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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**  14th Meeting: Geneva, CH, 19–27 March 2019 | Document: JVET-N\_Notes\_dA |

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| *Title:* | **Meeting Report of the 14th Meeting of the Joint Video Experts Team (JVET), Geneva, CH, 19–27 March 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 fourteenth meeting during 19–27 March 2019 at the ITU-T premises in Geneva, CH. The JVET meeting was held under the chairmanship of Dr Gary Sullivan (Microsoft/USA) and Dr Jens-Rainer Ohm (RWTH Aachen/Germany). For rapid access to particular topics in this report, a subject categorization is found (with hyperlinks) in section 2.13 of this document. It is further noted that the unabbreviated name of JVET was formerly known as “Joint Video *Exploration* Team”, but the parent bodies modified it when entering the phase of formal development of a new standard. The name Versatile Video Coding (VVC) was chosen in April 2018 as the informal nickname for the new standard.

The JVET meeting began at approximately 0900 hours on Tuesday 19 March 2019. Meeting sessions were held on all days (including weekend days) until the meeting was closed at approximately 1850 hours on Wednesday 27 March 2019. Approximately XXX people attended the JVET meeting, and approximately 800 input documents, 13 CE summary reports, and 19 AHG reports were discussed. The meeting took place in a collocated fashion with a meeting of ITU-T SG16 – one of the two parent bodies of the JVET. The subject matter of the JVET meeting activities consisted of developing video coding technology with a compression capability that significantly exceeds that of the current HEVC standard, or otherwise gives better support regarding the requirements of future application domains of video coding. As a primary goal, the JVET meeting reviewed the work that was performed in the interim period since the thirteenth JVET meeting in producing a fourth draft of the VVC standard and the fourth version of the associated VVC test model (VTM). Further important goals were reviewing the results of 13 Core Experiments (CE), reviewing other technical input on novel aspects of video coding technology, and 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 18 output documents from the meeting (update):

* JVET-N1001 Versatile Video Coding specification text (Draft 5)
* JVET-N1002 Algorithm description for Versatile Video Coding and Test Model 5 (VTM 5)
* JVET-N1003 Guidelines for VVC reference software development
* JVET-N1005 Methodology and reporting template for coding tool testing
* JVET-N1010 and JVET-N1011, JVET common test conditions and software reference configurations for SDR and, HDR/WCGvideo, respectively
* JVET-N1021 through JVET-N1031, Description of Core Experiments 1 through 11

For the organization and planning of its future work, the JVET established 17 “ad hoc groups” (AHGs) to progress the work on particular subject areas. At this meeting, 11 Core Experiments (CE) were defined. The next four JVET meetings were planned for 3–12 July 2019 under WG 11 auspices in Gothenburg, SE, during 1–9 October 2019 under ITU-T SG16 auspices in Geneva, CH, during 8–17 January 2020 under WG 11 auspices in Brussels, BE, and during 15–24 April 2020 under WG 11 auspices in Alpbach, AT.

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 fourteenth meeting during 19–27 March 2019 at the ITU-T premises in Geneva, CH. The JVET meeting was held under the chairmanship of Dr Gary Sullivan (Microsoft/USA) and Dr Jens-Rainer Ohm (RWTH Aachen/Germany).

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

## Meeting logistics

Information regarding logistics arrangements for the meeting had been provided via the email reflector [jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de) and at <http://wftp3.itu.int/av-arch/jvet-site/2019_03_N_Geneva/>.

## Primary goals

As a primary goal, the JVET meeting reviewed the work that was performed in the interim period since the thirteenth JVET meeting in producing a fourth draft of the VVC standard and the fourth version of the associated VVC test model (VTM). Further important goals were reviewing the results of 13 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, 12 March 2019. Any documents uploaded after 1159 hours Paris/Geneva time on Wednesday 13 March 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, CE summaries, and other such reports which can only be produced after the availability of other input documents.

It was remarked that various CE results documents (both proponent proposal documents and CE summary reports) were arriving late, and that it is especially important for CEs to be thoroughly studied. JVET-N0104 for CE3-3.5 was an example of this (for which the proponent said that a software bug causing a need to regenerate VTM anchors was a problem). The timing of availability of software and text for CEs was also discussed. One of the purposes of a cross-check is to determine whether the technical description and text are correct. Having an earlier deadline for CE proposal documents (not necessarily CE summary documents) was suggested. It was agreed to have 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-N0500 were registered after the “officially late” deadline (and therefore were also uploaded late). However, some documents in the “M0501+” 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-N0XXX (a proposal on …), uploaded 03-XX.
* ….

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

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

* JVET-N0XXX (a document on …), uploaded 03-XX.
* ….

All cross-verification reports were both registered late and uploaded late (all with numbers higher than JVET-N0500) 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-N0156 (withdrawn), JVET-N0231 (withdrawn), JVET-N0244 (withdrawn), JVET-N0245 (withdrawn), JVET-N0315 (withdrawn), JVET-N0422 (withdrawn), JVET-N0431 (withdrawn), JVET-N0501 (withdrawn), JVET-N0530 (withdrawn), JVET-N0561 (withdrawn), JVET-N0633 (withdrawn), JVET-N0733 (withdrawn), JVET-N0773 (withdrawn), JVET-N0784 (withdrawn), JVET-N0858 (withdrawn), JVET-N0863 (withdrawn), JVET-N0871 (withdrawn), JVET-N0731 (missing by the end of meeting), JVET-N0836 (missing by the end of meeting), JVET-N0850 (missing by the end of meeting).

“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-N0213 and JVET-N0366.

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

* JVET-N0XXX (…)
* …

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-M1000, the Versatile Video Coding specification text (Draft 4) JVET-M1001, the Algorithm description for Versatile Video Coding and Test Model 4 (VTM 4) JVET-M1002, the Algorithm descriptions of projection format conversion and video quality metrics in 360Lib Version 9 JVET-M1004, the Methodology and reporting template for coding tool testing JVET-M1005, the Methodology and reporting template for neural network tool testing JVET-M1006, the JVET common test conditions and software reference configurations for SDR video JVET-M1010, and the Description of Core Experiments 1 through 13 (JVET-M1021 through JVET-M1033), had been completed and were approved. The software implementation of VTM (versions 4.0, 4.0.1 and 4.1), and the 360Lib software implementation (version 9.0) were 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 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 1129.

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.
* **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.
* **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**).
* **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.
* **BCW**: Bi-prediction with CU based weighting
* **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.
* **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**: …
* **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
* **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.
* **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.
* **MMLM**: Multi-model (cross component) linear mode.
* **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).
* **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.
* **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.
* **RDOQ**: Rate-distortion optimized quantization.
* **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 Tuesday 19 March (chaired by GJS and JRO) were as follows.

* The meeting logistics, agenda, working practices, policies, and document allocation were reviewed.
* 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 [1 JVET Viewing room and 1 MPEG Viewing room all in -1 of Montbrillant, M04B and MO3B and possibly a 3rd room in the -2 of the Tower if needed]
* Principles of standards development were discussed.
* Standardization timelines [CD July, DIS October (possibly Jan), 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:

* Tue. 19 March, 1st day
  + 0900–1230, 1430-1700 JVET opening plenary in CICG 1 (chaired by GJS & JRO)
  + 0930–1045 SG16 opening plenary (parent level outside of JVET)
  + 1115-1300 WP3/16 opening plenary (parent level outside of JVET)
  + 1730 Room A HLS BoG in Room A (JB, starting with 6.18.2 general HLS category)
  + 1730-2200 Track B CE2 Subblock MC in Room C (GJS)
  + 1730-1830, 1845-2200 Track A CEs in CICG 1, then Popov
* Wed. 20 March, 2nd day
  + Track A
    - 900-1345 CE3 in Room 1
    - 1500-1815 CE6, CE7 in Room 1
    - 1830-2215 CE8 in Room C
  + Track B in Room K
    - 0900-1100 CE2 Subblock MC
    - 1115-1300, 1430-1640 CE4 Inter pred and MV coding
    - 1645-1900 CE9 Decoder MV derivation
  + 0900-1300 HLS BoG in Room 5
  + 1430 Coded picture regions BoG in Room 5
  + 1530 Intra BoG in Room 13
  + 1830 Coded picture regions BoG in Room A
  + 1845 CE3 and related BoG in Room A (G. v. d. Auwera)
  + 1900-2345 CE2-related BoG in Room K (C.-C. Chen and Y. He)
  + 1500-1145 BoG on CE3 and related BoG (G. v. d. Auwera)
* Thu 21 March
  + Track A in CICG1
    - 0900-0930 CE8
    - 0930-1130 CE13
    - 1150-1400 CE1 related
    - 1600-1945 CE7 related
    - 1945-2030 Quantization (6.14)
  + Track B in Room K
    - 0900-1000 CE10 Combined intra/inter prediction
    - 1000-1230 CE12 and related tile set boundary motion comp handling
  + 0900-1000 Coded picture regions BoG in Room 5 (S. Deshpande)
  + 1100-1300 CE3 and related BoG in Room A (G. v. d. Auwera)
  + 1400-1600 CE1 subjective viewing
  + 1430-1545 VCEG (Q6/16) in Room A (parent level outside of JVET)
  + 1615 Coded picture regions BoG in Room A (S. Deshpande)
  + 1430-1600 CE2-related BoG in Room K (C.-C. Chen and Y. He)
  + 1615-2230 CE4-related BoG in Room K (H. Yang)
  + 1800-2130 CE5 subjective viewing
  + 1900 CE3 and related BoG (G. v. d. Auwera)
  + 2000 CE9-related BoG in Room H1 (S. Esenlik)
  + 2030 CE8 BoG in Room H1 (X. Xu)
* Fri 22 March
  + 0900 CE3 BoG in CICG 1 (G. v. d. Auwera)
  + 0900 Coded picture regions BoG in Room K1 (S. Deshpande)
  + 0900 JCT-VC opening plenary (outside of JVET)
  + 0900-1130 CE11 subjective viewing
  + 0915-1515 CE4-related BoG in Room K2 (H. Yang)
  + Track A in CICG 1
    - 1130-1445 Quantization (6.14), Entropy coding (6.15)
    - 1445 CE5 and CE11 viewing results
  + 1300-1530 CE8 SCC BoG in Room A
  + 1300 JPEG closing plenary in Room H1
  + 1600-1800 JVET plenary in CICG 1
  + 1900 CE1 subjective viewing in M04b
  + 1800 Track A on CE11 in CICG 1
  + 1845 Track A on CE11, CE5 related and CE11 related in Room C
  + CE3 BoG in Room A
  + HLS BoG in Room K1
  + CE6 BoG in Room K2
  + CE8 BoG in Room H1
  + CE9 BoG in Room H2
* Sat 23 March
  + 0900 CE8 BoG in H2
  + 0900 CE5 BoG in Room K2
  + 0900 CE6 BoG in Room A
  + 0900 CE13 BoG in Room H1 [brief]
  + 0900 Track A in Popov
    - 0900-1230 LMCS (6.16)
    - 1500-1530 Other coding tools (6.17)
    - 1530-1945 CE3 related (BoG report)
  + 0900-1230 HLS and coded picture regions (with Systems) in Room L
  + 1400 Track B in Room L
    - 1400-1740, 1800-1815 Coded picture regions
    - 1815 Gradual decoder refresh
    - Hypothetical reference decoder
    - Other high-level syntax
* Sun 24 March
  + 0900-1330, 1500-1800 JVET plenary in Popov
    - Review of track activities
    - Alternative chroma formats (4:4:4/4:2:2/Monochrome)
    - BoG review on CE2 related subblock motion compensation JVET-N0776
    - BoG review on CE8 related screen content coding JVET-N0780
    - Adaptive resolution conversion
  + After 1900 (if MPEG AHGs done): A, C, K1, K2
  + 1030-1300, 1500- HLS / coded picture regions BoG in Room L
  + 1800 MPEG chairs meeting (parent level outside of JVET)
  + 1800 HLS / coded picture regions in Popov
* Mon 25 March
  + 0900 MPEG opening plenary (parent level outside of JVET)
  + 1100 Track A CICG 1
    - 1100-1400 CE6 related (BoG report)
    - 1500-1830 CE8 related (BoG report)
    - 1850-2030 (continued in C2)
    - 2030-2040 CE5 related (BoG report)
    - 2040-2115 CE13 related (BoG report)
  + 1030-1330, 1500- Track B Room H
    - 1030 BoG review of CE4-related inter prediction and MV coding JVET-N0809
    - 1600 BoG review of CE2-related subblock motion compensation JVET-N0776
    - 1720-2225 BoG revew of CE9-related decoder motion vector derivation JVET-N0815
  + 1100-1330, [more?] HLS BoG in Room M1
* Tue 26 March
  + 0900-1000 VCEG & MPEG joint meeting in CICG 1 (parent level outside of JVET)
  + 1115-1315 JCT-VC (outside of JVET) [TBC]
  + 0930-1300 OMAF (outside of JVET) [TBC]
  + 0900-1330 Track A revisits in CICG
  + 1430-1700 CE and AHG planning in CICG
  + 1700-1745 Complexity analysis (7), encoder optimization (8)
  + 1800-2030 Text and software (4.1), test conditions (4.2) in C2, chaired by Y. Ye
  + Track B
    - 1500 BoG review coded picture regions
    - 1745 BoG review high-level syntax
  + Further BoG coded picture regions N0754
  + Further BoG high-level syntax N0724
* Wed 27 March
  + 0900 MPEG mid-week plenary (parent level outside of JVET)
  + 1030 Plenary: BoG resports (360°, HLS, coded pic regions), revisits, remaining doc review
  + 1500 Editing process guidance meeting
  + 1400-1600 VCEG (parent level outside of JVET)
  + 1430-1850 Closing plenary: SW and CE Timelines, CE doc reviews, document approval, list of adoptions, AHG setup, resolutions & future plans

## 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 (19) (section 3) (Plenary)
* Project development (X) (section 4) (Plenary)
  + Text and software development (5)
  + Test conditions (5)
  + Peformance assessment (1)
  + Coding studies on specific use cases (14)
    - Adaptive resolution conversion (6)
    - 360° video coding (4)
    - Chroma formats (4)
  + Test Material (2)
* Core Experiments (xx) (section 5) with subtopics
  + CE1: Post prediction and post reconstruction filtering (9) (section 5.1) (Track A)
  + CE2: Subblock motion compensation (20) (section 5.2) (Track B)
  + CE3: Intra prediction and mode coding (19) (section 5.3) (Track A)
  + CE4: Inter prediction and motion vector coding (18) (section 5.4) (Track B)
  + CE5: Adaptive loop filtering (4) (section 5.5) (Track A)
  + CE6: Transforms and transform signalling (4) (section 5.6) (Track A)
  + CE7: Quantization and coefficient coding (4) (section 5.7) (Track A)
  + CE8: Screen content coding tools (9) (section 5.8) (Track A)
  + CE9: Decoder motion vector derivation (7) (section 5.9) (Track B)
  + CE10: Combined intra/inter prediction (2) (section 5.10) (Track B)
  + CE11: Deblocking (4) (section 5.11) (Track A)
  + CE12: Tile set boundary motion comp handling (2) (section 5.12) (Track B)
  + CE13: Neural network based loop filtering (5) (section 5.13) (Track A)
* Non-CE technology proposals (xx) (section 6) with subtopics
  + CE1 related – Post prediction and post reconstruction filtering (10) (section 6.1) (Track A)
  + CE2 related – Subblock motion compensation (17) (section 6.2) (Track B)
  + CE3 related – Intra prediction and mode coding (54) (section 6.3) (Track A)
  + CE4 related – Inter prediction and motion vector coding (40) (section 6.4) (Track B)
  + CE5 related – Adaptive loop filtering (3) (section 6.5) (Track A)
  + CE6 related – Transforms and transform signalling (26) (section 6.6) (Track A)
  + CE7 related – Quantization and coefficient coding (11) (section 6.7) (Track A)
  + CE8 related – Screen content coding tools (40) (section 6.8) (Track A)
  + CE9 related – Decoder motion vector derivation (33) (section 6.9) (Track B)
  + CE10 related – Combined intra/inter prediction (3) (section 6.10) (Track B)
  + CE11 related – Deblocking (3) (section 6.11) (Track A)
  + CE12 related – Tile set boundary motion comp handling (3) (section 6.12) (Track B)
  + CE13 related – Neural network based loop filtering (1) (section 6.13) (Track A)
  + Quantization (3) (section 6.14) (Track A)
  + Entropy coding (9) (section 6.15) (Track A)
  + Luma mapping with chroma scaling (9) (section 6.16) (Track A)
  + Other coding tools (2) (section 6.17) (Track A)
  + High-level syntax (78) (section 6.18) (Track B)
* Complexity analysis and reduction (2) (section 7) (Track A)
* Encoder optimization (2) (section 8) (Track A)
* Metrics and evaluation criteria (0) (section 9) (Track none)
* 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 (58+174) was generally chaired by JRO, and Track B (49+173) by GJS.

# AHG reports (19)

These reports were discussed Tuesday 19 March XXXX–XXXX (chaired by GJS and JRO).

[JVET-N0001](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6334) 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.

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\_01\_ M\_Marrakech/](http://wftp3.itu.int/av-arch/jvet-site/2019_01_%20M_Marrakech/) ), particularly including the following:

* The meeting report (JVET-M1000) [Posted 2019-03-18]
* Versatile Video Coding (Draft 4) (JVET-M1001) [Posted 2019-02-01, last update 2019-03-17]
* Algorithm description for Versatile Video Coding and Test Model 4 (VTM 4) (JVET-M1002) [Posted 2019-02-16]
* Algorithm descriptions of projection format conversion and video quality metrics in 360Lib Version 9 (JVET-M1004) [Posted 2019-02-17]
* Methodology and reporting template for coding tool testing (JVET-M1005) [Posted 2019-01-30]
* Methodology and reporting template for neural network coding tool testing (JVET-M1006) [Posted 2019-01-30]
* JVET common test conditions and software reference configurations (JVET-M1010) [Posted 2019-02-07]
* Description of CE 1..13 (JVET-M1021..35) [all first posted 2019-01-18, further updates during the CE definition period of 3 weeks after the meeting, until 2019-02-08]. The following CE description documents had later updates (more than 4 weeks after the meeting):
  + - JVET-M1022 [last updated 2019-03-15]
    - JVET-L1023 [last updated 2019-03-14]
    - JVET-L1024 [last updated 2019-03-17]
    - JVET-L1026 [last updated 2019-03-14]
    - JVET-L1028 [last updated 2019-02-28]
    - JVET-L1029 [last updated 2019-03-14]
    - JVET-L1030 [last updated 2019-03-17]

The nineteen *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 600 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 70 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.

Discussed aspects:

draft text should be marked as draft 4

draft text to be updated

another version of VTM?

CE4 and CE9 had some clarifications

78 on HLS

[JVET-N0002](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6329) 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 13th meeting in Marrakech, MA (9–18 January 2019) and the 14th meeting in Geneva, CH, (19–27 March 2019).

At the 13th JVET meeting, it was decided to include additional coding features for intra picture-prediction, inter-picture prediction, transform, CABAC engine and de-blocking filter in the fourth draft of Versatile Video Coding (VVC D4) and the VVC Test Model 4 (VTM4) encoding. Draft reference software to implement the VVC decoding process and VTM3 encoding method has also been developed.

The normative decoding process for Versatile Video Coding is specified in the VVC draft 4 text specification document. The VVC Test Model 4 (VTM 4) Algorithm and Encoder Description document provides an algorithm description as well as an encoder-side description of the VVC Test Model 4, which serves as a tutorial for the algorithm and encoding model implemented in the VTM4.0 software.

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

**JVET-M1001 VVC specification (Draft 4)**

Seven versions of JVET-M1001 were published by the Editing AHG between the 13th meeting in Marrakech, MA (9–18 January 2019) and the 14th meeting in Geneva, CH, (19–27 March 2019).

JVET-M1001 has been established based on JVET-L1001 and now contains the following:

* Incorporated JVET-M0102: Intra subpartitions (ISP).
* Incorporated JVET-M0142: chroma format dependent CCLM downsampling filter.
* Incorporated JVET-M0064: table reduction in CCLM model parameter calculation.
* Incorporated JVET-M0092: intra reference sample filtering cleanup.
* Incorporated JVET-M0238: PDPC linear interpolation on the secondary boundary for adjacent angular modes is changed to nearest neighbour.
* Incorporated JVET-M0407: CPR search range.
* Fixed bug [#154](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/154) Availability check for CPR/IBC chroma CU reference block is missing.
* Aligned PDPC filtering for INTRA\_ANGULAR18 and INTRA\_ANGULAR50 to VTM.
* Fixed bug [#167](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/167) on PDPC size condition.
* Incorporated JVET-M0497: Fast DST-7/DCT-8.
* Incorporated JVET-M0303: Shape adaptive transform selection.
* Incorporated JVET-M0464/JVET-M0201: Combined transform skip(TS) and MTS syntax plus extended TS sizes.
* Incorporated JVET-M0297: Zero-out of last 16 samples for 32 samples DST-7/DCT-8.
* Incorporated JVET-M0140: Subblock transform for inter CUs.
* Incorporated JVET-M0251/M0257: Zero-out of last 32 samples for 64 samples DCT-2 fix.
* Incorporated JVET-M0273/M0240/M0116/M0338/M0204: only using left neighbor for SbTMVP fetching
* Incorporated JVET-M0246: AMVR for affine
* Incorporated JVET-M0145: affine sub-block MV clipping
* Incorporated JVET-M0166/M0228/M0477: remove MV comparison for constructed merge candidates
* Incorporated JVET-M0170: Parallel processing for merge mode
* Incorporated JVET-M0147: Decoder side motion vector refinement
* Incorporated JVET-M0361: fix of cu\_cbf for merge mode
* Incorporated JVET-M0487: using integer samples instead of bilinear interpolation for extended region of BDOF.
* Incorporated JVET-M0483: IBC signalled as a separate CU prediction mode.
* Incorporated JVET-M0063: Generalization of BDOF bit-depth.
* Incorporated triangular modifications including:
  + JVET-M0118/M0185/M0190/M207(test 1)/M0216(the first aspect)/M0234 (change corresponding to the result table 7 and 8)/M0317(section 2.2)/M0328: Do not signal the triangular prediction mode flag in cases where the combination is not allowed (MMVD, CIIP),
  + JVET-M0328: always use second weight group in triangular prediction.
* Incorporated JVET-M0883: signaling change of triangular merging candidate which does not need LUT.
* Incorporated JVET-M0193: pairwise average merging candidate reduction.
* Incorporated HMVP modifications including:
  + JVET-M0436 reduce HMVP number from 6 to 5,
  + JVET-M0300 HMVP initialization for parallel processing with tiles,
  + JVET-M0264 GBI weight is also stored in HMVP,
  + JVET-M0126 reduced HMVP candidate pruning.
* Incorporated JVET-M0255: MMVD mode without fractional sample offsets for screen content coding.
* Incorporated JVET-M0171/M0068: remove redundant MV scaling in MMVD.
* Incorporated JVET-M0444: symmetrical MVD coding for L0 to L1.
* Incorporated JVET-M0479: MV clipping to 18 bits.
* Incorporated JVET-M0512: TMVP storage reduction.
* Incorporated JVET-M0192: subblock chroma MV derivation for affine from two luma MVs.
* Incorporated JVET-M0111: weighted prediction (WP) and disable GBI signalling if WP is enabled.
* Incorporated JVET-M0281/M0117: modified AMVP pruning with rounding.
* Fixed bug [#175](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/175) incorrect derivation of CCLM parameter b.
* Incorporated JVET-M0128: Reference picture management
* Incorporated JVET-M0132: Adaptation parameter set (APS)
* Incorporated JVET-M0853: Adding the support of rectangular tile groups in addition to the existing raster-scan tile groups, and enabling extraction of MCTSs without changing VLC NAL units
* Incorporated JVET-M0160: Adding loop\_filter\_across\_tile\_group\_enabled\_flag to the PPS
* Incorporated JVET-M0101:
  + Replace the existing IRAP\_NUT with 3 new NAL unit types: IDR\_W\_RADL, IDR\_N\_LP, CRA\_NUT (from JVET-M0101).
  + Add external means flag HandleCraAsCvsStartFlag, with similar text as in HEVC. Text provided in a v3 of JVET-M0101.
  + Add a NUT value for step-wise temporal access STSA (from JVET-M0101).
  + Add a NUT value for AUD (from JVET-M0101).
  + Add sps\_max\_sub\_layers\_minus1 syntax element to SPS, and decoding process in 8.1.1, 8.1.2 and 8.1.3 of JVET-M0101.
  + Add text of sections 7.4.2.4 to 7.4.2.4.5 on NAL unit order and AU boundary detection from JVET-M0101, which is primarily editorial, but has some technical aspects.
  + Add profile\_tier\_level( ) syntax structure which includes sub-layer level idc (similar to HEVC but without sub-layer-specific profiles).
  + Add general\_non\_packed\_constraint\_flag with semantics as in JVET-M0101 (rename the flag to display\_suitability\_flag? – that's editorial).
  + Add the temporal scalability sub-bitstream extraction process in JVET-M0101.
  + Add RASL and RADL NUTs
* Incorporated JVET-M0451: Add new constraint flags corresponding to VVC WD 3 tools.
* Incorporated JVET-M0415: Change the sps\_ref\_wraparound\_offset to sps\_ref\_wraparound\_offset\_minus1 and changing the units to be MinCbSizeY as in option 1 (minor cleanup).
* Incorporated JVET-M0381: Reduce merge idx ctx coded bins (test 2.2.2a).
* Incorporated JVET-M0502: Add one context for pred\_mode\_flag (method 2).
* Incorporated JVET-M0453: Modified CABAC probability estimation (5.1.13\* + init from 5.1.2).
* Fixed bug [#147](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/147) on coefficient coding.
* Incorporated JVET-M0470: Limited EGk for abs\_rem/ dec\_abs\_level.
* Incorporated JVET-M0173: Move rem\_abs\_gt3\_flag into first coding pass.
* Incorporated JVET-M0119: Modified dequantization scaling for TS.
* Incorporated JVET-M0685: QP prediction fix for parallel encoding.
* Incorporated JVET-M0113/M0188: Bug fix for quantization group QP signalling.
* Incorporated JVET-M0421: Split-first signalling for partitioning.
* Incorporated JVET-M0446/M0888/M0905: Inferred QT split to avoid 32x128/128x32 partitions at picture boundaries.
* Incorporated JVET-M0427: Picture reconstruction with luma mapping and chroma scaling (LMCS).

The following adoptions have not yet been integrated:

* Incorporated JVET-M0908: Deblocking of CIIP boundaries.
* Incorporated JVET-M0471: Deblocking with long tap filters (also alignment with SBT).
* Incorporated JVET-M0277: Apply pcm\_loop\_filter\_disabled\_flag for ALF.

**Integration Issues**

The following items have been discussed within the AHG:

* Deblocking over ISP internal TU boundaries: Two different approaches have been identified resulting from interaction between JVET-M0102 Intra Subpartitions (ISP) and JVET-M0471 long deblocking:
  + Do not deblock (originally proposed and adopted ISP design)
  + Deblock all internal TU boundaries, i.e. for Subblock Transforms (SBT) and ISP.

The current draft and VTM-4.0.1 incorporates 1. However, it needs to be discussed which solution is preferred. The following document was identified to be related:

JVET-N0473 Non-CE11: On ISP transform boundary deblocking [K. Misra, A. Segall (Sharp Labs of America), M. Ikeda, T. Suzuki (Sony)]

* Last position coding fix for large size transform zero-out: JVET-M0251 and JVET-M0257 have been adopted to change the following:
  + Last x/y position is coded using the reduced non-zero size, e.g. 32x32 for a 64x64 block (affects binarization)
  + The context derivation of last x/y position still depends on the larger transform size
* The current draft incorporates 1. and 2. while VTM-4.0.1 incorporates only 1. However, it needs to be discussed which solution is preferred. The following documents were identified to be related:
  + JVET-N0189 Non-CE7: Unified last position coding for 32-point transforms [Y. Piao, K. Choi (Samsung)]
  + JVET-N0194 CE6-related: Context selection of last non-zero coefficient position coding based on reduced TU size (related to JVET-M0297 and JVET-M0251/M0257)
* [Check revised AHG report about shared merge list for CPR; text had not been integrated yet]

**Model 4 (VTM 4) Algorithm and Encoder Description**

Two versions of JVET-M1002 was published by the Editing AHG between the 13th meeting in Marrakech, MA (9–18 January 2019) and the 14th meeting in Geneva, CH, (19–27 March 2019).

JVET-M1002 has been established based on JVET-L1002. It provides the algorithm description for majority of coding tools in VVC. In this editing period, the following changes were included:

* Incorporated JVET-M0427: luma mapping with chroma scaling (previously known as adaptive in-loop reshaper)
* Incorporated JVET-M0102: Intra subpartitions (ISP)
* Incorporated JVET-M0147: Decoder side motion vector refinement
* Incorporated JVET-0471: Long Deblocking
* Incorporated JVET-0483: Intra block copy
* Incorporated JVET-M0453: CABAC core engine
* Incorporated JVET-M0118, JVET-M0328 and JVET-M0883: triangle prediction related changes
* Incorporated JVET-M0487 and JVET-M0063: BDOF related changes
* Incorporated JVET-M0273: SbTMVP related changes
* Incorporated JVET-M0111: BWA related changes:
* Incorporated JVET-M0142: Alternative CCLM downsampling filter
* Incorporated JVET-M0064: Reduced table size of CCLM parameter derivation
* Incorporated JVET-M0238: Simplification of PDPC reference samples
* Incorporated JVET-M0407: IBC reference region modification
* Incorporated JVET-M0297: 32-length DST-7/DCT-8 using zero-out
* Incorporated JVET-M0464: Unified MTS and transform skip syntax
* Incorporated JVET-M0173: rem\_abs\_gt3\_flag in first coding pass
* Incorporated JVET-M0246: Affine AMVR

In this editing period, the descriptions of most new coding tools from Marrakech meeting have been included in the latest release. Refinements of some existing tools in VTM3 have not been integrated. General encoder description, High Level Syntax, tiling mechanism and miscellaneous small coding features (such PCM mode and Delta QP signaling) are still missing at this moment. The VTM editors will work on those aspects in the following meeting circles.

**Recommendations**

The AHG recommended to:

* Approve the edited JVET-M1001 and JVET-M1002 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.

[JVET-N0003](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6366) JVET AHG report: Test model software development (AHG3) [F. Bossen, X. Li, A. Norkin, K. Sührung]

This report summarizes the activities of the AhG3 on test model software development that has taken place between the 13th and 14th JVET meetings.

The mandates given to the AHG are:

* 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 4 behaviour relative to HEVC and VTM 3 using the VTM common test conditions and the multi-resolution streaming test conditions described in JVET-M0466.
* 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.

The software development continued on the GitLab server. VTM version 3.2 was tagged on Jan. 19., VTM 4.0 on Feb. 12. and VTM 4.0.1 on Feb. 26. VTM 4.1 is expected during the 14th JVET meeting.

For core experiments (CEs) the same development workflow was followed as for the last meeting.

**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 3.2 was tagged on Jan 19, 2019.

* Changes relate to VTM 3.1 include:
* Removed JVET-Lxxx macros
* Fix for CU results reuse with dual tree (~7% encoder run time reduction for AI)
* Fix for block statistics generation

After one release candidates, VTM 4.0 was tagged on Feb. 12, 2019.

Changes related to VTM 3.2 include:

* JVET-M0453: modified CABAC core engine
* JVET-M0090: change default C[b,r]QpOffsetDualTree to 0, change C[b,r]QpOffset to 1 for CTC
* JVET-M0421: Split-first signalling for partitioning
* JVET-M0464: UniMTS
* JVET-M0479: 18-bit Mv clip
* JVET-M0502: context for prediction mode flag
* JVET-M0407: CPR range extension
* JVET-M0173: moving gtr2 flag to first pass
* JVET-M0142: CCLM collocated- hroma
* JVET-M0068/M0171: MMVD cleanup
* JVET-M0064: CCLM Simplification
* JVET-M0444: SMVD
* JVET-M0446/M0888/M0905: VPDU constraint at picture boundary
* JVET-M0487: integer positions in extended region
* JVET-M0497: Fast DST-7/DCT-8 with dual implementation support
* JVET-M0170: shared merging list candidate
* JVET-M0409: ATMVP fix when IBC is on
* JVET-M0118/M0185/etc: on merge\_triangle\_flag redudant signaling when a CU uses MMVD or CIIP
* JVET-M0381 Test CE2.2.2.a: one context for Merge\_subblock\_idx (AffMergeIdx in VTM software)
* JVET-M0145: Affine MV clip
* JVET-M0512: TMVP storage reduction using floating-point representation
* JVET-M0228/M0166/M0477: Remove CPMV comparisons for construnted affine merge candidates
* JVET-M0265: MV rounding cleanup
* JVET-M0255: MMVD without Fractional Distances for SCC
* JVET-M0273 (change 1)/JVET-M0240/JVET-M0116 (method 1)/JVET-M0338(method 1)/JVET-M0204(method 2):Only use left neighbor for ATMVP offset derivation
* JVET-M0264: Harmonization between HMVP and GBi
* JVET-M0063: BDOF bitDepth bugfix
* JVET-M0328: Only keep the second weight group during TPM MC
* JVET-M0192: modifications - affine chroma MV is average of two luma sub-block MVs
* JVET-M0193: allow only the first pairwise candidate, remove the remaining five
* JVET-M0883: Using regular merge index signaling for triangle mode
* JVET-M0257: Scan only non zero-out regions of large TUs (width or height > 32)
* JVET-M0312/M0255: disable fractional MVD for UHD sequences
* JVET-M0823: encoder optimization for MMVD
* JVET-M0246: adaptive MV precision for affine inter mode
* JVET-M0470: Fixed transition point between GR and TU + EG(k) escape codes for coefficient
* JVET-M0839: increase number of SATD candidates in Affine Merge from 1 to 2
* JVET-M0238: Nearest neighbor instead of linear interpolation in PDPC
* JVET-M0281 test a: perform all AMVP rounding before pruning even if AMVR is off
* JVET-M0436: Reduce HMVP table size
* JVET-M0117: On MVP candidate list generation for AMVP
* JVET-M0247: encoder optimization of affine AMVR
* JVET-M0471: Long deblocking filters
* JVET-M0908: CIIP deblocking
* JVET-M0303: implicit MTS
* JVET-M0427: Picture reconstruction with mapping
* JVET-M0119: remove scaling of ts coefficients
* JVET-M0253: Hash-based motion search
* JVET-M0147: DMVR (Decoder-side Motion Vector Refinement)
* JVET-M0102: Intra Sub-Partitions (ISP)
* JVET-M0126: HMVP merge pruing
* JVET-M0483: IBC
* JVET-M0297: skipping high frequency coefficients in wide/high blocks
* JVET-M0140 Sub-block Transform (SBT) for inter blocks
* JVET-M0854: MMVD precision for UHD (encoder only)
* JVET-M0055: VTM transcoding capabilities/DebugCTU
* removal of SPSNext / SPS alignment with draft text
* CABAC states init retraining
* configuration file for class F
* various bug fixes and cleanups
* software manual updates

VTM 4.0.1 was tagged on Feb. 26, 2019. Changes include:

* Bug fixes
* JVET-M0277: PCM and loop filter
* JVET-M0428: Deblocking optimization
* JVET-M0451: Interoperability syntax
* JVET-M0600: Rate control
* JVET-M0102: encoder speedup for ISP
* Macro to disable MMVD

It should be noted that version 4.0.1 addresses an issue where sequential and parallel encoding modes for the random access (RA) configuration were yielding different results.

VTM 4.1 is expected to be tagged during the 14th JVET meeting. Changes include:

* JVET-M0132: APS implementation
* JVET-M0685: QP parameter predictor derivation
* JVET-M0113/M0188 quantization groups based on area
* JVET-M0111: disable GBI signalling when WP is enabled
* JVET-M0864: 2D cache model
* JVET M0445 MCTS
* JVET-M0091: sub-CTU QPA for <=HD sequences, share mean-value calculations via computeAvg( )
* SPS/SPSNext cleanup
* various bug fixes and cleanups

At the beginning of the 14th meeting, some high level syntax implementations are still pending:

* JVET-L0686 Spec text for the agreed starting point on slicing and tiling (may be superseded by JVET-M0853)
* JVET-M0101: On VVC HLS (merge request submitted)
* JVET-M0415: horizontal reference wrap-around signaling (merge request submitted)
* JVET-M0853: tile groups PPS Signalling implementation (merge request for partial implementation submitted)

**Common test conditions performance**

The following table shows **VTM 4.0** performance over **HM 16.20**:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra Main10** |  |  |
|  |  |  | **Over HM-16.20** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -23.74% | -39.31% | -36.64% | 1375% | 170% |
| Class A2 | -22.96% | -25.04% | -19.85% | 2155% | 179% |
| Class B | -19.12% | -24.27% | -31.03% | 2341% | 179% |
| Class C | -19.52% | -21.31% | -24.54% | 3136% | 189% |
| Class E | -22.80% | -23.91% | -27.15% | 1860% | 174% |
| **Overall** | -21.23% | -26.19% | -28.01% | 2170% | 179% |
| Class D | -16.30% | -18.23% | -19.63% | 3471% | 184% |
| Class F | -33.58% | -36.53% | -38.27% | 3251% | 183% |
|  |  |  |  |  |  |
|  |  |  | **Random Access Main10** |  |  |
|  |  |  | **Over HM-16.20** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -31.64% | -43.55% | -45.48% | 717% | 174% |
| Class A2 | -36.35% | -40.36% | -35.20% | 800% | 170% |
| Class B | -30.96% | -42.07% | -42.78% | 780% | 161% |
| Class C | -26.08% | -31.79% | -33.50% | 941% | 173% |
| Class E |  |  |  |  |  |
| **Overall** | -30.87% | -39.28% | -39.33% | 810% | 169% |
| Class D | -25.20% | -29.25% | -30.34% | 989% | 176% |
| Class F | -35.75% | -40.34% | -41.42% | 498% | 137% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay B Main10** |  |  |
|  |  |  | **Over HM-16.20** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -24.33% | -33.19% | -32.22% | 745% | 150% |
| Class C | -21.17% | -27.80% | -28.90% | 853% | 156% |
| Class E | -24.36% | -30.57% | -33.01% | 382% | 119% |
| **Overall** | -23.29% | -30.74% | -31.31% | 660% | 143% |
| Class D | -21.07% | -24.72% | -25.38% | 843% | 159% |
| Class F | -31.86% | -38.71% | -39.89% | 421% | 117% |

The following table shows **VTM 4.0** performance compared to **VTM 3.2**:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra Main10** |  |  |
|  |  |  | **Over VTM-3.2** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -2.66% | -3.82% | -4.59% | 132% | 96% |
| Class A2 | -2.65% | -2.97% | -2.75% | 126% | 103% |
| Class B | -2.18% | -1.75% | -2.17% | 124% | 104% |
| Class C | -2.40% | 1.58% | 1.21% | 124% | 117% |
| Class E | -2.45% | 1.57% | 1.27% | 130% | 111% |
| **Overall** | -2.43% | -1.01% | -1.35% | 126% | 107% |
| Class D | -2.18% | 0.09% | 0.08% | 117% | 115% |
| Class F | -18.38% | -14.24% | -14.34% | 211% | 111% |
|  |  |  |  |  |  |
|  |  |  | **Random Access Main10** |  |  |
|  |  |  | **Over VTM-3.2** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -5.43% | 6.44% | 3.69% | 147% | 115% |
| Class A2 | -6.83% | 5.50% | 6.18% | 156% | 119% |
| Class B | -5.04% | 5.89% | 5.33% | 153% | 124% |
| Class C | -5.16% | 7.10% | 7.61% | 157% | 127% |
| Class E |  |  |  |  |  |
| **Overall** | -5.51% | 6.25% | 5.78% | 153% | 122% |
| Class D | -4.90% | 6.63% | 6.93% | 170% | 126% |
| Class F | -17.37% | -9.37% | -9.08% | 164% | 126% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay B Main10** |  |  |
|  |  |  | **Over VTM-3.2** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -4.15% | 19.69% | 20.48% | 151% | 115% |
| Class C | -4.19% | 14.54% | 15.70% | 157% | 131% |
| Class E | -1.95% | 9.93% | 12.19% | 142% | 124% |
| **Overall** | -3.61% | 15.53% | 16.81% | 151% | 122% |
| Class D | -4.48% | 15.65% | 18.69% | 168% | 121% |
| Class F | -13.29% | 0.70% | 1.13% | 151% | 125% |

The following table shows **VTM 4.0** performance compared to **VTM 3.2** under old CTC (**no chroma QP adjustment**):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra Main10** |  |  |
|  |  |  | **Over VTM-3.2** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -2.66% | -3.82% | -4.59% | 132% | 97% |
| Class A2 | -2.66% | -3.00% | -2.77% | 126% | 102% |
| Class B | -2.18% | -1.77% | -2.21% | 124% | 105% |
| Class C | -2.40% | 1.58% | 1.21% | 124% | 117% |
| Class E | -2.45% | 1.57% | 1.27% | 130% | 113% |
| **Overall** | -2.43% | -1.02% | -1.36% | 126% | 107% |
| Class D | -2.17% | 0.09% | 0.09% | 117% | 114% |
| Class F | -18.38% | -14.24% | -14.33% | 211% | 112% |
|  |  |  |  |  |  |
|  |  |  | **Random Access Main10** |  |  |
|  |  |  | **Over VTM-3.2** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -4.07% | -2.33% | -3.32% | 148% | 115% |
| Class A2 | -5.27% | -3.04% | -2.29% | 157% | 119% |
| Class B | -4.54% | -3.22% | -2.95% | 154% | 121% |
| Class C | -4.60% | 0.20% | 0.51% | 157% | 127% |
| Class E |  |  |  |  |  |
| **Overall** | -4.61% | -2.09% | -1.97% | 154% | 121% |
| Class D | -4.39% | 0.41% | 0.73% | 170% | 125% |
| Class F | -16.87% | -12.89% | -12.71% | 165% | 127% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay B Main10** |  |  |
|  |  |  | **Over VTM-3.2** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -3.31% | -1.45% | -0.41% | 152% | 116% |
| Class C | -3.20% | -0.79% | -0.20% | 156% | 129% |
| Class E | -1.48% | -0.78% | 0.28% | 143% | 125% |
| **Overall** | -2.82% | -1.06% | -0.17% | 151% | 122% |
| Class D | -3.65% | -1.46% | 0.11% | 169% | 122% |
| Class F | -12.22% | -8.78% | -8.63% | 151% | 123% |

The following table shows VTM 4.0.1 performance compared to VTM 4.0:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra Main10** |  |  |
|  |  |  | **Over VTM-4.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.03% | -0.01% | 0.07% | 97% | 102% |
| Class A2 | 0.03% | 0.11% | 0.02% | 97% | 101% |
| Class B | 0.03% | -0.01% | 0.06% | 97% | 102% |
| Class C | 0.04% | -0.03% | -0.03% | 96% | 102% |
| Class E | 0.05% | 0.05% | 0.01% | 96% | 103% |
| **Overall** | 0.04% | 0.02% | 0.03% | 97% | 102% |
| Class D | 0.02% | -0.02% | -0.13% | 96% | 101% |
| Class F | 0.07% | 0.08% | -0.01% | 97% | 103% |
|  |  |  |  |  |  |
|  |  |  | **Random Access Main10** |  |  |
|  |  |  | **Over VTM-4.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.02% | 0.00% | 0.00% | 101% | 100% |
| Class A2 | -0.01% | -0.02% | -0.01% | 100% | 102% |
| Class B | 0.00% | -0.10% | -0.15% | 101% | 100% |
| Class C | -0.01% | -0.14% | -0.25% | 101% | 102% |
| Class E |  |  |  |  |  |
| **Overall** | 0.00% | -0.08% | -0.12% | 101% | 101% |
| Class D | 0.00% | -0.14% | 0.11% | 100% | 99% |
| Class F | 0.21% | 0.00% | 0.05% | 101% | 102% |
|  |  |  |  |  |  |
|  |  |  | **Low Delay B Main10** |  |  |
|  |  |  | **Over VTM-4.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | 0.00% | -0.40% | 0.16% | 100% | 101% |
| Class C | -0.01% | 0.46% | 0.08% | 100% | 101% |
| Class E | 0.05% | 1.75% | 0.47% | 101% | 101% |
| **Overall** | 0.01% | 0.42% | 0.21% | 100% | 101% |
| Class D | -0.02% | 0.06% | 0.38% | 100% | 102% |
| Class F | 0.12% | -0.11% | -0.09% | 100% | 99% |

There is a notable performance drop for random access and low delay in class F. Bug fixes to address this issue have been submitted for inclusion in VTM 4.1.

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

**Multi-resolution streaming test conditions**

An updated method is proposed in JVET-N0446. The contribution reports the following performance data. In the tables below, AS-RA and MR-RA denote test conditions typically used in adaptive streaming, when a source video may be downsampled prior to encoding at a lower bitrate if encoding downsampled video results in a better rate-distortion trade-off than encoding the original video at that bitrate. The choice of resolution-QP pairs in AS-RA is done once per sequence and is based on the anchor, with 4 resolution-QP points in total. The MR-RA corresponds to encoding the video at four spatial resolutions each at 4 QP (total of 16 points), then determining the convex hull for both anchor and test for the BD-rate calculations. The PSNR is calculated between the original source video and upsampled (if needed) reconstructed video. Both test conditions use closed-GOP encoding and 2s intra picture intervals.

**BD-rate between VTM 4.0 and HM 16.19 using the JVET CTC, AS-RA and MR-RA test conditions for classes A1, A2 and B.**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **JVET RA CTC** | | | **AS-RA** | | | **MR-RA** | | |
| **Class** | **Seq.** | **Y [%]** | **U [%]** | **V [%]** | **Y [%]** | **U [%]** | **V [%]** | **Y [%]** | **U [%]** | **V [%]** |
| **Class A1** | Tango2 | -34.57 | -49.75 | -47.42 | -29.18 | -43.36 | -37.71 | -28.85 | -48.96 | -43.85 |
| FoodMarket4 | -34.05 | -32.94 | -35.92 | -31.05 | -31.39 | -30.98 | -30.14 | -35.07 | -35.31 |
| Campfire | -29.34 | -34.61 | -42.86 | -22.14 | -18.47 | -30.87 | -24.32 | -32.28 | -40.95 |
| **Average** | **-32.65** | **-39.10** | **-42.07** | **-27.46** | **-31.07** | **-33.19** | **-27.77** | **-38.77** | **-40.03** |
| **Class A2** | CatRobot1 | -40.26 | -46.15 | -39.99 | -40.38 | -45.56 | -40.64 | -39.68 | -45.03 | -39.94 |
| DaylightRoad2 | -40.51 | -41.81 | -33.47 | -39.96 | -46.72 | -36.52 | -39.91 | -44.96 | -37.16 |
| ParkRunning3 | -31.53 | -18.89 | -16.40 | -25.96 | -22.82 | -19.69 | -23.30 | -19.85 | -17.41 |
| **Average** | **-37.43** | **-35.62** | **-29.95** | **-35.44** | **-38.37** | **-32.28** | **-34.29** | **-36.61** | **-31.50** |
| **Class B** | MarketPlace | -32.06 | -33.91 | -40.09 | -29.28 | -27.71 | -28.04 | -28.81 | -32.15 | -33.57 |
| RitualDance | -27.99 | -30.08 | -37.09 | -27.14 | -29.30 | -31.95 | -26.57 | -31.84 | -34.86 |
| Cactus | -32.93 | -39.15 | -31.87 | -36.29 | -44.90 | -41.35 | -32.50 | -39.60 | -34.96 |
| BasketballDrive | -32.50 | -41.11 | -41.53 | -35.29 | -43.09 | -39.45 | -29.14 | -40.47 | -37.55 |
| BQTerrace | -31.07 | -40.71 | -40.11 | -32.91 | -45.74 | -50.67 | -26.67 | -39.38 | -42.59 |
| **Average** | **-31.31** | **-36.99** | **-38.14** | **-32.18** | **-38.15** | **-38.29** | **-28.74** | **-36.69** | **-36.71** |
| **Overall Average** | | **-33.35** | **-37.19** | **-36.98** | **-31.78** | **-36.28** | **-35.26** | **-29.99** | **-37.24** | **-36.19** |

**BD-rate between VTM 4.0 and VTM 3.0 using the JVET CTC, AS-RA and MR-RA test conditions for classes A1, A2 and B.**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **JVET RA CTC** | | | **AS-RA** | | | **MR-RA** | | |
| **Class** | **Seq.** | **Y [%]** | **U [%]** | **V [%]** | **Y [%]** | **U [%]** | **V [%]** | **Y [%]** | **U [%]** | **V [%]** |
| **Class A1** | Tango2 | -5.95 | 8.82 | 6.48 | -4.79 | 6.25 | 4.11 | -4.86 | 4.23 | 3.59 |
| FoodMarket4 | -4.22 | 4.38 | 3.99 | -4.66 | 4.94 | 6.08 | -4.64 | 3.10 | 2.87 |
| Campfire | -6.15 | 6.08 | 0.67 | -1.52 | 1.40 | 4.95 | -3.77 | 5.06 | -0.17 |
| **Average** | **-5.44** | **6.43** | **3.71** | **-3.66** | **4.20** | **5.05** | **-4.42** | **4.13** | **2.10** |
| **Class A2** | CatRobot1 | -5.23 | 3.96 | 5.11 | -6.12 | 1.24 | 1.71 | -6.12 | 1.36 | 2.79 |
| DaylightRoad2 | -6.09 | 6.55 | 6.86 | -6.63 | 0.64 | 1.75 | -6.43 | 4.89 | 7.02 |
| ParkRunning3 | -9.24 | 6.16 | 6.74 | -6.06 | 2.47 | 2.64 | -6.66 | 4.87 | 5.49 |
| **Average** | **-6.85** | **5.56** | **6.24** | **-6.27** | **1.45** | **2.03** | **-6.40** | **3.70** | **5.10** |
| **Class B** | MarketPlace | -7.33 | 3.58 | 1.94 | -3.71 | 16.74 | 16.56 | -1.78 | 10.99 | 8.51 |
| RitualDance | -4.76 | 4.04 | 4.90 | -5.28 | 10.17 | 12.15 | -3.09 | 6.19 | 8.36 |
| Cactus | -3.70 | 4.85 | 4.42 | -3.92 | 1.52 | 1.91 | -3.68 | 1.94 | 2.63 |
| BasketballDrive | -4.90 | 6.93 | 7.57 | -5.79 | 8.70 | 10.47 | -3.69 | 9.93 | 9.79 |
| BQTerrace | -4.60 | 10.99 | 8.22 | -4.39 | 7.67 | 4.84 | -5.40 | 5.01 | 6.65 |
| **Average** | **-5.06** | **6.08** | **5.41** | **-4.62** | **8.96** | **9.18** | **-3.53** | **6.81** | **7.19** |
| **Overall Average** | | **-5.65** | **6.03** | **5.17** | **-4.81** | **5.61** | **6.11** | **-4.56** | **5.23** | **5.23** |

**Differences in CTC between HM and VTM**

A difference in coding conditions between HM and VTM was found as follows:

JCT-VC decided at some point that parameter sets should be repeated at every IRAP picture. With the joint call for proposals for VVC, this was not made a requirement. The VVC CTC were inherited from the CfP conditions. VTM did not have the ability to repeat parameter sets, while the HM CTC configuration files still used the parameter.

A configuration parameter for repetition of parameter sets was implemented on top of VTM 4.0 and included in VTM 4.0.1. The following table shows the performance impact of repeating parameter sets (AI and RA configurations):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra Main10** |  |  |
|  |  |  | **Over VTM-4.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.06% | 0.06% | 0.06% | 100% | 101% |
| Class A2 | 0.03% | 0.03% | 0.03% | 100% | 101% |
| Class B | 0.10% | 0.09% | 0.10% | 100% | 100% |
| Class C | 0.26% | 0.23% | 0.24% | 100% | 99% |
| Class E | 0.34% | 0.30% | 0.31% | 100% | 99% |
| **Overall** | 0.16% | 0.14% | 0.15% | 100% | 100% |
| Class D | 0.76% | 0.67% | 0.69% | 100% | 97% |
| Class F | 0.26% | 0.29% | 0.19% | 101% | 100% |
|  |  |  |  |  |  |
|  |  |  | **Random Access Main10** |  |  |
|  |  |  | **Over VTM-4.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.01% | 0.01% | 0.01% | 98% | 100% |
| Class A2 | 0.01% | 0.01% | 0.01% | 98% | 99% |
| Class B | 0.03% | 0.03% | 0.03% | 99% | 97% |
| Class C | 0.08% | 0.07% | 0.07% | 99% | 100% |
| Class E |  |  |  |  |  |
| **Overall** | 0.03% | 0.03% | 0.03% | 99% | 99% |
| Class D | 0.22% | 0.21% | 0.21% | 99% | 97% |
| Class F | 0.14% | 0.06% | -0.12% | 99% | 98% |

In the discussion, it was agreed to repeat the parameter sets at random access points in VTM testing.

**Software manual**

The software manual was updated to reflect general scope and compilation instructions. The encoding and decoding parameter description though still reflects HM, rather than VTM.

Although the software coordinators requested contributions to the software manual for changed parameters twice on the JVET email reflector, not a single input was received.

**Update to Guidelines for VVC reference software development**

A proposed update for the guidelines was uploaded as JVET-N0503.

**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.

**Recommendations**

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
* Review and approve updated guidelines for reference software development

[JVET-N0004](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6231) JVET AHG report: Test material and visual assessment (AHG4) [T. Suzuki, V. Baroncini, R. Chernyak, P. Hanhart, A. Norkin, J. Ye]

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

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

Not much activity was reported.

Regarding establishing a new structure at the 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 last 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, 360.

At the meeting, it was agreed that the coordinator has discretion over changes to the directory structure as needed.

The following related contributions were submitted.

* JVET-N0386 AOV YUV4:4:4 sequence for VVC standardization and suggestions for class F [X. Xu, J. Ye, X. Li, S. Liu, L. Wu, C. Xie, K. Liu, B. Wang, P. Liu, K. Dong, Y. Kuang, W. Feng (Tencent)]
* JVET-N0502 Five SCC TGM sequences of both YUV4:4:4 and YUV4:2:0 formats [T. Lin, K. Zhou, S. Wang (Tongji), L. Zhao (Shaoxing)] [late]

The AHG recommended:

* To review related contributions
* To discuss further ftp directory structure
* To continue to collect new test sequences available for JVET with licensing statement

[JVET-N0005](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6367) 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 13th and the 14th JVET meetings.

Mandates:

* 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.

Relevant contributions to this meeting were identified as follows.

* JVET-N0068 “CE2: On restriction of memory bandwidth consumption of affine mode (CE2-4.8)”, M. Zhou (Broadcom)
* JVET-N0195 “CE2: Memory bandwidth reduction for the affine mode (Test 2.4.3)”, J. Li, C.-W. Kuo, C. S.Lim (Panasonic)
* JVET-N0199 “CE2-related: Combined test of affine memory bandwidth and complexity reduction (Test2.4.6+Test2.4.8)”, J. Li, C.-W. Kuo, C. S.Lim (Panasonic), M. Zhou (Broadcom)
* JVET-N0256 “CE2: Worst-case Memory Bandwidth Reduction for affine (Test 2.4.5)”, H. Huang, L. Pham Van, W.-J. Chien, M. Karczewicz (Qualcomm)
* JVET-N0323 “CE2: Reducing worst-case memory bandwidth of affine mode (CE2-4.2.a, CE2-4.2.b, CE2-4.2.c and CE2-4.2.d)”, Y.-W. Chen, X. Wang (Kwai Inc.), H. Chen, T. Solovyev, H. Yang, J. Chen (Huawei)
* JVET-N0369 “CE2-related: On restriction of memory bandwidth consumption of affine mode (2x2 variant)”, M. Zhou (Broadcom)
* JVET-N0398 “CE2-4.4: Affine block memory bandwidth reduction by MV clip”, X. Li, G. Li, X. Xu, S. Liu (Tencent)
* JVET-N0633 “CE2-related: on the memory reduction for affine motion inheritance”, H. Huang, W.-J. Chien, M. Karczewicz (Qualcomm)
* JVET-N0166 “Non-CE4: Advanced Multi-hypothesis Inter Prediction for bandwidth reduction in B frame”, Y. Sun, F. Chen, L. Wang (Hikvision)
* JVET-N0397 “AHG16: Memory bandwidth reduction for small CUs”, X. Li, G. Li, X. Xu, S. Liu (Tencent)

The AHG recommends to review all related contributions.

It is suggested to further improve the cache model. It is also suggested to perform further study on DMVR.

[JVET-N0006](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6337) JVET AHG Report: 360 video conversion software development (AHG6) [Y. He, K. Choi]

The mandates of this AHG are as follows:

* Prepare and deliver the 360Lib-9.0 software version and common test condition configuration files according to JVET-L1012.
* Generate CTC VTM anchors according to JVET-L1012, and finalize the reporting template for the common test conditions.
* Produce documentation of software usage for distribution with the software.

Brief summary for the activities:

The 360Lib-9.0 software package included following changes:

Projection format conversion:

1. Modified chroma sample location based on chroma sample location type in blending process for PHEC (JVET-M0368).

Configurations:

1. Added MV wrap around in the encoding parameter settings for PERP.

Software:

1. Fixed the bug between the interaction between DMVR and horizontal MV wrap-around used in PERP coding.

360Lib-9.0 related release:

360Lib-9.0 with support of VTM-4.0 was released on Mar. 4, 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-9.0 can be found at:

<https://jvet.hhi.fraunhofer.de/svn/svn_360Lib/tags/360Lib-9.0/>

360Lib-9.0 testing results can be found at:

[ftp.ient.rwth-aachen.de/testresults/360Lib-9.0](ftp://ftp.ient.rwth-aachen.de/testresults/360Lib-9.0)

360Lib bug tracker

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

Table 1 is for the projection formats comparison using VTM-4.0 according to 360o video CTC (JVET-L1012). It compares padded hybrid equi-angular cubemap (PHEC) coding and padded equi-rectangular projection (PERP) coding using VTM-4.0.

Table 2 is for PERP coding comparison between VTM-4.0 and HM-16.16. Table 3 is to compare VTM-4.0 with PHEC coding and HM-16.16 with CMP coding.

Table 1. VTM-4.0 PHEC vs PERP (VTM-4.0 PERP as anchor)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **PHEC over PERP (VTM-4.0) [Arial]** | | | | | |
|  | **End-to-end WS-PSNR** | | | **End-to-end S-PSNR-NN** | | |
|  | Y | U | V | Y | U | V |
| Class S1 | -11.14% | -8.91% | -9.36% | -11.06% | -8.79% | -9.30% |
| Class S2 | -5.15% | -6.10% | -6.11% | -5.13% | -5.98% | -6.01% |
| **Overall** | -8.75% | -7.78% | -8.06% | -8.69% | -7.67% | -7.98% |

Table 2. VTM-4.0 PERP vs HM-16.16 PERP (HM-16.16 PERP as anchor)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **VTM-4.0 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 | -23.38% | -39.08% | -39.73% | -23.36% | -39.09% | -39.68% |
| Class S2 | -32.35% | -38.20% | -38.19% | -32.34% | -38.23% | -38.24% |
| **Overall** | -26.97% | -38.73% | -39.12% | -26.95% | -38.75% | -39.10% |

Table 3. VTM-4.0 PHEC vs HM-16.16 CMP (HM-16.16 CMP as anchor)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **VTM-4.0 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 | -27.65% | -40.47% | -40.84% | -27.53% | -40.44% | -40.79% |
| Class S2 | -35.15% | -41.54% | -41.51% | -35.14% | -41.53% | -41.52% |
| **Overall** | -30.65% | -40.90% | -41.11% | -30.57% | -40.88% | -41.08% |

The AHG recommends:

* To integrate the JVET-M0452 (Hemisphere cubemap projection format).
* 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.

It is noted that there was some misalgnment between the original adoption of M0452 and the submitted software. Currently proponents are working on the final version, which will then be integrated and released as 9.1.

[JVET-N0007](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6368) JVET AHG report: Coding of HDR/WCG material (AHG7) [A. Segall, E. François, W. Husak, D. Rusanovskyy]

The AHG was established with the following mandates:

* Study and evaluate available HDR/WCG test content.
* Study objective metrics for quality assessment of HDR/WCG material, including investigation of the correlation between subjective and objective results of the CfP responses.
* Compare the performance of the VTM and HM for HDR/WCG content.
* Prepare for expert viewing of HDR content at the 14th JVET meeting if feasible.
* Coordinate implementation of HDR anchor aspects in the test model software with AHG3.
* Study additional aspects of coding HDR/WCG content.

The AHG used the main JVET reflector, [jvet@lists.rwth-aachen.de](mailto: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. This work is described in the following subsection.

During the anchor generation process, it was observed that the definition of the HDR anchors currently does not use the “luma mapping with chroma scaling” tool (LMCS), otherwise known as reshaping. There is no knowledge of this being an intentional decision at the Marrakech meeting, and it appears more due to the following scenario happening:

[Fix formatting]

* January 30th: LMCS tool committed to the VTM.

VTM configuration files enable luma dQP for coding HDR-PQ sequences

HDR CTC specifies that the configuration files should be used.

* February 4th: VTM-4.0rc1 tagged
* February 7th: Bug found with the combination of LMCS and luma dQP tool enabled.

Patch submitted by LMCS proponent to disable LMCS when luma dQP is

enabled.

* February 11th: VTM-4.0 tagged

VTM configuration files still enable luma dQP

This created a poorly defined situation, as the HDR CTC describes that luma dQP should be enabled as defined in the configuration files, and there was no update for the HDR CTC scheduled as an output of the Marrakech meeting.

Further evaluation showed that the performance of the anchor was not dramatically affected. And, given that the time between tagging VTM-4.0 and the document release date for the Geneva meeting was less than one month, it was deemed best to defer clarifying and/or correcting this issue at the Geneva meeting.

The AhG performed experiments comparing the performance of VTM 4.0 and VTM 3.0 codecs on HDR content. A summary of the performance is provided below.

*Please note, and to be abundantly clear, results marked as “VTM 4.0 (Luma dQP Disabled)” define the performance of the VTM 4.0 with LMCS enabled and Luma dQP disabled. “VTM 3.0 (Luma dQP Enabled)” define the existing VTM 3.0 HDR anchor.*

VTM 4.0 versus VTM 3.0

[This table is a picture!]





VTM 4.0 versus HM 16.18





VTM 4.0 LMCS performance





VTM 4.0 performance – HLG Content





Contributions

There is one contribution related to HDR video coding:

|  |  |  |  |
| --- | --- | --- | --- |
| JVET-N0221 | m46879 | Chroma Quantization Parameter Qpc Table for HDR Signal | T. Lu, F. Pu, P. Yin, S. McCarthy, W. Husak, T. Chen(Dolby) |

Additional Comments

While not part of any official AhG activity, informal comments related to the AhG activity were made to one or more of the AhG chairs and captured here:

*Question: Should the non-PSNR metrics be removed for HLG content? Revisit, possibly BoG later*

*Question: Should the fixed bit-rate category be removed from the CTC? Revisit, possibly BoG later*

The AHG recommends the following:

* Review all input contributions
* Discuss the configuration of the HDR anchor and align VTM 5 and/or reissue the HDR CTC document as needed

To clarify the problem above, the VTM4 software disables LMCS when dQP is enabled. Therefore, it was not possible to test the benefit of LMCS for HDR in the old CTC. Currently, there is no means of testing luma dQP approaches tailored for HDR and LMCS together. This aspect should be further studied, there are no inputs on that. Likely the encoders for the two cases are not aligned.

New CTC for HDR should be issued. Revisit.

[JVET-N0008](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6286) JVET AHG report: 360° video coding tools and test conditions (AHG8) [J. Boyce, K. Choi, P. Hanhart, J.-L. Lin]

The AHG was established with the following mandates:

* 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

There was no AHG email activity on the main jvet reflector, [jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de), with an [AHG8] indication on message headers.

There was no 360º related CE for this meeting. There are 7 input documents related to 360º video coding, which are listed and categorized below. The 3 contributions in the inloop filter disabling category are also related to high-level syntax.

Input contributions:

Reference wraparound

[JVET-N0070](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5790) AHG16/AHG8: Proposed Cleanup for Reference Wraparound [B. Heng, M. Zhou, W. Wan (Broadcom)]

Projection formats

[JVET-N0219](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5939) Coding of 360° video in HEC using different numbers of tiles per face [J. Sauer, M. Bläser (RWTH Aachen)]

[JVET-N0232](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5952) [AHG8] Coding performance of 360° Videos in PHEC format with different face sizes [A. DSouza, C. Pujara, R. Gadde, W. Choi, K. Choi, K.P. Choi (Samsung)] [late]

[JVET-N0233](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5953) [AHG8] Alternate face arrangement for PHEC [A. DSouza, C. Pujara, R. Gadde, W. Choi, K. Choi, K.P. Choi (Samsung)] [late]

Inloop filter disabling

[JVET-N0234](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5954) [AHG12/AHG17] Signaling of virtual boundaries [A. DSouza, C. Pujara, R. Gadde, W. Choi, K. Choi, K.P. Choi (Samsung)] [late]

[JVET-N0275](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5996) AHG14/AHG8/AHG17: Sections for intra refresh and inloop filter disabling [J. Boyce, R. Lei, L. Xu (Intel)]

[JVET-N0438](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6160) AHG12: Loop filter disabled across virtual boundaries [S.-Y. Lin, L. Liu, J.-L. Lin, Y.-C. Chang, C.-C. Ju (MediaTek), P. Hanhart, Y. He (InterDigital)]

The AHG recommends the following:

* Review input contributions
* Consider in-loop filter disabling contributions in coordination with high-level syntax experts
* Review common test conditions for 360° video, including objective metrics and viewports
* Review 360° video test material, and consider adding or replacing test sequences for common test conditions

In previous meetings, it had been demonstrated that disabling the filters at cube face boundaries provided subjective benefit. There are different solutions that will be discussed in context of HLS. The wraparound contribution is an implementation issue which is not too specific on 360. BoG activity (J. Boyce) on the projection formats, which could have impact on an update of CTC for 360 video.

[JVET-N0009](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6330) JVET AHG report: Neural Networks in Video Coding (AHG9) [S. Liu, K. Kawamura, Y. Li, L. Wang, P. Wu, H. Yang]

The AHG was established at Marrakech, Morocco with the following mandates:

* Investigate the benefit of using neural networks in video compression such as CNN loop filter, intra prediction, re-sampling 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 the impact of training materials on the performance of neural network coding tools.
* Investigate the impact of the training process on performance and complexity.

The AHG used the main JVET reflector, [jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de), with [AHG9] in message headers. Subjects such as software sharing, training data and process, neural network structure and complexity, etc. have been actively discussed among proponents and participants. The reporting template for evaluating neural network coding tools is updated [1]. This AHG worked closely with CE13. Detailed discussions about tool performance and complexity evaluations are included in CE13 report.

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

CE13 contributions

* Y.-L. Hsiao, O. Chubach, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei, “CE13-1.1: Convolutional neural network loop filter,” JVET-N0110, Geneva CH, 19–27 March 2019
* J. Yao, L.Wang, “CE13-2.1: Convolutional Neural Network Filter (CNNF) for Intra Frame,” JVET-N0169, Geneva CH, 19–27 March 2019
* Y. Wang, Z. Chen, Y. Li, L. Zhao, S. Liu, X. Li, “CE13: Dense Residual Convolutional Neural Network based In-Loop Filter (Test 2.2 and 2.3),” JVET-N0254, Geneva CH, 19–27 March 2019
* H. Yin, R. Yang, X. Fang, S. Ma, “CE13-1.2: Adaptive convolutional neural network loop filter,” JVET-N0480, Geneva CH, 19–27 March 2019
* Y. Dai, D. Liu, N. Yan, F. Wu, “CE13: Experimental results of CNN-based In-Loop Filter (USTC),” JVET-N0513, Geneva CH, 19–27 March 2019

CE13-related contributions

* S. Wan, M.-Z.Wang, H. Gong, C.-Y. Zou, Y.-Z. Ma, J.-Y. Huo, Y.-F. Yu, Y. Liu, “CE13-related: In-loop filter with only CNN-based filter,” JVET-N0133, Geneva CH, 19–27 March 2019

AHG9-related contributions

* M. Li, P. Wu, “AHG17 & AHG9: Comments on carriage of coding tool parameters in Adaptation Parameter Set,” JVET-N0065, Geneva CH, 19–27 March 2019

The AHG recommends:

* To review all related contributions
* To continue investigating the benefits and complexity of using neural networks in video coding

It is commented that currently no aspect other than LF is investigated in input contributions. Further review with CE13.

[JVET-N0010](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6369) JVET AHG report: Encoding algorithm optimization (AHG10) [A. Duenas, A. Tourapis, C. Helmrich, S. Ikonin, A. Norkin, R. Sjöberg, T. Toma]

At the 13th JVET meeting, the AHG on Encoding algorithm optimizations was established with the following mandates:

* Study the impact of using techniques such as GOP structures and perceptually optimized adaptive quantization for encoder optimization.
* Study the impact of adaptive quantization on individual tools in the test model.
* Study the quantization adaptation tool in the test model.
* Investigate the feasibility of adding a CTC test category in which adaptive quantization is turned on.
* Study quality metrics for measuring subjective quality using e.g. the CfP response MOS scores.
* Investigate other methods of improving objective and/or subjective quality, including adaptive coding structures, adaptive quantization without signalling, and multi-pass encoding.
* Study methods of rate control and their impact on performance, subjective and objective quality.

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

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

JVET-N0247: Non-CE: An improvement to hash-based motion estimation

This document presents an improvement to hash-based motion estimation. In the proposed method, all rectangle block can perform hash-based motion estimation without building corresponding hash map. In addition, we reuse the MV of hash mode to initialize the MV in the normal motion estimation. For TGM sequences, experimental results report 1.01% and 2.04% coding gain for RA and LD\_B, with encoding time reduced to 92% and 92%. The anchor is VTM-4.0 and IBC is off. If IBC is on, 0.65% and 1.43% coding gain is reported, with encoding time reduced to 91% and 95%.

JVET-N0249: Non-CE8: An alternative search area for IBC

This document presents an alternative search area setting for intra block copy when CTU size is 128x128. For class F/4:2:0 TGM, the BD-rate numbers of the proposed setting are -0.90%/-2.12% for AI, -0.74%/-1.74% for RA.

JVET-N0329: CE8-related: Encoder improvements on IBC search

In this contribution, several encoder improvements are proposed to enhance the intra block copy (IBC) search in the VTM-4.0, including 1) enhanced IBC local search by using block vector (BV) candidates from previously IBC coding units (CUs); 2) enhanced predictor-based IBC search by considering the BV candidates derived by history-based BV prediction (HBVP) and extended BV derivation; 3) adaptive SAD and SATD for encoder rate-distortion (R-D) calculation; 4) simplified IBC hash table generation in original sample domain. Compared to CE8 anchors, for Class SCC sequences, the proposed encoder improvements reportedly provide 1.26%, 0.84% and 0.34% BD-rate reductions for AI, RA and LD configurations, respectively, without increasing encoding and decoding time.

JVET-N0506: Disabling raster search in integer-pel ME for common test condition

This contribution reports the performance change in VTM when raster search is turned off. When turning it off, a 0.15 % increase is observed for RA case in Y BD-rate, but the encoding time is reduced to 95 % for RA, on average, in comparison with VTM 4.0. Since turning off raster search as a default can reduce encoding burden for experiments, this contribution recommends disabling raster search for CTC.

Recommendation

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

It is commented that most inputs above relate to further optimization in SCC, except the last one which suggests improved ME.

Further work on other aspects such as quantization should be encouraged.

[JVET-N0011](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6331) JVET AHG report: Screen Content Coding (AHG11) [S. Liu, J. Boyce, A. Filippov, Y.-C. Sun, J. Xu, M. Zhou]

The AHG was established at Marrakech, Morocco with the following mandates:

* Investigate coding tools targeted at screen content in terms of compression benefit and implementation complexity.
* Identify test materials, discuss testing conditions for screen content coding, and propose associated updated common test conditions.
* Study the impact of loop filters on screen content coding.

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 emails exchanged on the JVET reflector with some discussions about testing sequences. There were many email exchanges among CE8 participants under [CE8] with tool specific discussions. During the spec editing of VVC Draft 4, CPR (current picture referencing) was restructured and replaced by IBC (intra block copy) such that the intra-picture block prediction tool is now enabled and signaled at block level. Reference software VTM4 was updated accordingly.

In total there are 57 SCC related technical contributions identified so far, among which 31 IBC related technical contributions, 6 Palette related technical contributions, 12 Transform Skip related technical contributions, 6 other SCC tool (e.g. BDPCM) technical contributions and 2 SCC test material contributions identified for this meeting. They are listed in the next section.

Input documents related to AHG11 are summarized as follows. [fix formatting or remove list]

*IBC related contributions*

1. JVET-N0094, CE8-related: Context modelling of transform skip mode,  M. G. Sarwer, O. Chubach, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)
2. JVET-N0095, CE8-related: Unified method for coding BVD and MVD, S.-T. Hsiang, S.-M. Lei (MediaTek)
3. JVET-N0096, CE8-related: A fixed updating order for IBC reference memory, C.-Y. Lai, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)
4. JVET-N0173, Non-CE8: IBC Reference Area Rearrange, H. Gao, S. Esenlik, B. Wang, A. M. Kotra, J. Chen (Huawei)
5. JVET-N0174, Non-CE8: Exclusive Regular Merge And IBC Merge in One Shared Merge List Area, H. Gao, S. Esenlik, B. Wang, A. M. Kotra, J. Chen (Huawei)
6. JVET-N0175, Non-CE8: IBC Reference Memory for Arbitrary CTU Size, H. Gao, S. Esenlik, B. Wang, A. M. Kotra, J. Chen (Huawei)
7. JVET-N0176, Non-CE8: IBC Merge List Simplification, H. Gao, S. Esenlik, B. Wang, A. M. Kotra, J. Chen (Huawei)
8. JVET-N0201, Non-CE8: IBC modifications, J. Li, C.-W. Kuo, C. S.Lim (Panasonic)
9. JVET-N0202, AHG16/Non-CE8: Report on conformance check failures of IBC block vectors, J. Li, C.-W. Kuo, C. S.Lim (Panasonic)
10. JVET-N0249, Non-CE8: An alternative search area for IBC, J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)
11. JVET-N0250, Non-CE8: Reference memory reduction for intra block copy, J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)
12. JVET-N0251, Non-CE8: Intra block copy clean-up, J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)
13. JVET-N0255, CE8: Combination of MMVD and IBC mode (test 1.3a and 1.3b), Y. Li, Z. Chen (Wuhan Univ.), X. Xu, X. Li, S. Liu (Tencent)
14. JVET-N0260, Non-CE8: Disabling fractional MVD search in DMVR for SCC, W. Zhu
15. JVET-N0289, CE8-Related: On MVD Coding, M. Salehifar, S. Paluri, S. Kim (LGE)
16. JVET-N0315, CE8-related: Unification of Motion Vector Rounding Method for Chroma IBC Mode, Y. Han, W.-J. Chien, M. Karczewicz (Qualcomm)
17. JVET-N0316, CE8-related: Default Processing for IBC Mode, Y. Han, W.-J. Chien, M. Karczewicz (Qualcomm)
18. JVET-N0317, CE8-related: Simplification on IBC Merge/Skip Mode, Y. Han, W.-J. Chien, M. Karczewicz (Qualcomm)
19. JVET-N0318, CE8-related: Block Size Limitation for IBC Mode, Y. Han, W.-J. Chien, M. Karczewicz (Qualcomm)
20. JVET-N0329, CE8-related: Encoder improvements on IBC search, X. Xiu, Y.-W. Chen, T.-C. Ma, X. Wang (Kwai Inc.)
21. JVET-N0382, CE8-related: unified IBC block vector prediction, X. Xu, X. Li, S. Liu (Tencent)
22. JVET-N0383, AHG16/Non-CE8: IBC search range adjustment for implementation consideration, X. Xu, X. Li, S. Liu (Tencent)
23. JVET-N0384, Non-CE8: IBC search range increase for small CTU sizes, X. Xu, X. Li, S. Liu (Tencent)
24. JVET-N0457, CE8-1.1: Block vector prediction for IBC, J. Nam, J. Lim, S. Kim (LGE)
25. JVET-N0458, CE8-1.2: Block vector coding for IBC, J. Nam, J. Lim, S. Kim (LGE)
26. JVET-N0459, CE8-related: Modified block vector coding for IBC, J. Nam, H. Jang, J. Choi, J. Heo, J. Lim, S. Kim (LGE)
27. JVET-N0460, CE8-related: Default candidates for IBC merge mode, J. Nam, H. Jang, J. Lim, S. Kim (LGE)
28. JVET-N0461, CE8-related: Signaling on maximum number of candidates for IBC merge mode, J. Nam, H. Jang, J. Lim, S. Kim (LGE)
29. JVET-N0466, Non-CE8: The corner case handling regarding mv derivation for Chroma IBC in dual tree structure, H. Jang, J. Nam, N. Park, J. Lim, S. Kim (LGE)
30. JVET-N0467, Non-CE8: Experimental result for various size of IBC block with optimized syntax signaling, H. Jang, J. Nam, N. Park, J. Lim, S. Kim (LGE)
31. JVET-N0472, Non-CE8: On IBC reference buffer design, J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)

*Palette related contributions*

1. JVET-N0258, CE8-related: Palette Mode Coding, W. Zhu, L. Zhang, J. Xu, K. Zhang, H. Liu, Y. Wang (Bytedance)
2. JVET-N0259, CE8-related: compound palette mode, W. Zhu, J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)
3. JVET-N0346, Non-CE8: Palette Mode in HEVC for YUV4:4:4 format, Y.-H. Chao, H. Wang, W.-J. Chien, V. Seregin, M. Karczewicz (Qualcomm)
4. JVET-N0404, CE8: Palette Mode Improvements (CE8-2.2), Y.-C. Sun, T.-S. Chang, J. Lou (Alibaba), Y.-H. Chao, V. Seregin, M. Karczewicz (Qualcomm), R. Chernyak, S. Ikonin, J. Chen (Huawei)
5. JVET-N0405, CE8-related: Palette Mode Simplification, Y.-C. Sun, T.-S. Chang, J. Lou (Alibaba), Y.-H. Chao, V. Seregin, M. Karczewicz (Qualcomm)
6. JVET-N0550, CE8-related: Line-based CG Palette Mode, Y.-H. Chao, T. Hsieh, M. Karczewicz (Qualcomm)

*Transform skip related contributions*

1. JVET-N0094, CE8-related: Context modelling of transform skip mode, M. G. Sarwer, O. Chubach, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)
2. JVET-N0122, CE6/CE8-related: Alternative implementation of residual rearrangement for transform skipped blocks, T. Tsukuba, M. Ikeda, T. Suzuki (Sony)
3. JVET-N0123, Non-CE6/CE8: Chroma Transform Skip, T. Tsukuba, M. Ikeda, T. Suzuki (Sony)
4. JVET-N0280, CE8: Residual Coding for Transform Skip Mode (CE8-4.3a, CE8-4.3b, CE8-4.4a, and CE8-4.4b), B. Bross, T. Nguyen, H. Schwarz, D. Marpe, T. Wiegand (HHI)
5. JVET-N0337, CE8-related: Adaptive disabling of intra sample interpolation for screen content coding, X. Xiu, Y.-W. Chen, T.-C. Ma, X. Wang (Kwai Inc.)
6. JVET-N0357, CE8-related: Context Modelling of Sign for TS Residual Coding, B. Bross, T. Nguyen, H. Schwarz, D. Marpe, T. Wiegand (HHI)
7. JVET-N0401, Non-CE3/8: Enable Transform Skip in CUs using ISP, S. De-Luxán-Hernández, T. Nguyen, B. Bross, H. Schwarz, D. Marpe, T. Wiegand (HHI)
8. JVET-N0428, CE8-4.1: Rearrangement of the residual block for transform skip, S. Yoo, J. Choi, J. Heo, J. Choi, L. Li, J. Lim, S. Kim (LGE)
9. JVET-N0429, CE8-4.2: Residual Coding for transform skip with various maximum context coded bins, S. Yoo, J. Choi, J. Heo, J. Choi, J. Lim, S. Kim (LGE)
10. JVET-N0430, CE8-related: Transform skip restriction, J. Choi, J. Heo, S. Yoo, J. Choi, J. Lim, S. Kim (LGE)
11. JVET-N0431, CE8-related: sign flag coding for transform skip residual, S. Yoo, J. Choi, J. Heo, J. Choi, J. Lim, S. Kim (LGE)
12. JVET-N0455, CE8-related: Sign context modelling and level mapping for TS residual coding, M. Karczewicz, M. Coban (Qualcomm)

*Other SCC tool related contributions*

1. JVET-N0214, CE8: BDPCM with harmonized residual coding and CCB limitation (CE8-3.1a, CE8-3.1b, CE8-5.1a, CE8-5.1b) , G. Clare (bcom), F. Henry (Orange), B. Bross, T. Nguyen, P. Keydel, H. Schwarz, D. Marpe, T. Wiegand (HHI), X. Zhao, X. Li, X. Xu, S. Liu (Tencent)
2. JVET-N0247, Non-CE8: an improvement to hash-based motion estimation, J. Li, J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance), R. Xiong (Peking Univ.)
3. JVET-N0366, CE8-related: Modified limitation on context coded bins for CE8-3.1a and CE8-5.1a, X. Zhao, X. Li, X. Xu, S. Liu
4. JVET-N0413, CE8-related: Quantized residual BDPCM, M. Karczewicz, M. Coban (Qualcomm)
5. JVET-N0464, Non-CE8: MMVD Motion vector rounding for SCC, H. Jang, J. Nam, N. Park, J. Lim, S. Kim (LGE)
6. JVET-N0501, CE8 related: Optimal Scan Order for BDPCM Residues, A. Singh, A. Konda, C. Pujara, R. Gadde, W. Choi, K.P. Choi (Samsung)

*Test material contributions*

1. JVET-N0386, AOV YUV4:4:4 sequence for VVC standardization and suggestions for class F, X. Xu, J. Ye, X. Li, S. Liu, L. Wu, C. Xie, K. Liu, B. Wang, P. Liu, K. Dong, Y. Kuang, W. Feng (Tencent)
2. JVET-N0502, Five SCC TGM sequences of both YUV4:4:4 and YUV4:2:0 formats, Tao Lin, Kailun Zhou, Shuhui Wang (Tongji), Liping Zhao (Shaoxing)

The AHG recommends:

* To review all related contributions.
* To continue investigating SCC coding tool performance, complexity and interactions between themselves and with other coding tools.
* To continue evaluating new test materials.

It is emphasized that an update on the SCC test conditions is urgently needed. See further notes under plenary and BoG CE8.

[JVET-N0012](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6256) 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]

At the 13th JVET meeting, the AHG on High-level syntax was established with the following mandates:

* 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.

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

Input documents related to AHG12 were listed in the AHG report. There were a total of 39 documents identified.

[JVET-N0013](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6370) 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, S. Liu, D. Luo]

This document summarizes the activity of AHG13: “Tool reporting procedure” between the 13th Meeting in Marrakech, MA (9–18 Jan. 2019) and the 14th meeting in Geneva, CH (19–27 March 2019). Tool on/off experimental results vs. VTM anchor are provided for the tools specified in JVET-M1005.

The initial version of JVET-M1005 “Methodology and reporting template for tool testing” was provided on Jan. 30th. The document contained a reporting template.

All tests described in JVET-M1005 were conducted. VTM tool tests were conducted on VTM-4.0 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.

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

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Tool Name** | **Acronym** | **Document reference(s)** | **AI** | **RA** | **LD** | **Tester** | **Crosscheck** |
| Chroma separate tree | CST | JVET-K0230, JVET-K0556 | X | X | X | Tzu-Der Chuang (peter.chuang@mediatek.com) | Wei-Jung Chien (wchien@qti.qualcomm.com) |
| Dependent quantization\* | DQ | JVET-L0274, JVET-M0173, JVET-M0251, JVET-M0470, | X | X | X | Tzu-Der Chuang (peter.chuang@mediatek.com) | Daniel Luo (daniel.luo@interdigital.com) |
| Cross-component linear model | CCLM | JVET-L0085, JVET-L0136, JVET-L0191, JVET-L0338, JVET-L0340, | X | X | X | Roman Chernyak (chernyak.roman@huawei.com) | Shan Liu (shanl; leolzhao@ tencent.com) |
| multiple transform set | MTS | JVET-L0059, JVET-L0111, JVET-L0118, JVET-L0285, JVET-M0297, JVET-M0464, JVET-M0497 | X | X | X | Kiho Choi (kiho14.choi@samsung.com) | Shan Liu (shanl; xinzzhao@ tencent.com) |
| Adaptive loop filter | ALF | JVET-L0082, JVET-L0083, JVET-L0147, JVET-L0392, JVET-L0664, JVET-M0132 | X | X | X | Wei-Jung Chien (wchien@qti.qualcomm.com) | Daniel Luo (daniel.luo@interdigital.com) |
| Affine motion model | AFF | JVET-L0045, JVET-L0047, JVET-L0142, JVET-L0265, JVET-L0260, JVET-L0271, JVET-L0632, JVET-L0694, JVET-M0145, JVET-M0192 |  | X | X | Roman Chernyak (chernyak.roman@huawei.com) | Shan Liu (shanl; guichunli@ tencent.com) |
| subblock-based temporal merging candidates | SbTMVP | JVET-L0055, JVET-L0104, JVET-L0195, JVET-L0257, JVET-L0369, JVET-L0468, JVET-M0273 |  | X | X | Shan Liu  (shanl; guichunli@ tencent.com) | Wei-Jung Chien (wchien@qti.qualcomm.com) |
| Adaptive motion vector resolution | AMVR | JVET-L0377, JVET-M0246 |  | X | X | Shan Liu (shanl; guichunli@ tencent.com) | Wei-Jung Chien (wchien@qti.qualcomm.com) |
| Pairwise merge candidate | PMC | JVET-L0090, JVET-M0193 |  | X | X | Tzu-Der Chuang (peter.chuang@mediatek.com) | Roman Chernyak (chernyak.roman@huawei.com) |
| Triangular partition mode | TPM | JVET-L0124, JVET-L0208, JVET-M0328, JVET-M0883 | X | X | X | Kiho Choi (kiho14.choi@samsung.com) | Shan Liu (shanl; leolzhao@ tencent.com) |
| Bi-directional optical flow | BDOF | JVET-L0256, JVET-M0487 |  | X | X | Kiho Choi (kiho14.choi@samsung.com) | Tzu-Der Chuang (peter.chuang@mediatek.com) |
| Combined intra/inter prediction | CIIP | JVET-L0100 |  | X | X | Kiho Choi (kiho14.choi@samsung.com) | Tzu-Der Chuang (peter.chuang@mediatek.com) |
| Merge with MVD | MMVD | JVET-L0054, JVET-M0068, JVET-M0171, JVET-M0255 |  | X | X | Kiho Choi (kiho14.choi@samsung.com) | Hyeongmun Jang ([hm.jang@lge.com](mailto:hm.jang@lge.com)) |
| Bi-predictive with CU weights | BCW | JVET-L0646, JVET-M0111, JVET-M0264 |  | X | X | Daniel Luo (daniel.luo@interdigital.com) | Tzu-Der Chuang (peter.chuang@mediatek.com) |
| Multi-reference line prediction | MRLP | JVET-L0283 | X | X | X | Shan Liu (shanl; leolzhao@ tencent.com) | Hyeongmun Jang (hm.jang@lge.com) |
| Intra block copy mode\*\* | IBC | JVET-M0407, JVET-M0483 | X | X | X | Shan Liu (shanl; xiaozhongxu@ tencent.com) | Wei-Jung Chien (wchien@qti.qualcomm.com) |
| Intra sub-partitioning | ISP | JVET-M0102 | X | X | X | Roman Chernyak (chernyak.roman@huawei.com) | Hyeongmun Jang (hm.jang@lge.com) |
| Decoder motion vector refinement | DMVR | JVET-M0147 |  | X |  | Daniel Luo (daniel.luo@interdigital.com) | Roman Chernyak  ([chernyak.roman@huawei.com](mailto:chernyak.roman@huawei.com)) |
| Sub-block transform | SBT | JVET-M0140 |  | X | X | Roman Chernyak (chernyak.roman@huawei.com) | Shan Liu (shanl; xinzzhao@ tencent.com) |
| Luma mapping with chroma scaling | LMCS | JVET-M0427 | X | X | X | Taoran Lu (tlu@dolby.com) | Hyeongmun Jang (hm.jang@lge.com) |
| CABAC | CABAC | JVET-M0453, JVET-M0725 | X | X | X | Yi-Wen Chen (yiwenchen@kwai.com) | Hyeongmun Jang (hm.jang@lge.com) |
| Symmetric motion vector difference | SMVD | JVET-M0444 |  | X | X | Yi-Wen Chen(yiwenchen@kwai.com) | Hyeongmun Jang (hm.jang@lge.com) |
| Transform skip mode | TSM | JVET-M0464 | X | X | X | Shan Liu (shanl; xinzzhao@ tencent.com) | Wei-Jung Chien ([wchien@qti.qualcomm.com](mailto:wchien@qti.qualcomm.com)) |
| Shared merging candidate cist | SML | JVET-M0170 |  | X | X | Shan Liu (shanl; xlxiangli@ tencent.com) | Hyeongmun Jang ([hm.jang@lge.com](mailto:hm.jang@lge.com)) |
| Shape-adaptive transform selection\*\*\* | SATS | JVET-M0303 | X | X | X | Shan Liu (shanl; xinzzhao@ tencent.com) | Kiho Choi ([kiho14.choi@samsung.com](mailto:kiho14.choi@samsung.com)) |

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

\*\* Test was conducted by enabling IBC

\*\*\* Test was conducted by disabling MTS and enabling SATS

[integrate terminology]

The results of the tests are summarized in the table below. The attached spreadsheet provides additional data. 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-4.0/

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 | 0.29% | 11.28% | 12.41% | 121% | 101% | 121% | 99% |
| DQ | 1.84% | 1.04% | 0.73% | 89% | 104% | 86% | 106% |
| CCLM | 2.08% | 19.05% | 19.23% | 99% | 100% | 99% | 99% |
| MTS | 1.95% | 1.39% | 1.39% | 63% | 96% | 63% | 95% |
| ALF | 2.25% | 2.96% | 3.17% | 100% | 88% | 100% | 89% |
| MRLP | 0.45% | 0.24% | 0.25% | 96% | 99% | 97% | 100% |
| CPR | -0.46% | -0.38% | -0.42% | 148% | 100% | 147% | 100% |
| SAO | 0.24% | 0.33% | 0.62% | 100% | 97% | 100% | 96% |
| ISP | 0.61% | 0.45% | 0.46% | 83% | 95% | 84% | 97% |
| ILRS | 0.87% | -1.17% | -1.00% | 101% | 100% | 100% | 100% |
| CABAC | 1.01% | 1.10% | 1.21% | 95% | 103% | 93% | 97% |
| TSM | 0.26% | 0.35% | 0.34% | 100% | 97% | 100% | 99% |
| SATS | -1.04% | -1.36% | -1.36% | 99% | 103% | 99% | 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 | 0.16% | 4.90% | 6.35% | 102% | 99% | 101% | 99% |
| DQ | 1.57% | 0.78% | 0.25% | 99% | 103% | 96% | 102% |
| CCLM | 0.91% | 17.37% | 17.31% | 99% | 100% | 101% | 102% |
| MTS | 0.87% | 0.47% | 0.59% | 97% | 100% | 95% | 97% |
| ALF | 3.84% | 3.53% | 3.11% | 101% | 88% | 101% | 88% |
| AFF | 2.62% | 1.84% | 1.75% | 88% | 99% | 89% | 99% |
| SbTMVP | 0.46% | 0.27% | 0.30% | 100% | 100% | 101% | 100% |
| AMVR | 1.04% | 1.50% | 1.46% | 85% | 101% | 86% | 100% |
| PMC | 0.19% | 0.04% | 0.13% | 102% | 100% | 99% | 99% |
| TPM | 0.39% | 0.61% | 0.61% | 91% | 100% | 92% | 102% |
| BDOF | 0.75% | 0.15% | 0.10% | 96% | 94% | 98% | 93% |
| CIIP | 0.51% | 0.42% | 0.55% | 96% | 99% | 98% | 99% |
| MMVD | 0.53% | 0.48% | 0.52% | 89% | 101% | 88% | 100% |
| BPWA | 0.42% | 0.52% | 0.57% | 93% | 103% | 96% | 101% |
| MRLP | 0.23% | -0.06% | 0.00% | 99% | 100% | 99% | 100% |
| IBC | 0.01% | -0.07% | -0.05% | 99% | 99% | 99% | 100% |
| SAO | 0.57% | 0.87% | 0.92% | 101% | 99% | 100% | 99% |
| ISP | 0.26% | 0.29% | 0.05% | 97% | 98% | 99% | 100% |
| DMVR | 0.73% | 1.05% | 1.08% | 100% | 94% | 99% | 94% |
| SBT | 0.38% | 0.32% | -0.04% | 94% | 99% | 93% | 97% |
| ILRS | 1.38% | -2.46% | -2.37% | 93% | 98% | 94% | 99% |
| CABAC | 0.94% | 1.00% | 0.79% | 100% | 102% | 98% | 98% |
| SMVD | 0.26% | 0.24% | 0.24% | 97% | 104% | 96% | 100% |
| TSM | 0.18% | 0.03% | -0.06% | 98% | 99% | 98% | 99% |
| SML | -0.01% | -0.05% | -0.06% | 101% | 102% | 101% | 101% |
| SATS | -0.53% | -0.50% | -0.65% | 101% | 102% | 101% | 102% |

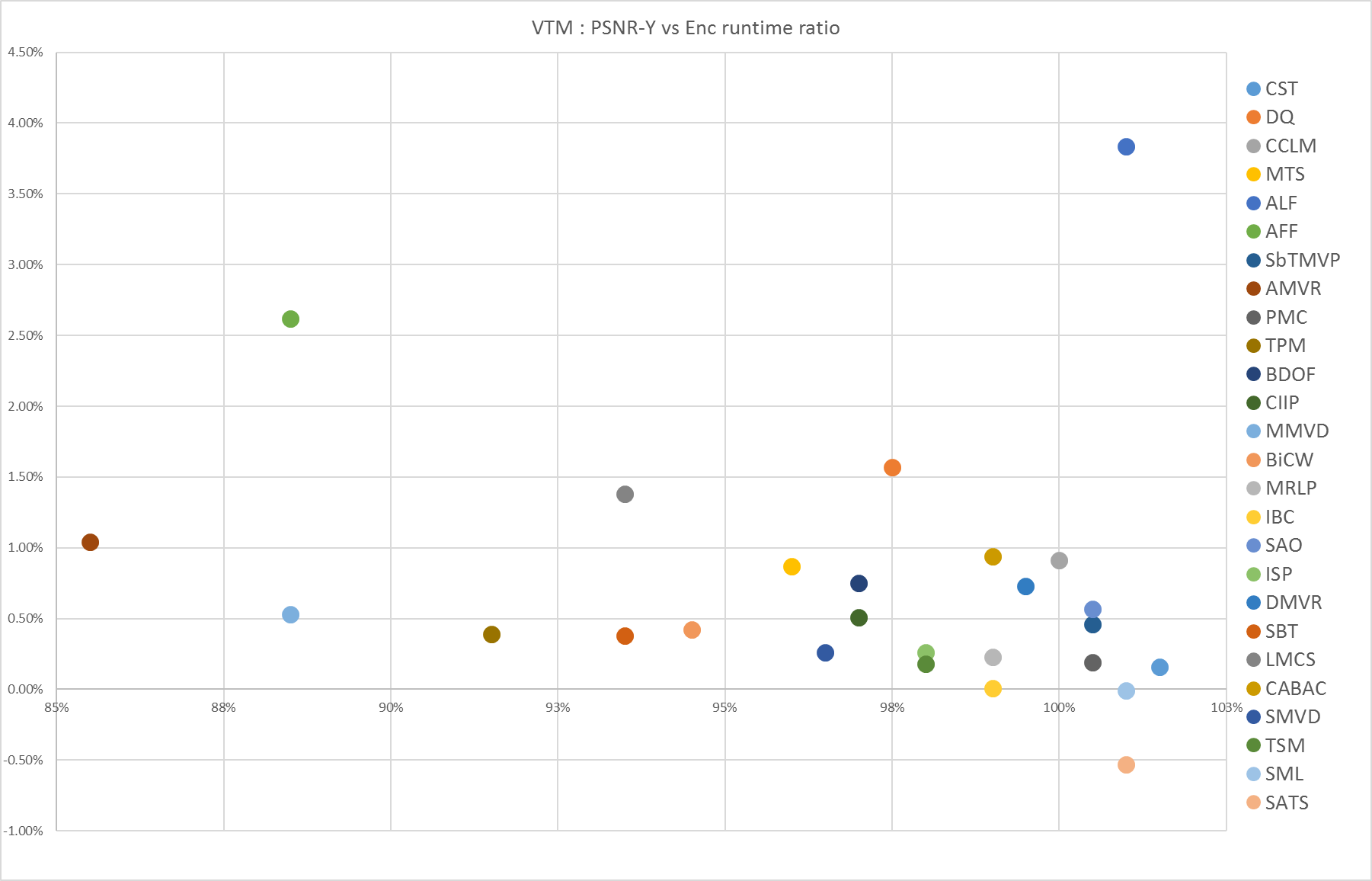
Simulation results in low delay B configuration (LDB) of VTM tool tests. (VTM anchor)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | **LDB** |  |  |  |
| **Acronym** | **BDR-Y** | **BDR-U** | **BDR-V** | **Tester EncTime** | **Tester DecTime** | **XChecker EncTime** | **XChecker DecTime** |
| CST | 0.08% | 1.71% | 3.03% | 99% | 101% | 100% | 101% |
| DQ | 1.33% | 1.47% | 0.57% | 96% | 102% | 98% | 102% |
| CCLM | 0.05% | 4.63% | 5.56% | 100% | 99% | 100% | 104% |
| MTS | 0.24% | 0.58% | 0.21% | 100% | 100% | 98% | 97% |
| ALF | 2.56% | 3.33% | 3.03% | 103% | 93% | 100% | 90% |
| AFF | 2.07% | 1.31% | 0.98% | 84% | 96% | 85% | 96% |
| SbTMVP | 0.63% | 0.78% | 0.39% | 101% | 97% | 101% | 101% |
| AMVR | 0.38% | 0.66% | 0.95% | 91% | 102% | 92% | 102% |
| PMC | -0.02% | 0.08% | -0.22% | 99% | 100% | 100% | 100% |
| TPM | 0.95% | 1.34% | 1.27% | 88% | 101% | 88% | 104% |
| CIIP | 0.47% | 0.99% | 1.13% | 95% | 98% | 93% | 100% |
| MMVD | 0.45% | 0.42% | 0.27% | 92% | 100% | 90% | 101% |
| BPWA | 0.29% | 0.31% | 0.23% | 97% | 100% | 97% | 100% |
| MRLP | 0.09% | 0.36% | 0.09% | 98% | 100% | 100% | 101% |
| IBC | 0.05% | 0.24% | -0.05% | 105% | 99% | 103% | 98% |
| SAO | 1.24% | 2.48% | 3.92% | 102% | 97% | 101% | 99% |
| ISP | 0.13% | 0.35% | -0.20% | 99% | 99% | 100% | 101% |
| SBT | 0.66% | 1.22% | -0.20% | 92% | 99% | 90% | 95% |
| ILRS | 0.76% | -1.71% | -2.10% | 93% | 96% | 92% | 98% |
| CABAC | 0.88% | 0.55% | 0.16% | 99% | 100% | 97% | 101% |
| TSM | 0.11% | 0.07% | 0.17% | 97% | 97% | 98% | 102% |
| SML | -0.01% | 0.05% | -0.04% | 103% | 105% | 100% | 100% |
| SATS | -0.13% | -0.01% | 0.00% | 100% | 103% | 102% | 102% |

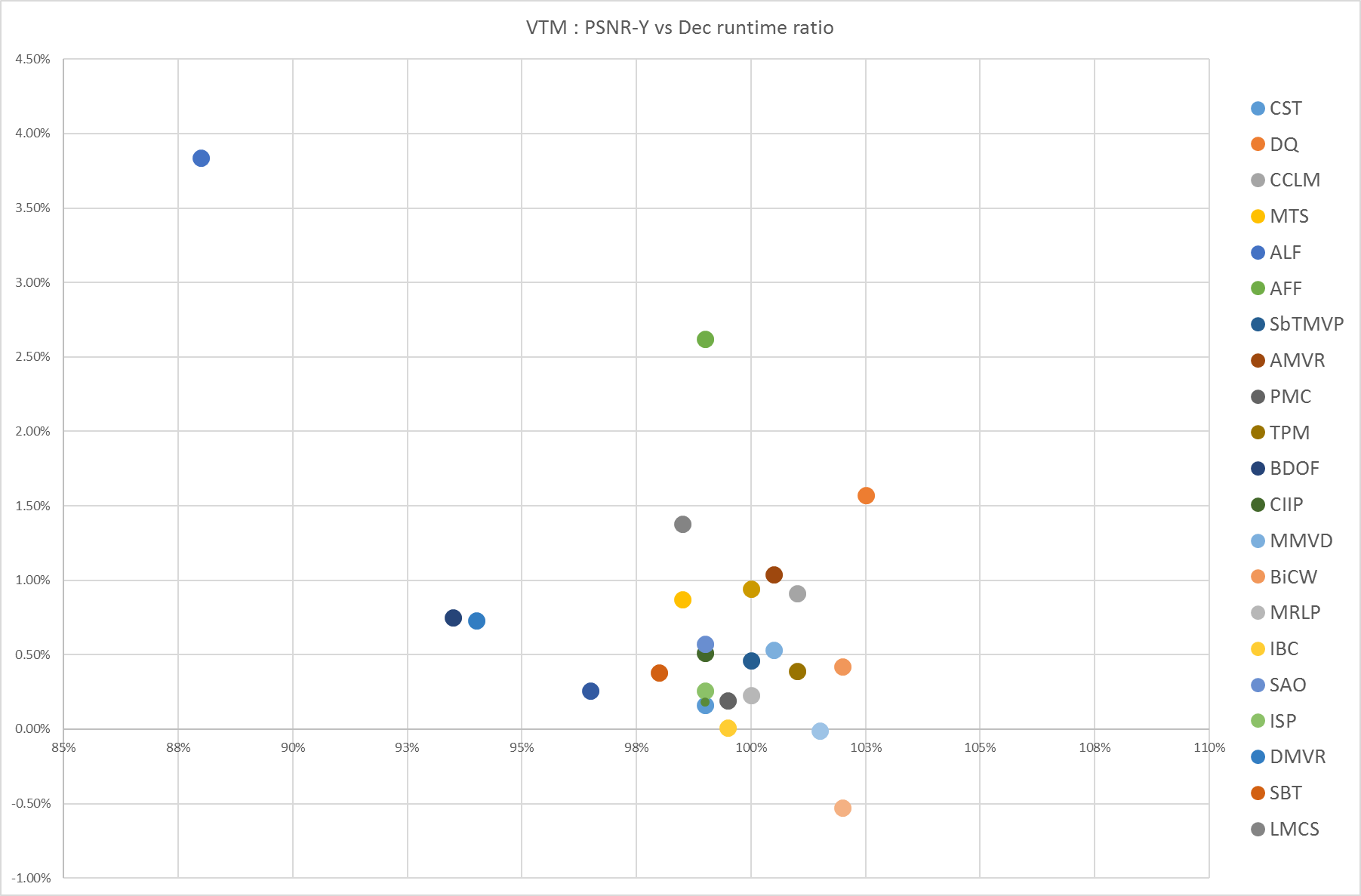
Pixel usage and memory bandwidth results of VTM tool “off” test. (VTM anchor)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | AI |  | RA |  |  | LDB |  |
| Acronym | Pixel usage | Pixel usage | Ave mem BW | Max mem BW | Pixel usage | Ave mem BW | Max mem BW |
| CCLM | 50.87% | 3.34% |  |  | 0.81% |  |  |
| ALF | 99.00% | 55.66% |  |  | 44.87% |  |  |
| AFF |  | 20.40% |  |  | 26.99% |  |  |
| SBTMC |  | 12.34% |  |  | 13.81% |  |  |
| AMVR |  | 4.91% |  |  | 2.12% |  |  |
| TAP |  | 2.52% |  |  | 6.02% |  |  |
| BDOF |  | 43.80% |  |  |  |  |  |
| CIIP |  | 1.30% |  |  | 1.65% |  |  |
| MMVD |  | 8.70% |  |  | 9.12% |  |  |
| BPWA |  | 10.17% |  |  | 8.54% |  |  |
| MRLP | 6.41% | 0.65% |  |  | 0.31% |  |  |
| SAO | 54.71% | 11.13% |  |  | 18.41% |  |  |
| DMVR |  | 40.21% |  |  |  |  |  |
| SBT |  | 2.53% |  |  | 4.15% |  |  |
| SMVD |  | 3.00% |  |  |  |  |  |
| TSM | 1.61% | 0.58% |  |  | 1.01% |  |  |

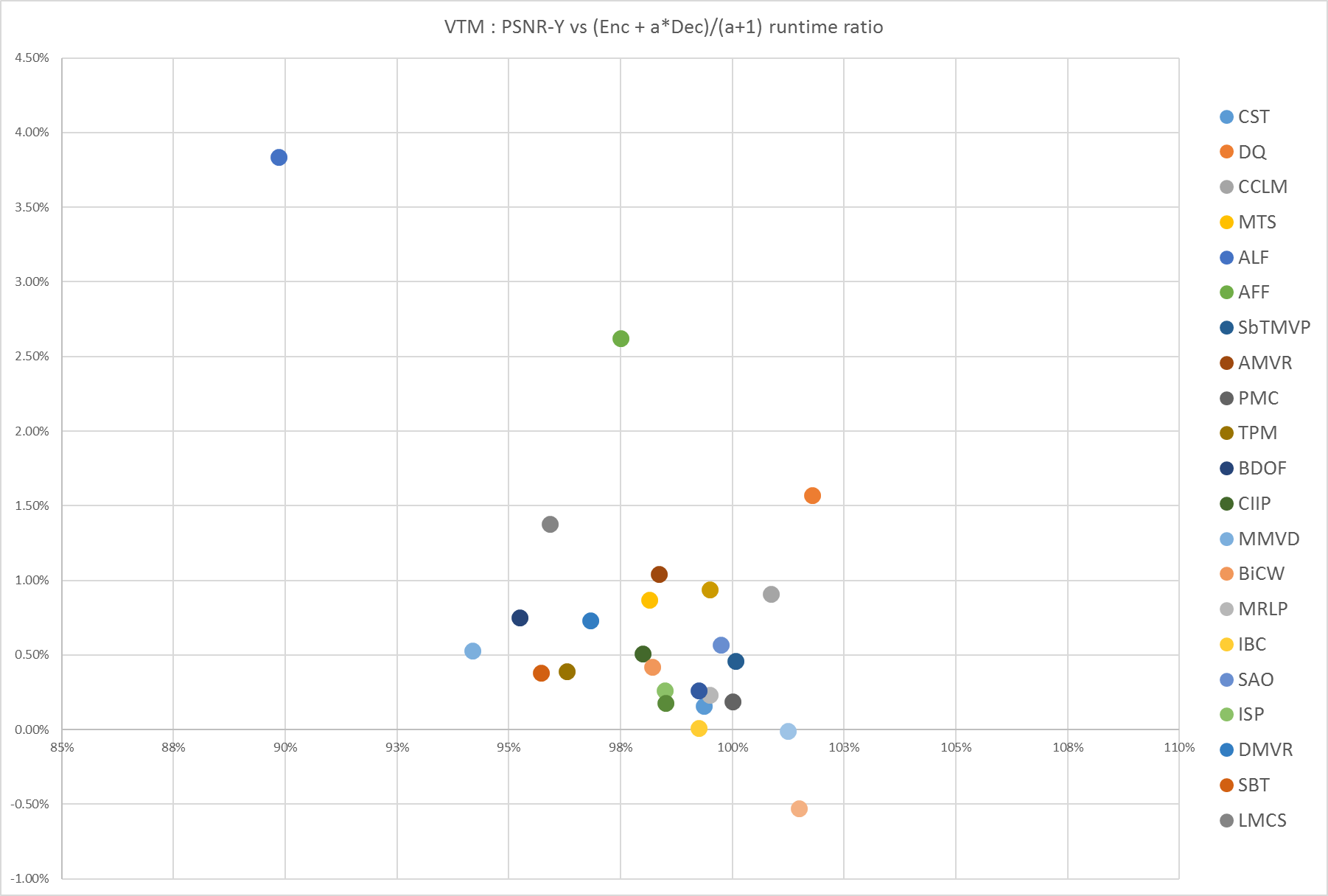
PSNR-Y vs encoding runtime ratio of VTM with VTM tool tests (VTM anchor)



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 asked whether there are some features we could turn off in the LB configuration to save runtime. AMVR was suggested as a potential candidate (0.4% gain for 10% runtime in the LB case; helps more for high-resolution RA).

Related contributions:

JVET-N0123 AHG13/Non-CE6/CE8: Chroma Transform Skip T. Tsukuba, M. Ikeda, Y. Yagasaki, T. Suzuki (Sony)

Additional tests on transform skip mode (TSM) were conducted in the contribution.

* TSM: Disable transform skip on top of VTM-4.0 (AhG13 Test, JVET-M0464 enabled)
* TSM1: Restrict transform skip size up to 4x4 on top of VTM-4.0 (JVET-M0464 enabled)
  + Encoder option: --MTS=1 --TransformSkipLog2MaxSize=2
  + Chroma Transform skip: N/A
  + Configuration for TSM\_1 are found in config\_TSM\_1.
* TSM2: Restrict transform skip size up to 4x4 on top of VTM-4.0 with JVET-M0464 disabled (including ticket#185)
  + Encoder option: --EMT=1 --EMTFast=1 --TransformSkipLog2MaxSize=2 with JVET-M0464 macro disabled
  + Chroma Transform skip: 2x2/4x2/2x4/4x4 can be used
  + Configuration and source changes for TSM\_2 are found in config\_TSM\_2.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **Random Access** |  |  |
|  |  |  | **Over TM- 4.0** |  |  |
|  | Y | U | V | EncT | DecT |
| **TSM** | 0.18% | 0.03% | -0.06% | 98% | 99% |
| **TSM1** | 0.17% | -0.07% | -0.07% | 100% | 100% |
| **TSM2** | 0.00% | -0.10% | -0.42% | 104% | 101% |

JVET-N0238 AHG13: ISP Tool-off Tests in VTM-4.0.1 S. De-Luxán-Hernández, B. Bross, H. Schwarz, D. Marpe, T. Wiegand (HHI)

Additional tests on intra sub-partitioning (ISP) were conducted in the contribution.

* ISP: Disable ISP on top of VTM-4.0 (AhG13 Test)
  + Anchor: VTM-4.0 with ISPFast set to 0.
* ISP1: Disable ISP on top of VTM-4.0.1
  + Anchor: VTM-4.0.1 with ISPFast set to 0.
* ISP2: Disable ISP on top of VTM-4.0.1
  + Anchor: VTM-4.0.1 with ISPFast set to 1.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra** |  |  |
|  |  |  | **Over TM- 4.0** |  |  |
|  | Y | U | V | EncT | DecT |
| **ISP** | 0.61% | 0.45% | 0.46% | 83% | 95% |
| **ISP1** | 0.61% | 0.45% | 0.46% | 83% | 96% |
| **ISP2** | 0.58% | 0.44% | 0.43% | 87% | 96% |

The AHG recommends the following:

* Consider the reported tool test results during tool adoption decision making
* Review related contributions
* Refine list of tested tools and test methodology for the next meeting cycle
  + Consider the reported tool test results as a benchmark for CE tests
  + Consider including reporting of compute system information for testers and cross-checkers
  + Consider additional performance or complexity metrics

[JVET-N0014](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6371) JVET AHG report: Progressive intra refresh (AHG14) [J.-M. Thiesse, A. Duenas, K. Kazui, R. Sjöberg, A. Tourapis]

This document summarizes activities of AhG on Progressive intra refresh between the 13th and the 14th JVET meetings.

There were several mail exchanges on the main JVET email reflector ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de)) with an [AHG14] indication on message headers. Three topics have been discussed on these mails:

* First, the relevance of intra refresh for low delay has been discussed. Thanks to the early sharing of a latency study by Huawei, the appropriateness of intra refresh was demonstrated without or together with DU.
* Second, there were emails regarding the opportunity of having normative changes to support intra refresh. One expert indicates that the potential additional checks for the decoder may be complex to support and this should be justified by a very high performance benefit threshold. Another expert indicated a use-case where having a smaller latency could be relevant as well as having a granularity to balance between latency and coding efficiency.

Another expert said that practical implementation using intra refresh are complex for handling of entertainment/broadcasting applications. In particular, scene changes and commercial insertion were mentioned. Also, this expert and other expert commented on the complexity due to camera motions which are not in the same direction than the intra refresh scanning.

* Third, there was a discussion on modifying the test condition which leads to the following conditions being agreed and proposed:
* Basis = Low-Delay B Main10 configuration.
* Do not use a pyramidal B structure (=> GOPSize = 1) in order to have all pictures with a somewhat similar bits sizes.
* Use a QP offset of +1 between the first I and the first B picture (the B picture having a higher QP than the I picture).
* Set the intra refresh period equal to 1 second, meaning that the stream shall be refreshed after a cycle of 1 second (can be less).
* PSNR and bitrates should be computed without the first I picture + the first cycle minus 1 (meaning that the first 30 pictures are not considered in 30Hz, 60 in 60Hz…)

An updated version of the encoder only implementation has been shared on the AHG 14 Gitlab (<https://vcgit.hhi.fraunhofer.de/jvet-l-ahg-14/VVCSoftware_VTM/tree/AHG14-IntraRefresh_EncOnly>).

The following contributions were identified for the AHG.

* Contribution on general aspects
  + JVET-N0114, “AHG14: A delay analysis for IRAP and GDR”, Hendry, Y.-K. Wang, M. Sychev (Huawei)
* Contributions on normative intra refresh handling including software
  + JVET-N0080, “AHG14: Revised software for ultra low-latency encoding”, K. Kazui(Fujitsu)
  + JVET-N0391, “AHG14: Updates on intra refresh proposal”, J.-M. Thiesse, D. Gommelet, D. Nicholson (VITEC)
* Contributions on normative intra refresh handling
  + JVET-N0115, “AHG14/AHG17: GDR - gradual decoding refresh”, Hendry, Y.-K. Wang, J. Chen, S. Hong (Huawei)
  + JVET-N0116, “AHG14/AHG17: DDR - distributed decoding refresh”, Y.-K. Wang, M. Sychev, Hendry (Huawei)
  + JVET-N0275, “AHG14/AHG8/AHG17: Sections for intra refresh and inloop filter disabling”, J. Boyce, R. Lei, L. Xu
  + JVET-N0310, “AHG14: On gradual decoding refresh”, M. M. Hannuksela, K. Kammachi-Sreedhar, A. Aminlou (Nokia)
* Contributions on clean random access in case of intra refresh
  + JVET-N0101, “AHG14/ AHG17: On Gradual and Clean Random Access”, S. Deshpande (Sharp)
  + JVET-N0495, “AHG14: Recovery point indication NAL unit”, R. Sjöberg, M. Pettersson, M. Damghanian (Ericsson)

The AhG recommended:

* To review all related contributions.
* To integrate the encoder-only modifications into the next VTM software, update the anchor appropriately, and to continue investigating the benefits of normative progressive intra refresh solutions.
* To consider updating the common test conditions for integrating the intra refresh scenario.

[JVET-N0015](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6287) JVET AHG report: Bitstream decoding properties signalling (AHG15) [J. Boyce, J. Chen, S. Deshpande, M. Karczewicz, A. Tourapis, Y.-K. Wang, S. Wenger]

This document summarizes the activity of AHG15: Bitstream decoding properties signaling, between the between the 13th meeting in Marrakesh, MA (9–18 Jan. 2019) and the 14th meeting in Geneva, CH (19-27 Mar. 2019).

There was no email activity on the reflector during this period.

Two related input contributions were identified:

* JVET-N0276 AHG15: On interoperability point signalling [J. Boyce (Intel)]
  + JVET-N0276 proposes adding a sub-profile indicator to the profile\_tier\_level( ) syntax structure which would be managed by a 3rd party registration authority, and suggests parent body level discussion.
* JVET-N0278 AHG17/AHG15: On VVC HLS relevant to MPEG requirements on immersive media delivery and access (N18134) [J. Boyce (Intel)]
  + Both JVET-N0276 and JVET-N0278 have interactions with other high-level syntax contributions.

In the discussion it was noted that JVET-N0276 proposes a fixed length of 3 bytes for the sub-profile identifier, structured as in T.35 (assuming a one-byte country code and a one-byte terminal provider code, this would provide one additional byte for the subprofile ID within a profile for each terminal provider). To the extent of awareness of those present, only one byte has been needed for the country code and one byte for the terminal provider code.

The AHG chair also described the recently formed MC-IF organization, which is considering activity to develop sub-profiles.

The BoG recommends:

Review contributions

Coordinate with high-level syntax experts on high-level syntax location(s) and scope for tool restriction syntax

Initiate parent body discussion about 3rd party registration authority for sub-profile indicator

[JVET-N0016](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6226) 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 13th JVET meeting in Marrakesh, MA (9–18 January 2019) and the 14th JVET meeting in Geneva, CH (19–27 March 2019).

There were seome, but not many, email exchanges on the main JVET email reflector in the interim period.

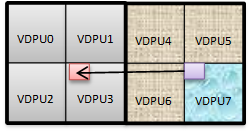
**Comments posted on the email reflector before the finalization of CE descriptions**

1. **Small block size (e.g. 2x2) chroma intra-prediction** is a known issue when the QTBTT was adopted. Processing four times of intra chroma blocks (compared to 4x4 minimum chroma block size) alone is not something affordable for high performance VVC decoder designs. The CCLM has made the situation worse because the luma and chroma reconstruction can no longer be made parallel. It is desirable to have a consistent solution to resolve this issue. Potential solutions for the separate tree case were proposed at the last meeting; more difficult might be to find a solution for the combined tree case.
2. **Memory bandwidth** remains an issue to be resolved for motion compensation of both the regular inter prediction mode and the affine mode. For the regular inter prediction mode, the HEVC design (i.e. bi-pred 8x8, uni-pred 8x4/4x8) might be a straightforward solution if no better options can be found. For the affine mode where 4x4 sub-block size is used for motion compensation, designs should consider not only the constraint of the worst case memory bandwidth consumption and the worst number of reference block requests out of the cache memory, but also the computational complexity reduction of the 4x4 block based motion compensation process.
3. **Separate luma/chroma partitioning tree** introduces a long latency for chroma intra prediction when the CCLM is on. In the worst case, the chroma intra prediction cannot be kicked off until the whole 64x64 luma block is reconstructed (e.g. when a 64x64 luma block is split horizontally while the chroma blocks are split vertically, and vice versa). It might be interesting to see if the CCLM can be disabled for 4x4 blocks without harming coding efficiency.
4. Having **hard coded limits on the maximum number of context coded bins per 4x4 CG** does not appear to be useful for implementation, replacing them with implicit limits is preferable as it simplifies design and avoids potential quality issues.
5. The quantization noise can increase the dynamic range of inverse transform output. It is recommended to clip the output of the **non-separable** **secondary inverse transforms (NSST) 16-bit range before fed into the primary inverse transforms,** to avoid potential impact on the primary inverse transforms in terms of the intermediate precisions and intermediate transform buffer size.
6. Sub-partitions of 1xN and 2xN in **the newly adopted sub-partition intra prediction** create implementation difficulties; it is desirable to remove those elements from the current design.
7. **Intra Block Copy (IBC)** is now treated a separate mode in VTM4.0. The separate IBC merge/AMVP list derivation is down to 4x4 block level, the IBC merge list derivation should be simplified significantly to meet the throughput requirement. Moreover, the current IBC design is optimized for 128x128 CTU size only in terms of the local buffer usage (~23 Kbytes). If the CTU size is reduced to 64x64 for instance, only ¼ of the 23 Kbytes local memory gets used and the rest of local buffer gets idle. This should be fixed.
8. It is desirable to split the large block size **local illumination compensation (LIC)** into multiple of 16x16 blocks(similar to what has been done for the DMVR), to minimize the buffer usage and processing overhead.  In the current design of inter prediction loop, the motion compensation, DMVR and BDOF can all be processed on a 16x16 block basis. **This additional LIC variant is tested in CE1.**
9. It might be more straightforward to design a **de-blocking filter** which operates on 4x4 grids and uses a line buffer of e.g. 6 luma lines (increase the line buffer size for chroma accordingly if it helps), to minimize the number of conditional checks and avoid inconsistent operations along different edges (e.g. inside the CTU and along the top CTU boundary).

**Other feedback provided to the proponents**

1. For **palette mode** suggested the following changes to reduce the buffer size and improve the throughput:
   1. Limit the number of palette\_index\_idc to a maximum (e.g. 256). For every 256 index runs (or some other number), interleave palette\_index\_idc and copy\_above\_palette\_index\_flag/palette\_run. In which case the palette\_index\_idc only need to be buffered 256 entries.
   2. And signal the quantized sample values immediately after the “escape code” to avoid multiple-pass CU block reconstruction.
   3. Restrict the palette size especially for small size PUs to constrain the worst case bin rate.
   4. Fix the maximum palette size for the standard (currently it is signalled in SPS).
2. For **newly adopted luma in-loop reshaping (aka DRA),** suggested the following changes to reduce the implementation cost and latency:
   1. Avoid computing the luma average value at TU level to reduce the latency. In the current design, the chroma residual scaling cannot take place until the whole TU size of the luma prediction block is generated and the average is computed, resulting in high latency in the chroma reconstruction even in the shared tree case for large TUs (e.g. 64x64).
   2. Avoid storing the chroma residual in high-precision (currently 16-bit) for the chroma residual scaling purpose. (roughly 2.5 Kbytes local buffer saving if it is reduced to 11-bit for 10-bit video).
   3. Signal the temporal domain reshaping parameters using picture-level parameter sets to avoid potential negative impact on “trick mode”.
3. For **newly adopted intra sub-partition prediction (ISP),** identified that the current design breaks the 64x64 decoder pipeline, because for e.g. 128x64 or 64x128 CUs, the luma part is split but the chroma part is not, which creates 64x32 or 64x32 size chroma TUs. For the 64x64 block based decoder pipeline, the chroma TU size can only be up to 32x32. This was communicated with the proponents.
4. For **Intra Block Copy (IBC)**, suggested to disallow the IBC local copy from beyond the most recently decoded three (preceding) VDPUs and the already decoded area of the current VDPU. It is asserted that reading and writing data from the same memory is not desirable, as it may create a race condition in terms of memory access. It is also desirable to add assertions to the decoder side to make sure that the IBC copies the data from the valid reference area.

The first CU of the current VDPU (i.e. VDPU7) can copy from VDPU3 in the current IBC design, as shown below:



It was discussed whether this was intended to be allowed. It was commented that this was intended to be prohibited, and is prohibited in the meeting notes, and is described as prohibited in the VTM document but is not prohibited in the draft text or software. It was reported that contribution JVET-N0383 shows that the coding efficiency impact of prohibiting this is minor (0.2% for TGM in AI, less in RA) and provides text.

Decision (BF): Fix this bug

**Memory bandwidth study for VTM4.0**

Broadcom conducted a memory bandwidth study by running both the VTM4.0 and VTM3.0 for CTC with a commercial motion compensation cache model integrated. The summary results of the random access configuration are provided in the table below (for informational purposes).

The DMVR is the tool which may cause the difference in memory bandwidth consumption between the VTM4.0 and VTM3.0. For RA configuration, this tool appears to increase the average memory bandwidth consumption by roughly 3% (see ABW\_diff column) relative to VTM3.0, but the increase in the peak memory bandwidth (see MBW\_diff column) is very limited (roughly 1% in class A1).

Memory bandwidth comparison (VTM4.0 vs.VTM3.0, RA):

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access Main 10** | | | | | | | |
|  | **VTM4.0 Over VTM-3.0** | | | | | | | |
|  | Y | U | V | TCM\_diff | ABW\_diff | MBW\_diff | EncT | DecT |
| Class A1 | -5.44% | 6.42% | 3.71% | 2.77% | 2.82% | 0.97% | 155% | 100% |
| Class A2 | -6.85% | 5.56% | 6.23% | 2.43% | 2.42% | 0.00% | 146% | 90% |
| Class B | -5.06% | 6.08% | 5.41% | 1.48% | 1.47% | -1.10% | 151% | 100% |
| Class C | -5.14% | 6.98% | 7.68% | 2.66% | 2.81% | 0.23% | 155% | 112% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -5.52% | 6.28% | 5.84% | 3.12% | 3.34% | 3.19% | 152% | 101% |
| Class D | -4.91% | 6.22% | 6.88% | 3.68% | 3.81% | 3.19% | 165% | 114% |
| Class F (optional) | -17.34% | -9.43% | -9.17% | 5.71% | 6.70% | 0.63% | 149% | 113% |

Where

* TCM\_diff : Total cache misses (over all the frames coded), percentage increase relative to VTM3.0.
* ABW\_diff: Average memory bandwidth (over all the frames coded), percentage increase relative to VTM3.0.
* MBW\_diff : Worst case (Max) memory bandwidth (among all the frames coded), percentage increase relative to VTM3.0.

MBW\_diff is the most important measure, which shows the percentage of the worst case memory bandwidth increase of VTM4.0 relative to VTM3.0.

**Bin to bit ratio in VTM4.0 and HM16.19**

It has been observed that the bin to bit ratio in VTM4.0 is double digits percentage higher than that of HM16.19 for CTC. The summary results of the RA configuration are provided in Table 2 for informational purposes (data from JVET-N0049).

BD-binrate and bin to bit ratio (VTM4.0 vs.VTM3.0):

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access Main 10** | | | | | | | | | | | |
|  | **Over HM16.19** | | | | | | | | | | | |
|  | **BD-bitrate** | | | **BD-binrate (average, weighted)** | | | **Bin2bit ratio (peak, weighted)** | | | **Bin2bit ratio (peak, unweighted)** | | |
|  | Y | U | V | Y | U | V | HM16.19 | VTM4.0 | Diff (%) | HM16.19 | VTM4.0 | Diff (%) |
| Class A1 | -32.65% | -39.10% | -42.07% | -22.00% | -29.31% | -32.78% | 0.94 | 1.13 | 20.49% | 1.22 | 1.43 | 16.67% |
| Class A2 | -37.43% | -35.62% | -29.96% | -28.45% | -25.82% | -19.33% | 0.95 | 1.13 | 17.94% | 1.23 | 1.42 | 15.18% |
| Class B | -31.31% | -36.99% | -38.14% | -21.90% | -27.91% | -29.16% | 0.93 | 1.08 | 15.90% | 1.22 | 1.37 | 12.32% |
| Class C | -26.50% | -27.38% | -29.19% | -14.87% | -15.71% | -17.78% | 0.88 | 1.03 | 16.42% | 1.18 | 1.33 | 12.20% |
| Class E |  |  |  |  |  |  |  |  |  |  |  |  |
| **Overall** | **-31.52%** | **-34.58%** | **-34.90%** | **-21.36%** | **-24.52%** | **-24.88%** | **0.93** | **1.09** | **17.39%** | **1.21** | **1.38** | **13.75%** |
| Class D | -25.61% | -25.09% | -26.33% | -15.20% | -14.46% | -15.91% | 0.86 | 1.02 | 18.44% | 1.17 | 1.32 | 13.32% |
| Class F (optional) | -36.12% | -38.21% | -39.22% | -22.29% | -24.45% | -25.49% | 0.84 | 1.03 | 23.01% | 1.16 | 1.31 | 12.98% |

For a given minimum compression ratio (MinCR) of a level, a higher bin to bit ratio implies that a CABAC engine needs to process bins at a faster pace in order to deal with the peak bit-rate in real time.

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 were identified for the AHG.

* Contributions relating to the small block size chroma intra prediction
  + JVET-N0453, “AHG16/Non-CE3: on chroma 2xN and Nx2 intra prediction in single tree”, Y. Zhao, A. Karabutov, H. Yang, J. Chen (Huawei)
  + JVET-N0465, “CE3-related: Restrict 2xN, Nx2 chroma processing for dual tree structure”, H. Jang, J. Nam, N. Park, J. Lim, S. Kim (LGE)
  + JVET-N0396, “CE3-related: Enabling parallel reconstruction of small intra-coded blocks’, L. Pham Van, G. Van der Auwera, A. K. Ramasubramonian, V. Seregin, H. Huang, M. Karczewicz (Qualcomm)
* Contribution relating to the memory bandwidth reduction
  + JVET-N0397, “AHG16: Memory bandwidth reduction for small CUs”, X. Li, G. Li, X. Xu, S. Liu (Tencent)
* Contributions aiming for simplifications and cleanups of the in-loop luma reshaper
  + JVET-N0069, “AHG16/AHG17: Proposed Cleanup for Reshaper High Level Syntax”, B. Heng, M. Zhou, W. Wan (Broadcom)
  + JVET-N0117, “AHG16/AHG17: Signalling of reshaper parameters in APS”, Y.-K. Wang, Hendry, J. Chen (Huawei), P. Yin, T. Lu, F. Pu, S. McCarthy (Dolby)
  + JVET-N0113, “AHG16: Subblock-based chroma residual scaling”, Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)
  + JVET-N0220, “AHG16: Simplification of Reshaper Implementation”, T. Lu, F. Pu, P. Yin, S. McCarthy, W. Husak, T. Chen(Dolby)
  + JVET-N0389, “Chroma residual scaling with separate luma/chroma tree”, E. Francois, C. Chevance (Technicolor)
* Contributions aiming for addressing the 64x64 decoder pipeline and 1xN/2xN sub-partitions issues of the intra sub-partition prediction (ISP)
  + JVET-N0308, “AHG16/Non-CE3: Restriction of the maximum CU size for ISP to 64x64”, S. De-Luxan-Hernandez, B. Bross, T. Nguyen, V. George, B. Stabernack, H. Schwarz, D. Marpe, T. Wiegand (HHI)
  + JVET-N0469, “CE3-related : Disable ISP mode for 128xN, Nx128 Block”, H. Jang, J. Heo, J. Nam, J. Lim, S. Kim (LGE)
  + JVET-N0372: “Non-CE3: ISP with independent sub-partitions for certain block sizes”, S. De-Luxán-Hernández, B. Bross, T. Nguyen, V. George, B. Stabernack, H. Schwarz, D. Marpe, T. Wiegand (HHI)
  + JVET-N0432, “AHG16/Non-CE3: On 1xN and 2xN subpartitions in intra subpartition coding”, A. K. Ramasubramonian, G. Van der Auwera, T. Hsieh, V. Seregin, L. Pham Van, M. Karczewicz
* Contributions aiming for reducing the chroma reconstruction latency in the separate tree case
  + JVET-N0376, “AHG16/CE3-related: CCLM mode restriction for increasing decoder throughput”, J.-Y. Jung, Y.-L. Lee (Sejong Univ.), D.-Y. Kim, W. J. Jeong (Chips&Media), S.-C. Lim, J. Kang (ETRI)
  + JVET-N0390, “AHG16/non-CE3: Study of CCLM restrictions in case of separate luma/chroma tree”, E. Francois, F. Galpin, F. Le LÃ©annec, T. Poirier (Technicolor)
* Contributions aiming for addressing the IBC related issues
  + JVET-N0383, “AHG16/Non-CE8: IBC search range adjustment for implementation consideration”, X. Xu, X. Li, S. Liu (Tencent)
  + JVET-N0384, “Non-CE8: IBC search range increase for small CTU sizes”, X. Xu, X. Li, S. Liu (Tencent)
  + JVET-N0202, “AHG16/Non-CE8: Report on conformance check failures of IBC block vectors”, J. Li, C.-W. Kuo, C. S.Lim (Panasonic)
  + JVET-N0201, “Non-CE8: IBC modifications”, J. Li, C.-W. Kuo, C. S.Lim (Panasonic)
* Contribution relating to cleanups for the reference wraparound
  + JVET-N0070, “AHG16/AHG8: Proposed Cleanup for Reference Wraparound”, B. Heng, M. Zhou, W. Wan (Broadcom)
* Contribution relating to CABAC bin to bit ratio study
  + JVET-N0049, “AHG16/Non-CE7: A study of bin to bit ratio in VTM4.0 and HM16.19”, M. Zhou (Broadcom)
* Contribution relating to MPM list derivation
  + JVET-N0183, “AHG16/Non-CE3: Shared MPM list”, A. M. Kotra, S. Esenlik, J. Chen, B. Wang, H. Gao (Huawei)

Recommendations

* The AHG recommended reviewing the input contributions.

[JVET-N0017](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6342) JVET AHG report: High-level syntax (AHG17) [R. Sjöberg, S. Deshpande, M. M. Hannuksela, R. Skupin, Y.-K. Wang, S. Wenger, H. Yu]

This document summarizes the activities of the AHG on High-level syntax (HLS) between the 13th JVET meeting in Marrakesh, MA (9-18 Jan. 2019) and the 14th meeting in Geneva, CH (19-27 Mar. 2019).

It is reported that the amount of input contributions related to the mandates of this AHG has increased from 22 in Marrakesh to 42 for this meeting. It can be noted that 11 of these 42 were also marked with another AHG in their titles.

For the wider category of high-level syntax contributions including also AHG12/CE12, AHG14 and AHG15, the number of input contributions is reported to have increased from 50 in Marrakesh to 78 for this meeting.

It is reported that of the 12 JCT-VC meetings for HEVC version 1, 3 meetings had a higher number of high-level syntax contributions than this JVET meeting with a peak of 96 of high-level syntax contributions at the 11th meeting in Stockholm 2012.

An informal analysis of the Geneva and Marrakesh input document titles as well as Macau and Ljubljana meeting reports shows that the number of documents in the broad high-level syntax category has increased from 8 to 78 in three meeting cycles.

Relevant contributions were listed in the AHG report. 42 of the input documents registered by March 17 had been registered with AHG17 relevance identified in their titles.

No e-mail related to AHG17 was sent to the JVET reflector during the AHG period except a kick-off message.

[JVET-N0018](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6251) JVET AHG report: Quantization control (AHG18) [R. Chernyak, E. François, C. Helmrich, A. Segall]

This document summarizes the activity of AHG18: Quantization control between the 13th meeting in Marrakech, MA (9–18 Jan. 2019) and the 14th meeting in Geneva, CH (19–27 Mar. 2019).

No e-mail related to AHG18 activity was sent to the JVET reflector during the AHG period.

Input documents related to AHG18 were summarized as follows.

* JVET-N0090, CE7-related: Support of signalling default and user-defined scaling matrices, O. Chubach, C.-Y. Lai, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)
* JVET-N0204, AHG18: Support of quantization matrices, T. Toma, K. Abe (Panasonic), S.-C. Lim, J. Kang (ETRI)
* JVET-N0221, Chroma Quantization Parameter Qpc Table for HDR Signal, T. Lu, F. Pu, P. Yin, S. McCarthy, W. Husak, T. Chen (Dolby)
* JVET-N0246, Modified dequantization scaling, K. Sharman, S. Keating (Sony)
* JVET-N0341, On reporting combined YUV BD rates, F. Bossen (Sharp)

Contributions specific to luma-based chroma residual scaling

* JVET-N0113, AHG16: Subblock-based chroma residual scaling, Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)
* JVET-N0299, On Luma Dependent Chroma Residual Scaling of In-loop Reshaper, J. Zhao, S. Kim (LGE)
* JVET-N0389, Chroma residual scaling with separate luma/chroma tree, E. Francois, C. Chevance (Technicolor)
* JVET-N0417, Simplified luma dependant chroma residual scaling of in-loop reshaper, N. Hu, V. Seregin, M. Karczewicz (Qualcomm)
* JVET-N0477, On luma mapping with chroma scaling, Y. Ye, J. Chen, R. Liao (Alibaba)

The AHG recommended:

* To review all related contributions

It was commented that in v1 of HEVC, there were distinct QP offsets for the two chroma components at the slice level (but at the CU level, delta QP was applied to all three components, with chroma also going through a mapping table). In RExt, we added separate chroma QP control at the CU level.

[JVET-N0019](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6358) JVET AHG report: Layered coding and resolution adaptivity (AHG19) [S. Wenger, A. Segall, M.M. Hannuksela, Hendry, S. McCarthy, Y.-C. Sun]

AHG19 was established by the 13th meeting (Marrakech) to study layered coding and resolution adaptivity. Little reflector activity took place; besides the kickoff message, JVET chair Gary Sullivan summarized certain activities during the Marrakech meeting and requested information on planned documents for the 14th (Geneva) meeting, and two organizations answered in public. Ten documents were submitted to JVET that include the AHG19 marker in their respective titles. The ten documents were summarized in the AHG report. The AHG recommended that those contributions be studied during the meeting.

There was limited activity of the AHG between the Marrakech and the Geneva meeting. A total of four emails included the [AHG19] marker. Besides the kick-off message, JVET cochair Gary Sullivan summarized certain activities related to the AHG’s subject matter during the Marrakech meeting, and requested information on planned documents for the 14th (Geneva) meeting. Per this request Alibaba/Huawei responded that they are working towards a contribution on the subject of ARC for the Geneva meeting. Similarly, the University for Science and Technology, China (USTC) suggested that they “hopefully” will contribute, but only to the July meeting.

In the discussion of the AHG report, there was some discussion of potential use of reduced-resolution update, and local spatial adaptivity of the resolution of the picture components – e.g., spatially localized switching of picture resolution or inter-picture switching between 4:2:0 and 4:4:4.

Bit depth was also suggested as something that could change adaptively.

It was mentioned that mixing of different bitstreams could cause issues – e.g., extraction and rewriting could cause mixtures of bit depth and chroma format (and perhaps colour space). It was commented that some of this might best be handled by a system outside of the video decoder.

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

# Project development (X)

Contributions in this category were discussed at 1820-2120 Tuesday 26 March, chaired by Y. Ye.

## Text and software development (5)

[JVET-N0468](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6190) AhG2: Editorial suggestion on the text specification for inter and IBC mode [H. Jang, J. Nam, N. Park, J. Lim, S. Kim (LGE)]

In VTM4.0, IBC mode is signalled as a separate CU prediction mode, and IBC mode has its own candidate list including IBC coded spatial neighbor blocks. This contribution introduces editorial suggestions to VVC WD specification for clarifying regarding IBC mode addition.

The proponent said that all suggested changes are editorial in nature. Suggested changes are for inter and intra block copy, as follows:

#1. Derivation process for spatial merging candidates from the neighboring spatial blocks which is coded MODE\_INTER.

#2. Derivation process for spatial motion vector predictor candidates from the neighboring spatial blocks which is coded MODE\_INTER.

#3. Derivation process for IBC spatial merging candidates from the neighboring spatial blocks which is coded MODE\_IBC.

It was suggested that VTM software functions correctly, but the corresponding checks performed in the software are missing from the VVC draft spec.

The proponent said that they were not able to trace back to the contribution(s) that caused the mismatch between text and software.

The proponent suggested some text changes to fill in the missing part. The proponent also said that they had offline conversation with B. Bross. B. Bross confirmed that some problems exist in this part of the draft spec.

It was suggested to file a bug report on this with the suggested text changes.

[JVET-N0470](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6192) AhG2: Mismatch between text specification and reference software on SMVD [H. Jang, J. Nam, N. Park, J. Lim, S. Kim (LGE)]

This contribution provides a fix to align specification and software (VTM4) regarding symmetric MVD flag (sym\_mvd\_flag). Specifically, the parsing condition for sym\_mvd\_flag and BDOF applying condition based on sym\_mvd\_flag are updated to match VTM4.

The suggested changes were related to the adoption of M0444.

The first suggested change was about parsing of sym\_mvd\_flag. It was suggested by the proponent that the intention was to not signal sym\_mvd\_flag when mvd\_l1\_zero\_flag is equal to 1. This was implemented in VTM, but not in VVC spec. During track discussion, it was agreed that under CTC, whether to have the suggested condition or not will produce the same results. Given this, it was agreed to align the VTM to the VVC draft spec. The proponent of M0444 will submit a bug fix to change the software to align to the VVC draft spec.

The second suggested change was about BDOF condition. It was suggested that the intention was to disable BDOF when symmetric MVD is used. It was implemented in VTM but not in VVC spec. It was confirmed by the proponent of M0444 that this was the design intention, and such design intention was also confirmed to be included in the Marrakech meeting notes. The editors will incorporate the suggested text into the next release of VVC draft spec.

[JVET-N0474](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6196) Comments on algorithm description document for VTM [S.-H. Park, J.-W. Kang (Ewha W. Univ.)]

Authors of this contribution were not present for discussion. F. Bossen reviewed the contribution and confirmed that some of the suggested changes should be delegated to the test model editors to incorporate in a future release.

[JVET-N0503](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6225) Proposed update to Guidelines for VVC reference software development [F. Bossen, X. Li, K. Sühring] [late]

This contribution includes proposed updates to VTM guidelines.

It was noted that the current output document on software guidelines (JVET-K1003) is a couple of meeting cycles old.

The proposed updates were agreed. An updated output document N1003 should be produced at this meeting.

During discussion, it was noted that the sps\_mts\_enabled\_flag in spec text produces a certain behavior that is not duplicated in the VTM software. It was suggested to file a bug report on this so it can be fixed.

It was suggested if someone is not sure whether to file a bug report to VTM or to spec text, they should use their best judgement and file in either category.

[JVET-N0512](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6238) AhG2: Editorial Suggestion on the text specification for intra with interaction part between intra and IBC [H. Jang, J. Heo, J. Nam, S. Yoo, J. Choi, J. Lim, S. Kim (LGE)] [late]

This contribution introduces editorial suggestions to VVC WD specification for clarifying derivation processes for INTRA and corner case handling when Intra DM for IBC mode is enabled at dual tree structure (i.e., tile\_group\_type is equal to Intra).

presentation to be uploaded.

During the discussion, it was noted that the contribution that was being presented was not available on the JVET site. Given this was the second to last day of meeting, it was suggested to not discuss this contribution further.

It was suggested that in the future, for such cases, people are encouraged to file bug reports rather than making contributions. Making contributions might still be appropriate when necessary changes are not purely editorial in nature.

## Test conditions (5)

[JVET-N0320](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6041) On improving reports of software encoder run times [F. Bossen (Sharp)]

Encoder run times are reported as averages in the Excel sheet provided with the common test conditions document. It is asserted that other metrics such as total and maximum encoder run times are more closely related to the resources required to generate a set of results. It is thus proposed to add total and maximum encoder run time metrics in the summary sheet. It is also suggested to cap the encoder run time increase with respect to HM.

It was suggested that two aspects are important to recording encoding time:

* the total time it takes to encode all test points
* the longest time it takes to encode any test point

It was suggested that the current reporting of averages is not a very good indicator as it gives equal weight to all data points.

Suggestions to enhance the reporting xls by additionally including the following:

* Total encoding time for each configuration (AI, RA, LB, LP)
* Maximum encoding time for each configuration (AI, RA, LB, LP)
* Total encoding time for all configurations together
* Maximum encoding time for all configurations together, where RA times are divided by 4 to account for segment-based encoding
* Ratios of the values above with respect to the reference (e.g., VTM 4.0)

VTM3.2 takes 187.5 days (more than half a year) to complete all simulations on a single core. VTM4.0 takes 288.8 days (more than nice months). The maximum run time in LDB increased from 67 hours (2.8 days) to 116 hours (4.8 days).

In comparison, HM16.2 only needs 31.7 days (roughly one month) to complete all simulations on a single core. Considering the sum of all simulation hours, the ratio between VTM4.0 and HM16.2 is rougly 9x, whereas for the longest simulation (which occurs in LDB), VTM4.0 is roughly 12x that of HM16.2.

In terms of meaningful target for VVC, this contribution suggests a 6x ratio between VTM and HM. This ratio would roughly translate to 5% increase in runtime for every 1% of bit-rate reduction.

It was asked whether comparison to HM should be performed for all contributions. Could be too much burden.

Regarding whether to add the suggested additional data to the reporting template, it was commented that such information does not seem to burden people in a significant manner, and could provide useful information. It was commented that hetereogeneous grid might produce unreliable information, especially for encoding time ratios in the “max” category.

Agreed to add the suggested additional data.

[JVET-N0331](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6052) On interpolation for BD rate computation [F. Bossen (Sharp)]

A BD rate number represents the average distance between two rate-distortion curves. Such rate-distortion curves are interpolated from a few rate-distortion points using cubic or piecewise cubic methods. It is asserted that such interpolating curves can diverge significantly from actual rate-distortion curves, and that commonly reported BD rate numbers may be inaccurate. It is proposed to increase the sampling rate of rate-distortion curves such as to improve accuracy.

The BD rate difference between the piecewise cubic function obtained from 4 QP points {22, 27, 32, 37} and the piecewise linear function obtained from 16 QP points (22…37) was calculated for our CTC set. The Min and Max of such difference were reported to be -19.7% and 6.6%, respectively.

It was suggested that sampling of rate points (i.e. QP points) is not dense enough in the current CTC.

It was proposed to extend the number of QP points from 4 to 6. The suggested QP values are {21, 24, 28, 31, 35, 38}.

It was commented that not all sequences have the problem of producing “irregular” R-D curves. So an alternative to increasing the number of QP points could be to use other test sequences to replace the sequences that do not “behave well.”

It was commented that the main idea is to highlight the potential problems of using these problematic sequences and evaluating coding tools based on their BD rate numbers.

Changing the CTC may not be the right action to take at this stage of project development.

[JVET-N0341](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6062) On reporting combined YUV BD rates [F. Bossen (Sharp)]

(Also relevant to quantization and contains a normative technical proposal.)

It is proposed to report combined YUV BD rate numbers in addition to separate Y, U, and V numbers. Additionally, it is suggested to modify the relationship between luma and chroma QPs by adjusting the luma to chroma QP mapping table and setting a chroma offset to 0. It is asserted that this provides a coding efficiency benefit under the combined YUV metric.

In a first aspect of this proposal, it is suggested to include the following additional information in the reporting template summary sheet:

Combined YUV PSNR (already reported by the VTM software on a per-sequence basis) computed based on the MSE across all components

BD rate values for the combined YUV PSNR metric

It was commented that during development of HEVC range extension, the YUV PSNR value is also used, but weighting of 4:1:1 (in MSE domain) or 6:1:1 (in PSNR domain) is applied to the Y:U:V components, respectively. The current YUV PSNR calculation in VTM applies 1:1:1 weighting for the three colour components in the SSE domain. It was commented that equal weighting of Y:U:V components in the SSE domain might not match the rule-of-thumb weighting of 6:1:1 or 90:5:5 that we sometimes use.

It was suggested that further study of this topic may be necessary. And further study is encouraged.

In a second aspect of this contribution, a modified QPc table (mapping from luma QP to chroma QP) is proposed such that chroma QP adjustments kick in at a higher QP value. It is further proposed to remove the offset between luma and chroma QP values we adopted at Marrakech meeting.

It was commented that with the QP offset that we are currently using in the CTC, it’s equivalent to using a larger than luma QP for chroma in the low QP range and using a smaller than luma QP for chroma in the high QP range. This was agreed to be not the intended relationship between luma and chroma QP. It was commented that when discussing related contribution (JVET-N0221) on QPc table for HDR, it was suggested to maybe not have fixed QPc table in the spec text, and to use explicit signaling of QPc table instead.

No action was taken on this second aspect.

Further study encouraged to identify proper chroma QP offset values to use in the CTC.

[JVET-N0446](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6168) New Adaptive Streaming Test Conditions for the VVC development [M. Afonso, A. Norkin, J. Sole, K. Swanson, A. Aaron (Netflix), J. Kim, K. Kolarov, D. Singer, A. Tourapis (Apple), Y. Ye, W. Jiang (Alibaba)]

This document describes an updated proposal for the Adaptive Streaming test conditions for VTM, originally proposed in the document JVET-M0466. These test conditions are intended to simulate a video streaming scenario where streams with different bitrates, qualities, and spatial resolutions can be adaptively selected for the same video content. More specifically, two sets of test conditions, AS-RA and MR-RA are proposed. Experimental results between VTM 4.0, VTM 3.0 and HM 16.19 demonstrate that BD-rate gains when using AS-RA/MR-RA test conditions can be different from the BD-rate gains on RA CTC. In addition, tool off experiments using two adopted tools, ALF and SAO are presented. It is proposed to adopt one of the proposed test conditions as part of the CTC to better cover the adaptive streaming use case.

Presentation to be uploaded.

Two conditions are proposed. The first condition, AS-RA, using 4 rate points, at each rate point, the input may have a different resolution customized to that sequence and that rate point. Also, closed GOP and 2 second IRAP are suggested to be used.

The second condition, MR-RA, uses 16 rate/resultion points.

The BD rate results between VTM3.0 and VTM4.0 for Y/U/V are reported to be:

JVET RA CTC: -5.65%/6.03%/5.17%

AS-RA: -4.81%/5.61%/6.11%

MR-RA: -4.56%/5.23%/5.23%

Tool-on/off experiments were conducted for SAO and ALF and results were reported as well. Difference in BD rate numbers using JVET RA CTC and using AS-RA was reported.

It was commented that after adding these conditions to check the performance between VTM3.0 and VTM4.0 after the Marrakech meeting, it seems that we had learned limited additional information from the additional data. And adding AS-RA or MR-RA creates more simulation burden.

It was commented that in the case of ALF performance difference between CTC and AS-RA, one possible reason could be because up- and down-sampling filters are used in AS-RA, and another reason could be because the QP ranges are different.

It was commented that more data on more coding tools would be welcome.

It was commented that some of the test content in our test set had copyright conditions that may disallow up- and down-sampling of the data.

No action was taken on this.

[JVET-N0506](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6229) Disabling raster search in integer-pel ME for common test condition [S.-H. Park, J.-W. Kang (Ewha W. Univ.)] [late]

F. Bossen briefly presented the contribution. This contribution proposes to modify certain part of the integer-pel ME related to the 384-sample-wide search range to obtain some encoder speedup (~5%). However, the contribution does not include class A results. Given the lack of complete results and cross check, no action was taken on this.

Further study is encouraged.

## Performance assessment (2)

[JVET-N0605](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6346) Comparative study of video coding solutions VVC, AV1, EVC versus HEVC [Y. Chen, E. François, F. Galpin, R. Jullian, M. Kerdranvat (Technicolor)] [late]

This was discussed Wed 27 1250 (GJS & JRO).

This contribution reports the results of a comparative study between video coding schemes including encoders for HEVC (ITU-T and ISO/IEC) and AV1 (Alliance for Open Media), or still in development such as VVC in the JVET group of IEC/ISO and ITU-T, and the new draft of EVC (Essential Video Coding) of MPEG. One-second clips were encoded.

A participant said that there were some problems in the configuration of AV1. The presenter acknowledged that it was not a completely fair comparison, generally in favour of AV1 in the testing.

The quantization applied for the I frames (key frames) and “alt-ref” frames was not controlled.

Two-pass encoding was used for AV1 (~13-15% benefit).

It was asked about how much extra gain may be from these issues in the AV1 configuration, and the author said perhaps about 23% (13-15% from two-pass, 3-4% from key frame QP control, 3-4% from adaptive GOP structure).

The methodology is somewhat based on the common test conditions (CTC) defined in JVET by using the same configuration parameters on all the sequences of classes A1, A2, B, C and D.

The performances according the average BD-rate PSNR metrics of VTM-4.0 (VVC after Marrakech meeting January 2019), AV1, and ETM 1.0 (EVC after Marrakech meeting) versus HM-16.18 was reported as 29.5%, 21%, and 15% gains for all the CTC clips. When considering only UHD and HD clips the measured gains were higher, 33.5%, 22.4% and 19.8% respectively. The run times versus HM-16.18 for encoding are respectively 7.4x, 6.7x, 3.6x and for decoding 1.2x, 2.5x, 1.4x.

In terms of decoding time, VTM performed relatively well in the test, about 20% slower than the HM.

The contributor remarked that high coding performance is important for success of the project.

[JVET-N0828](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6583) [AHG13] Compression performance analysis for 4K and 8K HLG test sequences [S. Iwamura, S. Nemoto, A. Ichigaya (NHK)] [late]

[add abstract]

This was discussed Wed 27 1330 (GJS & JRO).

This includes a proposed CTC change for HDR.

This was discussed Wed.

Proposes to turn off LMCS for HLG, but this was already agreed in other discussions [see notes elsewhere]. Decision (CTC): Disable LMCS for HDR.

It also suggests just to use YUV PSNR for HLG rather than the metrics used for PQ. Decision (CTC): Agreed.

It also suggests doing some testing on non-CTC test sequences. It was agreed to study this issue further in an HDR AHG.

The contribution describes unusual behaviour in the luma histogram of some test sequences and requests further study of this, also for CTC test sequences.

It was suggested to remove the fixed bit rate testing from the CTC for HDR, since it is difficult to run and typically thus not reported in practice. Decision (CTC): Agreed.

## Coding studies on specific use cases (14)

### Adaptive resolution conversion (6)

Contributions in this category were discussed in plenary at 1720 Sunday 24 March (GJS & JRO).

This topic had been studied to some degree in prior work.

It was suggested that proposals N0048, N0052, N0118, N0279 were conceptually similar, with differences in details.

N0279 says that ARC can be supported with relatively low additional implementation burden.

N0532 is about resampling filters.

Some issues identified:

* Dyadically downscaled I pictures
* Resolution changes in predicted pictures
* Non-dyadic relationships
* Configurable filters
* Partial-picture resolution changes (e.g., for extraction/merging applications)

Some application use cases were discussed:

* Resolution changes for bit rate adaptivity (unicast, dynamic streaming, or real time)
* Extraction/merging applications
* Both upconversion and downconversion of whole pictures (with constant resampling rates) for predictive coding were generally agreed as basic functionality that should be supported
* For arbitrary ratio support versus itemized ratio support, it did not seem necessary to support only a few itemized ratios
* Horizontal versus vertical could be considered issues, but it did not seem necessary to constrain

Decision: It was agreed in principle to use the following (at least as an initial approach):

* Having the resolution of the stored reference picture being different from that of the current picture
* A range of a factor of 4 in each dimension was suggested

Revisit for further discussion.

[JVET-N0048](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5768) AHG19: On adaptive resolution changing [M. M. Hannuksela, A. Aminlou (Nokia)]

[JVET-N0052](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5772) [AHG19] On Signaling of Adaptive Resolution Change [S. Wenger, B. Choi, S. Liu (Tencent)]

[JVET-N0118](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5838) AHG19: Adaptive resolution change (ARC) support in VVC [Hendry, S. Hong, Y.-K. Wang, J. Chen (Huawei), Y.-C Sun, T.-S Chang, J. Lou (Alibaba)]

[JVET-N0279](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6000) AHG19: Adaptive resolution change [Peisong Chen, Tim Hellman, Brian Heng, Wade Wan, Minhua Zhou (Broadcom)]

[JVET-N0532](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6260) AHG19: Resampling filters for adaptive resolution change (ARC) in VVC [Pankaj Topiwala, Madhu Krishnan, Wei Dai (FastVDO)] [late]

[JVET-N0669](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6420) Crosscheck of JVET-N0532 (AHG19: Resampling filters for adaptive resolution change (ARC) in VVC) [?? (??)] [late]

### 360° video coding (6)

Contributions in this category were discussed XXday XX March XXXX–XXXX (chaired by XXXqq).

[JVET-N0070](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5790) AHG16/AHG8: Proposed Cleanup for Reference Wraparound [B. Heng, M. Zhou, W. Wan (Broadcom)]

[JVET-N0219](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5939) Coding of 360° video in HEC using different numbers of tiles per face [J. Sauer, M. Bläser (RWTH Aachen)]

[JVET-N0232](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5952) [AHG8] Coding performance of 360° Videos in PHEC format with different face sizes [A. DSouza, C. Pujara, R. Gadde, W. Choi, K. Choi, K.P. Choi (Samsung)] [late]

[JVET-N0233](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5953) [AHG8] Alternate face arrangement for PHEC [A. DSouza, C. Pujara, R. Gadde, W. Choi, K. Choi, K.P. Choi (Samsung)] [late]

[JVET-N0831](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6586) Study on Immersive Media Decoding Interface for VVC (m47925) [S. Wenger (Tencent)] [late]

### Chroma sampling and chroma formats (7)

[JVET-N0671](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6422) Support of 4:4:4 and 4:2:2 chroma formats in VVC [A. Filippov, V. Rufitskiy, T. Solovyev, R. Chernyak, J. Chen (Huawei), X. Zhao, X. Li, X. Xu, S. Liu (Tencent), H. Wang, Y.-H. Chao, W.-J. Chien, V. Seregin, M. Karczewicz (Qualcomm)] [late]

Discussed in plenary Sunday 1220 (GJS & JRO).

No separate presentation was needed for JVET-N0229, JVET-N0367, JVET-N0392, JVET-N0414, and JVET-N0671; see notes for JVET-N0671.

This document proposes modifications of the VTM software and the VVC spec draft to support YUV4:4:4, RGB4:4:4, and YUV4:2:2. For enabling that, straightforward changes of CCLM and affine sub-block motion vector derivation were made. In addition, some software bugs affected YUV 4:4:4 and YUV 4:2:2 were fixed. Besides, a minor editorial change is proposed for ISP. In order to evaluate compression performance, we use the HM-16.18+SCM8.7 software as the anchor. The proposed modifications reportedly show the following overall results with RExt cfg-files for YUV4:4:4 content: -21.8% (Y), -13.7% (U), -14.2% (V) with encoding time of 1475% and decoding time of 141% for AI configuration, as well as -31.9% (Y), -23.2% (U), -19.5% (V) with encoding time of 573% and decoding time of 128% for RA configuration and -27.4% (Y), -14.7% (U), -9.4% (V) with encoding time of 527% and decoding time of 116% for LDB configuration.. The proposed modifications reportedly show the following overall results with RExt cfg-files for RGB 4:4:4 content: -21.7% (Y), -14.5% (U), -15.3% (V) with encoding time of 2000% and decoding time of 143% for AI configuration, as well as -31.7% (Y), -19.3% (U), -21.7% (V) with encoding time of 723% and decoding time of 134% for RA configuration. The proposed modifications reportedly show the following overall results with RExt cfg-files for YUV 4:2:2 content: -17.8% (Y), -19.5% (U), -20.0% (V) with encoding time of 2435% and decoding time of 157% for AI configuration, as well as -22.1% (Y), -25.9% (U), -23.2% (V) with encoding time of 665% and decoding time of 138% for RA configuration and -20.1% (Y), -21.2% (U), -18.9% (V) with encoding time 564% and decoding time of 119% for LDB configuration.

The gain on 4:4:4 camera content was roughly similar as for 4:2:0.

Some losses were observed for TGM content – likely due primarily due to the lack of a palette mode in VVC.

It was commented that separate tree usage has a negative effect on 4:4:4 content coding (as tested).

There was somewhat less gain for 4:2:2.

[Copy in table of test results when available.]

4:2:2 is also considered in the contribution.

The proposal is to disable reference smoothing for chroma and not use the longWeight for triangle edge blending, as was suggested to be more consistent with what is done for 4:2:0. (HEVC does the reference sample smoothing.)

Any place in the text where there is an explicit assumption of 4:2:0 should be fixed.

Decision: Adopt.

[JVET-N0842](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6597) Crosscheck of JVET-N0671: Support of 4:4:4 and 4:2:2 chroma formats in VVC [Y.-C. Sun (Alibaba)] [late]

[JVET-N0229](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5949) Non-CE3: CCLM prediction for 4:2:2 and 4:4:4 color format [J. Choi, J. Heo, J. Lim, S. Kim (LGE)]

No separate presentation was needed for JVET-N0229, JVET-N0367, JVET-N0392, JVET-N0414, and JVET-N0671; see notes for JVET-N0671.

[JVET-N0367](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6088) Support of chroma 4:4:4 format in VVC [X. Zhao, X. Li, X. Xu, S. Liu (Tencent)]

No separate presentation was needed for JVET-N0229, JVET-N0367, JVET-N0392, JVET-N0414, and JVET-N0671; see notes for JVET-N0671.

[JVET-N0392](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6114) 4:4:4 and 4:2:2 chroma formats support for VVC [A. Filippov, V. Rufitskiy, T. Solovyev, R. Chernyak, J. Chen (Huawei)] [late]

No separate presentation was needed for JVET-N0229, JVET-N0367, JVET-N0392, JVET-N0414, and JVET-N0671; see notes for JVET-N0671.

[JVET-N0827](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6582) Cross check of JVET-N0392 [K. Misra (Sharp Labs of America)] [late]

[JVET-N0414](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6136) Modifications to support the YUV 4:4:4 chroma format [H. Wang, Y.-H. Chao, W.-J. Chien, V. Seregin, M. Karczewicz (Qualcomm)]

No separate presentation was needed for JVET-N0229, JVET-N0367, JVET-N0392, JVET-N0414, and JVET-N0671; see notes for JVET-N0671.

[JVET-N0225](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5945) Various chroma format support in VVC [L. Li, J. Heo, J. Nam, M. Koo, J. Lim, S. Kim (LGE)] [late]

Discussed in plenary Sunday 1250 (GJS & JRO).

In this contribution, several aspects are proposed to support various chroma formats in VVC.

* The separate colour plane ID aspect is adopted, but effectively editorial. The standard will prohibit having separate colour planes uses.
* The remaining aspects of the proposal are to not parse chroma-related syntax when there is only one colour plane; this is reportedly consistent with what is done in HEVC.

Decision: Adopted.

[JVET-N0224](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5944) CE3-related: ISP support for 4:2:2 and 4:4:4 [L. Li, M. Koo, J. Heo, J. Nam, J. Lim, S. Kim (LGE)]

Discussed in plenary Sunday 1315 (GJS & JRO).

This contribution proposes some changes to ISP to support 4:2:2 and 4:4:4 chroma format.

However, in this meeting, the maximum ISP size was restricted to 64x64 (see JVET-N0308), which resolves the issue.

## Test material (2)

[JVET-N0386](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6108) AOV YUV4:4:4 sequence for VVC standardization and suggestions for class F [X. Xu, J. Ye, X. Li, S. Liu, L. Wu, C. Xie, K. Liu, B. Wang, P. Liu, K. Dong, Y. Kuang, W. Feng (Tencent)]

Discussed in CE8 related BoG.

[JVET-N0502](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6224) Five SCC TGM sequences of both YUV4:4:4 and YUV4:2:0 formats [T. Lin, K. Zhou, S. Wang (Tongji), L. Zhao (Shaoxing)] [late]

Discussed in SCC BoG N0780.

# Core Experiments

Tuesday 1730 Initial discussion in track A how to organize subjective tests

– CE1: 1 test session on CE1-6 (12 cases), no mutual comparison in initial round

– CE5: set of up to 4 test sessions (48 cases)

– CE11: separate test sessions for ALF on/off cases, but mix CE11-1 and CE11-2. Sets of up to 3 test sessions (34 cases) in each

Up to 5 groups of 3 experts needed for each complete set of test sessions

M. Wien will set up a plan/timeline to run the tests, could likely be started on Wed evening or Thursday. Sequence of CEs as above.

## CE1: Post-prediction and post-reconstruction filtering (9)

Contributions in this category were discussed Tuesday 19 March 1930–2130 in Track A (chaired by JRO).

[JVET-N0021](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6298) CE1: Summary Report on Post-prediction and post-reconstruction filtering [J. Ström, S. Ikonin, V. Seregin]

The tests are of two types: post-prediction and post-reconstruction filters (CE1-1.1, CE1-1.2, CE1-1.3, CE1-1.7, CE1-2.1, CE1-2.4, all CE1-4 tests, all CE1-5 tests and all CE1-6 tests), and traditional loop-filters (CE1-1-5, CE1-2.3). The restrictions are different for these two types of filters.

Restrictions for post-prediction and post-reconstruction filters:

The size of the smallest processed block is 64 luma samples.

Processing should not be applied on intra blocks, nor should it be applied to combined intra/inter blocks (CIIP blocks) or intra block copy (IBC) / current picture reference (CPR) blocks.

For all tests, the following three constraint conditions may be tested:

* No restriction on using samples to the left and above the block (mandatory)
* Samples to the left and above can be used, but only if they come from an inter block (i.e., not from an intra block or a CIIP block or an IBC/CPR block). (mandatory)
* No samples outside the block can be used. (non-mandatory)

For CE1-1.6, these constraints are relaxed:

* No restriction to apply for intra blocks or intra/inter blocks and thus also no restriction to use samples to the left or above the block (same as intra prediction in VTM).

For loop-filter tests (CE1-1.5 and CE1-2.3), different constraints are used:

* There is no restriction on the smallest processed block.
* There is no restriction to apply filtering on intra blocks, i.e., both intra and inter blocks can be filtered.
* There is no restriction on using samples to the left or above the block, as long as the used samples reside in the same CTU as the filtered pixels.

In these latter tests, RDO was employed (in a similar fashion as used for deblocking in JVET-M0428, i.e. a RD decision would know that such a loop filter would be applied). In a cross-check document (N0617), it is reported that the method of CE1-2.3 without such RDO mechanism would result in small loss.

The table below provides a summary of the tested technologies. For a more detailed description, please refer to Section 5.

Table 1.

|  |  |  |
| --- | --- | --- |
| **Test#** | **Description** | **Document#** |
| CE1-1 | Reduced complexity bilateral filter | JVET-M0885, JVET-M0884 |
| CE1-2 | Hadamard transform domain filter | JVET-M0468 |
| CE1-4 | Uniform Luma Inter Prediction Filter | JVET-M0042 |
| CE1-5 | Local illumination compensation | JVET-M0088, M0115, M0182, M0224, M0450, M0500 |
| CE1-6 | Intra Reference Sample Deblocking | JVET-M0138 |
| CE1-7 | Combined tests | Combinations of above documents |

The table below gives a comparison between the technologies.

Table 2.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test** | **filter shape** | **Comp. complex. per sample\*** | **Precis. of mult** | **Sequential operations to get one sample processed** | **Operations before block processing** | **Parallel friendly** | **Latency**  **(in clock cycles)** | **Memory. required**  **(bytes)** | **How to derive filter coeffs** | **Min. and max. filtered**  **CU size** |
| CE1-1.1a  CE1-1.1b  CE1-1.1c | 5 pixel “plus”-shape;  For inter, 5x5 area is used to calculate filter weights. | 4 mult 23 adds (of which 1 rounding) 8 checks  5 shifts (of which 4 fixed) | 2×8 and 10×11 | 4 to get dNL  3 to get weight  1 to get weight\*diff  1 to sum and round  7 in total | lookup s and k using qp  calc m and c1 (1 variable shift each)  calc c2 (1 add) | yes | Estimation: 3 clock cycles. | 30 |  | Min:  8x8  Max:  Intra: 64x64  Inter: 16x64, 64x16 |
| CE1-1.2a  CE1-1.2b  CE1-1.2c | —”— | 2 mult 25 adds (of which 3 rounding) 8 checks  7 shifts (of which 6 fixed) | 6x9 | As above, plus one more to get sI from I.  8 in total | —”— | yes | Estimation: 3 clock cycles. | 24 | —”— | —”— |
| CE1-1.3a  CE1-1.3b  CE1-1.3c | 5 pixel “plus”-shape | 2 mult  13 adds  4 checks  5 shifts (of which 4 fixed) | 7x9 | —”— | —”— | yes | Estimation: 2 clocks cycles | 24 | —”— | —”— |
| CE1-1.5 | 5 pixel “plus”-shape;  For inter, 5x5 area is used to calculate filter weights. | intra: 2 mult  13 adds  4 checks  5 shifts (of which 4 fixed)  inter:  +12 adds  +4 checks  +2 shifts (both fixed) | 7x9 | —”— | —”— | yes | Estimation:  Intra: 2 clock cycles  Inter: 3 clock cycles | 47 | intra:  inter: | Min:  4x4  Max:  Intra: 64x64  Inter: 16x64, 64x16 |
| CE1-1.7 | 5 pixel “plus”-shape;  For inter, 5x5 area is used to calculate filter weights. | 4 mult 23 adds 10 checks  5 shifts (of which 3 fixed) | 8×10 and 8×12 |  |  | yes | Estimation: 3 clock cycles. | 120 |  | Min:  8x8  Max:  Intra: 64x64  Inter: 16x64, 64x16 |
| CE1-2.1a  CE1-2.1b  CE1-2.1c | 3x3 | 18+4 l-bit add for round 8 shifts 6 checks | n/a | 5 add;  1 look-up table (16\*7bits);  2 checks | Load 16\*7bits per CU if the QP is switched to a different range | yes | 1 clock:  @770MHz 16nm  @450MHz 28nm 2 clocks:  @770MHz 28nm | 70 bytes (16 7-bit values per qp group) | Pre-calculated in LUT | min: 8x8 max: 16xN or Nx16  (N<128) |
| CE1-2.3 | —”— | —”— | —”— | —”— | —”— | —”— | —”— | —”— | —”— | Min: no restrictions  Max: Intra: 64x64  Inter: 16x64, 64x16 |
| CE1-2.4a  CE1-2.4b  CE1-2.4c | —”— | —”— | —”— | —”— | —”— | —”— | —”— | 84 bytes (16 7-bit values per qp group) | —”— | min: 8x8 max: 16xN or Nx16  (N<128) |
| CE1-4.2a  CE1-4.2c | 5 pixel “plus” shape or 9tab filter (horizontal or vertical) | 6 adds  4 shifts |  |  |  | yes |  |  |  | Inter Min: 8x8  Max: 64x64 |
| CE1-4.3a  CE1-4.3c | —”— | —”— | —”— | —”— | —”— | —”— | —”— | —”— | —”— | —”— |
| CE1-5.1a  CE1-5.1b | 1 sample | 1 mult  1 add |  |  | Linear regression.  Operations per CU:  Mult: 4 \* min(width, height) + 12  Add 8 \* min(width, height) + 12  Shifts: 36 | yes |  | 128 for LUT | Linear regression.  Operations per CU:  Mult: 4 \* min(width, height) + 12  Add 8 \* min(width, height) + 12  Shifts: 36 | Inter  Min: 64 samples  Max: 64x64 |
| CE1-5.3a  CE1-5.3b |  |  |  |  |  |  |  |  |  |  |
| CE1-5.4a  CE1-5.4b |  |  |  |  |  |  |  |  |  |  |
| CE1-5.5a  CE1-5.5b |  |  |  |  |  |  |  |  |  |  |
| CE1-5.6a  CE1-5.6b | 1 sample | 1 mult  1 add |  |  | Linear regression.  Operations per CU:  Mult: 4 \* min(width, height) + 12  Add 8 \* min(width, height) + 12  Shifts: 36 | yes |  | 128 for LUT | Linear regression.  Operations per CU:  Mult: 4 \* min(width, height) + 12  Add 8 \* min(width, height) + 12  Shifts: 36 | Inter  Min: 64 samples  Max: 64x64 |
| CE1-5.7a  CE1-5.7b | 1 sample | 1 mult  1 add |  |  | Linear regression.  Operations per CU:  Mult: 4 \* min(8, width, height) + 12  Add 8 \* min(8, width, height) + 12  Shifts: 36 | yes |  | 128 for LUT | Linear regression.  Operations per CU:  Mult: 4 \* min(8, width, height) + 12  Add 8 \* min(8, width, height) + 12  Shifts: 36 | Inter  Min: 64 samples  Max: 128x128 |
| CE1-6.1 | 2-taps | Multi  0.891  Add  2.979  shift  0.554  checks  0.166 | 6×10 | For filter decision:  3 multi / 7 add / 2 shift / 3 check  For filter operation:  1 multi / 16 add / 2 shift | Get tc, beta from LUT based on slice QP | Yes | Estimation:  2 clock cycle | 7 values of 6-bit unsigned integer for filter coefficients | Derive from LUT | Width >= 32 and Height >= 32 |
| CE1-6.2 | 2-taps | multi  1.980  add  3.992  shift  0.996  checks  0.039 | 7×10 | For filter decision:  1 multi / 3 add / 1 shift / 3 check  For filter operation:  1 multi / 3 add / 1 shift | None | yes | Estimation:  2 clock cycle | none | Linear combination of distance to corner samples | Width >= 32 and Height >= 32 |

\* max/min/abs are counted as checks

Below is a summary of the test results for the non-combination tests.

\*: SIMD optimization for the proposed technology

\*\*: running time unreliable

\*\*\*: different SIMD settings (other than default settings) are used

Table 3a

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **AI** | | | | | **RA** | | | | | **LDB** | | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE1-1.1a |  |  |  |  |  | -0.35% | -0.13% | -0.06% | 102% | 100% | -0.35% | 0.65% | 0.81% | 101% | 101% |
| CE1-1.1b |  |  |  |  |  | -0.34% | -0.10% | -0.05% | 101% | 100% | -0.34% | 0.68% | 0.56% | 101% | 99% |
| CE1-1.1c |  |  |  |  |  | -0.31% | -0.08% | -0.05% | 102% | 102% | -0.31% | 0.64% | 0.74% | 100% | 98% |
| CE1-1.2a |  |  |  |  |  | -0.33% | -0.13% | -0.10% | 102% | 100% | -0.23% | 0.74% | 0.52% | 100% | 98% |
| CE1-1.2b |  |  |  |  |  | -0.31% | -0.13% | -0.12% | 103% | 102% | -0.20% | 0.84% | 0.68% | 100% | 98% |
| CE1-1.2c |  |  |  |  |  | -0.27% | -0.12% | -0.11% | 102% | 100% | -0.19% | 0.70% | 0.56% | 101% | 99% |
| CE1-1.3a |  |  |  |  |  | -0.25% | -0.09% | -0.07% | 102% | 101% | -0.09% | 0.88% | 0.41% | 100% | 97% |
| CE1-1.3b |  |  |  |  |  | -0.24% | -0.09% | -0.07% | 103% | 101% | -0.09% | 0.74% | 0.57% | 100% | 98% |
| CE1-1.3c |  |  |  |  |  | -0.21% | -0.08% | -0.09% | 100% | 100% | -0.04% | 0.93% | 0.60% | 99% | 97% |
| CE1-1.5 | -0.16% | 0.25% | 0.24% | 107% | 108% | -0.44% | -0.09% | -0.11% | 105% | 102% | -0.26% | 0.99% | 0.64% | 104% | 103% |
| CE1-1.7a |  |  |  |  |  | -0.35% | -0.04% | -0.01% | 90% | 89% | -0.39% | 0.54% | 0.50% | 88% | 94% |
| CE1-1.7c |  |  |  |  |  | -0.31% | -0.03% | -0.03% | 89% | 89% | -0.40% | 0.57% | 0.38% | 83% | 93% |
| CE1-2.1a |  |  |  |  |  | -0.32% | -0.13% | -0.06% | 102% | 100% | -0.34% | 0.64% | 0.59% | 101% | 100% |
| CE1-2.1b |  |  |  |  |  | -0.31% | -0.11% | -0.09% | 102% | 100% | -0.35% | 0.66% | 0.59% | 101% | 101% |
| CE1-2.1c |  |  |  |  |  | -0.30% | -0.09% | -0.06% | 102% | 100% | -0.36% | 0.75% | 0.72% | 101% | 100% |
| CE1-2.3 | -0.18% | 0.39% | 0.35% | 108% | 105% | -0.45% | -0.05% | -0.19% | 104% | 100% | -0.34% | 0.99% | 0.54% | 103% | 101% |
| CE1-2.4a |  |  |  |  |  | -0.32% | -0.58% | -0.56% | 109% | 100% | -0.30% | 0.38% | 0.44% | 114% | 100% |
| CE1-2.4b |  |  |  |  |  | -0.29% | -0.51% | -0.46% | 110% | 99% | -0.29% | 0.50% | 0.17% | 115% | 100% |
| CE1-2.4c |  |  |  |  |  | -0.30% | -0.42% | -0.41% | 109% | 99% | -0.27% | 0.57% | 0.34% | 114% | 100% |
| CE1-4.2a |  |  |  |  |  | -0.35% | -0.70% | -0.69% | 114% | 101% | -0.15% | 0.42% | 0.23% | 125% | 102% |
| CE1-4.2c |  |  |  |  |  | -0.35% | -0.59% | -0.52% | 112% | 98% | -0.12% | 0.55% | 0.47% | 125% | 102% |
| CE1-4.3a |  |  |  |  |  | -0.33% | -0.67% | -0.66% | 111% | 101% | -0.14% | 0.42% | 0.19% | 118% | 101% |
| CE1-4.3c |  |  |  |  |  | -0.33% | -0.49% | -0.50% | 109% | 98% | -0.08% | 0.61% | 0.43% | 118% | 101% |
| CE1-5.1a |  |  |  |  |  | -0.43% | -0.17% | -0.16% | 113% | 100% | -0.42% | -0.04% | -0.36% | 111% | 101% |
| CE1-5.1b |  |  |  |  |  | -0.35% | -0.28% | -0.30% | 115% | 100% | -0.36% | -0.11% | -0.30% | 114% | 101% |
| CE1-5.3a |  |  |  |  |  | -0.56% | -0.25% | -0.25% | 122% | 101% | -0.59% | -0.49% | -0.60% | 119% | 100% |
| CE1-5.3b |  |  |  |  |  | -0.47% | -0.40% | -0.46% | 125% | 101% | -0.54% | -0.38% | -0.57% | 121% | 101% |
| CE1-5.4a |  |  |  |  |  | -0.52% | -0.17% | -0.19% | 123% | 100% | -0.56% | -0.35% | -0.65% | 127% | 102% |
| CE1-5.4b |  |  |  |  |  | -0.43% | -0.38% | -0.38% | 124% | 101% | -0.49% | -0.29% | -0.40% | 129% | 102% |
| CE1-5.5a |  |  |  |  |  | -0.42% | -0.16% | -0.11% | 108% | 101% | -0.50% | -0.11% | -0.42% | 108% | 101% |
| CE1-5.5b |  |  |  |  |  | -0.30% | -0.29% | -0.24% | 109% | 102% | -0.45 | -0.19 | -0.48 | 110% | 102% |
| CE1-5.6a |  |  |  |  |  | -0.43% | -0.25% | -0.23% | 112% | 99% | -0.42% | -0.09% | -0.36% | 111% | 101% |
| CE1-5.6b |  |  |  |  |  | -0.35% | -0.29% | -0.37% | 114% | 100% | -0.34% | 0.10% | -0.37% | 113% | 102% |
| CE1-5.7a |  |  |  |  |  | -0.39% | -0.24% | -0.22% | 113% | 100% | -0.33% | -0.08% | -0.34% | 112% | 101% |
| CE1-5.7b |  |  |  |  |  | -0.30% | -0.33% | -0.32% | 114% | 100% | -0.30% | -0.18% | -0.35% | 114% | 101% |
| CE1-6.1 | -0.03% | 0.01% | -0.02% | 93%\*\* | 100% | -0.02% | -0.01% | -0.09% | 94%\*\* | 100% | 0.00% | 0.52% | 0.51% | 98%\*\* | 99% |
| CE1-6.2 | 0.02% | 0.05% | 0.01% | 96%\*\* | 101% | 0.00% | 0.02% | -0.04% | 104%\*\* | 100% | -0.01% | 0.25% | -0.03% | 101%\*\* | 100% |

Below is a summary of the test results for the combination tests.

Table 3b

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **AI** | | | | | **RA** | | | | | **LDB** | | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE1-7.1 | -0.16% | 0.25% | 0.24% | 105% | 106% | -0.69% | -0.46% | -0.48% | 117% | 100% | -0.27% | 1.47% | 1.04% | 125% | 103% |
| CE1-7.2 |  |  |  |  |  | -0.59% | -0.49% | -0.41% | 115% | 101% | -0.36% | 1.01% | 0.89% | 123% | 104% |
| CE1-7.3b | -0.18% | 0.39% | 0.35% | 108% | 105% | -0.72% | -0.40% | -0.54% | 114% | 100% | -0.35% | 1.41% | 1.25% | 122% | 100% |
| CE1-7.4b |  |  |  |  |  | -0.58% | -0.47% | -0.46% | 111% | 100% |  |  |  |  |  |
| CE1-7.5 |  |  |  |  |  | -0.74% | -0.62% | -0.56% | 125% | 102% | -0,45% | 0,51% | 0,34% | 131% | 101% |
| CE1-7.6 |  |  |  |  |  | -0.72% | -0.64% | -0.64% | 123% | 100% |  |  |  |  |  |
| CE1-7.7.1a |  |  |  |  |  | -0.75% | -0.17% | -0.15% | 114% | 100% | -0.76% | 0.56% | 0.23% | 111% | 100% |
| CE1-7.7.1b |  |  |  |  |  | -0.66% | -0.34% | -0.32% | 116% | 101% | -0.71% | 0.59% | 0.24% | 114% | 101% |
| CE1-7.7.2a |  |  |  |  |  | -0.74% | -0.67% | -063% | 123% | 99% | -0.70% | 0.37% | 0.31% | 126% | 100% |
| CE1-7.7.2b |  |  |  |  |  | -0.65% | -0.74% | -0.73% | 125% | 99% | -0.63% | 0.26% | 0.00% | 129% | 100% |
| CE1-7.7.3a |  |  |  |  |  | -0.87% | -0.63% | -0.61% | 125% | 100% | -0.75% | 0.85% | 0.33% | 127% | 100% |
| CE1-7.7.3b |  |  |  |  |  | -0.79% | -0.73% | -0.74% | 127% | 100% | -0.63% | 0.77% | 0.50% | 126% | 101% |
| CE1-7.8a |  |  |  |  |  | -0.44% | -0.53% | -0.50% | 111% | 99% | -0.34% | 1.01% | 0.69% | 115% | 100% |
| CE1-7.8b |  |  |  |  |  | -0.44% | -0.47% | -0.42% | 111% | 100% | -0.33% | 0.73% | 0.72% | 116% | 100% |
| CE1-7.8c |  |  |  |  |  | -0.43% | -0.40% | -0.38% | 111% | 99% | -0.31% | 0.86% | 0.76% | 115% | 100% |

1-1.5 is in terms of complexity similar to 1-1.2

From the discussion:

All approaches are only applied to inter coded blocks (except the “loop filters” which are decoupled from the immediate prediction/reconstruction processes)

There are two aspects of complexity, first using intra reconstructed samples (which are the cases 1-x.ya) that causes interdependency such that for performing the prediction or reconstruction of an inter coded block we have to wait for the neighbored intra block to be reconstructed, and additional processing can start only then. These “a” cases were introduced as an additional reference to understand how large the loss of a given tool would be if it was made more implementation friendly and avoid possible latency.

The second aspect is the processing complexity as such, which is probably different for the different methods (as per table above). This applies to cases b which use reconstructed samples from inter coded neighbors only, c does not use any neighboring blocks at all.

The additional worst case processing complexity (in terms of number of operations) is exactly the same also for the loop filter versions. The advantage would be that it comes as an independent stage, and therefore does not require the restrictions a-c, and can be applied to intra coded blocks as well. On the other hand, it would be undesirable to have possible impact on the pipeline of loop filters. Some impact on encoder as well.

It is further pointed out that at least LIC has some dependency with LMCS, since the reference picture is stored in the original domain, whereas the reconstruction of neighbored blocks is in reshaped domain. The related LUT access is not in the table above, but seems not to be a big deal.

For bilateral (CE1-1), Hadamard (CE1-2) and uniform (CE1-4), the differences between cases a,b,c are low (<0.05%), all in the range of around 0.3%. The additional logic e.g. for doing boundary padding for cases b and c is not considered in the tables above, but seems not to be a big deal.

CE1-4 appears to be the most regular design among the methods investigated in CE1. It is asked how the gain would relate to that of adaptive interpolation filters reported elsewhere, or if it would be possible to combine in one filter stage with variable coefficients, because that might be more desirable in terms of decoder complexity. Currently, no information available on this aspect.

For LIC (CE1-5), the differences between a and b are in the range of 0.1%, overall for case b the gains are in the range 0.3%-0.4%, depending on configuration with bi pred, etc.

For the methods that use additional filtering in the prediction (CE1-5x, CE1-4x, CE1-2.4 which is Hadamard as post-pred. filter), encoding time increase of 8-25% is observed, due to additional RD checks.

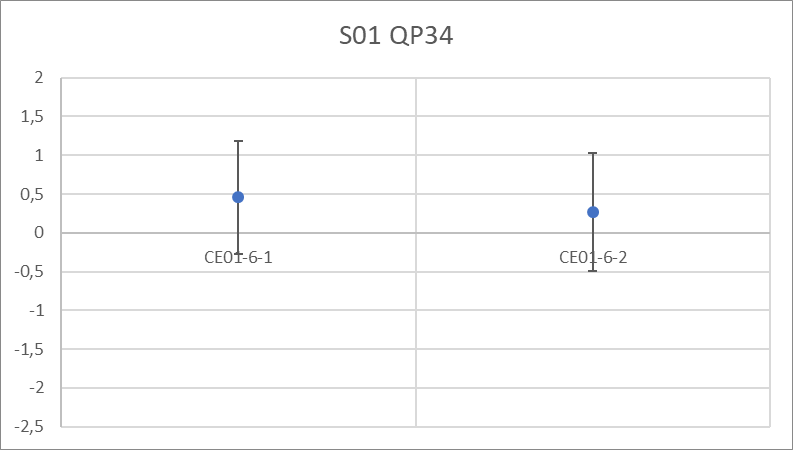
For hardware implementation, processing in 16x16 block units would be desirable. For LIC this was investigated (CE1-5.7x vs. CE1-5.1x) which results in approx. 0.05% loss. For CE1-2.4.x and CE1-4.x, it was not tested but could be expected (comparing .b and .c results) that the loss might be marginal. Implementation-wise, it would be desirable, and should be specified accordingly in case that such technology would be adopted.

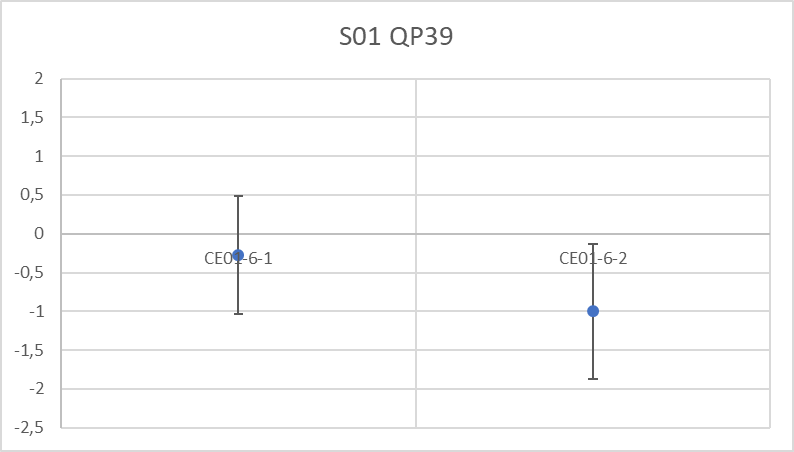
For the loop filter variants of Hadamard and bilateral, gain of approx. 0.45% is reported for RA, lower for LB (whereas in post rec. configuration, similar gains for both RA and LB). This gain is pretty low for justifying another stage in the chain of loop filters. Furthermore, it is noted that the gain is lower (or even loss in case of Hadamard) when not tested in RDO.

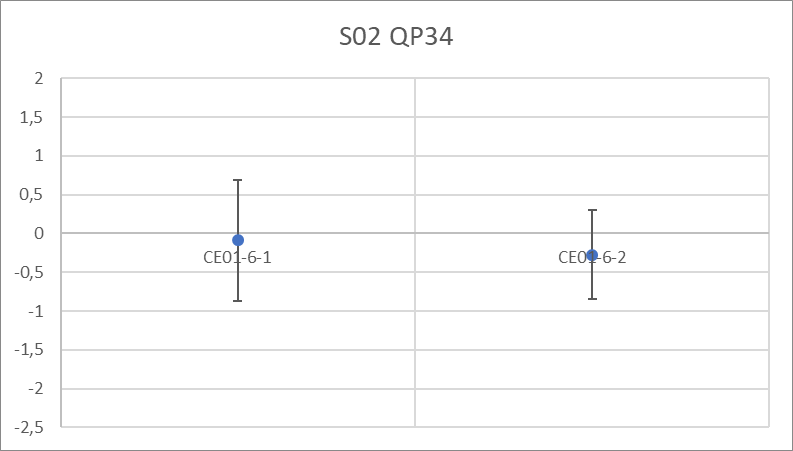
For LIC, it is remarked that the gain is relatively high for sequences with illumination changes. However there are no typical cases for that in CTC (gains between 0.2% and 0.8% per sequence in RA). For sequences with illumination changes, weighted prediction may also help.

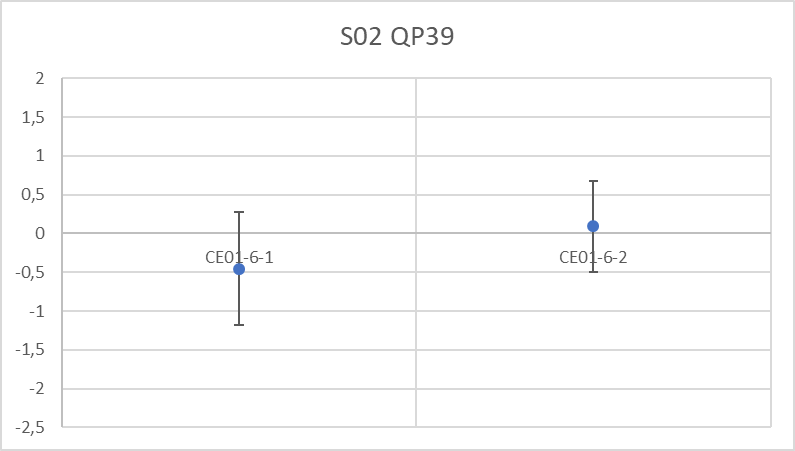
All methods investigated in CE1-1…1-5 come either with not-insignificant additional building blocks, or not-insignificant increase in encoder runtime, or both. Compared to that, the benefit in compression is relatively low, no good enough tradeoff for adoption of any of these.

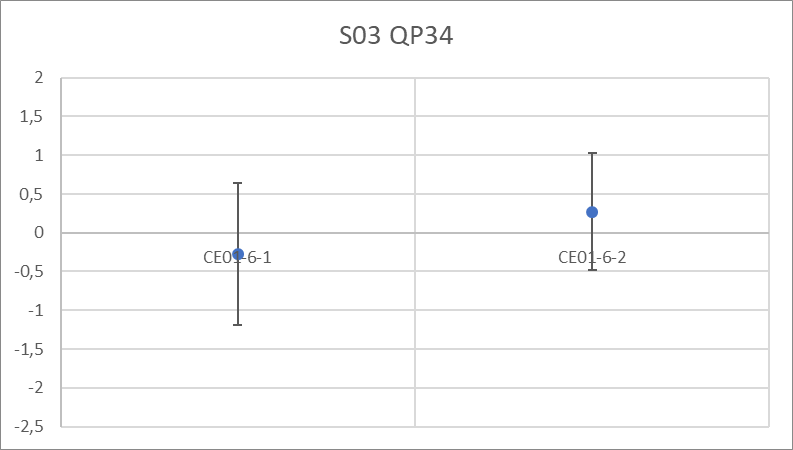
Further discussion on CE1-6 was conducted on 03-23 12:30, after subjective viewing had been performed.

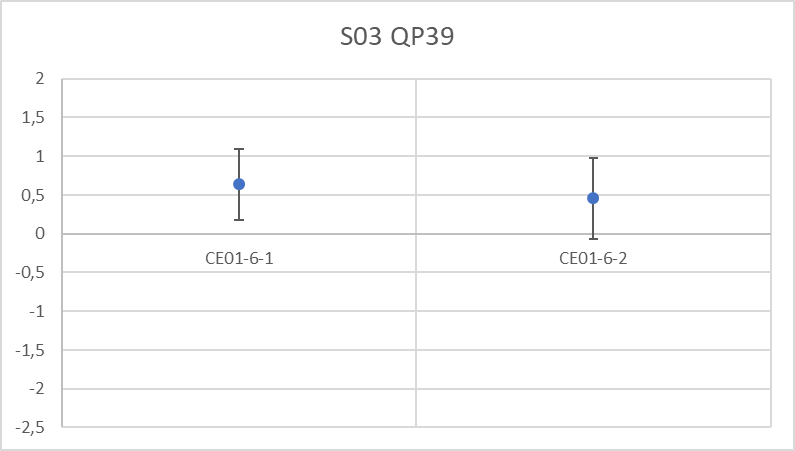




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For CE1-6.2 (HEVC strong smoothing), it is either same quality, or in one case worse.

For CE1.6.1, it is either same quality, or in one case better.

The benefit is relatively small, even more as the effect only is visible at QP39, which is not the typical point of operation. The method would require a new building block in the intra prediction pipeline, which is only invoked in case of large blocks, but non-trivial in operation (simplified version of the long deblocking without clipping). The benefit does not justify the additional complexity.

[JVET-N0059](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5779) CE1: Uniform Luma Inter Prediction Filter [J. Rasch, A. Henkel, J. Pfaff, M. Albrecht, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

[JVET-N0074](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5794) CE1-5.5: Simplification of local illumination compensation [C.-M. Tsai, C.-C. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0521](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6247) Crosscheck of JVET-N0074 (CE1-5.5) [P. Bordes (Technicolor)] [late]

[JVET-N0639](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6389) Cross-check of JVET-N0074 (CE1-5.5: Simplification of local illumination compensation) [S. Bandyopadhyay (InterDigital)] [late]

[JVET-N0205](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5925) CE1: Pipeline restriction and DBF modification on LIC (test 1.5.6, test 1.5.7) [K. Abe, T. Toma, J. Li, C.-W. Kuo, V. Drugeon (Panasonic)]

[JVET-N0636](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6386) Cross-check of JVET-N0205 (CE1-5.6: Pipeline restriction and DBF modification on LIC) [S. Bandyopadhyay (InterDigital)] [late]

[JVET-N0283](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6004) CE1-5.4 mutual exclusion of LIC and BPWA [P. Bordes, F. Urban, T. Poirier (Technicolor)]

[JVET-N0343](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6064) CE1: Unidirectional illumination compensation (CE1-5.1) [V. Seregin, W.-J. Chien, T. Hsieh, N. Hu, M. Karczewicz (Qualcomm)]

[JVET-N0632](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6381) Crosscheck of JVET-N0343 (CE1: Unidirectional illumination compensation (CE1-5.1)) [K. Abe (Panasonic)] [late]

[JVET-N0370](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6092) CE1: Intra reference sample deblocking (CE1.6) [Z. Zhang, K. Andersson, R. Sjöberg, J. Ström (Ericsson)]

[JVET-N0406](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6128) CE1: LIC applied after bi-prediction (CE1-5.3) [S. Bandyopadhyay, Y. He (InterDigital)]

[JVET-N0478](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6200) CE1: Hadamard transform domain filter (CE1-2) [S. Ikonin, V. Stepin, A. Karabutov, J. Chen (Huawei)]

[JVET-N0617](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6359) Crosscheck of JVET-N0478 (CE1: Hadamard transform domain filter): additional test results for HTDF at the “loop filter” position (CE1-2.3) [?? (??)][late]

[JVET-N0489](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6211) CE1: Bilateral filter tests [J. Ström, P. Wennersten, J. Enhorn (Ericsson), K. Reuze, D. Rusanovskyy, M. Karczewicz (Qualcomm)]

## CE2: Subblock motion compensation (20)

[JVET-N0022](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6456) CE2: Summary report on sub-block based motion prediction [C.-C. Chen, Y. He, H. Liu]

This report was discussed Tuesday 1730-2200, Wed 0900-1100 (GJS)

The goal of Core Experiment 2 (CE2) is to investigate sub-block based motion prediction techniques on top of VTM-4.0. It comprises 5 categories, as follows:

CE 2-1: Affine motion compensation and affine MV coding (2)

CE 2-2: Affine merge mode (2)

CE 2-3: Sub-block based Merge Mode (1)

CE 2-4: Memory bandwidth reduction for sub-block modes (10)

CE 2-5: Storage reduction for sub-block modes (6)

In each test, a comparative study along with related tests is conducted, results and complexity analysis are provided. Crosschecking reports of all tests are integrated in this document as well.

**CE2-1: Affine Motion Compensation and Affine MV Coding**

|  |  |  |
| --- | --- | --- |
| **Test#** | **Description** | **Document#** |
| 2-1.1a | Interweaved prediction for affine motion compensation for luma only | JVET-N0261 |
| 2-1.1b | Test 2-1.1a + chroma |
| 2-1.1c | Test 2-1.1a + Test 2-4.6 |
| 2-1.1d | Test 2-1.1a + Test 2-4.8a |
| 2-1.2a | SMVD with signaling MVDs of all control points for L0 | JVET-N0319 |
| 2-1.2b | SMVD with signaling MVDs of TL control point for L0 and set TR and BL control point MVD for L0 to 0 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access Main 10** | | | | | **Low delay B Main10** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 2-1.1a | -0.30% | 0.02% | -0.02% | 100% | 100% | -0.14% | 0.04% | -0.15% | 101% | 101% |
| 2-1.1b | -0.32% | -0.21% | -0.18% | 100% | 99% | -0.14% | -0.13% | -0.18% | 101% | 100% |
| 2-1.1c | -0.28% | 0.03% | 0.03% | 101% | 100% | -0.11% | 0.10% | 0.03% | 101% | 102% |
| 2-1.1d | -0.28% | 0.01% | 0.02% | 101% | 101% | -0.13% | -0.13% | 0.22% | 101% | 101% |
| 2-1.2a | -0.10% | -0.06% | -0.06% | 106% | 100% |  |  |  |  |  |
| 2-1.2b | -0.07% | -0.05% | -0.05% | 105% | 100% |  |  |  |  |  |

The gains are larger for affine-friendly test sequences. Cactus had 1.25% coding gain. For the Slideshow Class F sequence, the LB gain was reported as 2.86%. It was commented that the worst case is not affected, since this is applied as a uni-pred mode. Memory access is also reportedly not affected, since the same memory region in the reference picture is fetched for both prediction signals. A position-dependent weighting function is applied with a 4x4 weighting pattern.

The spirit of this is sort of to get some of the advantage that would be gained by using 2x2 subblocks for affine MC rather than 4x4 subblocks. (There is also a proposal to just use 2x2 subblocks, JVET-N0273.)

It was commented that another related contribution JVET-N0399 reported that using ordinary averaging could provide roughly the same gain.

It was commented that the grid shifting requires some delay in the processing pipeline and some line buffering, e.g., as contrasted with ordinary sub-block bipred, in which case the results of each block can be written out block by block without delay.

It was commented that also JVET-N0399 uses higher precision in the intermediate stage prior to the averaging (which is how the current biprediction operates).

A non-CE contribution JVET-N0236 was also mentioned, which combines predictions from a sample-based optical flow and affine.

Due to implementation concerns and other potential approaches that may interact with this, it was agreed that further study would be needed.

The 2-1.2x proposals provide very little gain and significantly increased encoding time and require some additional logic and syntax, so did not seem appropriate for action.

**CE2-2: Affine Merge Mode**

|  |  |  |
| --- | --- | --- |
| **Test#** | **Description** | **Document#** |
| 2-2.1 | Only select the MV with reference index equal to 0 as CPMV | JVET-N0075 |
| 2-2.2a | Affine MMVD with POC-based offset mirroring and a distance table {1/2, 1, 2, 4, 8} | JVET-N0378 |
| 2-2.2b | Affine MMVD with POC-based offset scaling |
| 2-2.2c | Test 2-2.2a + Affine MMVD with resolution-based distance tables: {1/2, 1, 2, 4, 8}/N, where N=1,4,8 |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access Main 10** | | | | | **Low delay B Main10** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 2-2.1 | 0.02% | -0.01% | 0.00% | 100% | 99% | 0.02% | 0.04% | -0.08% | 100% | 101% |
| 2-2.2a | -0.13% | -0.15% | -0.10% | 101% | 100% | 0.01% | -0.09% | -0.26% | 103% | 99% |
| 2-2.2b | -0.12% | -0.17% | -0.19% | 102% | 100% | -0.06% | -0.05% | -0.26% | 104% | 99% |
| 2-2.2c | -0.15% | -0.11% | -0.10% | 101% | 100% | -0.03% | -0.02% | 0.09% | 103% | 99% |

2-2.1 eliminates reference picture index logic for affine merge, proposing to always use reference picture index 0 for affine merge. This reportedly reduces the worst case number of needed comparisons for determining the validity and matching of reference picture indexes from about 60 to 47. It was asked what is the frequency of picking non-zero reference indexes and commented that QP control could affect whether the non-zero reference indexes would be desirable to use or not. The LB case was suggested to consider, since in this case we use a QP hierarchy without reordering reference picture lists, and may in such a case tend to use more nonzero indexes for referencing. It was commented that two test sequences showed some loss in that case (0.2% in one case and 0.4% in another).

Another contribution JVET-N0203 was also reported to show potential gain for using a non-zero reference indexes more often (e.g. in the LB case).

The benefit here did not seem very significant. No action.

2-2.2x tests related to affine MMVD offsets. In the current spec, MMVD is not applied to affine mode. This would add some additional logic and syntax parsing that is different for affine than in other modes. The gain seemed too small for action on this.

The 2-2.3 category was withdrawn.

**CE2-4: Memory bandwidth reduction for sub-block modes**

|  |  |  |
| --- | --- | --- |
| **Test#** | **Description** | **Document#** |
| 2-4.1 | Withdrawn | n/a |
| 2-4.2a | Affine sub-block size setting: 4x4 for UNI, 8x4 for BI | JVET-N0323 |
| 2-4.2b | Affine sub-block size setting: 4x4 for UNI, 4x8 for BI |
| 2-4.2c | Affine sub-block size setting: 4x4 for UNI, adaptive 8x4/4x8 for BI |
| 2-4.2d | Affine sub-block size setting: 4x4 for UNI, 8x8 for BI |
| 2-4.3 | Clip sub-block MVs based on the bounding box pointed to by top-left one | JVET-N0195 |
| 2-4.4a | Clip sub-block MVs based on limiting max differences among 4x4 MVs within an 8x8 block are no larger than Tx =1 and Ty=0 | JVET-N0398 |
| 2-4.4b | Test 2-4.4a with Tx =1 and Ty=1 |
| 2-4.4c | Test 2-4.4a with Tx =1 and Ty=1 and distance-based MVmin MVmax determination off |
| 2-4.5a | Reduce worst-case memory bandwidth by switching sub-block size: 4x4, 8x8 | JVET-N0256 |
| 2-4.5b | Reduce worst-case memory bandwidth by switching interpolation filter: 4-, 8-tap |
| 2-4.5c | Reduce worst-case memory bandwidth by imposing encoder bitstream conformance |
| 2-4.6 | Complexity and bandwidth reduction for 4x4 sized partition using 6-tap filter | JVET-N0196 |
| 2-4.7a | Motion compensation with padding for 4x4 UNI and 4x8/8x4/4x16/16x4 BI | JVET-N0253 |
| 2-4.7b | Based on Test 2-4.7a, padding with 1 less column or row for 4x8 BI and 4x4 UNI |
| 2-4.8a | Encoder/decoder conformance, the fallback mode is not triggered, δ*x* = δ*y* = 2 | JVET-N0068 |
| 2-4.8b | Decoder conformance, the fallback mode is triggered, δ*x* = δ*y* = 2 |
| 2-4.9a | Withdrawn | JVET-N0210 |
| 2-4.9b-1 | Integer motion compensation for regular inter mode 4x4/4x8/8x4 |
| 2-4.9b-2 | Test 2-4.9b-1 + Rounded MVs for storage |
| 2-4.10a | Affine MVp range limit on constructed affine candidates with parameter threshold=2 | JVET-N0379 |
| 2-4.10b | Test 2-4.10a with parameter threshold=1 |
| 2-4.10c | Affine MVp range limit on all affine blocks with parameter threshold=2 |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access Main 10** | | | | | **Low delay B Main10** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 2-4.1 |  |  |  |  |  |  |  |  |  |  |
| 2-4.2a | 0.10% | 0.02% | 0.04% | 99% | 100% | 0.11% | 0.14% | 0.15% | 101% | 98% |
| 2-4.2b | 0.11% | 0.04% | 0.03% | 102% | 103% | 0.12% | 0.12% | -0.05% | 98% | 97% |
| 2-4.2c | 0.10% | 0.03% | 0.06% | 101% | 102% | 0.11% | 0.11% | 0.05% | 99% | 97% |
| 2-4.2d | 0.21% | 0.10% | 0.12% | 100% | 102% | 0.18% | 0.08% | -0.01% | 99% | 98% |
| 2-4.3 | 0.01% | -0.06% | 0.00% | 101% | 100% | -0.03% | 0.05% | -0.26% | 101% | 100% |
| 2-4.4a | 0.09% | -0.01% | 0.00% | 102% | 100% | -0.01% | 0.10% | -0.17% | 103% | 99% |
| 2-4.4b | 0.01% | -0.03% | -0.05% | 102% | 99% | -0.02% | -0.14% | -0.28% | 103% | 100% |
| 2-4.4c | 0.01% | -0.03% | -0.05% | 104% | 102% | -0.02% | -0.14% | -0.28% | 105% | 103% |
| 2-4.5a | 0.04% | -0.06% | -0.03% | 102% | 104% | 0.00% | 0.21% | -0.22% | 100% | 100% |
| 2-4.5b | 0.07% | 0.05% | 0.07% | 101% | 104% | 0.02% | -0.09% | -0.10% | 100% | 101% |
| 2-4.5c | 0.03% | 0.01% | 0.06% | 103% | 104% | 0.04% | 0.09% | -0.28% | 100% | 98% |
| 2-4.6 | 0.08% | -0.05% | -0.01% | 101% | 100% | 0.11% | 0.16% | -0.15% | 101% | 100% |
| 2-4.7a | 0.01% | -0.04% | -0.08% | 98% | 99% | 0.00% | -0.05% | -0.01% | 99% | 99% |
| 2-4.7b | 0.00% | -0.05% | -0.07% | 99% | 99% | -0.01% | 0.07% | -0.05% | 99% | 100% |
| 2-4.8a | 0.02% | 0.00% | 0.03% | 95%\* | 97%\* | 0.00% | 0.18% | -0.19% | 92%\* | 94%\* |
| 2-4.8b | -0.01% | -0.01% | 0.01% | 98%\* | 99%\* | 0.01% | 0.17% | -0.26% | 102%\* | 100%\* |
| 2-4.9b-1 | 0.09% | 0.11% | 0.18% | 102% | 96% | 0.09% | 0.35% | 0.12% | 101% | 96% |
| 2-4.9b-2 | 0.06% | 0.15% | 0.21% | 98% | 100% | 0.07% | 0.17% | 0.17% | 100% | 102% |
| 2-4.10a | -0.01% | 0.02% | 0.00% | 100% | 100% | -0.02% | 0.21% | 0.01% | 101% | 100% |
| 2-4.10b | -0.01% | -0.02% | -0.04% | 100% | 100% | 0.00% | 0.10% | 0.08% | 100% | 99% |
| 2-4.10c | 0.00% | 0.01% | 0.00% | 100% | 100% | -0.01% | 0.13% | 0.04% | 99% | 99% |
| \* It is reported from proponents that the encoding and decoding runtime of respective tests may not be reliable. | | | | | | | | | | |

One category of these tests is reducing computation for subblock MC (e.g. using shorter filters on small blocks), others affect memory bandwidth and the number of fetches from cache memory.

* 2-4.6 (uses shorter filters for all 4x4 subblocks for regular inter and affine)
* 2-4.7x (uses padding for all 4xN & Nx4 subblocks with N<32 only for regular inter)
* 2-4.9b-x (applying integer MC for 4x8 and 8x4 bipred and enable 4x4 integer MC bipred in regular inter) use shorter filters for smaller blocks.

It was commented that the loss in high resolutions for 2-4.6 is very small.

It was commented that eliminating the use of 4x4 for affine might cause visual artefacts.

It was commented that 4x4 bipred with short filters requires less computation than 8x8 bipred.

It was commented that for some non-CTC “heavily affine” test sequences (e.g., SpinCalendar), using shorter filters has a significant penalty.

It was noted that DMVR has some padding, although only for large blocks.

For 2-4.9b-x, it was commented that removing the 4x4 bipred from it has negligible loss (e.g., 0.01%).

It was said that actually just removing 4x4 unipred, and 4x8/8x4 bipred regular inter modes (as in HEVC) is reported in JVET-N0266 and has a very similar penalty (0.08% for RA, 0.11% for LB) as the integer MC proposal 2-4.9b-x. However, it was commented that this could have a penalty for SCC.

Decision (complexity reduction): Adopt JVET-N0266 test 2, to remove 4x4 unipred, and 4x8/8x4 bipred regular inter modes (as in HEVC) (pending text check).

It was commented that adopting this might remove the need for shared merge candidates from the regular merge list. The coding efficiency impact of this was reported to be negligible. Decision (cleanup): Remove the use of for shared merge candidates in the regular merge list. (The text impact is a simplification and will be provided in a revision of JVET-N0266.)

Shared merge candidates are still used for the IBC merge list.

This action does not address the computational issue with affine mode.

Further testing of 2-4.6 during the meeting, relative to the JVET-N0266 anchor and relative to a JVET-N0266 anchor with affine entirely disabled, was suggested. Such results were requested.

Testing for non-CTC sequences (e.g., SpinCalendar) was also suggested. Some participants thought the CTC adequate, as the CTC includes some affine-benefitting sequences with rotation (CatRobot and Cactus) or other affine effects (e.g. MarketPlace, ParkRunning3, DaylightRoad2).

It was agreed that if test results for some non-CTC sequences also become available, they could also be reviewed.

(Note that IBC still supports 4x4. Note that the current name is IBC, not CPR.)

This was further discussed in track B on 25 March 2019 1720-2225, chaired by Y. Ye.

The results were provided in N0821 and were reviewed. Two tests were performed.

Test 1 (the proposed method vs. VTM4.0): 0.16% for RA, 0.1% for LDB

Test 2 (the proposed method vs. VTM4.0 with affine off): -2.48% for RA, full results of LDB not yet available, partial LDB results: -1.15% and -2.0% for class C and E respectively.

The AHG13 reports 2.62% for RA and 2.07% for LDB for affine tool off tests.

N0860 provides additional test results for N0821 method using the non-CTC affine sequences. It reports 0.22% for RA and 0.77% for LD over N0266, and -15.26% for RA and -31.32% for LDB over N0266 with affine off. Performance of a couple of individual sequences in LDB configuration was reported: for “SpinCalendar,” the loss was 1.96% over N0266, the gain was -36.43% over N0266 with affine off; for “JetsPart,” the loss was 1.98% over N0266 and the gain was -28.15% over N0266 with affine off. This indicates that 90-95% of the affine gain can be preserved even in the most extreme cases.

It was agreed that the proposed 6-tap filter for affine motion compensation preserves most of the affine gains. It reduces computation and amount of data fetched from cache for motion compensation. Coupled with N0068, which was already adopted, this proposed 6-tap filter reduces the affine 8x8 memory bandwidth to be the same as normal inter prediction.

It was commented that some minor adjustments to the N0068 spec text needed to be done in combination with N0821.

Decision (complexity reduction): Adopt 6-tap filters per N0821, which is an updated version of N0196 combined with N0068 and N0266 (pending a revised spec text that incorporates N0068 and N0821 to be uploaded and reviewed/confirmed by the editors).

The following notes are from previous discussion.

Moving on to memory bandwidth consideration, the above action helps already. Memory bandwidth approaches for affine mode were then further discussed.

Complexity analysis

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test#** | **Bandwidth measurement for uni/bi-prediction** | **Operations of SB MV derivation per 8x8 block (e.g. clipping)** | **Complexity of MC per 8x8 bi-prediction:**  **Multiplication, addition** | **Others (additional operations per CU to determine SB size, MC fetching unit)**  **Multiplication, addition, comparison, look-up size** |
| Inter | 10.69 / 14.69 | n/a | 2944+352=3296 Mul.  2704+296=3000 Add | no |
| Affine | 9.09 / 18.19 | no clipping | 960\*4+352=4192 Mul.  872\*4+296=3784 Add | no |
| 2-4.1 |  |  |  |  |
| 2-4.2a | 9.09 / 13.38 | same | 1920\*2+352=4192 Mul.  1744\*2+296=3784 Add | 1 comparison per CU (1 for uni/bi) |
| 2-4.2b | 9.09 / 13.38 | same | 1472\*2+352=3296 Mul.  1352\*2+296= 3000 Add | 1 comparison per CU (1 for uni/bi) |
| 2-4.2c | 9.09 / 13.38 | same | 1920\*2+352=4192 Mul.  1744\*2+296=3784 Add | 2 comparisons per CU (1 for width/height + 1 for uni/bi) |
| 2-4.2d | 9.09 / 11.06 | same | 2944+352=3296 Mul.  2704+296=3000 Add | 1 comparison per CU (1 for uni/bi) |
| 2-4.3 | 6.59 /13.19 | same | 4\*624+352 = 2848 Mul.  4\*552+296 = 2504 Add | same |
| 2-4.4a | 5.28 /10.56 | 15 comparisons for each 8x8 block, may be performed in parallel | same | no |
| 2-4.4b | 5.53 / 11.06 | 15 comparisons for each 8x8 block, may be performed in parallel | same | no |
| 2-4.4c | 5.53 / 11.06 | 14 comparisons for each 8x8 block, may be performed in parallel | same | no |
| 2-4.5a | 9.09 / 11.06 | no change | same | 13 comparisons per CU (1 for uni/bi + 12 for restriction) |
| 2-4.5b | 9.09 / 11.07 | no change | same | 14 comparisons per CU (1 for uni/bi + 12 for restriction) |
| 2-4.5c | 9.09 / 11.08 | no change | same | no |
| 2-4.6 |  |  |  |  |
| 2-4.7a | 15.25 / 20.19 | no change | same | no |
| 2-4.7b | 15.25 / 22.25 | no change | same | no |
| 2-4.8a | See JVET-N0068 |  |  |  |
| 2-4.8b | See JVET-N0068 |  |  |  |
| 2-4.9a | See JVET-N0068 |  |  |  |
| 2-4.9b-1 | 10.69 / 10.09 | no change | same as 8x8 bi-prediction | no change |
| 2-4.9b-2 | 10.69 /10.09 | no change | same as 8x8 bi-prediction | no change |
| 2-4.10a | no change | no change | same | no |
| 2-4.10b | no change | no change | same | no |
| 2-4.10c | no change | no change | same | no |

Relevant approaches were suggested to be 2-4.2, 2-4.3, 2-4.4, 2-4.5, 2-4.8

The CE plan said to use the memory cache analysis model, but the data provided for the complexity analysis tabulated above did not do that.

2-4.8b computes a bounding box and prevents affine motion from referencing outside the box by replacing the affine model with a single MV for the whole CU if the bounding box constraint is violated.

2-4.4 limits the range of motion vectors within each 8x8 area so the integer part differs by at most 1

2-4.5 is similar in spirit to 2-4.8 but has a different fallback

2-4.10 imposes an encoder constraint

It seemed clear that some approach in this area can effectively fix the memory bandwidth problem that could be caused in affine mode with “evil” data, with little loss of coding efficiency.

It was said that 2-4.8 and 2-4.4 are roughly similar for 8x8 PUs. For larger PUs one of them uses a whole-PU operation where the other operates separately in each 8x8 region. The worst case is the 8x8 case regardless.

It was commented that with a sufficiently “evil” encoder, the MVs of different 8x8 regions in a larger PU could be very disjoint, and that the behaviour of 2-4.8 can prevent that, while 2-4.4 does not.

However, there would still be a worst case with 8x8 bipred PUs either way.

There was substantial nonproponent support for 2-4.8b.

Decision (complexity reduction): Adopt 2-4.8b (with a max difference of 2 integer positions).

Without a cache model the worst case memory bandwith per luma sample for this was reported to be 17x17/64.

One more subsection remained in CE2 for review as of Tuesday 2200, targeted at memory reduction.

Discussion resumed Wednesday 0900.

There was discussion of the allowed range of MVD. No action appeared to be needed, as the draft already constrains this. The resulting MVs are also modulo wrapped to prevent them from having too large a range.

**CE2-5: Storage Reduction for Sub-block Modes**

|  |  |  |
| --- | --- | --- |
| **Test#** | **Description** | **Document#** |
| 2-5.1a | Replace spatial affine inheritance with inheritance from affine HMVP | JVET-N0377 |
| 2-5.1b | Test 2-5.1a + affine inheritance from line buffer |
| 2-5.2a | Directly derive sub-block MV by using affine inheritance merge candidate | JVET-N0257 |
| 2-5.2b | Test 2-5.2a + Affine inheritance using sub-block MVs |
| 2-5.2c | Test 2-5.2b + Shifting affine CPMVs by (2,2) |
| 2-5.2d | Test 2-5.2d + Changing neighboring block checking order for top-right and bottom-left CPMVs prediction in the constructed affine MVP |
| 2-5.2e | Test 2-5.2d + 16x16 grid affine inheritance |
| 2-5.3 | 2 or 3 sub-block MVs with half CU height or half CU width for affine inheritance | JVET-N0076 |
| 2-5.4 | Affine parameters storage to replace CPMVs and the block dimensions storage | JVET-N0272 |
| 2-5.5a | Parameter-based HMVP affine candidates | JVET-N0263 |
| 2-5.5b | Test 2-5.5a + 2.5.1.a |
| 2-5.5c | Test 2-5.5a + 2.5.1.b |
| 2-5.6a | Test 2-5.3 + Two subblock MVs with a fixed distance (4) for affine inheritance | JVET-N0078 |
| 2-5.6b | Test 2-5.4 + Two subblock MVs with a fixed distance (8) for affine inheritance |
| 2-5.6c | Test 2-5.4 + Two subblock MVs with a fixed distance (16) for affine inheritance |

For CE2-5.3, it was noted that the CE description had an error in a diagram, as the proposal had later been modified to operate differently from what was shown in the figure.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access Main 10** | | | | | **Low delay B Main10** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 2-5.1a | 0.08% | 0.00% | 0.02% | 100% | 100% | 0.09% | 0.10% | -0.22% | 100% | 98% |
| 2-5.1b | 0.03% | 0.00% | -0.02% | 99% | 100% | 0.05% | 0.05% | 0.08% | 100% | 98% |
| 2-5.2a | 0.00% | -0.06% | -0.02% | 100% | 100% | 0.00% | 0.18% | -0.39% | 100% | 100% |
| 2-5.2b | 0.01% | -0.08% | -0.05% | 100% | 100% | 0.01% | -0.05% | -0.10% | 100% | 99% |
| 2-5.2c | 0.03% | -0.04% | 0.05% | 100% | 100% | 0.04% | 0.22% | -0.17% | 101% | 99% |
| 2-5.2d | 0.01% | 0.01% | 0.02% | 1001% | