support is an implementation and testing burden to decoder implementations, and that its continued inclusion adds unnecessary complication to the standard. The proposal recommends removing PCM mode in its entirety from the text.

Several experts expressed support.

It was argued in favour of PCM that in the case of weird content such as white noise, it may help. On the other hand, an encoder could switch to a higher QP to avoid buffer overflow.

There seemed to be no evidence that it is really needed. If evidence is brought in the future, it can be reinvoked.

It should also be removed from VTM software.

Decision: Adopt JVET-O0525

[JVET-O0526](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7133) AHG16: Setting the minimum CTU size to 32x32 [T. Hellman, M. Zhou (Broadcom)]

This contribution claims that the present minimum CTU size of 16x16 represents a burden to decoder implementation without any corresponding benefit. Reported VTM-5.0 test results show a 33.67% RA coding loss when using a 16x16 CTU size in place of the 128x128 CTU size in the CTC. It is alleged that such a coding loss makes the use of the 16x16 CTU size impractical.

This contribution recommends setting the minimum CTU size to 32x32, and using a more efficient encoding of CTU size in the SPS header.

From the discussion – might there be applications requiring 16x16?

* Transcoding from MPEG-2 without full decoding? Likely not, and would be easy to split into 16x16
* Extreme low latency? Perhaps, but might use HEVC
* Flexible sizes of picture regions/tiles?
* GRA?

The main burden would be throughput problems in decoder implementation, e.g. for loop filter, and pipelining at CTU level.

The proposal is supported by other hardware implementers

No objection is raised.

Decision: Adopt JVET-O0526

As a follow-up question, it is also asked if the spec should define a maximum CTU size. There was no clear need for action on this.

[JVET-O0537](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7144) Non-CE: Weighted intra and inter prediction mode [L. Zhao, X. Zhao, X. Li, S. Liu (Tencent)]

In this contribution, JVET-N0395 is further investigated on top of VTM-5 with modifications. A new mode, namely Weighted Intra and Inter Prediction (WIIP) mode, is signaled together with CIIP mode. Two alternatives are proposed in this proposal. The first one is the same as JVET-N0395, wherein PDPC filtering process is applied to the inter prediction samples indicated by merge index. In the second one, the prediction samples in WIIP mode is calculated as a weighted average of intra prediction and inter prediction sample values, which is similar to CIIP mode. In addition, implicit transform scheme is applied to the prediction residues for WIIP mode in both methods. It is reported that the first method achieves -0.13%, -0.37%, and -0.45% luma BD-rates for RA, LDB, and LDP configuration with 101%, 102% and 103% encoding and 99%, 100% and 99% decoding time respectively, and the second method achieves -0.13%, -0.34%, and -0.44% luma BD-rates for RA, LDB, and LDP configuration with 101%, 102% and 103% encoding and 100%, 100%, and 100% decoding time respectively. It is also reported that when further applying CIIP and WIIP modes to 4x8 and 8x4 blocks, it achieves -0.19%, -0.39%, and -0.58% luma BD-rates for RA, LDB, and LDP configuration with 101%, 102% and 103% encoding and 100%, 100% and 100% decoding time respectively.

Powerpoint deck not provided.

Cross-checker and other independent experts support this proposal. It is asserted that the issues that were raised in the last meeting are resolved.

After some discussion, method 2 seems to be the better choice, as it is better aligned with current CIIP data flow and keeps the intra and inter pipelining more independent, even though it may require some more logic than method 1, e.g. for the weighting of inter prediction samples (which can however be implemented as shift operations).

It was initially suggested in track B to adopt JVET-O0537 method 2 (same block size restrictions as CIIP). However, as the compression benefit is small and the method requires additional logic, that decision was reverted in Monday afternoon plenary.

[JVET-O0778](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7399) Crosscheck of JVET-O0537 (Non-CE: Weighted intra and inter prediction mode) [Y.-W. Chen (Kwai Inc.)]

[JVET-O0548](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7160) Combined bilateral/SAO loop filter [J. Ström, P. Wennersten, J. Enhorn, D. Liu, K. Andersson, R. Sjöberg (Ericsson)]

This contribution proposes a combination of the bilateral filter from JVET-N0493 with the sample adaptive offset (SAO) loop filter. It is reported that both SAO and the bilateral filter will operate on the same input, i.e., the output from the deblocking filter. Their outputs are then summed together and clipped. It is claimed that the same per-pixel complexity is reached as for JVET-N0493 with a total of 18 additions, 8 shifts and 8 checks are used per pixel, of which five of the additions are reported to be rounding operations. BD rate figures for luma are reported to be -0.41% (AI), -0.49% (RA) and -0.32% (LD) over VTM-5.0. Decoder run times are reported to be 104% (AI), 102% (RA) and 104% (LD). Encoder run times are reported to be 106% (AI) and 102% (RA).

Filter depends on QP, CBF and size of transform block.

Uses same pixel memory access as SAO.

Cross-checker reports that somehow the filter is called in the RDO decision of encoder. Would a practical encoder do this?

Several experts expressed that this provides interesting BD gain. Question is raised if it is providing subjective gain, as other loop filters do?

It is asked to prepare a subjective test (e.g. 6 sequences at QP 32 and 37 each) to identify if there are cases of subjective benefit.

Subjective viewing was performed with Cactus, Arena of Valor, KristenSara, Catrobot, BQTerrace and Daylight road (add results from Excel sheet)

Benefit is shown for ArenaOfValor, both for QP32 and QP37. Experts who participated in the viewing, the subjective differences is due to some sharpening effect that the current (HEVC style) SAO does not have, and possibly deringing.

It is mentioned that a version of SAO that goes back to the “old” SAO design (including sign in SAO edge offset) might have a similar sharpening effect.

Disabling at slice/tile/brick/360 boundaries should be aligned with SAO. Also disabling at picture boundary (no mirroring of samples).

A third crosscheck is announced (Huawei) that is not finished yet but as a preliminary report intends to make suggestions on improvements of the software. Also Qualcomm reports that they still have some questions on software.

There is no consensus on adoption of this proposal, as several experts expressed opinion that better understanding is necessary. It is agreed that, as there is evidence that this filter gives subjective benefit that is additional to existing loop filter stages, there would be justification for including it in VVC. The gain of 0.5% would not justify inclusion of another loop filter.

Study in CE. The CE should also test a mode where bilateral filter replaces SAO, and bilateral as a post filter. The CE shall primarily investigate the subjective benefit, for which it is also suggested to include non-CTC sequences. The CE shall also test the version without RDO optimization in mode decision for subjective quality.

[JVET-O1099](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7736) Crosscheck of JVET-O0548 (Combined bilateral/SAO loop filter) [J. Rasch (HHI)]

[JVET-O1035](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7672) Crosscheck of JVET-O0548: Combined bilateral/SAO loop filter [H. Wang (Qualcomm)]

[JVET-O1175](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7812) Crosscheck of JVET-O0548: Combined bilateral/SAO loop filter [A. Karabutov, S. Ikonin (Huawei)]

[JVET-O0584](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7199) Comments on transform quantization bypassed mode [H. Jang, J. Nam, N. Park, J. Choi, S. Kim, J. Lim (LGE)]

No need to be presented – There is a joint proposal JVET-O1061 which combines aspects of O0460, O0584, and O0591

[JVET-O0591](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7206) Modifications to support the lossless coding [T.-C. Ma, Y.-W. Chen, X. Xiu, X. Wang (Kwai Inc.)]

No need to be presented – There is a joint proposal JVET-O1061 which combines aspects of O0460, O0584, and O0591

[JVET-O1033](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7670) Crosscheck of JVET-O0591: Modifications to support the lossless coding [T. Poirier (InterDigital)]

[JVET-O1061](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7698) Modifications to support the lossless coding [T.-C. Ma, Y.-W. Chen, X. Xiu, X. Wang (Kwai Inc.), T. Poirier, F. Le Léannec, F. Galpin (InterDigital), H. Jang, J. Nam, N. Park, J. Choi, S. Kim, J. Lim (LGE)] [late]

This joint proposal combines the technology describes in three contributions from the 15th JVET meeting about lossless coding. Both Software and specification text are proposed.

The lossless coding mode is achieved by simply bypassing transform, quantization, and in-loop filters (de-blocking filter, sample adaptive offset, and adaptive loop filter). In VVC, several new tools are developed for transform, quantization and in-loop filter but some of them does not support lossless coding.

Meanwhile, lossless mode is included in the VTM software but the encoder fails with --TransquantBypassEnable=1 as reported by ticket #205 and is not included in the Draft Text as reported by ticket #333. In order to support lossless coding in VVC, this contribution suggests cu\_transquant\_bypass\_flag and operation of low-level coding tools when cu\_transquant\_bypass\_flag is equal to 1 as follows:

1. Transform/quantization bypass enable flag at PPS
2. Transform/quantization bypass flag for coding unit level
3. Syntaxes related transform which is MTS, LFNST, SBT and transform skip.
4. Sign data hiding disable for transform/quantization bypass block.
5. Disable LMCS for lossless mode
6. Disable JointCbCr for transform/quantization bypass block.
7. ALF processing for transform/quantization bypass block.

The compression benefit over HEVC is approx. 5.2% for AI, 3.1% for RA. RA is better compressing than AI over all classes. Encoder/decoder runtimes in similar compared to HEVC as they are for lossy coding.

Beyond the configuration above which is called “test 1” in the contribution, there is “test 2” which disables DMVR and BDOF, as these don’t have much effect for lossless.

Lossless coding is applied similar as in HEVC, trans/quant bypass. Regular entropy coding is used.

It is pointed out that transform skip with QP4 would also allow lossless, transquant bypass would not be needed. What is currently missing is transform skip for chroma.

The aspects to be clarified include:  
- benefit of a dedicated “lossless coding” flag. Even though lossless coding at picture level could already be realised now by disabling the above mentioned tools and always using TS with QP4 (except for chroma where currently TS is missing), this would not be possible at CU level, as there is no possible to disable ALF at this granularity.

- Would it be better to use the TS residual coding for the lossless case; in this context it could also be relevant to further reduce its max number of context coded bins (as proposed in O1169).

- Would BDPCM have advantage in case of lossless coding?

It is agreed that VVC shall have a lossless mode; even though the additional compression benefit compared to HEVC in terms of percentage saving is less than for the lossy coding range, 5% for AI is still remarkable, and it is obvious that for RA the optimized MV coding is not effective in the lossless range, as the bulk of bits goes into the residual.

It is also agreed that no specific tools should be introduced for lossless coding.

The impact of necessary tool disabling mechanisms (in particular the inloop filters) should be investigated.

To be studied in AHG, which should also have a mandate of discussing and proposing a tool package for enabling lossless coding down to block level.

[JVET-O1114](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7751) Crosscheck of JVET-O1061 (Modifications to support the lossless coding) [L. Zhao (Tencent)]

## 360 degree video (5)

[JVET-O0419](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7024) AHG6: Wrap-around spatial merge candidate for inter prediction [M. Lee, J. Lee, J. Park, D. Sim, S. Oh (KWU), W. Lim, G. Bang, H. Kim (ETRI)]

The proponent indicated that presentation of this contribution was not required at this meeting. The contribution is available for study.

[JVET-O1137](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7774) Crosscheck of JVET-O0419 (AHG6: Wrap-around spatial merge candidate for inter prediction) [A. Konda (Samsung)]

[JVET-O0487](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7094) Geometry padding for cube based 360 degree video using uncoded areas [J. Sauer, M. Bläser (RWTH Aachen)]

[JVET-O0488](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7095) Parameterizable cubemap for 360 degree video coding [J. Sauer, M. Bläser (RWTH Aachen)]

[JVET-O0891](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7513) AHG6/AHG17: Cubemap-based projection syntax for 360-degree videos [Y.-H. Lee, J.-L. Lin, Y.-J. Chen, C.-C. Ju (MediaTek)] [late]

## AHG17: General high-level syntax (61)

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

### NAL unit header and reference picture indication (6)

[JVET-O0146](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6750) AHG17: On unspecified NAL unit types [Y.-K. Wang (Futurewei)]

[JVET-O0179](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6783) On NAL Unit Header Design [S. Deshpande (Sharp)]

[JVET-O0237](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6842) AHG17: Compact NAL unit header [M. Pettersson, R. Sjöberg, M. Damghanian (Ericsson)]

[JVET-O0359](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6964) AHG17: On identification of reference and non-reference picture [T. Suzuki (Sony)]

[JVET-O0181](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6785) Comments on High-Level Syntax of VVC [S. Deshpande (Sharp)]

Only the proposal 2 in the contribution belongs to this agenda item.

[JVET-O1037](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7674) AHG17: On NAL unit header [Y.-K. Wang (Futurewei)] [late]

### Parameter set mechanism and parsing dependency (6)

[JVET-O0113](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6717) AHG17: On parsing dependency between parameter sets [Y.-K. Wang (Futurewei), J. Boyce (Intel)]

[JVET-O0155](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6759) AHG17: Resolving PPS parsing dependency on SPS [Hendry, Y.-K. Wang (Futurewei)]

[JVET-O0236](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6841) AHG17: Making PPS parsing independent of SPS [R. Sjöberg, M. Pettersson, M. Damghanian (Ericsson)]

[JVET-O0490](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7097) AHG17: Independent parsing of parameter sets [K. Sühring, R. Skupin, Y. Sanchez, T. Schierl (HHI)]

[JVET-O0181](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6785) Comments on High-Level Syntax of VVC [S. Deshpande (Sharp)]

Only the proposal 1 (on parameter set activation) and proposal 4 (on DPS referencing by SPS) in the contribution belong to this agenda item.

[JVET-O0268](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6873) AHG17: Signalling SPS base and patch [L. Chen, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O1156](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7793) AHG17: Spec text for parameter sets referencing without an activation process [Y.-K. Wang (Futurewei), S. Deshpande (Sharp)]

### IOP point definition and signalling (2)

[JVET-O0044](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6648) AHG17: Signalling zero or more Sub-Profiles [S. Wenger, B. D. Choi, S. Liu (Tencent)]

[JVET-O0417](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7022) AHG17: On general constraint information [P. Bordes, M. Kerdranvat (InterDigital)]

### Picture types, random access, and sub-layer switching (5)

[JVET-O0147](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6751) AHG17: Constraints on IRAP pictures and leading pictures [Hendry, Y.-K. Wang (Futurewei)]

[JVET-O0226](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6831) AHG17: On constraint about position of leading pictures and trailing pictures associated to an IRAP [V. Drugeon, K. Abe (Panasonic)]

[JVET-O0149](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6753) AHG17: On external decoding refresh (EDR) [Y.-K. Wang, J. Chen (Futurewei), H. Yu, L. Yu (ZJU)]

[JVET-O1085](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7722) Crosscheck of JVET-O0149 (AHG17: On external decoding refresh (EDR)) [H. Liu (Bytedance)]

[JVET-O0393](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6998) AHG17: On cross-RAP referencing [M. M. Hannuksela (Nokia)]

[JVET-O0235](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6840) AHG17: Ensuring temporal switching with STSA pictures [R. Sjöberg, M. Damghanian, M. Pettersson (Ericsson)]

### Reference picture list signalling (2)

[JVET-O0148](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6752) AHG17: On reference picture list signalling [Y.-K. Wang, Hendry (Futurewei)]

[JVET-O0244](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6849) AHG17: On zero delta POC in reference picture structure [V. Seregin, M. Coban, A. K. Ramasubramonian, M. Karczewicz (Qualcomm)]

### Miscellaneous HLS topics (12)

[JVET-O0151](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6755) AHG17: On no\_output\_of\_prior\_pics\_flag [Y.-K. Wang (Futurewei)]

[JVET-O0154](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6758) AHG17: Miscellaneous AHG17 topics [Y.-K. Wang (Futurewei)]

[JVET-O0176](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6780) On Tiles, Bricks and Slices [S. Deshpande (Sharp)]

Only the proposal 5 (also covered in JVET-O0152) in the contribution belongs to this agenda item.

[JVET-O0178](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6782) On DPB Parameters [S. Deshpande (Sharp)]

[JVET-O0201](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6806) AHG17: On Gradual Random Access (GRA) [M. Coban, A. Ramasubramonian, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-O0234](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6839) AHG17: Slice header extension [R. Sjöberg, M. Damghanian, M. Pettersson (Ericsson)]

[JVET-O0238](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6843) AHG17: Parameters in SPS or slice headers [M. Pettersson, P. Wennersten, R. Sjöberg, M. Damghanian (Ericsson)]

[JVET-O0241](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6846) AHG17: On Decoding Process Steps [S. Deshpande (Sharp)]

[JVET-O0270](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6875) AHG17: Signalling refreshed regions associated with a GRA picture [L. Chen, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0391](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6996) AHG17: Avoiding dependencies on externally controlled variables in the decoding process [M. M. Hannuksela, K. Kammachi-Sreedhar (Nokia)]

[JVET-O0392](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6997) AHG17: Output of SEI messages [M. M. Hannuksela (Nokia)]

[JVET-O0497](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7104) AHG17: On layer grouping for independent regions and ARC [Y. Sanchez, R. Skupin, K. Sühring, T. Schierl (HHI)]

### APS and ALF parameters signalling (8)

[JVET-O0245](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6850) AHG17: On TemporalId and NuhLayerId in APS [V. Seregin, M. Coban, A. K. Ramasubramonian, N. Hu, M. Karczewicz (Qualcomm)]

[JVET-O0246](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6851) AHG17: Separate luma and chroma ALF APS types [V. Seregin, N. Hu, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-O0299](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6904) AHG17: APS support for default and user defined scaling matrices [S. Paluri, J. Zhao, J. Lim, S. Kim (LGE)]

[JVET-O0893](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7515) Crosscheck of JVET-O0302 (Non-CE5: Simplification of ALF Coefficients in the APS) [N. Hu (Qualcomm)]

[JVET-O0491](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7098) AHG17: High-level syntax cleanup [K. Sühring, R. Skupin, Y. Sanchez, T. Schierl (HHI)]

[JVET-O0561](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7175) AHG17: APS ID Control Mechanism [S. Paluri, J. Lim, S. Kim (LGE)]

### Virtual boundary signaling (3)

[JVET-O0339](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6944) AHG17: On virtual bounary signaling [B. Choi, S. Wenger, S. Liu (Tencent)]

[JVET-O0340](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6945) AHG17: On modifiaction of virtual boundaries signaling [G. Bang, W. Lim, H.Y. Kim (ETRI)]

[JVET-O0445](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7050) [AHG17] Signaling of uniform virtual boundaries [A. DSouza, C. Pujara, R. Gadde, W. Choi, K. P. Choi (Samsung)]

### HRD (11)

[JVET-O0043](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6647) AHG17: Clarification on role of pic\_struct to HRD and the output picture process [C. Fogg (MovieLabs)]

[JVET-O0152](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6756) AHG17: HRD support for GRA and changing the term GRA to GDR [Y.-K. Wang (Futurewei)]

[JVET-O0153](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6757) AHG17: HRD clean-ups [Y.-K. Wang (Futurewei)]

[JVET-O0177](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6781) On HRD Signalling [S. Deshpande (Sharp)]

[JVET-O0180](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6784) On Buffering Period [S. Deshpande (Sharp)]

[JVET-O0189](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6793) AHG17: Support of decoding unit in HRD [K. Kazui (Fujitsu)]

[JVET-O0227](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6832) AHG17: Parsing dependency of picture timing SEI message on SPS [V. Drugeon (Panasonic)]

[JVET-O0228](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6833) AHG17: Harmonized HRD parameters signaling [V. Drugeon (Panasonic)]

[JVET-O0495](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7102) AHG17: On HRD for Open GOP and DRAP [Y. Sanchez, R. Skupin, K. Sühring, T. Schierl (HHI)]

[JVET-O0496](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7103) AHG17: On HRD for splicing [Y. Sanchez, R. Skupin, K. Sühring, T. Schierl (HHI)

[JVET-O0667](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7284) DPB size analysis of VTM5.0 using RA configuration in current CTC [X. Ma, H. Yang (Huawei)]

### VUI and SEI (6)

[JVET-O0041](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6645) AHG17: On signalling of frame field information [Y.-K. Wang (Futurewei), K. Sühring (HHI), C. Fogg (MovieLabs)]

[JVET-O0042](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6646) AHG17: Replicating pic\_struct into separate elements for future extensibility [C. Fogg (MovieLabs)]

[JVET-O0360](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6965) AHG17: On sRGB and sYCC [T. Suzuki (Sony)]

[JVET-O0622](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=7237) AHG2/AHG17: Draft text to update BT.2100 references and ICTCP HLG coding equations [S. McCarthy, F. Pu, T. Lu, P. Yin, W. Husak, T. Chen]

[JVET-O0492](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7099) AHG17: On merging of bitstreams and conformance [R. Skupin, Y. Sanchez, K. Sühring, T. Schierl (HHI)]

[JVET-O1177](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7814) Frame\_field\_info text combining JVET-O0041, JVET-O0042, and JVET-O0043 [C. Fogg (MovieLabs)]

Not reviewed specifically – provided to assist the editor.

## AHG12: high-level parallelism and coded picture regions (42)

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

[JVET-O0800](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7421) A summary of HLS proposals on coded picture regions [Y.-K. Wang (Futurewei)] [late]

### Sequence-level independent regions (10)

[JVET-O0138](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6742) AHG12: Treating region boundaries as picture boundaries [Hendry, S. Hong, J. Chen, Y.-K. Wang (Futurewei)]

[JVET-O1116](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7753) Crosscheck for JVET-O0138 (AHG12: Treating region boundaries as picture boundaries) [K. Sühring, Y. Sanchez, R. Skupin (HHI)]

[JVET-O0141](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6745) AHG12: Sub-picture based motion-constrained independent regions [Y.-K. Wang, Hendry, J. Chen (Futurewei), R. Skupin, Y. Sanchez, K. Suehring (HHI)]

[JVET-O0176](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6780) On Tiles, Bricks and Slices [S. Deshpande (Sharp)]

Only the proposal 6 in the contribution belongs to this agenda item.

[JVET-O0182](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6786) AHG12: On picture and sub-picture signaling [Y. He, A. Hamza (InterDigital)]

[JVET-O0183](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6787) AHG12: On layer-based sub-picture extraction and reposition [Y. He, A. Hamza (InterDigital)]

[JVET-O0334](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6939) AHG8/AHG12: On sub-picture partitioning support with layers [B. Choi, S. Wenger, S. Liu (Tencent)] [late]

[JVET-O0394](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6999) AHG12: On independently coded picture regions [M. M. Hannuksela (Nokia)]

[JVET-O0493](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7100) AHG12: On independent regions and output sub-picture sets [R. Skupin, Y. Sanchez, K. Sühring, T. Schierl (HHI)]

[JVET-O0555](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7169) AHG12: Sub-pictures and sub-picture sets with level derivation [J. Boyce, L. Xu (Intel)]

[JVET-O0700](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=7320) AHG12: On sub-picture info SEI message [Y. He, A. Hamza (InterDigital)] [late]

[JVET-O1143](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7780) AHG12: Text for subpicture agreements integration [Y.-K. Wang, Hendry, J. Chen, S. Hong (Futurewei), J. Boyce, L. Xu (Intel), R. Skupin, Y. Sanchez, K. Suehring (HHI), M. M. Hannuksela (Nokia)] [late]

Discussed Thursday 2300. This text expresses a previously discussed design. Decision: Adopted.

### Mixed NAL unit types within a picture (2)

[JVET-O0140](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6744) AHG12: On mixed NAL unit types within a picture [Y.-K. Wang, Hendry (Futurewei)]

[JVET-O0498](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7105) AHG17: On marking process and unequal NALU types per AU [Y. Sanchez, R. Skupin, K. Sühring, T. Schierl (HHI)]

### Slice, tile, and brick signalling in PPS and slice header (16)

[JVET-O0143](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6747) AHG12: Signalling of addresses for rectangular slices [R. Sjöberg, M. Damghanian, M. Pettersson, J. Ström (Ericsson), Hendry, Y.-K. Wang (Futurewei)]

[JVET-O0156](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6760) AHG12: On brick signaling [W. Lim, G. Bang, H. Y. Kim (ETRI)]

[JVET-O0172](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6776) On rectangular slice address signaling [B.-K. Lee (Xris)]

[JVET-O0173](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6777) On brick information signaling [B.-K. Lee (Xris)]

[JVET-O0176](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6780) On Tiles, Bricks and Slices [S. Deshpande (Sharp)]

Only the proposals 1 to 4 in the contribution belongs to this agenda item.

[JVET-O0181](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6785) Comments on High-Level Syntax of VVC [S. Deshpande (Sharp)]

Only the proposal 3 in the contribution belongs to this agenda item.

[JVET-O0199](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6804) AHG12: On rectangular slices [M. Coban, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-O0225](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6830) AHG17: On signalling of bottom right brick for rectangular slices [V. Drugeon, T. Nishi (Panasonic)]

[JVET-O0269](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6874) AHG17: Suggested syntax improvement on PPS [L. Chen, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-O0338](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6943) AHG12: On signaling for slice, tile and brick [B. Choi, S. Wenger, S. Liu (Tencent)]

[JVET-O0403](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7008) AHG17: On brick index signalling [P. Bordes, M. Kerdranvat (InterDigital)]

[JVET-O0452](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7058) AHG12: On tile and brick partition [Y.-J. Chang, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-O0453](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7059) AHG12: On rectangular slice signaling [Y.-J. Chang, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-O0454](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7060) AHG12: On sub-bitstream extraction [Y.-J. Chang, M. Coban, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-O0610](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7225) AHG17: Association of VCL NAL units to coded pictures [B. Heng, W. Wan (Broadcom)]

[JVET-O1075](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7712) AHG12: On tile and brick signalling (combination of JVET-O0390 and JVET-O0551) [M. M. Hannuksela (Nokia), N. Ouedraogo, E. Nassor, F. Denoual (Canon)] [late]

### Signalling of brick/WPP entries (4)

[JVET-O0144](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6748) AHG12: On end\_of\_subset\_one\_bit, end\_of\_brick\_one\_bit, and byte alignment in the slice data syntax [Hendry, Y.-K. Wang (Futurewei)]

[JVET-O0145](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6749) AHG12: Miscellaneous AHG12 topics [Y.-K. Wang, Hendry (Futurewei)]

[JVET-O0215](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6820) AHG12: Clean up on wavefront parallel processing signaling [T. Ikai, E. Sasaki, T. Chujoh (Sharp)]

[JVET-O0306](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6911) AHG17: Entry point offsets without start code emulation [K. Abe, T. Toma, V. Drugeon (Panasonic)]

### New tile/brick/WPP partitioning schemes (5)

[JVET-O0198](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6803) AHG12: On brick partitioning [M. Coban, A. Ramasubramonian, Y.-J. Chan, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-O0358](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6963) AHG12: On uniform tile spacing [Y. Fujimoto, M. Ikeda, T. Suzuki (Sony)]

[JVET-O0390](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6995) AHG17: On tile and brick signalling [M. M. Hannuksela (Nokia)]

[JVET-O0511](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7118) AHG12: On tiles and bricks partitioning [N. Ouedraogo, E. Nassor (Canon)]

[JVET-O0462](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7069) AHG12: Separated Luma and Chroma wavefront for dual tree [T. Poirier, F. Le Léannec, F. Galpin (InterDigital)]

[JVET-O1095](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7732) Crosscheck of JVET-O0462 (AHG12: Separated Luma and Chroma wavefront for dual tree) [S. Blasi (BBC)]

### Loop filtering across boundaries of independently coded regions (4)

[JVET-O0142](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6746) AHG12: On turning off ALF filtering at brick and slice boundaries [Y.-K. Wang, J. Chen, Hendry (Futurewei)]

Also included in the agenda item 6.5.

[JVET-O0494](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7101) AHG12: On filtering of independently coded region [R. Skupin, Y. Sanchez, K. Sühring, T. Schierl (HHI)]

Also included in the agenda item 6.5.

[JVET-O0654](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7270) AHG12/Non-CE5: Unification of boundary handling for adaptive loop filter [N. Hu, V. Seregin, M. Karczewicz (Qualcomm)]

Also included in the agenda item 6.5.

[JVET-O0858](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7479) Crosscheck of JVET-O0654 (AHG12/Non-CE5: Unification of boundary handling for adaptive loop filter) [H. Liu (Bytedance)]

[JVET-O0662](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7279) Non-CE5: Modified ALF filtering for Slice, Brick and Virtual boundaries [A. M. Kotra, S. Esenlik, B. Wang, H. Gao, E. Alshina (Huawei)]

Also included in the agenda item 6.5.

## AHG8: layered coding and resolution adaptivity (25)

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

[JVET-O1123](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7760) AHG8: Summary of layered coding proposals [S. Wenger (Tencent), Y.-K. Wang (Futurewei), M. M. Hannuksela (Nokia)] [late]

### Reference picture resampling (RPR) (12)

#### RPR proposals with some non-HLS aspects

These topics were discussed in Track A Wednesday 10 July at 1545 (GJS).

The BoG produced a text starting point as JVET-O1164, with filters based on the MC interpolation filter, TMVP and DMVR and BDOF handling. In input proposal documents there were three tested designs with software.

[JVET-O0641](file:///C:\Users\y00441455\Downloads\current_document.php?id=7257) AHG8: AHG 8: JVET common test conditions for adaptive resolution change (ARC) [M. G. Sarwer, R. -L Liao, J. Chen, J. Luo, Y. Ye (Alibaba)]

This contribution proposes common test conditions for adding adaptive resolution change support into VVC. It is asserted that establishing the adaptive resolution change CTC enables the JVET to select coding tools with better performance vs. complexity trade-offs. This contribution further suggests to test both modes of resampling, i.e. picture-based and block-based, in a core experiment before selecting the solution that offers better performance vs. complexity trade-off.

Testing both types of PSNR is requested.

As one point of comparison, it was agreed to select fixed filters for the non-normative filtering stages. These filters should be the SHM filters.

2:1 and 1.5:1 as primary; 4:1 optional, with both dimensions changing together.

It was agreed to use low-delay with 0.5 second switch points as the primary test case. Test only 5 second length with the LB test set.

[JVET-O1055](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7692) Crosscheck of JVET-O0641 (AHG 8: JVET Common test conditions for adaptive resolution change (ARC)) [J. Choi, J. Lim (LGE)]

[JVET-O0133](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6737) AHG8: Support for reference picture resampling - handling of picture size signalling, conformance windows, and DPB management [Hendry, S. Hong, Y.-K. Wang, J. Chen (Futurewei), Y.-C Sun, T.-S Chang, J. Lou (Alibaba)]

[JVET-O0134](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6738) AHG8: Support for reference picture resampling - handling of resampling, TMVP, DMVR, and BDOF [Y.-C Sun, T.-S Chang, J. Lou (Alibaba), Hendry, S. Hong, Y.-K. Wang, J. Chen (Futurewei)]

[JVET-O0757](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7378) Crosscheck of JVET-O0134 (AHG8: Support for reference picture resampling - handling of resampling, TMVP, DMVR, and BDOF) [H.-J. Jhu (Kwai Inc.)]

[JVET-O0303](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6908) AHG8: Adaptive Resolution Change [P. Chen, T. Hellman, B. Heng, W. Wan, M. Zhou (Broadcom)]

[JVET-O0701](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7321) Crosscheck of JVET-O0303 (AHG8: Adaptive Resolution Change) [Y. He (InterDigital)]

[JVET-O0242](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6847) AHG8: Enabling BDOF and DMVR for reference picture resampling [V. Seregin, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-O0240](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6845) AHG8: Adaptive Resolution Change (ARC) with downsampling [J. Samuelsson, S. Deshpande, A. Segall (Sharp)]

[JVET-O0319](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6924) AHG8: On Adaptive Resolution Change [P. Topiwala, M- Krishnan, W. Dai (FastVDO)]

[JVET-O0395](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7000) AHG8: On adaptive resolution changing and scalable coding [M. M. Hannuksela, A. Aminlou (Nokia)]

[Also listed in another section]

Only the RPR part in the contribution belongs to this agenda item.

[JVET-O1164](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7801) AHG8: Integrated Specification Text for Reference Picture Resampling [P. Chen, T. Hellman, B. Heng, W. Wan, M. Zhou (Broadcom), M. M. Hannuksela, A. Aminlou (Nokia), V. Seregin, M. Coban, M. Karczewicz (Qualcomm), T.-S Chang, Y.-C Sun, L. Zhu, J. Lou (Alibaba), Hendry, S. Hong, Y.-K. Wang, J. Chen (Futurewei), J. Samuelsson, S. Deshpande, A. Segall (Sharp), Y. He, A. Hamza (InterDigital), P. Topiwala, M. Krishnan, W. Dai (FastVDO), S. Wenger, B. Choi (Tencent)] [late]

Discussed 2320 Thursday (GJS & JRO).

The collocated picture ColPic was not defined in the basis text. The provided text added a syntax element to identify it (roughly as in HEVC). It was commented that it would be common to want to use the same collocated picture for all slices in a picture although different slices might use different reference picture lists, so this seemed like the right fix.

There is an issue with how to deal with how scaling ratios are determined, which includes the effect of picture sizes that not a multiple of 8. This proposal uses conformance cropping window sizes to determine the scaling ratio and moves the conformance cropping window to the PPS. It was agreed that this is a good starting point but we are not confident that it is really the right approach.

To avoid “pan-scan” behaviour, which was not the motivation to move the cropping window to the PPS, a constraint was established that all pictures with the same picture width and picture height shall have the same cropping window offsets.

Decision: Adopted.

#### RPR proposals with some non-HLS aspects

[JVET-O0184](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6788) AHG8: On ARC indicator [Y. He, Y. He, A. Hamza (InterDigital)]

[JVET-O0204](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6809) AHG8: On Adaptive Resolution Change (ARC) High-Level Syntax (HLS) [J. Samuelsson, S. Deshpande, A. Segall (Sharp)]

[JVET-O0332](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6937) AHG8: Signalling and filtering for Reference Picture Resampling (RPR) [B. Choi, S. Wenger, S. Liu (Tencent)]

[JVET-O1040](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7677) AHG8: Summary of Resolution Adaptivity related proposals [S. Wenger (Tencent), Y-K. Wang (Futurewei)] [late]

### Scalability (13)

[JVET-O0045](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6649) AHG8: Spatial Scalability using Reference Picture Resampling [S. Wenger, B. D. Choi, S. C. Han, X. Li, S. Liu (Tencent)]

[JVET-O0135](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6739) AHG8: Scalability for VVC – general [Y.-K. Wang, Hendry, J. Chen (Futurewei)]

[JVET-O0136](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6740) AHG8: Scalability for VVC - handling of POC, RPL, and RPM [Y.-K. Wang, Hendry, J. Chen (Futurewei)]

[JVET-O0185](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6789) AHG8/AHG17: On layer dependency signaling [Y. He, A. Hamza (InterDigital)]

[JVET-O0243](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6848) AHG8: On inter-layer reference for scalability support [V. Seregin, M. Coban, A. K. Ramasubramonian, M. Karczewicz (Qualcomm)]

[JVET-O0333](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6938) AHG8: On spatial scalability support with reference picture resampling [B. Choi, S. Wenger, S. Liu (Tencent)]

[JVET-O0335](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6940) AHG8: E-Sport Use cases of VVC region-wise scalability and its system support [B. Choi, S. Zhao, I. Sodagar, S. Wenger, S. Liu (Tencent)]

[JVET-O0336](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6941) AHG8: Region-wise scalability support with reference picture resampling [B. Choi, S. Wenger, S. Liu (Tencent)]

[JVET-O0337](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6942) AHG8/AHG17: Layered Random Access point (LRA) [B. Choi, S. Wenger, S. Liu (Tencent)] [miss] [late]

[JVET-O0395](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7000) AHG8: On adaptive resolution changing and scalable coding [M. M. Hannuksela, A. Aminlou (Nokia)]

Only the scalability part in the contribution belongs to this agenda item.

[JVET-O0436](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7041) AHG8/AHG17: indication of shutter angle for variable frame rate application [S. McCarthy, T. Lu, F. Pu, P. Yin, W. Husak, T. Chen (Dolby)]

[JVET-O0471](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7078) AHG8/AHG12: Layer concepts clarifications and improvements for immersive media use cases [E. Thomas, A. Gabriel (TNO)]

[JVET-O0473](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7080) AHG8: On HRD operations for layers [E. Thomas, A. Gabriel (TNO)] [miss] [late]

[JVET-O1130](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7767) 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)] [miss] [late]

[JVET-O1150](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7787) AHG8: Single-layer scalability approach [M. M. Hannuksela (Nokia)] [late]

This topic was discussed Friday 12 July 0845 (GJS & JRO).

This was one of three unified scalability proposals, focusing on POC, RPL, and RPM, prepared following the HLS BoG agreements on the scalability category of proposals. Such proposals are O1150, O1159, O1160.

This contribution, in the category known as “approach 3”, proposes an approach that uses a single layer (i.e. all NAL units have the same NuhLayerId value) for spatial, quality, view, and other types of scalability. It is asserted that no specification text changes beyond a new SEI message or VPS metadata are needed, although changing the bit allocation in the NAL unit header to allocate a greater number of bits to TemporalId could be desirable for applications using both temporal and other types of scalability together. The following is proposed:

1. VPS metadata or SEI message with two parts:
   1. Indicating temporal sub-layer dependencies. This part enables a more sophisticated pruning of sub-layers than simply removing sub-layers is descending order of TemporalId values.
   2. Mapping of scalability types (temporal, multiview, spatial/quality) to TemporalId values. It was commented that it might be desirable to rename that variable if that is how it would be used. Dropping the highest layer numbers would produce decodable bitstreams but side information would be needed to know whether such dropping would be a temporal subsetting or some other subsetting (e.g., spatial or view).
   3. The current layer ID would become a simulcast subset ID.
2. Reallocation of bits in the NAL unit header
3. poc\_output\_period\_minus1 in the SPS syntax for controlling normatively whether the decoder outputs only the highest "layer" (for spatial and quality scalability) or all "layers" (view scalability etc.) or some specific layers. POC values would need to be assigned in a special way by the encoder. If the output period is a power of two, this is basically just using the LSBs of the POC to control the output.

It was asked whether this aspect has random access issues. The proponent indicated that this aspect should be OK.

poc\_output\_period\_minus1 is used to specify a POC output period in terms of adjacent POC values. Out of the decoded pictures of the same POC output period, the decoded pictures that precede the last decoded picture in decoding order are not output. poc\_output\_period\_minus1 greater than 0 is used for spatial and quality scalability to avoid outputting more than one picture of the same capture time.

This contribution is a follow-up of the scalability part of JVET-O0395 (which additionally contained adaptive resolution changing parts).

Asserted benefits of the proposal include:

1. No changes in the syntax, semantics, or decoding process in VVC Draft 5 are required (although a new bit allocation in the NAL unit header could be preferable).
2. The proposal supports profile-tier-level (PTL) and HRD signalling through the existing sub-layer specific PTL and HRD signalling in VVC Draft 5.

It was noted that with this approach, “diagonal” referencing would be possible.

POC distances would get larger with this approach, since the LSBs of the POC are being overloaded to give distinct POCs to pictures of different layers along the same POC “timeline”.

[JVET-O1159](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7796) AHG8: Scalability for VVC – Text for approach 1 [Y.-K. Wang, Hendry, J. Chen (Futurewei), V. Seregin, M. Coban, A. K. Ramasubramonian, M. Karczewicz (Qualcomm), Y. He, A. Hamza (InterDigital), M. M. Hannuksela (Nokia), S. Wenger, B. D. Choi (Tencent)]

This topic was discussed Friday 12 July 0845 (GJS & JRO).

This was one of three unified scalability proposals, focusing on POC, RPL, and RPM, prepared following the HLS BoG agreements on the scalability category of proposals. Such proposals are O1150, O1159, O1160.

This contribution provides proposed text for the suggested design of supporting scalability coding for VVC based on the discussion in HLS BoG with approach 1 from the 4 approach categories described in JVET-O0136. The proposal is the result of integration from contributions JVET-O0136, JVET-O0185, JVET-O0243, JVET-O0333, and JVET-O0395.

For each entry in the reference picture list there would be one additional flag. It is asserted that despite this change, approach 1 is still the most efficient approach of the four approaches of this doc (for multilayer obviously). For single layer coding, there would be no impact beyond a bit in the SPS.

In approach 1, spatial and temporal scalability can co-exist due to the basic design of RPS+RPR.

Picture marking would operate only within each layer. All inter-layer referencing is within the same AU – i.e., no “diagonal” referencing would be supported, similar to SHVC. It was said that if diagonal referencing is desirable, the RPL syntax for inter-layer references could include a POC delta as well as a layer indicator.

In the VPS would be a mode type indicating whether the highest layer is output, or all layers are output, or there is an explicit indication of which layers to output.

[JVET-O1160](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7797) AHG8: Scalability for VVC – Text for approach 3 [Y.-K. Wang, Hendry, J. Chen (Futurewei), V. Seregin, M. Coban, A. K. Ramasubramonian, M. Karczewicz (Qualcomm), Y. He, A. Hamza (InterDigital), M. M. Hannuksela (Nokia), S. Wenger, B. D. Choi (Tencent)]

This topic was discussed Friday 12 July 0845 (GJS & JRO).

This was one of three unified scalability proposals, focusing on POC, RPL, and RPM, prepared following the HLS BoG agreements on the scalability category of proposals. Such proposals are O1150, O1159, O1160.

This contribution provides proposed text for the suggested design of supporting scalability coding for VVC based on the discussion in HLS BoG with approach 3 from the 4 approach categories described in JVET-O0136. The proposal is the result of integration from contributions JVET-O0136, JVET-O0185, JVET-O0243, JVET-O0333, and JVET-O0395.

Different pictures in an AU have different POC values and the RPL syntax is unchanged.

“diagonal” referencing could be supported, by simply not prohibiting it.

The main difference between this approach and JVET-O1150 is that this actually uses the layer ID as a layer ID and it uses the temporal ID as a temporal sublayer ID. As with that proposal, the POC deltas can become large.

General discussion of O1150, O1159, and O1160.

Discussion Friday 12 July 0945 (GJS & JRO).

A participant commented that O1159 is the more clean approach, as it does not overload POC with information irrelevant to the presentation timeline.

In the end, the proposed scalability basically comes down to reference picture management.

It was concluded that all three of these contributions propose a form of (spatial, quality, view, and temporal) scalability support that is feasible with no special features in the decoding process and with little or no syntax change (other than some supplemental data to describe the characteristics).

It was noted that SHVC has inter-layer motion vector prediction. A participant said this had a gain of about 0.7%. These proposals would support that in some form, but not for spatial scalability. No proposals to support this aspect have been submitted to JVET.

Some participants requested a coding efficiency analysis of the proposed approach(es), e.g., relative to simulcast and single-layer coding. It was agreed that the three proposed approaches would be very similar in terms of coding efficiency characteristics. It was commented that there were at least two independently developed software implementations supporting variants of these proposals.

It was noted that the MPEG requirements document says that “scalability modalities (such as temporal, spatial, and SNR scalability) shall be supported” (WG 11 N 17074 section 5.14) and “the standard shall support the coding of stereo and multiview content.”

Decision: It was agreed to adopt O1159.

# Complexity analysis and reduction (X)

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

# Encoder optimization (5)

Contributions in this category were discussed Thursday 11 July 1100–1255 in Track B (chaired by JRO).

[JVET-O0256](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6861) Non-CE: Fast encoder with adjusted threshold in dependent quantization [M. Wang, J. Li, L. Zhang, K. Zhang, H. Liu (Bytedance), S. Wang, S. Ma (Peking University)]

In the current VVC design, reverse scanning of coefficients is applied. To save the encoding time, the determination of last non-zero coefficient in the dependent quantization process is based on a given threshold. With this scheme, several high frequency coefficients can be directly set to zero without quantization. However, as a bundle of advanced prediction and transform technologies have been adopted, the frequency domain energy becomes more compact. Therefore, a larger threshold is proposed, which is asserted to be more effective on saving the encoding time. Simulation results reportedly show that the proposed threshold setting is able to bring 6% and 4% encoding time saving with 0.02% and 0.00% BD-rate loss under the AI and RA configurations, respectively.

Decision (SW): Adopt JVET-O0256, also in CTC

[JVET-O1018](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7655) Crosscheck of JVET-O0256: Non-CE: Fast encoder with adjusted threshold in dependent quantization [C. Auyeung, X. Li (Tencent)]

[JVET-O0432](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7037) AHG10: LMCS encoder improvement [F. Pu, S. McCarthy, T. Lu, P. Yin, W. Husak, T. Chen (Dolby)]

This contribution proposes non-normative encoder algorithm optimizations for LMCS to improve coding performance for SDR and enable LMCS for HLG. The specific changes proposed are:

1. support LMCS for HDR-HLG CTC content in RA and AI test conditions;
2. replace the fixed 5x5 neighborhood size used to calculate local spatial variance with a variable neighborhood size that increases or decreases based on picture resolution;
3. simplify the method of allocating codewords based on histogram and local spatial variance; and,
4. provide LMCS encoder configuration parameters in accordance with “Guidelines for VVC reference software development.”

The coding performance for SDR CTC using the proposed encoder implementation compared to VTM5.0 anchor (LMCS enabled) in terms of BDRate for PSNR Y, U, and V and processing times is:

* AI {-0.30%, 0.33%, 0.32%}, Enc: 101%, Dec: 100%
* RA {-0.16%, -0.11%, -0.12%}, Enc: 98%, Dec: 99%
* LDB {-0.20%, -0.37%, -0.59%}, Enc: 100%, Dec: 99%

The coding performance for HLG CTC using the proposed encoder implementation compared to VTM5.0 anchor (LMCS disabled) in terms of BDRate for PSNR Y, U, and V and processing times is:

* AI {-0.17%, 2.04%, 1.99%}, Enc: 103%, Dec: 103%
* RA {-1.03%, 2.28%, 1.94%}, Enc: 100%, Dec: 103%

Previously LMCS encoding was disabled for HLG, as it would have given loss.

It is noted that the software code is reduced from approx. 1000 to 500-600 lines. Most sequence (resolution) dependent optimization is removed as well.

It is also reported that this encoder would resolve the situation reported in JVET-O0551 that for some non-CTC sequences LMCS is not beneficial at all – O0551 also reports that the new encoder is better for those sequences.

Decision (SW): Adopt JVET-O0432, replaces the old encoder (and therefore it is also in CTC for SDR), additionally use it in CTC for HLG (new CTC doc for HDR needed).

[JVET-O0658](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7275) Crosscheck of JVET-O0432 on LMCS encoder improvements [S. Iwamura (NHK)]

[JVET-O0675](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7293) Crosscheck of JVET-O0432: LMCS encoder improvement [J. Zhao (LGE)]

[JVET-O0635](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7251) AHG10-Related: Optimized CTU level bit allocation in inter frames [Y. Li, D. Liu, Z. Chen (USTC), L. Li, Z. Li (UMKC)] [late]

This contribution proposes a modification to the CTU level bit allocation method for rate control in VVC reference software, i.e. VTM. In the current software VTM-5.0, the frame level lambda value is calculated by the frame level alpha and beta parameters as well as the frame level target bpp, according to the R-lambda model. Then the initial bit weight of each CTU within the frame is obtained by the CTU level parameters and the frame level lambda. Due to the inaccuracy of the updated frame level alpha and beta value, the calculated frame level lambda may be not accurate. Thus the CTU level initial bit weight is not optimized in terms of coding efficiency. In this contribution, we first allocate a constant target bit for skip CTUs, then we propose to use a bisection method to calculate the frame level lambda. With this, the CTU level bit allocation can be optimized for inter frame rate control. Compared with VTM-5.0, an average 0.44% BD-rate reduction can be achieved under low delay configuration.

For natural sequences, gain mostly at higher rate points.

For screen content (slide editing|show) inconsistent behaviour.

Also for RA, some loss at low rate points in natural sequences, might be beneficial only for LDB

Benefit of 0.44% BD rate not much to judge rate control.

Suggested to perform further study for improvements.

[JVET-O1148](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7785) Crosscheck of JVET-O0635 (AHG10-Related: Optimized CTU level bit allocation in inter frames) [Y.-C. Sun (Alibaba)]

[JVET-O0888](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7510) AHG10: Adaptive Coding Sub-set for encoder optimization [M. Bhat, D Gommelet, J.-M. Thiesse, D. Nicholson (VITEC)] [late]

This contribution introduces an additional flexibility capacity at the encoder level. This proposal tries to optimize the coding cost of specific parameters in case of underuse of the full standard capacity. Two scenarios are considered: underuse due to specific content at a given encoding point and desired underuse of modes due to a specific encoder implementation. While several mechanisms are already available to handle these underuses in previous standards and in current VVC draft, including high level flags and CABAC probability update, it is asserted that higher flexibility might bring a better trade-off for encoder design. The contribution proposes a subset signalization of specific coding modes at PPS or Slice level. This is presented in this contribution for two coding elements: the SAO offsets and the intra coding modes. Three way of sub-set signaling are evaluated in the contribution and it is asserted that early results show a potential to be further investigated.

It is proposed to reduce signalling of parameters for tools, e.g. for the benefit of encoders which do not exercise all modes to reduce the signalling overhead.

Though the concept is generic, it would need to be specifically defined for each tool what these subsets would be. This would have impact on the parsing, though not on the subsequent decoding process.

Examples are given for SAO offset values and Intra mode directions.

As an example, if an encoder restricts its search to only 19 intra modes, the loss is approximately 2%. If it is signalled that less modes are used, the loss goes down to 1.5%. Such benefit does not seem to be large.

For SAO, the gain was marginal, and the encoder runtime reduction is also not large.

The specification of low level tools in terms of parsing becomes more complicated as well.

It may not be beneficial for any encoder – more sophisticated encoders may use a different strategy of testing subsets of modes. On the other hand, it makes decoders and specification of parsing more complicated.

No results on amount of reducing encoding time for the intra case.

Though the general idea is interesting, the data are not complete enough to take action here.

It was suggested to run a CE, but this does not seem to be possible as it would need to employ realistic encoders.

Further study recommended. More convincing data about the benefit should be provided.

[JVET-O0549](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7162) AHG10: Encoder-only GOP-based temporal filter [P. Wennersten, R. Sjöberg, J. Enhorn (Ericsson)]

This contribution was discussed along with those in section 6.15 on Friday 5 July 1800–2130 in Track B (chaired by JRO).

This contribution proposes an encoder-only temporal filter. The filtering is done at the encoder side as a pre-processing step. Source pictures before and after the original picture to encode are read and an 8x8 block-based motion compensation method relative to the original picture is applied on those source pictures. Samples in the original picture are temporally filtered using source picture sample values after motion compensation. Only pictures at temporal sub layers 0 and 1 are filtered.

A similar method was proposed as JCTVC-AI0023 and adopted to HM at the previous JCT-VC meeting.

The method was reportedly tested under VTM-5.0 RA, LDB and LDP common test configurations. The average Y/U/V BD-rates for the common test conditions (CTC) are reported to be −3.49%/−6.96%/−6.53% (RA), −1.00%/−1.24%/−2.24% (LDB) and −1.47%/−1.95%/−2.78% (LDP). All BDR numbers were computed using unfiltered source sequences. The method is not proposed for AI encoding.

The version 2 of this document contains updated BDR numbers for RA.

It is proposed to adopt the proposed method into the VTM software but to disable it in the CTC.

Filtering strength is QP adaptive.

The proposal received support by several experts expressing interest.

This should not be in CTC (as preprocessing is usually undesirable for comparison), but interesting for experimentation. Could also be used for additional investigation of AHG13 to assess benefit of tools as additional information.

Question: Does it generate visual artifacts in some cases? Could happen. Also problems with fading sequences.

Decision (SW): Adopt JVET-O0549 (not CTC)

[JVET-O1004](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7640) Crosscheck of JVET-N0549 (AHG10: Encoder-only GOP-based temporal filter) [S. Esenlik (Huawei)]

# Metrics and evaluation criteria (1)

Contributions in this category were discussed Thursday 11 July 1255–XXXX in Track B (chaired by JRO).

[JVET-O0310](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6915) On video quality analysis [P. Topiwala, M. Krishnan, W. Dai (FastVDO)]

For more than 30 years, the video coding industry has been using mean-squared error-based PSNR as a measure of video quality, despite evidence of its inadequacy. Moreover, in the encoder, SAD is used instead of MSE to save multiplications. The contribution quantifies how these measures are inadequately correlated to subjective scores and obtain new measures that correlate much better. It focuses on the problem of full-reference assessment of video degraded only by coding and scaling errors, such as experienced by streaming services, and put aside issues of transmission, such as timing jitters, rebufferings, etc. It reports about the Video Multi-Assessment Fusion (VMAF) algorithm introduced by Netflix. Results with up to 97% correlation accuracy to subjective scores are reported on two Netflix datasets, using a neural network model.

Include into study of AHG10, which already has a mandate which covers the aspect of subjectively tuned quality metrics.

# Withdrawn (X)

JVET-O0137 (withdrawn), JVET-O0150 (withdrawn), JVET-O0218 (withdrawn), JVET-O0239 (withdrawn), JVET-O0251 (withdrawn), JVET-O0344 (withdrawn), JVET-O0348 (withdrawn), JVET-O0435 (withdrawn), JVET-O0458 (withdrawn), JVET-O0459 (withdrawn), JVET-O0478 (withdrawn), JVET-O0479 (withdrawn), JVET-O0518 (withdrawn), JVET-O0638 (withdrawn), JVET-O0661 (withdrawn), JVET-O0784 (withdrawn), JVET-O0798 (withdrawn), JVET-O0920 (withdrawn), JVET-O0948 (withdrawn), JVET-O0959 (withdrawn), JVET-O0964 (withdrawn), JVET-O1000 (withdrawn), JVET-O1016 (withdrawn), JVET-O1050 (withdrawn), JVET-O1103 (withdrawn), JVET-O1110 (withdrawn), JVET-O1122 (withdrawn), JVET-O1163 (withdrawn), JVET-O1175 (withdrawn)

# Plenary meetings, joint meetings, BoG reports, and summary of actions taken

## High-level syntax / systems relation meeting Saturday 6 July 0900-XXXX

This session, held on 6 March at 1430, was co-chaired by GJS and Youngkown Lim.

[JVET-O1076](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7713) Report of BoG on high-level syntax [Y.-K. Wang, J. Boyce]

The BoG met on the following days and time slots:

1. 3 July 2019 Wednesday from 16:00 to 21:12
2. 5 July 2019 Thursday from 09:00 to 20:35
3. 6 July 2019 Friday from 09:00 to 20:50

The initial review of the BoG report was conducted in the systems coordination meeting of Saturday 6 July at 1430 (GJS & Youngkwon Lim).

The BoG recommended the following:

1. Decision: Adopt a nonref\_flag, in the slice header, unconditioned, to indicate whether the picture may be used by other pictures for inter prediction reference. [JVET-O0181]
2. Consider a sub-picture design based on the following pieces:
   * Normative changes to the low-level decoding processes for treating rectangular regional boundaries as picture boundaries proposed in JVET-O0138, JVET-O0141, and JVET-O0394. Apply these changes to the boundaries of sub-pictures, where each sub-picture consists of one or more rectangular-mode slices that collectively form a rectangular region. [JVET-O0138, JVET-O0141, JVET-O0394]
   * Adopt signalling sub-picture location and size in the SPS (unless a sub-picture based GRA solution is agreed in the CE11 discussion), using the SPS syntax in O0555 for this purpose as a starting point, with the sub-picture ID replaced with grid index (not considering scalability, ARC/RPR, GRA). [JVET-O0555]
   * Adopt the following, pending on review of spec text (J. Boyce to coordinate the work on the spec text):
     + In the SPS syntax for signalling of sub-picture size and position, add a flag for each sub-picture to control whether the sub-picture boundaries are treated as picture boundaries. [JVET-O0141]
     + In the SPS syntax for signalling of sub-picture size and position, add a flag for each sub-picture to control whether in-loop filtering (deblocking, SAO, and ALF) across sub-picture boundaries are enabled. [JVET-O0141]

Further discussion of this item Thursday 11 July 2300. Text in O1143 was discussed. See notes for O1143.

1. The BoG agreed that it is generally useful to have some information signalling conformance points for (sets of) sub-pictures. The BoG requested to discuss at track on whether it is sufficient to have information in SEI message for applications, or should we rather normatively specify conformance points for (sets of) sub-pictures.

In the track review it was said that in principle, decoder conformance should be a matter of testing the decoded output when presenting a decoder with a rewritten bitstream.

1. Consider a reference picture resampling (RPR) design based on the following pieces (draft spec text to be prepared; V. Seregin to coordinate):
   * On signalling of picture sizes and conformance window [JVET-O0182, JVET-O0204, JVET-O0303, JVET-O0319, JVET-O0395]:
     + Signal the maximum size in the SPS.
     + Signal the actual picture size in the PPS, using the same coding as currently for the SPS. Need to move some derivations equations that rely on active resolution currently in the SPS to the PPS.
     + Move the conformance window as currently in the SPS to the PPS.
   * Use the size of the cropped output pictures for calculating the scaling factor between the current and reference pictures. Detailed study required by low-level coding tools experts. [JVET-O0204]
   * DPB is managed based on the maximum picture size (i.e., each picture store is of the size of a decoded picture of the maximum spatial resolution signalled in the SPS, regardless of the actual picture size).
   * A block-based resampling process based on the existing VVC interpolation filter (16 phases for luma, 32 for chroma), for both upsampling and downsampling. [JVET-O0134, JVET-O0303, JVET-O0242].
   * The following constraints on TMVP, DMVR, and BDOF:
     + TMVP generally allowed but only when the collocated picture has the same resolution as the current picture. [JVET-O0134, JVET-O0242, JVET-O0303, JVET-O0395]
     + DMVR generally allowed but disabled for a coding block when referring to different resolution. [JVET-O0134, JVET-O0242, JVET-O0303]
     + BDOF generally allowed but disabled for a coding block when referring to different resolution. [JVET-O0134, JVET-O0242, JVET-O0303]

In the track review it was agreed that for the moment, RPR cannot be used when sub-pictures are used.

Further discussion of this item Thursday 11 July 2320. Text in O1164 was discussed. See notes for O1164.

1. ~~Discuss whether the existing affine fallback mode shall be triggered for a coding block when referring to a reference picture with a different spatial resolution than the current picture, which is proposed in JVET-O0303.~~

In the track review the expression of concern about this issue was withdrawn.

1. Establish CTC for reference picture resampling (RPR), based on the following details, coordinated by J. Luo:
   * Resampling ratios: 2:1, 1.5:1, and optionally 4:1, use same ratio in both dimensions.
   * Test configurations: 1) low delay, fixed in time, like 0.5 sec low, 0.5 sec high, and 2) random access, I picture only.

In the track review it was said that this is only for CEs that involve RPR.

1. Establish a CE on reference picture resampling filters, coordinated by V. Seregin.
2. Decision: Adopt changing the coding of pps\_virtual\_boundaries\_pos\_x[ i ] and pps\_virtual\_boundaries\_pos\_y[ i ] from u(v) to u(13).
3. Pending on review of spec text (to be prepared by S. Deshpande and Y.-K. Wang), rephrase to avoid phrases like "the active xPS" and not to specify a parameter sets activation process. [JVET-O0113]

In the track review it was agreed that this is just a matter of editorial activity for establishing constraints so that these aspects are specified correctly, and thus the matter of terminology may be delegated to the editor. We may wish to add some remark to indicate that the referenced PS may be called the active PS. The editor may also consider the text in O0181 proposal 2.

1. Decision: Adopt the following: signal num\_tiles\_in\_pic\_minus1 under the syntax condition "if( uniform\_tile\_spacing\_flag  &&  brick\_splitting\_present\_flag )", to avoid a PPS parsing dependency on SPS. [JVET-O0236]
2. Decision: Adopt the frame-field information SEI message, for separately signalling of the frame field information and the picture timing information in different SEI messages, and it is constrained that, when field\_seq\_flag is equal to 1 for a CVS, a frame-field information SEI message shall be present for each coded picture in the CVS. Accordingly, the condition "if( CpbDpbDelaysPresentFlag )" is removed from the picture timing SEI message. [JVET-O0041]
   1. Discuss whether the frame field information SEI message should be included in the base VVC spec (as the picture timing SEI message) or in the separate SEI part (as other SEI messages that do not directly affect the specification of conformance).

In the track review, it was agreed that since this does not affect HRD like picture timing does, it should go in the separate SEI part. It was noted that we may need further discussion with parent bodies about the division of VVC into multiple text specifications.

1. Decision: Adopt the following changes for signalling of sub profiles: allow signalling of zero or more sub profile fields, use 8 bits for the count, and use 32 bits for the sub profile field. [JVET-O0044]. In further Track A discussion 10 July at 1800, it was noted that we should keep in mind that this may imply variable-length carriage of interop enabling syntax by the systems layer, which was not done for HEVC and AVC.
2. Decision (basically editorial): Adopt a constraint to require that, for P and B slices, the number of active entries in RPL 0 is greater than 0, and for B slices, the number of active entries in RPL 1 is greater than 0. [JVET-O0148]
3. Decision: Adopt the following changes: [JVET-O0244]
4. Additionally signal weighted prediction enabled flags in SPS, which are signalled in the PPS currently, and to syntactically prevent zero delta POC values when weighted prediction is not enabled. Editorial: move the condition out of the RPL structure syntax.
5. Decision: Adopt the following: [JVET-O0151]
   * The value of no\_output\_of\_prior\_pics\_flag for CRA pictures starting a new CVS is used similarly as for IDR pictures.
   * The no\_output\_of\_prior\_pics\_flag is also signalled for GRA pictures and applied for GRA pictures starting a new CVS similarly as for IDR pictures.
   * This aspect withdrawn after discussion: ~~The no\_output\_of\_prior\_pics\_flag is also signalled for the reserved IRAP VCL NAL unit types.~~
6. Decision: Adopt text for the basically empty Annex B on byte stream format. The text is exactly the same as in HEVC, except for the addition of DPS\_NUT and APS\_NUT, along with VPS\_NUT, SPS\_NUT and PPS\_NUT, in the semantics of zero\_byte. [JVET-O0154]
7. Decision (bug fix): Adopt moving of slice\_pic\_order\_cnt\_lsb to be before recovery\_poc\_cnt in the slice header. [JVET-O0176]
8. No action after track review regarding proposal of coding of sps\_max\_dec\_pic\_buffering\_minus1[ i ] and sps\_max\_num\_reorder\_pics[ i ] using delta coding. [JVET-O0178]
   * Discuss whether sps\_max\_latency\_increase\_plus1[ i ] should also be delta-coded.Are the values of sps\_max\_latency\_increase\_plus1[ i ] are also monotonic non-decreasing? (after side discussion, they do not seem to be)
9. Decision (bug fix/cleanup): Adopt conditionally signalling of sps\_sub\_layer\_ordering\_info\_present\_flag based on the value of sps\_max\_sub\_layers\_minus1. [JVET-O0178]
10. Decision: Adopt changing the coding of recovery\_poc\_cnt to ue(v) instead of se(v), thus disallowing negative values that allow output gaps. [JVET-O0201]

The BoG was aware that negative and zero values were allowed for recovery\_poc\_cnt in HEVC and the same behaviour (allowing output gaps) was also allowed in AVC. Does the track know why an output gap was allowed in AVC and HEVC? Should we further disallow value zero? In the track discussion it was agreed not to disallow the value zero so that encoders that would like to just use GRA all the time would not need to sometimes use CRA instead.

1. Decision: Adopt the slice header extension mechanism that is essentially identical to that in HEVC. [JVET-O0234]
2. Decision (slice header bit savings): Adopt the following, but do it in the PPS instead of SPS. Further study whether some of those should be just in the PPS only: [JVET-O0238]
   * Add a sps\_or\_slice\_flag in the SPS that specifies whether the following syntax elements are always signalled in slice headers or conditionally signalled in the SPS or slice headers:
     + dep\_quant\_enabled\_flag
     + ref\_pic\_list\_sps\_flag
     + slice\_temporal\_mvp\_enabled\_flag
     + mvd\_l1\_zero\_flag
     + collocated\_from\_l0\_flag
     + six\_minus\_max\_num\_merge\_cand
     + five\_minus\_max\_num\_subblock\_merge\_cand
     + max\_num\_merge\_cand\_minus\_max\_num\_triangle\_cand
   * If sps\_or\_slice\_flag is equal to 1, the following applies:
     + The syntax elements are present in the SPS.
     + For each of these syntax elements, if the value in the SPS is equal to 0, the syntax element is also present in the slice header, and the value signalled in the slice header is used. Otherwise, the syntax element is not present in the slice header and the value signalled in the SPS is used.
   * Otherwise, the syntax elements are not present in the SPS and are present in the slice header.
3. Decision (bug fix): Adopt the following bug fixes: [JVET-O0241]
   * Setting of PictureOutputFlag in the general decoding process for a coded picture and in the process for generating unavailable reference pictures.
   * Correctly setting the POC value for long-term reference pictures in the decoding process for generating unavailable reference pictures.
   * Add the inference of slice\_pic\_order\_cnt\_lsb for the generated LTRP in the decoding process for generating unavailable reference pictures.

End of systems coordination reviewed part. up to 1810

Presentation of some system concepts by Younkwon Lim:

* Consider a system operating with
  + A collection of NAL units
  + A “BEAMer” (bitstream extraction and merge) functionality
  + A decoder
  + A renderer
* A layered bitstream could conceptually output multiple “layers”
  + Our plan is that the bitstream contains “access units”, and all layers in an access unit that are output from the decoder would have the same output time / order.
* Subpictures – it was suggested that a subpicture would have some identifier. Currently, slices have a slice ID. Subpictures don’t currently have an ID but this is likely to be considered.
* MPEG Systems has an interest in developing texts related to BEAMing, with a normative spec and informative guideline, and potentially software
* It was suggested that the video spec could be split, e.g., into a one spec for HLS and HRD and DPB, and a core coding technology spec for slice data and decoding process (with a third for SEI messages). Or a spec containing only aspects at the highest level such as PPS and above and a second spec for the VCL NAL units. Some other participants feared that attempting such a split would cause problems for trying to make a unified technical design. There was also some discussion of the relationship with profiles. Our goal has been to make the design features lightweight enough that we would not need a profile that does not support the key features.

end 1930

## Plenary meeting Monday 8 July 1400-1945

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):

* CE1 & related CABAC initialization (section 5.1)
  + Decision (cleanup): CE1-1.2, pending consideration of non-CE contributions or additional test results.
  + Related contributions (section 6.1) To revisit JVET-O0946
* CE3 & related intra prediction and mode coding (section 5.3)
  + Decision (complexity): Adopt JVET-O0106 for 3-1.6 (pending non-CE contribution review).
  + Decision (complexity reduction): Adopt 3-2.1.2 with spec text in JVET-O0050.
  + To revisit 3-3 CCLM chroma location & small blocks
  + BoG created for related contributions (section 6.3) [Geert Van der Auwera] ([JVET-O1093](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=7730)) – see notes for later track review
* CE6 & related transforms and transform signalling (section 5.6)
  + Decision (simplification): Adopt 6-2.1a from JVET-O0094.
  + BoG created for related contributions (section 6.6) [X. Zhao] ([JVET-O1115](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=7752)) – finished – to be reviewed
* CE7 & related quantization and coefficient coding (section 5.7)
  + Decision (throughput/worst-case): Adopt CE7-1.1 as in JVET-O0052 with the limit for chroma set the same as for luma.
  + A detail left over from the previous meeting on joint CCLM chroma residual coding: Decision (closing an open detail in joint chroma mode): Adopt CE7-2.1 from JVET-O0105.

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| **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 |
| **CE7-2.1** | -0.18% | -0.57% | 0.07% | 100% | 98% | -0.11% | -1.10% | 0.18% | 99% | 101% | 0.08% | -0.67% | 1.07% | 101% | 102% |

* + Transform skip residual coding: Decision (coding efficiency for SCC): Adopt CE7-3.10 of JVET-O0122.

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| **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 |
| **CE7-3.10** | -1.23% | -1.13% | -1.15% | 104% | 99% | -0.89% | -0.83% | -0.93% | 103% | 98% | -0.57% | -0.79% | -0.71% | 104% | 100% |

* + BoG created for related contributions (section 6.7) [Heiko Schwarz] ([JVET-O1117](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=7754)) – finished – to be reviewed
* CE11 & related gradual random access (section 5.11)
  + Revisit for further discussion of treating tile boundaries as picture boundaries after discussion of that in other contexts. We may also want to move the syntax for virtual boundaries to the slice level.
  + It was remarked in the plenary that some content for GRA was available for viewing, and participants were encouraged to have a look at it.
  + Further study on wavefront GRA (section 6.11)
* QP signalling (section 6.12)
  + VPDU pipeline issue: Decision (bug fix): Adopt JVET-O0046.
  + SPS-level luma-chroma QP mapping table syntax, separate for Cb and Cr, no default, offsets after the mapping table, revisit luma-chroma QP mapping table syntax, CTC, QP for joint chroma coding
  + Revisit CU-level chroma QP control
* Entropy coding (section 6.13)
  + Revisit CABAC disable mode O0308
  + Further study of alternative zero-word padding aspects and GT1 flag grouping
  + Can editorially remove 30-40 unused contexts
* Chroma formats (section 6.14)
  + Remove useless chroma syntax from slice header (no action on SPS)
  + Include BT.2100-2 update (in principle)
  + In plenary, it was noted that we plan for the text to referencing CICP rather than including the colour specifications in-line.
* High-level syntax
  + Coordination meeting held (section 11.3)
  + BEAMer concept
  + Sub-pictures
  + Reference picture resampling (CE on filters)
  + Frame-field information SEI message
  + Byte stream format
  + Slice header bit savings
  + BoG continuing Y.-K. Wang, J. Boyce ([JVET-O1076](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=7713))

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:

**CE2 Luma/Chroma dependency**

* CCLM, LMCS
* No direct adoption from CE, BoG work on CE related (not reported yet)
* Desire to achieve reduction of dependency without losing much efficiency
* From CE related, adopted some simplifications and bug fixes in LMCS (O0428/O0429)

**CE4 Inter prediction**

* Adoptions from CE:
  + Test 4-1.2 Switchable half-pel interpolation filter, signalling as AMVR mode (RA gain 0.26% luma, 0.8% chroma)
  + Test 4-2.1 PROF/BDOF on top of affine (RA gain 0.48%)
* Normative Adoptions from CE related (so far) – cleanups, simplifications, minor improvements
  + O0164 / O0587 (method 2): remove scaling of spatial motion vector candidates in AMVP list construction.
  + O0567: add a bitstream conformance that MvdL1 of SMVD mode shall be within the range of [-215, 215-1]. (it is clarified in the track B discussion that this only applies to SMVD MvdL1 after mirroring – generally larger ranges of MVD might be desirable)
  + O0284 (method 2) / O0579 (method 3): sym\_mvd\_flag is not signalled and is inferred to be false when mvd\_l1\_zero\_flag is true. (no impact on performance in CTC, fixes an issue of unreasonable usage in non-CTC)
  + O0438: affine AMVR control flag is conditioned on affine control flag in SPS.
  + O0366 (method 2): simplify BCW index derivation by setting it to the BCW index of the first candidate spatial neighbor block in the process of constructing an affine merge candidate.
  + O0681 (method 2) Disabled DMVR, BDOF and BCW for CIIP + inherit BCW index
* Decision: Range of MVD shall be extended to [-217, 217-1] (no specific doc)

**CE5: Loop filtering**

* Deblocking: Extensive subjective testing
* CE5-2 Align deblocking with 4x4 grid
  + No need in case of chroma
  + Luma shows visual improvement, complexity evaluation of 2 different methods ongoing (one of them seems slightly better than the other concerning the number of cases of improvement over anchor)
* CE5-3 MV difference threshold reduced to ½ pel
  + Visual benefit proven, adopt 0061

CE5-4 Adaptive loop filter

* 5-4.2, alternative chroma filters with CTU selection (8 filters), >2% chroma gain in RA and LD modes, adopt O0090

From CE related Deblocking

* Adopt O0159 Deblocking tC table for 10-bit video with the modification such that the downscaling operation would exactly reproduce the current 8 bit table.

From CE related ALF

* Various simplifications in APS signalling:
  + Coding of coefficients without prediction, without position dependency, only EG3
  + Coding of clipping value for nonlinear ALF by fixed length instead adaptive EGk
  + Remove floating point style expression of clipping value determination

On ALF APS

Multiple filters for chroma - switching between several chroma filters is desirable (results of CE5 indicate that up to 8 are beneficial)

Following options:

1. Stay with current APS (luma set + 1 chroma), but allow several APS for chroma in slice and select at CTU which one is best for luma and which one is best for chroma
2. Extend current APS such that several chroma filters are in, stay with 1 APS selection for chroma at slice, use direct indexing of selected chroma at CTU level rather than APS indexing (solution as suggested in CE5-4)
3. Have separate APS for chroma, either 1 per filter, or 1 with multiple filters

The most flexible solution would be 2., to have an APS that contains 0…25 luma filters and 0..8(or more?) for chroma. This would allow high flexibility in usage, including the case where an APS just carries a collection of chroma filters.

Decision from plenary: Agreed that the concept 2. mentioned above should be used. This is reflected in the adoption of O0090 from CE5-4, but this needs to be integrated with other changes of ALF APS.

Storage of APS parameters for local decoding

Results e.g. O0425 indicate that up to 25 filters may not always be needed.

Reasonable constraints for number per picture need to be identified.

One possibility could be to constrain the amount of memory needed for decoded APS parameters per picture. This aspect was discussed in plenary, and agreed to be further investigated.

Filtering at region boundaries

The current virtual boundary concept of ALF (adopted last meeting) only applies at horizontal boundaries. Slice/tile/brick boundaries and subpicture boundaries can also be vertical but always coincide with CTU boundaries.

When filtering is disabled across the boundaries (regardless if they are horizontal or vertical): The deblocking is turned off at the boundary, whereas SAO and ALF still are operated but require some padding. For SAO, a simple repetition of boundary is sufficient. The question is which padding method to use for the ALF within the current slice/tile/brick.

* At the horizontal boundary (except picture boundary), the virtual boundary concept is applied.
* At the vertical boundary, something must be defined. Track B recommends using the virtual boundary concept for that as well. As the content could be continuous across the vertical boundary, the simple padding method might cause some artifacts. Complexity-wise, extending the VB concept to vertical boundaries that shall not be filtered across boundary is not critical.
* Further, the current spec disables the virtual boundary concept at the lower CTU boundary if that is a slice/tile/brick boundary which is inappropriate and should be changed.

At picture boundary, the sample repetition should be retained. This is a simple coordinate clipping.

In the plenary, it is agreed that the best solution for slice/tile/brick/subpicture boundaries is applying the VB concept of ALF, including vertical and lower CTU boundaries. Decision which relates to an adoption of JVET-O0662, and JVET-O0625.

It is noted that the term “virtual boundary” was introduced in the text spec also for something related to 360 video. A better term should be found for this.

In 360 video, face boundaries could be at any multiple of eight, and not aligned with CTU boundaries. This would require a mechanism where any filtering is disabled at those positions, and for ALF invoke a simple padding mechanism. It was agreed in the plenary that this should be the same repetitive padding as used at the picture boundary.

Decision of plenary: For boundaries of 360 faces, allow disabling filtering, and use the same repetitive padding as for picture boundary. Perhaps call that “virtual picture boundary” to differentiate from the above case.

**CE8: Screen content coding tools**

On IBC BV coding:

* Same coding for MV and BV coding? It is reported that the maximum gain that is currently known when designing BVD coding different from MVD coding is around 1.3% for TGM/AI, and 0.5% for class F/AI. This would be more complex, increasing number of context coded bins.
* It is agreed that such gain is not substantial enough to justify deviating in BVD coding from MVD coding, or defining different MVD coding just for the benefit of screen content, and further decreasing the CABAC throughput by increasing number of context coded bins.

On BV validity check:

* Many opinions (and contributions) on the importance of encoder and decoder side availability checks, regarding the reference block addressed by BV
* Interesting new ideas (e.g. O0127) allow doing it with minimum effort and safely on either side. Most appropriate solution would be a simple definition of bitstream constraint, without making it mandatory to check for invalid bitstreams at decoder (also in the interest of keeping decoder conformance definition simple)
* Current restrictions seem over-engineered – additional gain reported when all blocks previously decoded can be addressed

Other aspects of SCC:

* Agreed that IBC for dual tree should be disabled – minimum loss, and BV derivation for chroma was complicated in that case
* For 4:4:4, single tree provides large gain (6% over dual tree in TGM)

Palette:

* Palette mode shows interesting gain for 4:4:4 (tested so far with YUV), and here it provides in particular more gain for the single-tree case, which is likely due to less overhead and ability to utilize the redundancy between the components in a single palette
* For 4:2:0, the gain is not large enough (even with the additional tools of CE8-2.2/3/5) to justify a complete different sample coding at CU level. It is noted that the gain of the baseline has even become lower in VTM5. This could be due to the adoption of TS. On the other hand, TS is not applied to chroma so far. Though a CE proposal for TS Chroma did not show benefit for 4:2:0 under CTC, it could better perform for 4:4:4-
* Investigation of palette on 4:2:0 should be discontinued in CE
* It is suggested to include a palette mode in VVC, which shall only be invoked for coding of 4:4:4 content. This should be the well-understood “base palette mode” from CE8-2.1, which can be used for both single tree and dual tree cases. Further investigation should be performed in CE to verify the gains with more 4:4:4 material, and further study improvements or simplifications. There is no need to stick to the HEVC palette method.

Decision of plenary: Adopt JVET-O0119, the CE8-2.1 “base palette” to VVC in 4:4:4 modes/profiles.

On BDPCM/TS/lossless

* BDPCM flag at high level
* BDPCM only enabled when TS is enabled
* When BDPCM is switched on locally, TS is inferred
* Intra prediction mode (h/v) alignment with BDPCM
* Some inconsistency with deblocking strength, quantization, etc. -> new AHG

**CE9: Decoder motion vector derivation**

CE9-1.2 /O0055 Use integer-distance DMVR cost for BDOF early termination & no early BDOF termination when DMVR disabled (no loss)

CE9-2.2 /O0108: Disable DMVR & BDOF when CIIP is used (no loss)

During the plenary discussion, proponents of CE9-2.1b again requested adoption of their method, which had been disagreed in track B. However, no agreement was reached in plenary.

From CE related:

* Slice level flags to disable DMVR and BDOF (O0504)
* Further simplification of DMVR early termination (O0590)

**CE10: Neural network based loop filtering**

Probably too early for normative action

Findings from CE:

* Interesting reduction of complexity, but the performance also drops then
* Generally most gain for intra / real in-loop training difficult

Subjective viewing to be conducted

Might better continue as AHG only, no CE

**Other coding tools**

Adopt JVET-O0525 – Remove PCM mode – agreed, as PCM mode is hardly used, and better concepts such as TS+ for lossless.

Adopt JVET-O0526 – minimum CTU size 32x32 - agreed

Also more discussion on VPDU concepts (in context of CE2 et al.): The latency of luma/chroma should not exceed one quarter of the VPDU size. The VPDU size would be min (CTU size, 64x64).

Adopt JVET-O0537 Weighted intra and inter prediction mode

* Pipelining in PDCP/CIIP OK with new concept
* 0.13% in RA, approx. 0.4% in LD modes, 1% encoder runtime

(no consensus reached in plenary – decision reverted).

This was again brought up in the Friday morning plenary. As the tool is not a simplification, but a modification of CIIP targeting compression benefit and the additional BD gain for RA is low, no action was taken.

Adopt JVET-O0549 Encoder-only GOP-based temporal filter

The method was reportedly tested under VTM-5.0 RA, LDB and LDP common test configurations. The average Y/U/V BD-rates for the common test conditions (CTC) are reported to be −3.49%/−6.96%/−6.53% (RA), −1.00%/−1.24%/−2.24% (LDB) and −1.47%/−1.95%/−2.78% (LDP). All BDR numbers were computed using unfiltered source sequences. The method is not proposed for AI encoding.

The general status of track B was then presented and discussed, which particularly included the following aspects:

* ..

Performance assessment contributions were discussed, except adaptive resolution conversion (section 4.3) 1730-1940.

Miscellany noted

* Signal processing aspects of
  + AHG12: high-level parallelism & coded picture regions
  + AHG8: layered coding & resolution adaptation
* Scalability
* 360 degree video (4) (section 6.16) (Track A) – covered in HLS BoG
* Project development (section 4): text & software (1), test conditions (1), performance assessment (5)
* Scheduling
* Docs waiting for approval

## Plenary meeting Thursday 11 July 1530

Discussion of ALF interaction with raster slices – example shown in figure below:

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Picture dimensions required to be a multiple of 8 – OK.

Previous schedule plan: Tue 1 Oct – Wed 9 Oct

Start meeting Afternoon 1 Oct.

Agenda of 1 & 2 Oct is only HLS, layered coding, resolution adaptivity, GDR, loop filtering. (Friday JCT-VC starts, Saturday coordination meeting.)

Workshop on 8th for World Standards Day.

End meeting by 1400 11 Oct.

It was agreed that the config files for HDR common test conditions should use chroma location type 2 for PQ content. Further study was recommended regarding HLG chroma location.

qq

## Closing Plenary meeting Friday 12 July

… .

## Joint meeting XXday XX March XXXX-

JVET with … .

## BoGs (X)

[JVET-O1039](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7676) BoG report on CE4 inter prediction with merge modifications [C.-C. Chen, H. Yang]

Reviewed in track B Sat 6 July 1445-1600 (chaired by JRO)

The CE4 BoG sessions on merge modifications were held 2045~2200 on July 3, 0900~1330 and 1500~1740 on July 4, 2000~1100 on July 5, 0900~1100 on July 6. There are 6 categories that either has been or is being discussed in this BoG as follows:

* Triangle prediction merge mode (22/22)
* Merge mode with MVD (3/3)
* Combined intra and inter prediction (5/5)
* Merge list construction (3/3)
* Merge mode syntax (0/17)
* Subblock temporal motion vector prediction (2/9)

The recommendations that were made during the BoG sessions cover the followings:

* General recommendation (3)
* Normative change (4)
* Non-normative change (1)
* Recommended CE4 test (2)
* Further discuss in Track (1)
* Contribution not presented (24)

**Normative changes (4)**

[JVET-O0222](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6827) Non-CE4: Modification of triangle merge mode enabling criterion [D. Liu, R. Yu (Ericsson)]

Since TPM supports 128xN/Nx128 CUs which exceed the size of 64x64 VPDU, the proposal disables these CU sizes in the application of TPM. (RA: 0.02% gain; LDB: 0.03% loss.)

It is stated that removing 128xN/Nx128 CUs helps align the processing unit to that of VPDU and also stated that this proposed method can reduce the storage size of weighting values (if they are not computed on the fly).

Same proposals: JVET-O0362 and JVET-O0249 Test 3.

The proponents of JVET-O0249 comments that disabling SBT in TPM is similar in spirit to remove 128xN/Nx128 CUs.

It is stated from a participant that this same topic was discussed in Marrakesh meeting in JVET-M0207/JVET-M0438. The related note is quoted from the CE10 BoG report (JVET-M0873), as below:

* It is remarked that 128x128 TPM might also violate VPDU condition. It is answered that this not the case, as it can be done on a 64x64 block basis.

As commented from several participants, it is noted that performing TPM on large block has complexity implications but no performance-wise benefit.

Recommendation: Adopt. (JVET-O0222/ JVET-O0249 Test 3/ JVET-O0362)

From the discussion in track B: There should not be a problem with VPDU, as motion comp in large block can be performed in sub-partitions, same with the weighting. There is basically no gain (very small in RA, but small loss in LDB). Benefit not clear. No action.

[JVET-O0629](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7244) Non-CE4: Simplification of motion field for triangle partition [R.-L. Liao, Y. Ye, J. Chen (Alibaba)]

Method 1: Enlarge the unit of motion storage from 4x4 to 8x8 (RA:0.03%/99%/99%; LB:0.04%/100%/99%)

A non-proponent commented that for larger CUs, this design creates motion field that fits blending process more closely.

With 8x8 unit storage, the number of comparisons to check whether each motion storage unit belongs to partition 1, partition 2 or blending area is reduced from 496 to 120 per 64x64 block (roughly 2 comparisons per 4x4 block).

It is also commented if a CE is formed to study TPM motion storage related techniques, complexity characteristics (i.e., number of comparisons to determine motion storage) should be reported.

A non-proponent supports adopting method 1 and also commented that the loss of 0.03% is relatively minor against VTM anchor.

Recommendation: Adopt method 1.

From discussion in track B: There is no issue with complexity. Benefit not obvious – no action.

JVET-O0681 CE9-related: Disabled DMVR, BDOF and BCW for CIIP [H. Huang, W.-J. Chien, M. Karczewicz (Qualcomm)]

It is proposed to disable BCW by reset the weighting to equal, and 1) reset BCW to equal weight, 2) inherit BCW index.

Performance: 1) -0.01% RA, 0.03% LDB (luma), 2) -0.01% RA, -0.02% LDB, no runtime impact observed.

It is claimed the benefit is software decoding complexity.

It is commented that conceptually not necessary to further weight inter as inter and intra will be combined with weighting.

It is asked whether we should do weighted prediction for CIIP. It is commented that weighted prediction is somewhat different as it is for fading and there is an offset in weighted prediction.

Two participants suggest adoption of method 2.

Recommendation: Adopt method 2 (inherit BCW index).

Decision: Adopt JVET-O0681 method 2

[JVET-O0167](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6771) Non-CE4: On SbTMVP motion data derivation [J. Zhao, S. Kim (LGE)]

Method 1: Use MV from collocated subblock at another position as base motion vector, where the proposed position is at the immediately bottom-right motion storage unit relative to the center point of collocated block pointed to by temporal MV.

(RA: 0.00%; LDB: 0.00%)

The proponent claimed the benefits are:

* Simplify SbTMVP base motion data derivation by re-using one of the sub-CU’s motion data as base motion data.
* Avoid a separate base motion data derivation process, and therefore remove the associated temporal motion vector scaling.

The benefit is to simplify the operation for certain type of decoder implementation because it can reuse the TMVP derivation of subblocks.

One non-proponent expresses interest to have this feature.

Recommendation: Adopt method 1.

From discussion in track B: There is no issue with complexity. Benefit not obvious – no action.

**Non-normative changes (1)**

[JVET-O0379](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6984) Non-CE4: Modified mode decision process for triangle mode [F. Chen, L. Wang (Hikvision)]

Encoder-only fast algorithm to speed up TPM mode.

In VTM-5.0, there are 40 RDO checks at least for TPM mode when best mode is skip, this proposal reduces the number of RDO check from 40 to 3. These 3 are selected depending on SATD and bit count without CABAC estimation for the 40 TPM candidates. The same encoder-only algorithm also applies when the condition that the best mode is not skip is satisfied.

As reported, this encoder-only fast algorithm saves encoding time by 5% in RA and 7% in LDB with around 0.02% of BD-rate reduction in LBD case.

(RA:-0.01%/95%/101%; LB:0.02%/93%/100%)

The cross-checker confirms that there is only one line of change in the current VTM software.

It was commented from a participant that JVET-O0280 proposes a SIMD-based implementation to speed up the blending process as for TPM. (~2% speed up to encoder)

Recommendation (SW): Adopt.

Decision (SW): Adopt JVET-O0379 – use this in CTC

The BoG further raises an issue related to MV storage in TPM. The solution that is preferred from the BoG discussion is the following “solution B”:

If both MVs share same ref pic list, then use bottom triangle partition's MV.

RA:0.00%; LB:0.07%

JVET-O0265 method 1 / JVET-O0629 method 2 / JVET-O0418 method 1 / JVET-O0329 method 1A / JVET-O0378 method 2 / JVET-O0411 test B / JVET-O0279 method 1B

The consensus is based on the assumption that this simplification is desirable to select Solution B from Solutions A-C.

It is commented this Solution can simplify the text of the spec significantly. Approximately 1 page of text is saved.

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|  |  |
| VTM | Solution B |

Decision: Adopt “Solution B” as per contributions listed above.

After subsequent meetings of the BoG, the following additional actions are suggested:

*Normative*:

[JVET-O0220](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6825) Non-CE4: On maximum number of subblock merge candidates [R. Yu, D. Liu (Ericsson)]

Method 2: The proposed fix solves the ambiguity in both spec and sw.

“when sps\_affine\_enabled\_flag=0 and sps\_sbtmvp\_enabled\_flag=1, there is one subblock merge mode, that is, sbTMVP. However, the problem is sbTMVP may not be always available, and thus a zero-MV affine candidate is used as a subblock merging candidate, which causes ambiguity.” -- quoted from JVET-O0328 Test 1.

In addition to sps\_sbtmvp\_enabled\_flag, SbTMVP can be turned off by slice\_temporal\_mvp\_enabled\_flag.

Assuming five\_minus\_max\_num\_subblock\_merge\_cand is not present (i.e., sps\_affine\_enabled\_flag=0):

MaxNumSubblockMergeCand = 5 − five\_minus\_max\_num\_subblock\_merge\_cand

= 5 – (5 − sps\_sbtmvp\_enabled\_flag)

= sps\_sbtmvp\_enabled\_flag ……….. which is 1 in this case.

The method replaces the inference scheme of “5 – sps\_sbtmvp\_enabled\_flag” by using “5 – (sps\_sbtmvp\_enabled\_flag && slice\_temporal\_mvp\_enabled\_flag)”.

(JVET-O0263 is identical to method 2)

Recommendation (Bugfix): Adopt the bugfix in method 2.

Decision (BF): Adopt JVET-O0220 method 2

*Non-normative/encoder:*

[JVET-O0280](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6885) CE4-related: SIMD implementation for weighted sample prediction process of triangle prediction mode [Y.-L. Hsiao, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

Encoder-only modification to TPM for SIMD implementation on TPM blending operation.

The encoding time is reduced by 2% for RA and 3% for LB without BD-rate changes.

Further discussed in BoG (discussion 10:40, July 7), there is no further issue spotted after code review by Xiang Li and (cc. to Frank Bossen).

The software implementation is confirmed.

Recommendation (SW): Adopt.

Decision (SW): Adopt JVET-O0280, also in CTC

JVET-O0592 CE4-related: Motion estimation improvements [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

Method 1:

The proposed method picks up one of the previously decoded MVs as (a) the starting MV for integer motion search and (b) the initial MV candidate for SMVD.

The source of MVs are from 20 previously decoded CUs and these MVs are all rounded to integer precision before being used.

Method 2:

Perform a two-pass local refinement of CPMVs in affine ME process at ¼ sample precision.

The first pass checks 4 neighboring positions (above/bottom/left/right).

Then, the 4 remaining search points at corners are searched in the second pass only if the first-pass search updates CPMVs.

The results are reported with 2 methods: RA: -0.31%/101%/99%; LDB:-0.16%/101%/100%.

Several non-proponents express interest in this method. In addition, there is consistent coding performance improvement over all sequences.

Recommendation (SW): Adopt both methods and use both methods in CTC.

Decision (SW): Adopt JVET-O0592, also in CTC

[JVET-O0220](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6825) Non-CE4: On maximum number of subblock merge candidates [R. Yu, D. Liu (Ericsson)]

Method 1: Propose sw bugfix. Parse merge\_subblock\_flag conditioned on MaxNumSubblockMergeCand.

In the sepc text, merge\_subblock\_flag is parsed conditioned on MaxNumSubblockMergeCand>0; however, the sw refers to sps\_sbtmvp\_enabled\_flag and sps\_affine\_enabled\_flag to determined whether to parse merge\_subblock\_flag or not.

Recommendation (BugfixSW): Adopt the bugfix in method 1 to align sw to spec text.

Decision (BFSW): Adopt JVET-O0220 method 1

Furthermore, the BoG suggests the following contributions to be studied in CE:

[JVET-O0489](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7096) Non-CE4: Geometrical partitioning for inter blocks [S. Esenlik, H. Gao, A. Filippov, V. Rufitskiy, A. M. Kotra, B. Wang, E. Alshina (Huawei), M. Bläser, J. Sauer (RWTH Aachen)]

This proposal introduces new geometric partitions for merge mode. This mode supports 32 angles & 5 distance values to indicate a variety of geometric partitioning patterns. In total there are only 140 new modes (but not 160=32\*5) because some of the redundant partitioning patterns as for TPM can be removed.

A lookup-table based weighting function is introduces for blending samples on partitioning boundary inside a CU. The lookup table stores pre-calculated values of sine and cosine functions.

For motion storage, it sums up the four weight values at the corner of each 4x4 unit, and depending on the sum to differentiate whether uni-pred mv of triangle partitions or bi-pred mv should be stored.

For transform coding, it is required to remap a parallelogram shape of prediction residuals along the partitioning edge to square block for transform. For other samples, they are assumed to be zero.

(RA:-0.24%/105%/100%;)

If proposed transform is not applied, RA:-0.22%/106%/101%; LB:-0.44%/108%/102%.

The proponent claims that GEO is a straightforward extension to current TPM in VTM.

Visual quality comparisons are provided in the proposal, showing comparable viewing experience to that of the VTM anchor.

Non-proponents support further studying this tool due to the improved visual quality as compared to VTM-5.0 anchor.

Crosscheck number: JVET-O1010.

Recommendation: Further study in a CE.

It is suggested in the track B discussion that investigation of subjective effects should be part of the CE.

[JVET-O0522](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7129) Non-CE4: CIIP using triangular partitions [S. Blasi, G. Kulupana, A. Seixas Dias (BBC)]

Method 1:

Process-wise, the proposed mode is more close-related to CIIP but not TPM. The complexity overhead as compared with CIIP is the proposed mode requires to not blending the whole prediction samples of inter and intra, but instead, allocate each of them to respect triangle partition.

In addition, the same TPM blending is required for this mode. This aspect is later commented that this may not incur extra decoding burden as CIIP mode already require similar blending operation for the whole CU.

For the triangle that is intra-coded, only planar pred is used.

There are only 3 modes (instead of 4) for each TPM partitioning pattern, because this proposal does not allow intra pred to be used at bottom-right triangle.

The mapping from syntax to the 3 modes is adaptive depending on whether left and above neighbor blocks are intra or inter coded. In total, 4 different combinations.

(RA: -0.08%; Class C LDB: -0.18%)

It is suggested to add checking of sps\_triangle\_enable\_flag for this mode.

It is commented that it is questionable whether the increase of decoder complexity (i.e., adding one new mode) could justify the improvement of coding improvement.

It is commented that whether the filter used in the TPM blending process is strong enough to filter the boundary between the intra predicted triangle and inter predicted triangle. As this would potentially introduce visual impact on this mode, subjective viewing is encouraged.

Three non-proponents express interest in this proposal and suggest further study in a CE.

Recommendation of BoG: Further study method 1 in CE.

It is suggested in the track B discussion that investigation of subjective effects should be part of the CE. As the method would require additional building blocks/logic, the low gain in BD rate would not justify adoption. Proponents were asked to prepare a demonstration in a viewing session that the method has subjective benefit. Version 4 of the contribution shows in the powerpoint deck still image samples where the method is used, and where it provides subjective benefit.

It was agreed in the track B (Wed. morning) to include this in the same CE as JVET-O0489. It is suggested to also look into possible combination with JVET-O0489.

The CE should primarily target for proving subjective benefit, as the BD rate gain is not justifying the additional processing.

Furthermore, the BoG reports following open issues:

JVET-O0285 CE4-related: On merging candidate list construction

Propose to enforce MaxNumMergeCand to be always 6 only in decoding process and no change to syntax signalling. (No experiment is required as this does not affect CTC cases)

The proponent claims this a bugfix since the decoder does not need to check whether the number of candidates has reached the maximal number.

It is requested to provide additional results on the configuration of MaxNumMergeCand=3,4,5 in addition to 2.

It is questioned on the cost of this additional check to this check. The proponent responds that the circuit design requires additional logic to accommodate different configurations of max merge cand numbers.

Was further discussed in BoG (1050, July 7) to review the additional results with MaxNumMergeCand 3, 4 or 5.

During the discussion in track B, the proponents reported that results cannot be provided at this meeting. No action from here.

JVET-O0163 Non-CE4: Simplification on SbTMVP

Test 1:

The proposed method removes the condition check to switch adaptively between L0 and L1 that is used to determine which of the L0 and L1 motion (when both available) is used as the temporal MV for sbTMVP. The order become constant: L0 first, then if MvL0 does not point to collocated picture, then L1.

(RA:0.00%; LDB:0.01%)

(JVET-O0588 method 1is identical to method 1)

A non-proponent expresses there is no problem in the current design.

Another non-proponent commented the loss is at noise level and the benefit is the saving of the number for checking (2).

It is agreeable that the benefit from this proposal is to reduce the number of checks that is applied to the adaptation between L0 and L1 selection.

A non-proponent supports the proposed method.

Since there is no consensus to have this proposed feature, it may not be adequate to adopt this.

This issue was discussed in Track B. It was agreed that the suggested approach is a reasonable cleanup where the current method of determining usage of L0 or L1 is no longer necessary due to some other changes that were introduced over the original SbTMVP concept.

Decision (cleanup): Adopt JVET-O0163 method 1.

JVET-O0666 Fix for missing MV in 4xN and Nx4 triangle partition mode

It is claimed that this proposal can fix a problem in existing TPM where an update of the motion buffer of current coding unit is required. In the current design, bi-directional motion is stored for all 4x4 subblocks inside a 4xN or Nx4 CU using TPM. Without this fix, 1 bit needs to be stored for each 4x4 block to distinguish which motion vector from the bi-directional motion is used for which partition, in one possible implementation. And 128 bytes buffer is required for the storage of this indication flag of the whole CTU. It is claimed this additional 128 bytes could be saved.

It is commented that in another implementation where the motion compensation is performed for each 16x16 block considering pipeline design, the buffer required is 2 bytes.

It is commented that the update of the motion buffer of the current coding unit already exists in the current VTM-5.0. And there is no practical problem if the update is performed for TPM as well.

Results combined with JVET-O0411 method B.

This contribution was again discussed in track B. It was not obvious that this provides benefit. Though it may save some storage, additional logic would be necessary to interpret the MVs correctly, also the spec text would need more specific conditions. No action.

JVET-O0795 CE4-related: On the context variables and syntax elements of merge index

Method 2.1: Move merge\_triangle\_split\_dir after merge\_triangle\_idx1. Group bypass bins of triangle\_idx 1 and merge\_triangle\_split\_dir.

Method 2.2: Group bypass bins from TPM cand idx.

It is commented that the benefit from grouping bypass bins is unclear.

No need for action. Grouping of bins does not give advantage, as discussed under JVET-O1046.

Merge mode syntax

(Solution C) Change syntax tree of merge mode flags and reduce checks.

Proposal: JVET-O0249 Test 1 to be adopted. See right figure below. It is agreed in the track B discussion that this is a clearly better and clearer parssing structure for all the different merge mode variants. As a side effect, it also removes parsing redundancy w.r.t. high-level flags, e.g. ciip\_merge\_flag is not parsed if TPM or CIIP is disabled (which does not affect CTC). As another side effect it has a small compression benefit in CTC (RA: -0.08%; LDB: -0.06%)

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Decision (cleanup): Adopt JVET-O0249 Test1. Note that Test1 also disables TPM 128xN and Nx128, which shall not be applied. It is further noted that a cleanup of the VTM software wrt merge mode parsing should also be done.

Another (Solution D) had been discussed in BoG: Impose more condition checks to avoid parsing redundancy in the previous merge parsing structure completely.

Proposal: JVET-O0431 / JVET-O0586 / JVET-O0309 / JVET-O0585 method 1 / JVET-O0534/ JVET-O0361 / JVET-O0278. RA:-0.20%; LDB: -0.22%. (Note: both anchor and test disable TPM.)

It is noted that the initial version of JVET-O0249 did not include the full parsing redundancy removal, this idea was added in a later update.

It was furthermore requested to re-consider JVET-O0500 which points out some misalignment between text and software. It is confirmed by the text editor that such a mismatch exists in that the spec defines different context models (but same derivation) for inter affine flag and subblock merge flag, whereas the software uses only one. The proponents confirm that their software implementation is sharing the same derivation.

As it needs to be decided if text follows software or software follows text, one or the other has to be chosen. As there is small coding gain (0.05% overall, 0.1% in A1 for RA), the SW should be implemented like the spec

Decision (SW/BF): Adopt JVET-O0500 method 1. It was later confirmed by cross checking parties that the SW matches with the text regarding context derivation.

[JVET-O1046](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7683) BoG report on CE4 related contributions for general inter prediction [H. Yang, C.-C. Chen]

Initial version presented in Track B Sat. 1230.

Three sessions were organized for BoG meeting, 35 contributions have been reviewed.

* 1800 to 2200 on July 4
* 0900 to 1400 on July 5
* 1540 to 1930 on July 5
* 1715 to 1815 on July 7

JVET-O0500 was identified to be more closely related CE4 BoG on merge modifications, and was recommended to be reviewed in that BoG.

Seven contributions on the alignment of BDOF and PROF operations are planned to be jointly reviewed with CE9 BoG.

Recommended adoptions

**Normative change**

O0164 / O0587 (method 2): remove scaling of spatial motion vector candidates in AMVP list construction.

O0567: add a bitstream conformance that MvdL1 of SMVD mode shall be within the range of [-215, 215-1]. (it is clarified in the track B discussion that this only applies to SMVD MvdL1 after mirroring – generally larger ranges of MVD might be desirable)

O0284 (method 2) / O0579 (method 3): sym\_mvd\_flag is not signalled and is inferred to be false when mvd\_l1\_zero\_flag is true. (no impact on performance in CTC, fixes an issue of unreasonable usage in non-CTC)

O0438: affine AMVR control flag is conditioned on affine control flag in SPS.

O0366 (method 2): simplify BCW index derivation by setting it to the BCW index of the first candidate spatial neighbor block in the process of constructing an affine merge candidate.

O0414 (method 2): put a constraint that SMVD can only be applied to STRPs. No impact on CTC results. (additional adoption from second review Monday 8 July evening)

Decision (Track B): The recommended adoptions listed above are agreed.

**SW change**

O0567: align SW with text in MVD clipping at the encoder side.

O0126: align SW with text in the binarization of BCW index by using zero-based truncated Rice code (which would be equivalent to truncated unary code).

(it is clarified that also the text requires some alignment wrt BCW index. This is also included in O0126.)

**Bugfix**

O0572 (method 1): align text with SW in the derivation of SMVD reference pictures, by adding the missing initialization at the beginning of the second stage derivation.

Decision (Track B): The recommended adoptions listed above are agreed.

The following aspects were recommended to revisit in track B:

O0434: TMVP derivation modification in two aspects, 1) apply clipping to bottom-right collocated location if the location is outside the picture or belong to different CTU line, 2) remove the derivation of central collocated motion vector.

From discussion in track B: There is no obvious problem here, and it is also not obvious as simplification. Benefit not clear – no action.

O0254: disable inherited affine motion prediction from a neighboring affine coded block if the width or height of the neighboring block is less than 16.

The saving of local buffer by this proposal is not critical. No action.

Furthermore, the following aspects were suggested for discussion in Track B:

Constraint on lMvd[ compIdx ] range: [-217, 217-1] or [-215, 215-1]. It is agreed in track B that it is consistent to use the [-217, 217-1], aligned with the precision of MV (which is 18 bits due to usage of 1/16th pel, and affine AMVR also uses this precision).

Context reduction: remove context of sym\_mvd\_flag (O0468).

From discussion in track B: There is no obvious problem here, and it is also not obvious as simplification. Benefit not clear – no action.

Additional aspects from follow-up presentation Monday evening:

O0456: grouping the syntax elements of motion vector differences.

O0795 grouping bypass coded bins of TPM syntax. This contribution is from CE4 BoG on merge modifications.The motivation is increasing the throughput of CABAC by grouping context coded bin and bypass coded bins together. The following arguments are brought against the proposals:

1. MV coding is not the critical path in terms of throughput, rather than residual coding

2. Additional logic is required at the decoder to re-sort the bins before the MV can be reconstructed

From the discussion in track B, there is non consensus that this would give benefit. No action.

[JVET-O1076](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7713) Report of BoG on high-level syntax [Y.-K. Wang, J. Boyce]

See section on systems coord meeting for the discussions of the first 23 items.

Remaining parts reviewed in Track A Wed 10 July 1645 (GJS)

Continuing from item #24. Decision: Adopted by Track except as otherwise noted.

1. Adopt a set of constraints on IRAP, RASL, and RADL pictures that are technically identical as in HEVC. [JVET-O0147]
2. Adopt the following constraint: [JVET-O0147, JVET-O0226]

If field\_seq\_flag is equal to 0 and the current picture is a leading picture associated with an IRAP picture, it shall precede, in decoding order, all non-leading pictures that are associated with the same IRAP picture. Otherwise, let picA and picB be the first and the last leading pictures, in decoding order, associated with an IRAP picture, respectively, there shall be at most one non-leading picture preceding picA in decoding order, and there shall be no non-leading picture between picA and picB in decoding order.

1. JVET-O0149 and JVET-O0393 on cross RAP reference.

Further discussed Friday 12 July 0005 (GJS).

The proposed referenced pictures are pictures of the bitstream that may be distant in decoding order in the “original” bitstream.

O0149 proposes a NUT that would indicate that it is possible to random access at that point in the bitstream with CRA-like behaviour (possibly with leading pictures) if those reference pictures are available. Extra syntax is provided to describe what pictures are reference pictures are needed. It was asked why the RPL syntax isn’t sufficient to provide this information.

O0393 proposes using independent layers. The proposal would decode all the layers and output them as a single sequence of pictures. There would be IRAP pictures in each layer that would each only flush the buffer of the layer in which they reside. Each DRAP picture would depend on only the previous IRAP picture in its layer. All layers would be decoded and output (like multiview but as a time series rather than as different views).

Further study of these was encouraged.

1. Consider mixed NAL unit types within a picture based on JVET-O0140.

Further discussed Friday 12 July 0035 (GJS).

A motivation is region-wise random access using subpictures. An example use case is viewport dependent streaming of 360° video. Basically it would be from a BEAMer scenario. It was commented that using layers would be an alternative way to provide this functionality while constraining to have only one NAL unit type per picture per layer.

There would be a level of indirection involved in identifying the random access properties of the picture from the NAL unit header. It was commented that this indication could be put into the AUD.

Mandating AUD could potentially simplify a lot of basic needs.

It was also commented that something like an SEI message instead of NAL unit type can be used to indicate the predictive properties of the bitstream.

The encoding of the different regions would need to be very carefully coordinated.

Further study of this was needed.

1. Unless there is adoption of the above item, the following items if no proposal of allowing mixed NAL unit types is adopted at this meeting: [JVET-O0235]
   * All VCL NAL units of a picture shall have the same NAL unit type.
   * A picture or a layer access unit is also referred to as having a NAL unit type equal to the NAL unit type of the coded slice NAL units of the picture or layer access unit.
2. Adopt the following constraints: [JVET-O0235]
   * STSA pictures shall have TemporalId greater than 0.
   * Constraints on RPLs such to make sure that step-wise sub-layer switching can occur at STSA pictures.
3. Adopt the following constraints: [JVET-O0245]
   * TemporalId of an APS NAL unit shall be greater than or equal to that of the layer access unit containing the NAL unit.
   * The value of TemporalId of VPS and DPS NAL units shall be equal to 0.
   * When multiple ALF APSs with the same value of adaptation\_parameter\_set\_id are referred to by two or more slices of the same picture, the multiple ALF APSs with the same value of adaptation\_parameter\_set\_id shall have the same content.
   * A constraint on layer ID of an APS NAL unit:
     + If scalability with inter-layer prediction is adopted: A slice shall only refer to APS NAL units with layer ID(s) of layers the layer containing the slice directly or indirectly depends on.
     + Otherwise: A slice shall only refer to APS NAL units with the same layer ID.
4. Adopt moving of scaling list matrices from SPS to APS, and constrain that all slices of a picture shall refer to the same matrix APS ID. [JVET-O0299]
5. Adopt a clarification in the draft text that different types of APSs have independent APS ID value spaces.
6. Discuss the following:
   * What are the maximum numbers of matrix and ALF APSs that may be needed? Decision: 8. On Friday 12 July at 0830 it was noted that all APS IDs are currently drafted as u(5). Decision: It was agreed to continue to use 5 bits in the APS syntax but in the SH to use only 3 for ALF and QM and 2 for LMCS APS indexes, and to restrict the value range allowed in the APS semantics correspondingly. The text may need editorial clarification that the APSs IDs in different APS types have separate value spaces.
   * What is the maximum number of APSs for each type that may need to be referred to by slices of one picture? Decision: 1 for QMs, 1 LMCS (see next item), 8 ALF.
7. Adopt the following constraints: [JVET-O0428]
   * When aps\_params\_type is equal to LMCS\_APS, the value of adaptation\_parameter\_set\_id shall be in the range of 0 to 3, inclusive.
   * All slices within a picture referring to an LMCS APS shall refer to the same LMCS APS.
8. Adopt to allow only u(n), u(v), ue(v), or se(v) coded syntax elements in syntaxes for slice header and all parameter sets, thus without using tu(v), tb(v), etc. [JVET-O0491] (not committing to stay with this approach in the future)
9. Adopt to allow association of a buffering period SEI message with a GRA picture, and some minor bug fixes and editorial improvements proposed in JVET-O0152, excluding the change of the trailing picture definition. [JVET-O0152]
10. Adopt the editorial bug fixes for HRD related texts proposed in JVET-O0153. [JVET-O0153]
11. Adopt the following: [JVET-O0177]
    * To allow signaling of HRD parameters for temporal sub-layers optionally controlled by a flag.
    * To remove timing\_info\_present\_flag, and conditionally signal syntax elements num\_units\_in\_tick and time\_scale based on hrd\_parameters\_present\_flag.
12. Adopt the following: [JVET-O0180, JVET-O0228]
    * Addition of a loop of temporal sub-layers into the buffering period SEI message syntax, to signal the initial CPB removal delay values for either all sub-layers or just highest sub-layer.
    * Addition of a syntax element that is equal to sps\_max\_sub\_layer\_minus1 to avoid parsing dependency on SPS.
    * A constraint that bp\_cpb\_cent\_minus1[ i ] shall be equal to sps\_cpb\_cent\_minus1[ i ].
    * An editorial improvement to keep tracking of the BitRate and CpbSize values for each sub-layer.
13. Adopt the decoding unit based HRD design that is the same as in HEVC. [JVET-O0189]
14. Adopt to remove a parsing dependency of the picture timing SEI message on SPS by signalling the number of temporal sub-layers of the bitstream within the picture timing SEI message. [JVET-O0227]
15. Consider aspect 2 of JVET-O0496.

1) This contribution provides details of an asserted bug of the HRD model of VVC and HEVC, specifically when splicing. The first aspect of this contribution proposes a bug fix for the reported issue.

2) The second aspect has two options. In option 1 it is proposed to add a flag to the PT SEI message that allows a splicer to easily identify pictures within the bitstream, at which seamless splicing can be achieved. In option 2, in addition to the option 1 flag, a value that may be different than the InitCpbRemovalDelay is signalled in the BP SEI message. With this signalling, a bistream that has InitCpbRemovalDelay greater than that of the current bitstream but less than the signalled value can be seamlessly spliced together.

Further discussed Friday 12 July at 0100 (GJS).

The bug report and requested approach needs further study to confirm the issue.

1. Adopt replicating the compound functionality of pic\_struct into separate elements (pic\_output\_period, bottom\_pic\_flag, field\_pairing\_idc) in an SEI message. [JVET-O0042]
2. Adopt the correction to the semantics of the transfer characteristics and matrix coefficients syntax elements to support IEC 61966-2-1, as proposed in JVET-O0360. [JVET-O0360] Track A: We intend to reference CICP rather than specify directly, so the correct needs to be incorporated there.
3. Adopt to mandate the presence of AU delimiter for each AU. [JVET-O0610]
4. Adopt a bug fix to the slice data syntax such that byte alignment is ensured at the end of each brick/WPP subset. [JVET-O0144]
5. Confirm the following design principles on scalability support in VVC:
   * To specify a scalability support in VVC edition 1. Revisit in plenary.
   * Since from technical perspective there is no undue burden to non-scalable applications when adding scalability, it can be assumed that scalability ought to be in baseline/main (non-scalable profiles). Revisit in plenary.
   * Signal the layer dependency information in the VPS.
   * VPS needs to be included in non-scalable bitstreams. Track A agreed to start with approach 1 as the goal and move to approach 2 if we see a good reason, and then to approach 3 if there’s a good reason.
     + Approach 1: Does not need to be in non-scalable bitstream
     + Approach 2 (like HEVC): Needs to be there, but not needed by decoder
     + Approach 3: Needed by non-scalable and scalable decoders
   * Support of outputting only the highest layer (for typical scalability) and support of outputting all layers (for multiview) are both needed.
6. Consider unified scalability proposals, focusing on POC, RPL, and RPM, prepared following the HLS BoG agreements on the scalability category of proposals.

This topic was discussed Friday 12 July 0845 (GJS & JRO). Such proposals are O1150, O1159, O1160. See notes for those proposals.

1. Consider the following documents: JVET-O0335 [only further study requested], JVET-O0336 [only further study requested], JVET-O0471 [presenter not present in closing plenary], JVET-O0473 [presenter not present in closing plenary].
2. Consider the following NAL unit header syntax options A, B, C:

Current

|  |  |
| --- | --- |
| nal\_unit\_header( ) { | **Descriptor** |
| **zero\_tid\_required\_flag** | u(1) |
| **nuh\_temporal\_id\_plus1** | u(3) |
| **nal\_unit\_type\_lsb** | u(4) |
| **layer\_id\_plus1** | u(7) |
| **reserved\_zero\_bit** | u(1) |
| } |  |

Original proposal from JVET-O0179 (A)

Motivation: More usable values for needed elements

|  |  |
| --- | --- |
| nal\_unit\_header( ) { | **Descriptor** |
| **nuh\_layer\_id** | u(8) |
| **nal\_unit\_type** | u(5) |
| **nuh\_temporal\_id\_plus1** | u(3) |
| } |  |

Additional proposal from JVET-O0179 (B)

Motivation: More like HEVC

Decision (cleanup): Option B.

|  |  |
| --- | --- |
| nal\_unit\_header( ) { | **Descriptor** |
| **forbidden\_zero\_bit** | f(1) |
| **nuh\_reserved\_zero\_bit** | u(1) |
| **nuh\_layer\_id** | u(6) |
| **nal\_unit\_type** | u(5) |
| **nuh\_temporal\_id\_plus1** | u(3) |
| } |  |

Option C from contribution JVET-O1037:

Motivation: Like option B but with reserved bit at the end.

|  |  |
| --- | --- |
| nal\_unit\_header( ) { | **Descriptor** |
| **forbidden\_zero\_bit** | f(1) |
| **nuh\_layer\_id** | u(6) |
| **nal\_unit\_type** | u(5) |
| **nuh\_temporal\_id\_plus1** | u(3) |
| **nuh\_reserved\_zero\_bit** | u(1) |
| } |  |

1. Adopt adding a flag to indicate that no additional constraints are set on the bitstream and to avoid signaling the individual constraint flags, and adding inference for the constraint flag when not present. Revised specification text with the inference of the constraint flags to be provided in a –v2 version of JVET-O0417. Editors to consider naming for the flag, perhaps no\_additional\_constraints\_flag. [JVET-O0417] Track A: Defer this to further study
2. Adopt adding the generalized CMP SEI message as modified to remove the 360\_video\_projection\_type syntax element and changing the cmp\_packing\_type syntax element to be u(3), to be reflected in the -v5 zip version of JVET-O0891. [JVET-O0891]. This signalling would be more efficient than coupling a CMP SEI message with a region-wise packing SEI message. [ Track A stopped here 1815 – continue after 1100 Thursday ] Closing plenary notes: This would also have support for projection mappings with better coding efficiency with the ordinary CMP as a special case. There was a discussion of the relationship with region-wise packing. It was commented that this is much more bit efficient and that the generality of region-wise packing is complex to support. The proponent said the proposed message would be sufficient for many purposes without needing region-wise packing. Further study was requested, as there was some reluctance to adopt this without additional study.
3. [Track A began here 1130 Thursday] Editorial action item: Clarify that the design intent of the HRD picture output is aligned with output patterns of pictures described by syntax elements in the frame\_field\_info SEI (formerly expressed as pic\_struct), including repetitions of pictures. This is intended to essentially work the same way as in HEVC. Delegate to editors to express this in the specification. [JVET-O0043]
4. Discuss the following to make a plan to fix the software: JVET-O0667 asserts that there is a mismatch in the bitstreams created using the CTC config files, with a DPB value of 6 in the bitstream, but 7 actually used. The encoder software should be fixed to properly set the DPB size based on the config file entries. [JVET-O0667]. The impact on the coding performance is said to be 0.6-0.7%. If both HEVC and VVC are configured similarly, the difference between the two is basically unaffected (within about 01%). This issue is deferred for further study. If confirmed, the HEVC used as a reference would probably need to be changed and the VVC configuration would probably also be changed similarly.
5. Consider the layered based subpicture design based on JVET-O0334, JVET-O0497, and JVET\_O0393. This has the same functionality as single-layer subpictures but puts each subpicture in its own layer without cross-layer referencing. An SEI message is used to define a spatial layout. Closing plenary notes: Text provided in O1130. It was commented that the relationship to single-picture subpictures and potential mixed-NAL-unit usage within a picture should be studied. A participant said it could be nice for independent streams and conformance signalling. Further study was encouraged.
6. Adopt JVET-O0143 option 2 on signalling of addresses for rectangular slices. [JVET-O0143]
7. Adopt replacing num\_brick\_rows\_minus1 with num\_brick\_rows\_minus2. [JVET-O0173, JVET-O0176, JVET-O0338]
8. Adopt addition of the following constraint to the semantics of rect\_slice\_flag: When brick\_splitting\_present\_flag is equal to 1, the value of rect\_slice\_flag shall be equal to 1. [JVET-O0176]
9. Adopt the following changes: Don't signal brick\_split\_flag[ i ] and brick info for the i-th tile when RowHeight[ i ] is equal to 1, but infer them; when brick\_split\_flag[ i ] is equal to 1 and RowHeight[ i ] is not greater than 2, don't signal uniform\_brick\_spacing\_flag[ i ] and further brick info, but infer them. Move the condition "if( RowHeight[ i ] > 1)" out of the "for" loop. [JVET-O0452]
10. Editorial: Considering adding a NOTE into the draft text to clarify such cases where sub-bitstream extraction without touching VLC NAL units need to be kept in mind, e.g., the PPS in the extracted sub-bitstream should typically have signalled\_slice\_id\_flag equal to 1, even when pictures referring to the PPS has only one slice in them.
11. Adopt the following bug fixes:
    * Remove the following constraint for rectangular slices: The slices of a picture shall be in increasing order of their slice\_address values. [JVET-O0338]
    * Change the inference "When rect\_slice\_flag is equal to 0 and single\_brick\_per\_slice\_flag is equal to 1, the value of num\_bricks\_in\_slice\_minus1 is inferred to be equal to 0." to "When single\_brick\_per\_slice\_flag is equal to 1, the value of num\_bricks\_in\_slice\_minus1 is inferred to be equal to 0." [JVET-O0181]
12. Consider the first aspect of JVET-O0145 and the second aspect of JVET-O0215 together.

Existing semantics of num\_entry\_point\_offsets in the draft text:

**num\_entry\_point\_offsets** is used to specify the variable NumEntryPoints, which specifies the number of entry points in the current slice as follows:

NumEntryPoints = entropy\_coding\_sync\_enabled\_flag ? num\_entry\_point\_offsets :  
 NumBricksInCurrSlice − 1

[Ed. (YK): The value range of the ue(v)-coded num\_entry\_point\_offsets is missing.]

Proposals for addressing the issue:

JVET-O0145 aspect 1: Remove the num\_entry\_point\_offsets syntax element and derive NumEntryPoints as follows:

The variable NumEntryPoints, which specifies the number of entry points in the current slice, is derived as follows:

if( !entropy\_coding\_sync\_enabled\_flag )  
 NumEntryPoints = NumBricksInCurrSlice − 1  
else {  
 for( numBrickSpecificCtuRowsInSlice = 0, i =0; i < NumBricksInCurrSlice; i++ )  
 numBrickSpecificCtuRowsInSlice += BrickHeight[ SliceBrickIdx[ i ] ]  
 NumEntryPoints = numBrickSpecificCtuRowsInSlice − 1  
}

JVET-O0215 aspect 2: Add the following constraint: "num\_entry\_point\_offsets shall be 0 or total number of CTU row minus 1."

Further discussed Friday 12 July 0120 (GJS). The basic difference between these proposals is whether the value 0 is allowed.

A participant suggested that instead of the current syntax element, send a entry\_point\_offsets\_present\_flag at the PPS level. If it is 1, the number of entry points is NumEntryPoints as derived above; otherwise, none are signalled. Decision: Agreed as described.

1. Make sure that the following bug is fixed, noting that how the ALF design should be specified to enable turning off ALF filtering across brick/slice/subpicture boundaries should be handled by a low-level coding tool group:

The semantics of existing PPS flags loop\_filter\_across\_bricks\_enabled\_flag and loop\_filter\_across\_slices\_enabled\_flag say that when equal to 0, filtering across brick/slice boundaries is turned off for all the three types of in-loop filters. However, the decoding process for ALF has lacked support for the functionality.

1. Discuss the following questions, which Track A identified for further study:
   * Do we need the functionality that enables turning off deblocking or SAO filtering across raster-scan slice boundaries when deblocking or SAO is on? This is supported in the syntax now, but only at the picture level. HEVC has control over this at the slice level, controlling the treatment of the top and left boundaries. Such slice level control is not currently in VVC.
   * Do we need the functionality that enables turning off ALF filtering across raster-scan slice boundaries when ALF is on? This is supported in the syntax now, only at the picture level. The low-level operation needs to account for this. Revisit. It was commented that there may be a bug in this aspect.
2. Consider whether the high-level syntax AHG should have an interim meeting before the October meeting, either F2F or a conference call. In the Track A discussion, no AHG meeting was planned.

[JVET-O1093](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7730) Report of BoG on intra prediction and mode coding [G. Van der Auwera]

Track A Monday 2000-2230 (GJS)

The BoG met during following hours:

* Thu 4 July: 14:30-19:45
* Fri 5 July: 14:30-19:45
* Sat 6 July: 14:30-20:00
* Sun 7 July: 14:30-19:45

The BoG reviewed proposals related to the intra prediction and mode coding topic (CE3-related). This report includes recommendations for the adoption of proposals and the creation of core experiment subtests.

* Adoptions recommended by the BoG with track A actions noted.
  + Decision (consistency/implementation simplification): JVET-O0277 (method 1): intra reference sample smoothing conditions are modified so that small blocks (4x4, 4x8, 8x4) are not smoothed for all angles and ‘DCT-IF’ interpolation is used. Needs only one type of filter instead of two for small blocks.
  + Decision (consistency/implementation simplification): JVET-O0341 (method 2): always apply ‘DCT-IF’ interpolation to ISP (also included in JVET-O0502)
  + Decision (consistency/implementation simplification/cleanup): JVET-O0364: includes several items for adoption (see detailed BoG notes)
  + Decision (consistency/implementation simplification/cleanup): JVET-O0426: alignment of neighbouring reference sample array ranges with block boundaries for DC mode (MRL)
  + Decision (consistency/implementation simplification/cleanup): JVET-O0502: enable use of all 67 intra modes for ISP (MPM, remaining modes); apply PDPC; always apply ‘DCT-IF’ interpolation (see also JVET-O0341, method 2)
  + Decision (bug fix/cleanup – need to coordinate with HLS): JVET-O0640: addresses small chroma block issue in bottom-right picture corner; proposes picture width, height multiple of max(8, MinCbSizeY) in addition to adoption of CE3-2.1.2 (removes 2x2, 2x4, 4x2 intra chroma blocks in shared tree); coordination with HLS needed
  + No action on JVET-O0651: chroma DM mode is set to horizontal intra mode if luma block is IBC/PCM when using separate chroma tree (note: from other actions at this meeting, PCM is removed and chroma does not have IBC when using separate chroma tree). Decision (text/software alignment): chroma DM mode is set to DC in this case.
  + Decision (bug fix): JVET-O0655: fixes defect related to wide-angle in chroma intra angle mapping table for 4:2:2 content
  + JVET-O0671: unifies binarization of intra chroma mode coding for CCLM enabled/disabled - see notes for O1153.
  + Decision (complexity reduction and cleanup): JVET-O0925: see detailed BoG notes
* Core experiment subtests recommended by the BoG:
  + MIP:
    - JVET-O0161 (aspect 2): MIP boundary downsampling process alignment
    - JVET-O0323, JVET-O0408 (updated in JVET-O1127, but results were not available): simplifies rightshift after matrix vector multiplication. It was agreed to do a CE on this.
    - JVET-O0571: fixed upsampling order
    - JVET-O0793: MIP mode index fixed length coding – no CE plan for this
  + CCLM:
    - JVET-O0343: use intra reference sample substitution process to pad unavailable samples; always use 4 samples for LM – consideration pending study of removal of downsampling)
    - JVET-O0412: increase samples used for LM computation for large blocks – no CE plan for this
    - JVET-O0673: align CCLM downsampling filtering of neighbours with MIP process (consideration pending study of removal of downsampling)
    - JVET-O0674: introduces 4 additional LM modes selecting sample locations – a coding efficiency proposal
    - Further study; no CE.
* BoG suggests defining the neighbouring blocks availability process in VVC specification text
* No presenter available for documents not presented (presenter unavailable): JVET-O0316, JVET-O0317, JVET-O0318

BoG review discussion ended in Track A Monday 8 July at 2230.

[JVET-O1100](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7737) BoG report on CE9 decoder motion vector derivation related contributions [S. Esenlik]

Reviewed in track B Sat 6 July 1615-1745 (chaired by JRO)

The BoG met in 2 sessions in order to discuss CE9 (decoder motion vector derivation) related contributions. The first session was held on 5 July 2019 from 09:00 to 13:45. The second session was held between on 5th of July 2019 between 18:30 to 22:00.

**Recommended for adoption by BoG:**

JVET-O0504 Non-CE9: Header flags to disable DMVR and BDOF at finer granularities [S. Sethuraman (Ittiam)]

Recommendation: add 1 slice header control flag for disabling DMVR and BDOF together (as per documents: JVET-O0250, JVET-0184, JVET-O0504)

Recommended syntax by BoG:

An SPS flag to indicate the presence of the slice level control flag, which is signalled in the SPS when either of DMVR or BDOF sps level control flags are true. And one flag is added after the fractional MMVD flag in the slice header to control DMVR and BDOF together. This flag is signaled in the slice header if the presence flag is true.

Proponents are requested to submit a contribution with text changes.

From discussion in track B: Makes sense, as there is no way of turning DMVR and BDOF off at a block level. An encoder that may not want to use it locally could now signal that at the slice level, instead of sending a new parameter set.

Reasonable change supported by experts.

Decision: Adopt.

[JVET-O0590](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7205) Non-CE9: Improvement of DMVR [Y.-W. Chen, X. Xiu, X. Wang (Kwai Inc.)]

-0.06%, -0.06%, -0.07% (Y/Cb/Cr) without processing time impact. Only one line is added in the spec.

The modified SAD for the center coordinate is used in early termination, DMVR integer refinement, and DMVR sub-pixel refinement processes. Value of Center SAD is reduced by 25%.

It is commented that there is only one sequence with loss (0.03%) in CTC, whereas all the other sequences have gain.

Decision: Adopt.

[JVET-O0609](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7224) CE9-related: On BDOF precision alignment for high internal bit-depth [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

The VVC spec has 2 problems according to the proponent.

1. Precision of the tempH and tempV decreases with increasing bit-depth. BdofOffset cannot be solved.
2. mvTreshold increases with increasing bit-depth.

Problem happens with bithdepth>12.

3 places are modified in the spec text: Clipping value for vx and vy to 32 samples (fixed value). Value of the shift3 is modified. A shift5 is introduced to align the precision of bdofOffset with prediction sample bit-depth.

According to the proposal if the internal bit-depth is greater than 12 bits, the derivation of the equations are identical to when bit-depth is smaller than 12 bits.

No impact on CTC. Behaviour is not changed between 8 to 12 bit-depth range.

Question in Track B discussion: Do we have evidence that high bit depth precision is needed for BDOF? Further study and experimentation with real data appears necessary before taking action here.

**Recommended to revisit in track**

[JVET-O0297](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6902) CE9-related: Simplification for DMVR padding process [Y.-C. Lin, C.-C. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

The contribution suggests that 16x16 subblock processing of DMVR is irregular. The contribution proposes to replace CU boundary padding with sub-PU boundary padding.

No change in coding gain, 3% decoding time increase.

Introducing padding might introduce artifacts. The decoding time increase is probably due to the additional padding operations that are incurred.

The proponent suggested that the benefit is for hardware, and the penalty in software should be fine.

The benefit is suggested to be that in the hardware you would not need to check each corner of the sub-PU, to decide whether it should be padded or not. There was one objection for this.

Hardware expert suggested that this approach is beneficial.

It was commented that the decoding time increase of 3% is on the order what totally DMVR has (%4). It is suggested that padding requires in the software buffer copying, which slows down the decoder.

Recommended to revisit after crosschecker and the tester obtains reliable decoding time measurements. Currently the tester and crosschecker decoding times are 3% and 6%.

There is no impact on compression performance.

From discussion in track B: It is agreed by hardware experts that there would be benefit for their implementations. Proponents are requested to work on further improving the software run time issue.

A new version with draft text was provided, aligned with draft5v10. It was confirmed by the text editor that the text is appropriate and further simplifies.

It is noted that JVET-O0125 proposes the same method.

Decision: Adopt JVET-O0297.

[JVET-O0304](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6909) Non-CE9: Simplification of BDOF [Y. Kato, T. Toma, K. Abe (Panasonic)]

In current VTM 9984 (6bit\*10bit multi) are necessary for MC and 3408 (13bit\*11bit multi), according to the proponent.

Proposed method reduces the number of multiplications in BDOF process to about 560 (6bit\*11bit multi), for 16x16.

Simulation results reportedly shows 0.02% luma BD-rate loss in RA and 1% decoding time reduction.

Second modification is about replacing BDOF division in calculation of vx and vy with lookup table. The second aspect itself can be applied to current BDOF design with 0.02% gain (this is just an estimation as nobody tested this). This is independent of the first part, and according to the assessment of the BoG it does not really simplify, as the number of LUT entries is relative large, and the current division is implemented in bit shifts.

Recommended to discuss modification 1 in track B (without replacing BDOF division with table).

Modification 1 has loss of 0.04%. This had been investigated in a previous CE (before previous meeting), but there the simplification in terms of reducing the number of operations had been more aggressive, and the loss had been 0.1%. It is further reported that the modification 1 alone reduces the decoding time by 2%.

Draft text (O0304v4) was reviewed in track B and is a straightforward simplification. Confirmed by crosschecker to match with the SW.The Crosscheckers also confirmed later that the BD numbers of Modification 1 only are precise. It was agreed that this is beneficial and should be adopted.

Decision: Adopt JVET-O0304 Modification 1 (reduction of number of multiplications; the modification 2, replacement of the division by a LUT operation is not adopted).

[JVET-O0644](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7260) Non-CE9: Evaluation of Threshold Value Applied to SAD-based Early Termination in DMVR [C.-C. Chen, W.-J. Chien, M. Karczewicz (Qualcomm)]

The proposal tests early termination thresholds of DMVR. It is suggested that the decoding time is increased by 1% if early termination is disabled.

[TH = 0] (Y) 0.00%, (U) -0.02%, (V) 0.00%, (Enc.) 100%, (Dec.) 101%;

Benefit not obvious – no action.

Further review Tue 9 July 1330 on CE investigations:

JVET-O0503 Non-CE9: Modifications to MMVD for CUs eligible for DMVR [S. Sethuraman (Ittiam)]

Minor gain – not worthwhile to be tested.

[JVET-O0508](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7115) Non-CE9: Refinement of optical flow estimates in BDOF [S. Sethuraman (Ittiam)]

Minor gain – not worthwhile to be tested.

[JVET-O0628](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7243) Non-CE9: SATD based DMVR [J. Chen, R.-L. Liao, Y. Ye, J. Luo (Alibaba)]

Minor gain for complexity increase (additional Hadamard transform for SATD) – not worthwhile to be tested.

[JVET-O0630](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7245) Non-CE4: DMVR on merge mode [R.-L. Liao, J. Chen, Y. Ye, J. Luo (Alibaba)]

Benefit not obvious, and some additional elements would be needed – not worthwhile to consider.

[JVET-O0631](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7246) Non-CE4: DMVR on SMVD and AMVP mode [R.-L. Liao, Y. Ye, J. Chen, J. Luo (Alibaba)]

Too much increase of encoding time – not worthwhile to consider.

[JVET-O0634](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7249) Non-CE9: BDOF simplifications [X. Chen, H. Yang (Huawei)]

Current block size restriction of BDOF is Nx4 only.

Test2, disabling BDOF for 8x8/4xN. This condition is the same as that of DMVR. The loss is 0.04%

Recommended to test test2 in CE.

From discussion in Track B:

* It is suggested that it would be beneficial to align the block sizes of DMVR and BDOF
* Test 2 which achieves that has loss of 0.04% in RA, but this mostly comes frm class C (0.08%), whereas the loss in higher resolutions is less (0% in A1); class D has almost 0.2% loss, which is not counted in the overall BD rate.

Decision: Adopt JVET-O0634 Test2 unify block sizes where DMVR and BDOF are used.

[JVET-O1106](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7743) BoG report on CE8 related contributions [X. Xu]

Presented in Track B Sunday 7 July, 9:00

The BoG report provides summary of recommendations from the discussion and detailed comments for each identified CE8 related contributions.

The following adoptions were recommended by the BoG

Recommendation: (Bugfix) adopt JVET-O0162 method 2/JVET-O0331 method 3/JVET-O0480 solution 1/JVET-O0574 solution 2. Signal mvp flag for IBC only when MaxNumMergeCand>1

Decision (BF): Adopt. Text from JVETO0162 method 2

Recommendation: (HLS) adopt JVET-O0455, the first aspect, having a separate signaling of max number of merge size for IBC at slice header. The range of the size will be the same as the one of inter merge, which is [1, 6].

The proposal is to control the number of merge candidates independently of inter. Currently, in PB slice, it is shared with inter coding.

Decision: Adopt JVET-O0455, 1st aspect, control the number of merge candidates independently for IBC in case of PB slice. Different from the proposal, the range shall be [1,6]

Recommendation: (Simplification) adopt JVET-O0626 method 1. Inside the shared merge region for IBC, remove the 2 spatial merge candidates from candidate list.

In Track B discussion, it is asked if there is at all a complexity problem in IBC merge, after shared merge list had been introduced. Other experts express that the shared merge list itself requires some duplication of logic.

Options:

* no action
* method 1: No spatial candidates
* method 2: Remove sharerd merge, and remove spatial candidates for 4x4

The opinion is expressed that there is not enough evidence of the benefit.

No consensus reached, and does not seem overly important.

No action.

The following open issues are raised:

JVET-O0325

This proposal contains changes to the binarization of BVD coding. One syntax is conditionally signaled based on the other and the ibc flag value. Conclusion of this proposal will be better made after the discussion of CE8-1.x discussion on BVD/MVD coding.

From Track B discussion Sun 7 July morning.

This would disallow the (0,0) case. If the BVD in y direction is zero, in x direction the gt0 is skipped.

It is reported that the maximum gain that is currently known when designing BVD coding different from MVD coding is around 1.3% for TGM/AI, and 0.5% for class F/AI. This would be more complex, increasing number of context coded bins.

It is agreed that such gain is not substantial enough to justify deviating in BVD coding from MVD coding, or defining different MVD coding just for the benefit of screen content, and further decreasing the CABAC throughput by increasing number of context coded bins. This statement also applies the still outstanding decision on CE results.

JVET-O0513, JVET-O0563, JVET-O0645

The proponents of these three proposals provided a joint contribution, using the same encoder to test various masks used for TPM blending off. Report back also the syntax changes relative to current design in the joint contribution. See further notes under JVET-O1172.

CE8 to be continued for

* further improvements and simplifications of palette
* TS and TS+BDPCM for chroma

[JVET-O1113](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7750) BoG report on CE2: luma-chroma dependency reduction [J. Chen, E. François, P. Yin]

Initially discussed Sat. 6 July 11:00-

The sessions were held 0940~1300, 1440~21:30 on Jul. 4th discussing 22 technical contributions in 3 categories:

* Luma-chroma latency reduction for CCLM (7)
* Luma-chroma latency reduction for CRS (8)
* LMCS simplification/modification (7)

**Luma-chroma latency reduction for CCLM**

There are 2 categories of proposals.

* Category 1 – partitioning restrictions, CCLM always enabled for all CBs.
* Category 2 – CCLM enabling restrictions based on partitioning, no partitioning restriction.

Note that all these restrictions only apply in the case of dual tree.

Regarding category 1:

1. It was agreed that ISP shall be disabled at VPDU level.
2. The simplest approach common in 3 contributions (O0273 method 1, O0274 method 1, O0524) consists in:

* restricting luma & chroma VPDU partitioning to not split or QT split

(Note that for CTC this implies that ISP is not used at 64x64 level for dual tree)

Performance of this approach (O0273 method 1 results):

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | AI |  |  | RA |  |  | LB |  |
| 0.18% | 2.35% | 2.30% | 0.05% | 0.76% | 0.84% | 0.03% | 0.61% | 0.71% |

1. Other methods add more partitioning options. The most performing proposal (O0273 method 2) adds enabling BT split for chroma CB at VDPU level, and implicit TB split. The intra reference samples availability check is also modified.

Performance of this approach is O0273 method 2:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | AI |  |  | RA |  |  | LB |  |
| 0.04% | 1.19% | 1.17% | 0.03% | 0.46% | 0.36% | 0.05% | 0.32% | 0.54% |

1. For category 1, it should be clarified if these restrictions also apply when CCLM is disabled at SPS level. (from the discussion in track B on this aspect: It was mentioned that this might introduce some coding loss if the restriction was also applied with CCLM disabled. As however this has not been tested (non CTC condition) and it is not known if it would be the case and how large such potential coding loss might be, it was agreed that the restriction should always be applied. If evidence is shown in a future contribution that this would be critical, the restiction might be released for the non-CCLM case)
2. As a general question, it should be clarified if the latency issue depends on the CTU size, i.e. if the latency should be at most ¼ of the CTU size.

In the follow-up discussion in track B, this aspect is clarified as follows: The latency should not exceed one quarter of the VPDU size (in a follow-up discussion on Mon 8 July evening, several experts raised the opinion that such constraint may not be necessary for the case of 32x32 VPDU size). The VPDU size would be min (CTU size, 64x64).

Regarding category 2:

1. It was agreed that CCLM shall not be used when ISP is used at VDPU level.
2. Common aspects from O0129, O0196, O0274 are:

* CCLM enabled if luma & chroma VDPU is not split or QT split
* CCLM enabled if luma VDPU is not split or QT split, and chroma is split by BT horizontal and further split shall be only vertical split, or no split

O0196 corresponds to this design. Performance is:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | AI |  |  | RA |  |  | LB |  |
| 0.07% | 1.06% | 1.07% | 0.02% | 0.41% | 0.29% |  |  |  |

1. O0273 method 3 is the closest category 1 solution to category 2 solution O0196. Performance is:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | AI |  |  | RA |  |  | LB |  |
| 0.10% | 1.53% | 1.49% | 0.03% | 0.46% | 0.44% |  |  |  |

Recommendation of adoption from BoG

1. Based on the performance and complexity, it is recommended to consider the simplest Category 1 approach (as per O0273 method 1, O0274 method 1, O0524) for adoption.
2. Disable ISP in VPDU level (included in O0273 method 1)

In the follow-up discussion in track B (Sat), some concern is raised that the loss of the recommended methods may be a bit too high. The BoG is asked to make some more detailed analysis of the different methods on the table in terms of complexity (number of condition checks at which level of the tree, solution to the latency requirements related to VPDU size as expressed above under 5.). Furthermore, implications on the spec text in terms of formulating the conditions should be assessed (e.g. certain specific split restrictions).

For the other aspect, luma/chroma latency in CRS, the BoG still needs further meeting.

It is recommended to adopt the encoder bug-fix from JVET-O0429.

Decision (SW/BF): Adopt JVET-O0429, only the encoder bug fix part relating to rounding operation in CRS chroma lambda computation.

On the aspects of LMCS simplifications / modifications, the BoG made the following recommendations for adoptions:

1. [JVET-O0262](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6867) Non-CE2: Removal of division operations in LMCS [K. Zhang, L. Zhang, H. Liu, J. Xu, Y. Wang (Bytedance)]
2. [JVET-O0428](file:///D:\2019\JVET\JVET-O\current_document.php%3fid=7033) AHG16/AHG17: LMCS related clean-ups [T. Lu, F. Pu, P. Yin, S. McCarthy, W. Husak, T. Chen (Dolby), J. Zhao, S.H. Kim (LGE)]

In the follow-up discussion, it is pointed out that the division only applies once per APS, which is not critical, and the replacement text is more complicated in the spec.

Decision (Text/SW/BF): Adopt JVET-O0428. Various cleanups in SW and Text:

* Bug fix in the process of identifying the index of inverse piecewise function (clause 8.8.2.3);
* LMCS code changes to improve readability, compactness, and software-specification correspondence without affecting coding performance;
* Constraints on LMCS APS,
  + The total number of LMCS APS per CVS shall be less than or equal to 4,
  + only one LMCS model per picture shall be allowed.

Interested experts are strongly encouraged participating in follow-up BoG discussions.

Follow up presentation after further meeting in Track B Monday 2000

BoG performed more detailed analysis and came to the conclusion that one of the “category 2” proposals provides the best benefit.

1. [JVET-O1124](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7285) Draft text for CCLM restriction to reduce luma-chroma latency for chroma separate tree [Yin Zhao, Haitao Yang (Huawei), Chia-Ming Tsai, Tzu-Der Chuang, Chih-Wei Hsu, Yu-Wen Huang, Shaw-Min Lei (MediaTek)]

Follow-up proposal of JVET-O0196

when the 64x64 luma coding tree node is partitioned with Not Split (and ISP is not used for the 64x64 CU) or QT, the chroma CUs in 32x32 / 32x16 chroma coding tree node are allowed to use CCLM in the following way:

* if the 32x32 chroma node is partitioned with Not Split or QT split, all chroma CUs in the 32x32 node can use CCLM
* if the 32x32 chroma node is partitioned with HBT, and the 32x16 child node does not split or uses VBT split, all chroma CUs in the 32x16 chroma node can use CCLM.

In other luma and chroma coding tree split conditions, CCLM is not allowed for chroma CU.

Among the available methods, this is the one with lowest loss (0.07% luma, approx. 1% chroma)

Decision: Adopt JVET-O1124.

It is noted that this has a latency of maximum 32x32 luma samples, regardless of the CTU size (i.e. also for 32x32 CTU).

Related to CRS (Chroma residual scaling)

[JVET-O1109](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7034) Non-CE2: unification of chroma residual scaling design [J. Chen, R. Liao, Y. Ye, J. Luo (Alibaba), Z. Deng, L. Zhang (ByteDance), T. Lu, P. Yin (Dolby), E. François, F. Hiron (InterDigital), J. Zhao, S. Paluri, S. H. Kim (LGE), Z.-Y. Lin, T.-D. Chuang (MediaTek)]

A unified chroma residual scaling design for both dual tree and single tree is proposed. In the proposed solution, a high-level switch in SPS enables switching between explicit signalling or implicit derivation of the scaling values. The explicit signalling spatial granularity can be controlled from CTU-scale to slice-scale. The implicit derivation is applied per VPDU using neighboring reconstructed luma samples of the VPDU. The proposed solution applies both for Dual Tree and Single Tree cases.

Question: Why a switch? It is argued that the explicit signalling would be beneficial for SDR, whereas implicit is better for HDR. However, the results that were reported in the BoG indicate that there is only minor difference, and the implicit version is closer to the original scheme and also fully resolves the latency problem by only using luma information from adjacent VPDU. It is therefore suggested during the track B discussion to only use the implicit version. This reflects an adoption of JVET-O0429 option 2 combined with JVET-O0271 method 4, and JVET-O0627

Decision: Adopt JVET-O1109, with the following update relative to v3: Remove all syntax and semantics related to explicit signalling, including the SPS flag for switching explicit/implicit.

(Note that the spec text of v3 was inspected and found to have some mistakes in the explicit part, which would be removed anyway).

Additional adoption regarding LMCS modification and simplification suggested by BoG:

[JVET-O0272](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6877) CE2-related: Simplified inverse luma mapping [Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

one encoder constraint is imposed as “For the variable LmcsPivot[ i ] with i = 0..15, it is a requirement of bitstream conformance that if LmcsPivot[ i ] is not multiples of 32, then (LmcsPivot[ i ] >> 5) shall not be equal to (LmcsPivot[ i + 1 ]>>5).”

This simplifies the determination of the index at the decoder, and is not difficult to test and correct for an encoder.

Decision: Adopt JVET-O0272.

No need to continue CE.

[JVET-O1115](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7752) BoG report on CE6 related transforms and transform signalling contributions [X. Zhao]

Discussed in Track A Tuesday 9 July 1440 (GJS).

This BoG was mandated to review the CE6 related contributions of the 15th JVET meeting. Totally 50 contributions have been reviewed, which are categorized as follows,

* Context reduction for transform signalling (10 Proposals)
* Simplification on LFNST (24 Proposals)
* Transform kernel selection (12 Proposals)
* Maximum TU size for chroma format 4:2:2 and 4:4:4 (1 proposal)
* Mismatch between text specification and reference software on MTS for IBC-coded block (1 proposal)
* Configurable maximum transform size (1 proposal)
* Modified DCT8/DST7 Transform Matrices for Faster Implementation (1 proposal)

The BoG met on Friday (July 5) from 08:40pm to 10:54pm, Saturday (July 6) from 10:00am to 02:20pm and 8:00pm to 10:42pm, Sunday (July 7) from 2:30pm to 9:00pm.

Recommended adoptions into VVC/VTM (9)

* JVET-O0294: Context modelling for signalling MTS index. Decision (cleanup): Instead of renaming the flag, flip the sense of the flag to keep it called a transform skip flag, and switch the meaning of 0 and 1
* Change transform\_skip\_flag in the VVC draft specification as transform\_not\_skip\_flag.
  + JVET-O0472: Simplified LFNST signalling
    - If either one of the two options of LFNST signalling (see section 1.2.1 further discussion, Option 1: Limiting LFNST to max TU size, Option 2: TU-level LFNST signalling) is adopted, BoG recommends adopting JVET-O0472: LFNST index signalling depends on last position instead of the number of significant coefficients. Decision: Adopt (confirmed after action recorded below)
* JVET-O0368 (Method #2), JVET-O0292 (Method #1), JVET-O0521, JVET-O0466 (without HLS changes): Removing LFNST when MTS index larger than zero
  + Disable LFNST for non-DCT2 MTS candidate normatively. Decision (cleanup/worst-case latency reduction/encoder speed-up): Adopt.
  + Worst-case latency reduction
  + Argued that LFNST works best with DCT2 anyway
  + Corresponds well with implicit case (as recommended)
  + Very slight gain for RA, very slight loss for AI
* JVET-O0538 (SW, non-CTC): SPS control of ISP and SBT transform selection
  + Decision (SW bug fix): SW fix to VTM to address a misalignment between VVC spec text and VTM.
* JVET-O0541 (non-CTC): Modified high-level syntax control on implicit transform
  + Decision (bug fix): Decouple the intra transform selection from a inter MTS related SPS flag.
* JVET-O0214, JVET-O0529, JVET-O0540 (non-CTC): Harmonization of LFNST, MIP and implicit MTS
  + Decision (cleanup): Disable LFNST and MIP for implicit MTS (identical text in O0529 or O0540).
  + Fixes the implicit transform in VTM-5.0, -0.79% luma BD-rate reduction for AI configuration is reported comparing to VTM-5.0 with MTS disabled and implicit MTS enabled.
  + Aligns with the notion that LFNST doesn’t work so well with non-DCT2
* JVET-O0219: On LFNST transform set selection for a CCLM coded block
  + Decision (cleanup): Utilizes the collocated luma intra prediction mode as the transform set selection table index to select the LFNST transform set for the chroma
  + DM mode operates this way; CCLM is also getting chroma with luma, so aligning them the same way makes logical sense
  + AI: -0.01% (Y) / -0.40% (Cb) / -0.34% (Cr), RA: 0.00% (Y) / -0.37% (Cb) / -0.33% (Cr)
* JVET-O0357: Maximum TU size for chroma format 4:2:2 and 4:4:4
  + Separate the max TB width and height according to the horizontal and vertical subsampling ratio. This aligns with the software and resolves a note in the text for 4:2:2. It would align chroma TUs with luma TUs (in the non-separate tree case). Decision (cleanup): Adopted.
  + The software is already doing this. The software and spec already do this for 4:4:4 also. However, an issue was noted with the track review notes on JVET-O0389. Revisit to confirm why the notes had the discrepancy.
  + “For 4:4:4, it would be OK in terms of pipelining in VPDU, but no results.
  + Further study recommended for 4:4:4, i.e. results should be provided both for RGB and YUV. If it shows benefit, 64x64 transform should be used for chroma in 4:4:4 case.
  + For 4:2:2, 32x32 should be retained. For the current draft, it should also be retained for 4:4:4, waiting for results as stated above to potentially change it in the future.”
* JVET-O0474: Mismatch between text specification and reference software on MTS for IBC-coded block.
  + In the current specification, MTS can be applied to IBC-coded block when MTS for inter is enabled in SPS-level, while MTS is not applied to IBC-coded block in the VTM-5.0 even though the SPS flag is equal to 1. In this proposal, MTS is not (ever) applied for IBC. Test results showed no benefit for the extra encoder runtime of aligning the software with the spec. Decision (align spec with SW): No MTS for IBC.
  + It is proposed to modify the spec text to align the transform selection for IBC-coded blocks in VTM SW. No SW changes are needed for the proposed changes, therefore no impact on coding performance.

Recommended CE work:

* JVET-O0373: An Improved Context Modelling for LFNST
  + Said to be motivated by coding efficiency (there was some discussion about being friendly to an encoder that might want to use LFNST for luma but not for chroma, but it was said that this is just one way an encoder could be designed)
  + Expected gain is small, only in chroma
  + No CE planned after Track A discussion
* JVET-O0292 (Method 2): Simplifications for LFNST
  + Remove the option of LFNST index equal to 2 and select the LFNST kernel using the intra prediction mode when LFNST index is equal to 1
  + Motivated by encoder runtime reduction (~20% AI encoder runtime reduction, loss expected less than 0.1%)
  + Will compare against encoder-only approach (expected gain of 0.6% relative to encoder-only approach)
  + May compare against using a context for the second bin
* JVET-O0350: LFNST with one mode
  + Together with encoder only approach being studied as part of CE.
  + To test together with O0292.
  + Define a single transform for each intra prediction mode by alternating between the available two transforms for consecutive intra prediction modes, +0.08 for both AI and RA configurations. The encoder runtimes with respect to VTM-5 are reported to be 83% and 95% for AI and RA.
* Three approaches for reducing coefficient memory
  + JVET-O0195 (aspect 3): Simplification on LFNST
    - Reduce four transform sets to three transform sets, which saves 25% memory for storing LFNST matrices, i.e., 2KB.
    - This aspect alone: 0.07%/-0.01%/0.04% and 0.02%/-0.19%/-0.11% Y/Cb/Cr BD-rates in AI and RA configuration, respectively.
  + JVET-O0539: Unified LFNST using block size independent kernel
    - Unified LFNST using block size independent kernel, 2KB memory saving, 0.00%, -0.01% luma BD-rate for AI and RA configurations (not relative to VTM5, but relative to something else).
    - A participant commented that the mathematics of this approach should be checked carefully.
  + JVET-O0620: Simplification with new LFNST transform basis
    - 1.54KB memory saving with 0.03% loss in CTC.
    - Reduces computation for the larger block sizes. Worst-case is 4x4 which is not changed.

Decision (cleanup): Adopt O0294, method 3, O0372\* (\*retrained init values), O0380, method 1.

Further discussion of remaining items in BoG report Wed 10 July 1130 (GJS)

**LFNST signaling**

Two Options (listed below) to be considered for solving the latency issue of LFNST

**Option #1**: Limit LFNST up to max TU size

* JVET-O0213, JVET-O0410, JVET-O0291 (Method #2), JVET-O0266 (Modification #1)

**Option #2**: TU-level LFNST

* **Signaled after residual coding (for Chroma components, it is signaled after Cr residual coding):** JVET-O0213, JVET-O0291 (Method #3.3), JVET-O0569 (Option #2), JVET-O0352 (Method #1), JVET-O0444
* **TB-level signaling (separate LFNST index for different color components):** JVET-O0352 (Method #2)
* **Signaled after last position but before coefficient coding:** JVET-O0293 (Method #2)
* **Signaled for only the first TU**
  + The LFNST index is shared among all TUs, JVET-O0569 (Option #1), JVET-O0291 (Method #3.1), JVET-O0476 (Test #2)
  + The LFNST index is only applied for the first TU: JVET-O0476 (Test #1), JVET-O0291 (Method #3.2)

The minimal fix for the VPDU issue is “option 1”. It was asserted that there are other benefits for the alternative proposals. Some proposals move the LFNST selection to the TU level. Another is said to reduce latency by moving the LFNST selection before coefficient level parsing, especially when considering other adoption actions at the meeting, see CE6-2.1a and O0472, the combination being JVET-O0293 method #3. Others commented that this would be a significant change of the transform parsing syntax. This would signal last position for Y, Cb, and Cr, then the LFNST index, then the rest.

It was said that the minimal “option 1” approach would be the simplest fix to the clear VPDU problem.

Decision: No LFNST for CUs larger than the max TU size.

Collecting more opinions on the CE6 test condition regarding the following issues:

* Training sequences
* Training software
* Cross-verification on training
* Reference SW used for deriving the training data

There was discussion of the potential of overfitting to the training set.

It was suggested to include a testing of retraining for the existing LFNST kernel (which was trained 9 months ago and kept unchanged since then in the interest of stability). Some potential participants of the CE were unsure whether they could release training software.

It was noted that training software for MIP was released (at least for the version adopted at the previous meeting). CABAC training algorithms and training sets have also been released in previous work.

It was agreed that the CE will require availability of the training set and training software for cross-checking and study.

JVET-O0545 proposes a configurable maximum transform size in VVC. Ordinarily, the TU size is equal to the CU size unless the CU is bigger than 64x64. ISP and SBT are the exceptions to this. The text is written in a generalized form with a MaxLumaTUsize variable, but the variable is set to a constant value of 64.

The proposal would add HLS variable at the SPS level to set this to smaller values. In an implementation, this would introduce a tiling of large CUs by smaller TUs.

It was commented that this would introduce a decoder flexibility requirement, with additional needs for conformance testing cases, for the purpose of enabling an encoder that would not support large transforms. An encoder could alternatively just use smaller CTUs, which would also reduce pipeline size for other aspects besides the transform (e.g., large-region motion comp with affine).

It was commented that an encoder that would not want to support large TUs would also probably cut a lot of other corners in its encoding process.

There was discussion of what would be the reasonable point of comparison if we have a CE; dropping the CTU size all the way to 32x32 was one comparison tested, but it was not clear that this was a reasonable point of comparison.

Decision: Enable the max luma transform size to be either 64 or 32 only with a flag at the SPS level. Max chroma transform size is derived from the chroma sampling ratio relative to the max luma transform size.

JVET-O0699: Modified DCT8/DST7 Transform Matrices for Faster Implementation

A similar idea had been proposed for other aspects, which were recommended for further study. So it was agreed in the track to also recommend further study for this proposal (although not in a CE).

Track A review closed 1330.

[JVET-O1117](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7754) BoG report on CE7-related and Non-CE7 contributions [H. Schwarz]

Reviewed Track A Wed 10 July 1330 (GJS)

This BoG met on 5th July 2019 from 9:30 to 17:45 to review the CE7-related and Non-CE7 contributions submitted to the 15th JVET meeting. In total, 27 contributions have been reviewed, which are categorized as follows:

* Transform skip residual coding (12 contributions)
* Coding of coded block flag (4 contributions)
* Context-coded bins & number of contexts (5 contributions)
* Scaling matrices (3 contributions)
* Joint chroma residual coding (3 contributions)

The BoG recommended the adoption of the following aspects:

* Decision (complexity reduction to reduce scan passes): 3-pass version of residual coding for transform skip (syntax only change, JVET-O0623 method 3.2, JVET-O0619 test 2):
  + Pass 1: sig\_coeff\_flag, coeff\_sign\_flag, abs\_level\_gt1\_flag, par\_level\_flag
  + Pass 2: abs\_level\_gt3\_flag, abs\_level\_gt5\_flag, abs\_level\_gt7\_flag, abs\_level\_gt9\_flag
  + Pass 3: abs\_remainder

WD text available in JVET-O0623 and JVET-O0619.

* Decision (consistency): Align counting of context-coded bins in transform skip residual coding and regular transform coefficient coding: Exclude coded\_subblock\_flag’s in transform skip residual coding (JVET-O0409, but without modifying the threshold).

WD text available in JVET-O0409.

* Decision (bug fix): QP clipping in scaling process for transform skip (in order to prevent cases in which the effective quantization step size for transform skip becomes smaller than 1) as proposed in JVET-O0919 (JVET-O0405 is conceptually similar). The minimum allowed QP is basically given by QP\* = 4 – 6\*(inputBitDepth – 8). In the scaling process for transform skip, the quantization parameter is clipped according to

qP = Max( QpTsMin, Qp’Y ).

The minimum QP value QpTsMin is derived from an SPS syntax element qp\_ts\_minimum\_minus4 according to

QpTsMin = 4 + qp\_ts\_minimum\_minus4.

Benjamin Bross agreed to provide WD text.

* Decision (cleanup): Simplify context derivation for coded block flag by removing the dependency on transform depth (JVET-O0193, JVET-O0375). WD text available in JVET-O0193 and JVET-O0375.
* Decision (cleanup): Context model reduction for sig\_coeff\_flag (JVET-O0617). Removes 30 out of 90 context models with straightforward modification of context derivation. WD text available in JVET-O0617.
* Disallow additional joint chroma coding modes (for adopted CE7-2.1) in non-I slices (JVET-O0543). WD text available in JVET-O0543. In the track review it was commented that this seemed inconsistent and instead disallowing it for non-I CUs rather than for non-I slices would be more rational. Decision (cleanup): Disallow additional joint chroma coding modes (for adopted CE7-2.1) in non-I CUs. (This includes disallowing additional joint chroma coding modes for IBC CUs.) It was noted that this was one aspect proposed in JVET-O0670.
* Decision (SW bug fix): Software-only fix regarding position of chroma CBFs for SBT TUs (in order to align software with WD text). Proponent of JVET-O0596 will provide fix for software.

The BoG recommends a further study of the following aspects in a CE:

* Multiple variants of organizing the syntax elements for transform skip residual coding into scan passes, including 2-pass, 4-pass variants as well as variants with re-positioning of the parity flag (JVET-O0295, JVET-O0623, JVET-O0619).
* Proposed concepts for restricting the switch to bypass mode (similar as in regular transform coefficient coding): JVET-O0619
* Advanced context modelling for syntax elements in transform skip residual coding (JVET-O0295)
* QP dependent binarization of quantization indexes in transform skip (JVET-O0559): Maximum dynamic range is divided into 4 intervals, interval index and remainder within the interval is transmitted.
* Modified signalling of chroma CBFs and joint chroma residual coding flag (JVET-O0231).
* Approaches for context reduction (JVET-O0928, JVET-O1098). – Note: The latter one was not reviewed in the BoG, but falls into the same category (and was submitted to a previous meeting).

For the following aspects, the BoG request a discussion in the track or JVET plenary:

* Scaling for transform blocks with LFNST. Contribution JVET-O0383 asserts that transform coefficients after LFNST do not relate to spatial frequencies. It is proposed to modify the scaling for such transform blocks as follows:
  + Scaling with flat scaling matrix (before LFNST)
  + Additional scaling with scaling matrix (after LFNST)

This was discussed and it was agreed to encourage further study. It seemed as if the proposal is conceptually sensible, but it would add some extra processing and hasn’t been studied by others.

* Complexity impact of using different scans in transform skip residual coding and regular transform coefficient coding (forward vs backward scan): JVET-O0619. The coding efficiency difference for TGM content was said to be 0.13 for RA and 0.3 for AI. It was commented that using the same scan would be desirable. Another participant said that the backward scan might have a latency issue for BDPCM but others said this was not the case in the manner likely to be implemented. Another participant said that an implementation could build a rotation into the subsequent process so that it wouldn’t really make a difference. HEVC had some rotation for TS blocks. Further study was encouraged (not in a CE).
* With the adoption of CE7-1.1, we use a different maximum number of context-coded bins for regular transform coefficient coding and transform skip residual coding (1.75 vs 2.0 context-coded bins per coefficient). Is that desirable? – Might be worth the further study the impact on coding efficiency. It was reported that an experiment to test the impact of this was being conducted and would be provided in O1169, and the impact was said from partial results to be 0.27% in AI TGM and 0.22% in RA TGM. Low QP tests would not be feasible until the other bug fix from the meeting was done. So some impact was observed. Further study was encouraged.

The following contribution had not been discussed in the BoG, but are related to CE7 topics:

* JVET-O0068 (study of bin-to-bit ratio): No presenter was available in the BoG; it is available for information. It was commented that for the CABAC engine, transform skip residual coding is a bottleneck and that the worst case bin-to-bit ratio has increased from VTM4 to VTM5.
* JVET-O0223, JVET-O0527 (scaling matrices): Already discussed in track A
* JVET-O0376: One aspect relates to CE7 (high-level flag for joint chroma coding). Decision: Yes, there should be a flag for this.
* JVET-O1098: Reduction of number of context models (same as JVET-M0107 submitted to 13th JVET meeting). – Could be tested together with other proposals in a corresponding CE.

JVET-O0783 proposes an SPS flag on whether to perform TS residual coding different from the residual coding of transform blocks. The asserted benefit would be to allow an encoder to use the same residual coding all the time. However, this would require a decoder to support two modes of operation, and there would need to be more conformance tests, etc. No action.

discussion end 1520.

[JVET-O1133](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7770) BoG report on PROF/BDOF harmonization contributions (CE4&CE9 related) [S. Esenlik, H. Yang]

The BoG met in 2 sessions in order to discuss CE9 (decoder motion vector derivation) related contributions. The sessions were held on 7 July 2019 from 11:30 to 13:45 and from 15:00 to 17:00.

Presented in track B Tuesday 1130-1330

Recommended for adoption

[JVET-O0594](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7209) CE4-related: Prediction sample padding unification for BDOF and PROF [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

Aspect 1:

The padding of PROF is applied to BDOF (unification). The coding impact is: Y:-0.05% U:-0.01% V:0.00% for RA configuration. It is proposed that the BDOF padding operation uses the nearest integer sample position.

Aspect 1a of JVET-O0252, JVET-O0506, JVET-O0615 and JVET-0624 method 3 are identical

Decision (cleanup): Adopt JVET-O0594. Though rounding is slightly more complex than truncating, the processes of BDOF and PROF are better aligned by that change regarding the sample access for padding after the rounding of the vector at subblock level. As the subblock size of BDOF is larger than PROF, it is not critical in terms of reusing the same logic for that.

It is further noted that, even though there is some commonality at the pixel processing level, BDOF and PROF are still quite different and only partially can use identical logic, in particular at the block level they are still more different. There are many proposals that try to resolve that, where a better understanding about the level of commonality that can be achieved, and how it might impact the compression performance, should be investigated in a CE.

The following contributions are suggested to be included in that CE (agreed in track B):

[JVET-O0123](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6727) Non-CE4: Alignment of BDOF refinement process with PROF [J. Li, C. Lim (Panasonic)]

There is a new contribution JVET-O1142, which combines JVET-O0593/JVET-O0252/JVET-O0281/JVET-O0615

Also include JVET-O0573 in this CE

CE should test different bit depth (8, 10, 12)

Revisit: Should previous CE4 & CE9 be merged?

There are other proposals proposing extension of PROF and BDOF for chroma. It is reported that artifacts may appear at chroma edges due to the fact that the additional pixel based alignment was not applied to chroma. It was however reported that in the BoG discussions the examples of such artifacts were not very obvious, and would only appear at rather high QP values (such as 37). In general, due to additional complexity, it would be undesirable to extend BDOF and PROF for chroma in the 4:2:0 case. The proponents of O0210, O0577 and O0583 are asked to provide more evidence about the severity of such artifacts, before starting a CE on this. The chroma gains for applying both BDOF and PROF for 4:2:0, if additive, would be in the range of 0.7%-0.9%, which is not justifying the additional compelxity, unless justification by subjective benefit was made. JVET-O0210 also reports results on 4:2:2 and 4:4:4 material with only BDOF enabled for chroma, which are around 0.6%-0.9% at maximum (and could be expected to be somewhat higher if it was also applied to PROF) when coding YUV. For RGB444, the gain goes up to 1%-1.5% for the R and B components. Further study is encouraged here to identify if there would be a subjective impact. As in the case of 4:4:4 the processing for BDOF and PROF would be triplicated, it might even be better disabling those tools for all components in 4:4:4 if they would cause chroma artifacts due to the inconsistency between luma and chroma.

No CE on these aspects

Further review in track B on the following contributions:

[JVET-O0570](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7185) Non-CE9: Unified gradient calculations in BDOF [H. Liu, L. Zhang, K. Zhang, Z. Deng, N. Zhang (Bytedance)]

Test 1:

Do shift first for both spatial and temporal gradient calculation. Prediction samples are first downshifted by 6 bits (in 10 bit coding) and subtraction is performed afterwards to obtain the gradients. The test1 applies to both PROF and BDOF. The motivation is to be able to perform the subtraction operation in 16 bit logic. Moreover it is reported that the current PROF might have an overflow issue due to implementation of this operation in 16 bit SIMD logic.

It is reported in track B that the change in BD rate is -0.02% in RA, so the method does seem to harm the compression.

An alternative would be to use 32 bit SIMD logic for PROF (as BDOF does), which would be less efficient in software implemention.

This is identical to the method proposed in JVET-O0211, which only uses that for BDOF.

Decision (Text/SW): Adopt JVET-O0570 test 1

[JVET-O0573](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7188) Non-CE9: Restriction on motion vector refinement in BDOF [H. Liu, L. Zhang, K. Zhang, H.-C. Chuang, J. Xu (Bytedance)]

The contribution restricts the refinement motion vector values to 0, -2^N and 2^N.

For BDOF 0.01 gain RA. For PROF and BDOF together 0.02 coding loss (the anchor is VTM5.0+PROF).

According to this contribution the PROF mv refinement is obtained by rounding to nearest 2^N. for BDOF the division operation is modified slightly.

2 multiplications per sample can be removed. On top of the adoption of JVET-O0304, this contribution would remove most of the remaining multiplications. 1 multiplication per 4x4 block would reportedly remain.

One expert expressed concern about the interaction of this with JVET-O0304.

One expert suggested that per sequence there is up to 0.09% luma coding loss.

One expert suggested that the benefit is large. The change is easy to understand by some.

The proponent of JVET-O0304 was in favor of this change.

From Track B discussion: Include this in CE on BDOF/PROF harmonization.

[JVET-O0664](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7281) CE4-related: Simplifications on PROF [H. Chen, H. Yang (Huawei)]

In the second aspect, the refinement offset is clipped within [-4096, 4095] to ensure the refined value is within 16-bit signed range.

Simulation results for aspect 2 reportedly show that the luma BD-rate -0.48% and -0.30% in RA and LB cases, respectively, when compared to VTM-5.0.

In current design, BDOF has no clipping since the offset is applied in the final prediction signal stage. In CE4-2.1a that PROF has overflow issue since it is applied in the prediction stage of each reference picture list.

If the uniform design of BDOF and PROF is adopted in this meeting cycle, there is no need to take action on this contribution. Otherwise, the bug-fix proposed in this contribution is recommended for adoption.

In the follow-up discussion in track B, if was agreed that the clipping is not needed, since the prediction before adding the offset is not using the full 16 bit range. No action.

[JVET-O0594](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7209) CE4-related: Prediction sample padding unification for BDOF and PROF [X. Xiu, Y.-W. Chen, T.-C. Ma, H.-J. Jhu, X. Wang (Kwai Inc.)]

Aspect 2:

A misalignment between the spec changes proposed in the adopted PROF contribution JVET-O0and the software.

According to the proponent the software should be aligned with the provided spec, since the bit-shift operation is aligned with BDOF in the spec, whereas the software uses a fixed shift operation that is 6 bits. This bitshift operation is actually always 6 bits between the operation range of 8 to 12 bits.

Recommendation (alignment of SW to spec): modify the software according to the provided spec. The gradient calculation should include the right shift operation of: >> max(6, BD-6).

There is no change in the performance.

Decision (CE-SW): Apply the bug fix suggested in aspect 2 of JVET-O0594.

## 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.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Category** | **Sub-Category** | **Rationale** | **Tool** | **Document** |
| **Inloop Filter** | |  |  |  |
|  | Deblocking | Subjective quality | Sub-sample MV threshold | JVET-O0061 |
|  | Deblocking | Cleanup | Deblocking tC table defined for 10-bit video | JVET-O0159 |
|  | Deblocking | Bug fix | Chroma line selection for gradient computation | JVET-O0637 |
|  | Deblocking | Subjective quality | Deblocking at 4x4 block boundaries | JVET-O0060 |
|  | ALF | Coding efficiency (chroma) | Alternative chroma filters + CTU chroma filter selection | JVET-O0090 |
|  | ALF | Simplification | Modification of clipping value signalling | JVET-O0064 |
|  | ALF | Simplification | Modification of ALF coefficient signalling | JVET-O0216 |
|  | ALF | Cleanup | Save the signalling of the APS index in cases where the number is <= 2 | JVET-O0247 |
|  | ALF | Bug fix | Apply VB when the bottom CTU boundary is a slice/tile/brick or “360 virtual” boundary | JVET-O0625 |
|  | ALF | Simplification | Modified ALF filtering for Slice, Brick and Virtual boundaries | JVET-O0662 |
|  | ALF | Simplification | Simplification of ALF Coefficient Signalling | JVET-O0669 |
|  | ALF | Cleanup | Syntax constraints of ALF APS | JVET-O0288 |
|  | LMCS | Cleanup/Bug fix | LMCS related clean-ups | JVET-O0428 |
|  | LMCS | Simplification | Unification of chroma residual scaling | JVET-O1109 |
|  | LMCS | Simplification | Simplified inverse luma mapping | JVET-O0272 |
|  |  |  |  |  |
| **Intra** |  |  |  |  |
|  | IBC | Simplification | Single HMVP table inside shared merge list region for IBC | JVET-O0078 |
|  | IBC | Simplification | Disabling IBC for chroma in case of dual tree | JVET-O0258 |
|  | IBC | Bug fix | IBC mvp flag conditioned on MaxNumMergeCand>1 | JVET-O0162 |
|  | IBC | Cleanup | Number of IBC merge candidates independent for P/B slices | JVET-O0455 |
|  | IBC | Simplification | Bitstream conformance with a virtual IBC buffer concept | JVET-O1170 |
|  | CCLM | Complexity reduction | CCLM restrictions for dualtree to reduce latency | JVET-O1124 |
|  | Palette | Coding efficiency (444/SCC) | Base palette mode for 4:4:4 | JVET-O0119 |
|  | Block sizes | Complexity reduction | Small chroma block size restrictions for shared tree | JVET-O0050 |
|  | Block sizes | Bug fix | MinCbSize >= 8 | JVET-O0640 |
|  | ISP | Complexity reduction | 4xN prediction regions for 4xN and 8xN (N > 4) ISP-coded blocks | JVET-O0106 |
|  | BDPCM | Bug fix/cleanup | Unified TS and BDPCM signalling | JVET-O1136 |
|  | BDPCM | Simplification | Intra prediction mode alignment for BDPCM | JVET-O0315 |
|  | PCM | Simplification | Remove PCM | JVET-O0525 |
|  | Prediction | Simplification | Small blocks (4x4, 4x8, 8x4) are not smoothed for all angles | JVET-O0277 |
|  | Prediction | Simplification | Always apply ‘DCT-IF’ interpolation to ISP | JVET-O0341 |
|  | Prediction | Simplification | Intra prediction simplifications | JVET-O0364 |
|  | Prediction | Simplification | MRL reference samples for DC | JVET-O0426 |
|  | Prediction | Simplification | Signal all 67 intra modes for ISP (MPM, remaining modes); apply PDPC | JVET-O0502 |
|  | Prediction | Bug fix | Wide-angle in chroma intra angle mapping table for 4:2:2 | JVET-O0655 |
|  | Mode coding | Bug fix | Chroma DM mode is planar in case of IBC | JVET-O0651 |
|  | Mode coding | Cleanup | Intra chroma mode coding cleanup | JVET-O1153 |
|  | MIP | Simplification | MIP 8-bit coefficient and simplifications | JVET-O0925 |
|  |  |  |  |  |
| **Trafo** |  |  |  |  |
|  | LFNST | Simplification | Simplification of 48x16 LFNST matrices | JVET-O0094 |
|  | LFNST | Simplification | LFNST index signalling depends on last position | JVET-O0472 |
|  | LFNST | Simplification | Disable LFNST for non-DCT2 MTS candidate | JVET-O0368 |
|  | LFNST | Cleanup | Disable LFNST and MIP for implicit MTS | JVET-O0529 |
|  | LFNST | Cleanup | LFNST transform set selection for a CCLM | JVET-O0219 |
|  | LFNST | Complexity reduction | Limit LFNST up to max TU size | JVET-O0213 |
|  | MTS | Cleanup | Context modelling for MTS index | JVET-O0294 |
|  | MTS | Cleanup | Context modelling for signalling MTS index | JVET-O0294 |
|  | MTS | Bug fix | Decouple intra transform selection from inter MTS related SPS flag | JVET-O0541 |
|  | MTS | Bug fix | MTS for IBC | JVET-O0474 |
|  | Block sizes | Cleanup | Configurable maximum transform size | JVET-O0545 |
|  | Block sizes | Cleanup | Maximum TU size for chroma format 4:2:2 and 4:4:4 | JVET-O0357 |
|  |  |  |  |  |
| **Quantization** | |  |  |  |
|  | QP signalling | Bug fix | CU > 64x64, always send cu\_qp\_delta in first TU | JVET-O0046 |
|  | QP signalling | Functionality | Signalling of chroma QP tables | JVET-O0650 |
|  | QP signalling | Functionality | CU level chroma QP control | JVET-O1168 |
|  | Scaling matrices | Cleanup | Use inter matrices for IBC | JVET-O0267 |
|  | Scaling | Bug fix | QP clipping in scaling process for transform skip | JVET-O0919 |
|  |  |  |  |  |
|  |  |  |  |  |
| **CABAC** |  |  |  |  |
|  | Coeff. coding | Troughput/worst case | TB-level constraints on context-coded bins | JVET-O0052 |
|  | Coeff. coding | Closing an open detail | Joint chroma residual coding with multiple modes | JVET-O0105 |
|  | Coeff. coding | Coding efficiency (SCC) | Sign context, level mapping, and bitplane coding for TS residual coding | JVET-O0122 |
|  | Coeff. coding | Complexity reduction | 3-pass residual coding for transform skip | JVET-O0623 |
|  | Coeff. coding | Cleanup | Exclude coded\_subblock\_flag in TSRC max ctx coded bin count | JVET-O0409 |
|  | Coeff. coding | Cleanup | Ctx derivation of coded block flag | JVET-O0193 |
|  | Coeff. coding | Cleanup | Context model reduction for sig\_coeff\_flag | JVET-O0617 |
|  | Coeff. coding | Cleanup | Disallow joint chroma coding for non-I CUs | JVET-O0543 |
|  | Coeff. coding | Cleanup | High-level flag for joint chroma coding | JVET-O0376 |
|  | Engine | Simplification | CABAC init | JVET-O0065 |
|  |  |  |  |  |
| **Inter** |  |  |  |  |
|  | AMVR | Coding efficiency | HPEL AMVR extension with alt. IF | JVET-O0057 |
|  | PROF | Coding efficiency | Affine prediction refinement with optical flow | JVET-O0070 |
|  | PROF/ BDOF | Cleanup | Prediction sample padding unification for BDOF and PROF | JVET-O0594 |
|  | PROF/ BDOF | SImplification | Unified gradient calculations | JVET-O0570 |
|  | BDOF | Simplification | BDOF 4x4 early termination threshold | JVET-O0055 |
|  | BDOF | Simplification | Reduction of number of multiplications | JVET-O0304 |
|  | DMVR/ BDOF | Simplification | disabling DMVR and BDOF for CIIP | JVET-O0108 |
|  | DMVR/ BDOF | Cleanup | Unify allowed DMVR and BDOF block sizes | JVET-O0634 |
|  | DMVR/ BDOF/ BCW | Simplification | Disabled DMVR, BDOF and BCW for CIIP | JVET-O0681 |
|  | DMVR | Simplification | modified SAD for the center coordinate | JVET-O0590 |
|  | DMVR | Simplification | Simplification for DMVR padding process | JVET-O0297 |
|  | Triangle merge | Simplification | MV storage in TPM | JVET-O0265 |
|  | Merge syntax | Cleanup | Change merge mode flags syntax tree | JVET-O0249 |
|  | SbTMVP | Bug fix | max. num. of subblock merge cand. Signalling | JVET-O0220 |
|  | SbTMVP | Cleanup | Remove switching between L0 and L1 for temporal MV | JVET-O0163 |
|  | AMVP | Simplification | remove spatial AMVP cand scaling | JVET-O0164 |
|  | Affine / AMVR | Cleanup | SPS affine AMVR control flag | JVET-O0438 |
|  | Affine / BCW | Simplification | copy BCW index from first spatial affine merge candidate | JVET-O0366 |
|  | SMVD | Cleanup | SMVD value range | JVET-O0567 |
|  | SMVD | Cleanup | condition sym\_mvd\_flag on mvd\_l1\_zero\_flag | JVET-O0284 |
|  | SMVD | Simplification | SMVD only for STRPs | JVET-O0414 |
|  | SMVD | Bug fix | Add missing initialization | JVET-O0572 |
|  | MVD | Cleanup | Extent MVD range to [-2^17, 2^17-1] | Plenary |
|  | BDOF | Simplification | Simplification of BDOF | JVET-O0304 |
|  | BDOF | Cleanup | Unified syntax for JVET-O0184/O0250/O0504 on DMVR and BDOF flag | JVET-O1140 |
|  |  |  |  |  |
| **Partitioning** | |  |  |  |
|  | Chroma formats | Cleanup | Do not signal SH chroma tool flags in case of 4:0:0 | JVET-O0616 |
|  | Coding tree | Bug fix | Store CuPredMode[x][y], cqtDepth[x][y], CbWidth[x][y], CbHeight[x][y], CbPosX[x][y] and CbPosY[x][y] for separate trees | JVET-O0194 |
|  | CTU size | Simplification | Increase Min CTU size to 32x32 | JVET-O0526 |
|  |  |  |  |  |
| **HLS** |  |  |  |  |
|  | VUI | Bug fix | update BT.2100 references and ICTCP HLG coding equations | JVET-O0622 |
|  | RPR | Functionality | Integrated Specification Text for Reference Picture Resampling: including elements of the following documents: JVET-O0133, JVET-O0134, JVET-O0182, JVET-O0204, JVET-O0242, JVET-O0303, JVET-O0319, and JVET-O0395. | JVET-O1164 |
|  |  |  | High level syntax decision from BoG report JVET-O1076 review | notes on JVET-O1076 |
|  |  |  |  |  |
| **Software** |  |  |  |  |
|  | Pre-filter | Coding efficiency | Encoder-only GOP-based temporal filter | JVET-O0549 |
|  | Triangle merge | Speedup | Modified mode decision process for triangle mode | JVET-O0379 |
|  | Triangle merge | Speedup | SIMD for triangle merge mode | JVET-O0280 |
|  | Subblock merge | Bug fix | Parse merge\_subblock\_flag conditioned on MaxNumSubblockMergeCand | JVET-O0220 |
|  | Subblock merge | Bug fix | Different ctx models (but same derivation) for inter affine flag and subblock merge flag | JVET-O0500 |
|  | Palette mode | Bug fix | 4:4:4 low QP bug fix | JVET-O0282 |
|  | Motion search | Coding efficiency | Motion estimation improvements | JVET-O0592 |
|  | MVD | Bug fix | MVD clipping | JVET-O0567 |
|  | BCW | Bug fix | BCW index binarization | JVET-O0126 |
|  | LMCS | Bug fix | CRS luma lambda computation | JVET-O0429 |
|  | LMCS | Coding efficiency , simplification | LMCS encoder improvement | JVET-O0432 |
|  | MTS | Bug fix | SPS control of ISP and SBT transform selection | JVET-O0538 |
|  | PROF | Bug fix | Align bit-shift operation with BDOF | JVET-O0594 |
|  | Coeff. coding | Bug fix | Align SW to text regarding position of chroma CBFs for SBT TUs | JVET-O0596 |
|  | Dep. quant. | Speedup | Fast encoder with adjusted threshold | JVET-O0256 |
|  | QP signalling | Functionality | Chroma QP table signalling | JVET-O0186 |
|  | IBC |  | IBC virtual buffer in decoder SW | JVET-O1170 |

# Project planning

## Core experiment planning

…

## 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 June 2019.

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-M1010.

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:

* VTM6.0 will be released by 2019-08-12 including all adoptions necessary for CTC and CE basis references. VTM6.1 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 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-O2001 VVC text specification draft 6. * Produce and finalize JVET-O2002 VVC Test Model 6 (VTM 6) 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 6 behaviour relative to HEVC and VTM 5 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, 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 | T. Suzuki, M. Wien (co-chairs), V. Baroncini, R. Chernyak, A. Norkin, J. Ye (vice-chairs) | N |
| **Memory bandwidth consumption of coding tools (AHG5)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * 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. | R. Hashimoto (chair), T. Ikai, X. Li, D. Luo, H. Yang, M. Zhou (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. * 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-9.1 software version and common test condition configuration files according to JVET-M1012. * Generate CTC (PHEC) anchors and PERP results for VTM according to JVET-M1012, and finalize the reporting template for the common test conditions. * 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. * 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. | 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 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 a software framework which allows testing various layered coding and resolution adaptivity modalities in the context of the VTM software * Study approaches for support of layered coding scalability including spatial, temporal, quality, and view scalability; and analyse their coding efficiency and complexity characteristics * Coordinate with CEx on resampling filters | S. Wenger and A. Segall (co-chairs), M. M. Hannuksela, Hendry, S. McCarthy, Y.-C. Sun, P. Topiwala, M. Zhou (vice-chairs) | N |
| **Neural networks in video coding (AHG9)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * 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. | S. Liu and Y. M. Li (co-chairs), B. Choi, K. Kawamura, Y. Li, L. Wang, P. Wu, H. Yang (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 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. | 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 restriction, including identifying implications on coding tools and implementation. * Study flexible tile partitioning (e.g. more flexible than HEVC and tile boundaries not spanning a full picture). * Study support of independently coded picture regions, including easy rewriting of such regions into a conforming sub-bitstream. * 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), M. M. Hannuksela, R. Sjöberg, R. Skupin, W. Wan, Y.-K. Wang S. Wenger (vice-chairs) | N |
| **Tool reporting procedure (AHG13)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * 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 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. | 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 |
| **Operation modes for low latency support (AHG14)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * 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. * Study a parallel framework for GRA assessment | J.-M. Thiesse (chair), S. Deshpande, A. Duenas, Hendry, K. Kazui, R. Sjöberg, A. Tourapis (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 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 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. | M. Zhou (chair), J. An, E. Chai, K. Choi, S. Sethuraman, T. Hsieh, X. Xiu (vice-chairs) | N |
| **High-level syntax (AHG17)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study NAL unit header, sequence parameter set, picture parameter set, adaptation parameter set, and tile group header syntax designs * Study reference picture buffering and list construction * Study random access signalling and random access approaches, including approaches with reference pictures provided by external means * Assist in software development and text drafting for the high-level syntax in the VVC design. * Study syntax approaches for interoperability point signalling * Study selection of constraint flags to be included in the VTM and their impact on syntax, semantics, and decoding process | R. Sjöberg, J. Boyce (co-chairs), S. Deshpande, M. M. Hannuksela, R. Skupin, A. Tourapis, Y.-K. Wang, W. Wan, S. Wenger (vice-chairs) | N |
| **Lossless and near-lossless coding tools (AHG18)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * 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 | T. Nguyen and T.-C. Ma (co-chairs), M. Ikeda, S. Iwamura, 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-O2000 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-O2001 Versatile Video Coding (Draft 6) [B. Bross, J. Chen, S. Liu] [WG 11 CD 23090-3, N18692] (2019-07-31)

(Initial version planned to be made available by 2019-07-18.)

See the list of elements under section 11.7, as agreed by the Fri. 12 July plenary.

JVET-O2002 Algorithm description for Versatile Video Coding and Test Model 6 (VTM 6) [J. Chen, Y. Ye, S. Kim] [WG 11 N 18693] (2019-09-09)

(Initial version planned to be made available by 2019-08-15.)

See the list of elements under section 0, as agreed by the Wed. 27 March plenary.

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-O2005 Methodology and reporting template for coding tool testing [W.-J. Chien and J. Boyce] (2019-07-31)

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-O2007 Supplemental enhancement information messages for coded video bitstreams [J. Boyce, G. J. Sullivan, Y.-K. Wang] [WG 11 CD 23002-7, N18699] (2019-07-31)

(.)

See the list of elements under section 11.8, as agreed by the Wed. 27 March plenary.

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)

(Old document revised for editorial refinement of headings.)

JVET-O2011 JVET common test conditions and evaluation procedures for HDR/WCG video [A. Segall, E. François, W. Husak, S. Iwamura, D. Rusanovskyy] (2019-07-31)

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)

[JVET-O2021](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7821) Description of Core Experiment 1 (CE 1): Reference picture resampling filters [D. Luo, V. Seregin, W. Wan]

Regarding 0.5 second switching point, it was agreed to round down the switching point frame number to be a multiple of 4 to align with the GOP structure in LDB. In terms of the number of pictures tested, it will be set equal to 5-second-worth of test material without rounding.

Because the dimensions of coded pictures (full-resolution and downsampled) must be multiple of 8, it was agreed that the CE coordinators and participants will fill out the detailed plan for what lower resolution to code for each of the different source resolutions and different resampling ratios in the CE description document.

For PSNR1 caluclation, averaging PSNR values of different picture sizes may not be desirable. One way to address this is to accumulate the MSEs of all pictures and only convert to PSNR at the end of coding. It was agreed that the CE coordinators and participants will fill out the detailed plan for PSNR1 caluclation in the CE description document.

[JVET-O2022](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7823) Description of Core Experiment 2 (CE2): Gradual decoding refresh [K. Kazui, J.-M. Thiesse, Hendry, K. Kawamura]

Reviewed in closing plenary 1245.

Will test normative change of intra boundary, normative change of MC boundary extrapolation, and wavefront GDR.

[JVET-O2023](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7816) Description of Core Experiment 3 (CE3): Intra prediction and mode coding [G. Van der Auwera, L. Li, A. Filippov]

[JVET-O2024](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7820) Description of Core Experiment 4 (CE4): Inter prediction [C.-C. Chen, H. Yang, X. Xiu]

[JVET-O2025](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=7822) Description of Core Experiment 5 (CE5): Loop filtering [C.-Y. Chen, A. Norkin]

Includes ALF, SAO, bilateral, HDTF, and deblocking.

Includes considering removal of SAO (or merging filters).

CE5-1.3 will include testing the proposed methods with DMVR off.

CE5-3.3 will include testing removal of SAO.

[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 Wednesday 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. 1 (afternoon) – Fri. 11 October 2019, 16th meeting under ITU-T auspices in Geneva, CH.
* Wed. 8 – 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.

The agreed document deadline for the 16th JVET meeting was planned to be Tuesday 24 September 2019. CE proposal documents are due one week ahead of that date. Plans for scheduling of agenda items within that meeting remained TBA.

SIS and Kenzler Conference Management were thanked for the excellent hosting and organization of the 15th meeting of the JVET. Divideon, Dolby, Ericsson, and SIS were thanked for financially supporting the social event.

Ericsson and Sharp Labs of America were thanked for providing equipment used for subjective viewing during the 15th JVET meeting. Kenneth Andersson, Andrew Segall and Mathias Wien were thanked for preparing and conducting the subjective test efforts related to CE5 and CE10, and Vittorio Baroncini was thanked for his advice. The experts who participated in the role as test subjects were also thanked.

The 15th JVET meeting was closed at approximately 1351 hours on Friday 12 July 2019.

# Annex A to JVET report: List of documents

# Annex B to JVET report: List of meeting participants

The participants of the fifteenth meeting of the JVET, according to an attendance sheet circulated during the meeting sessions (approximately XXX people in total), were as follows: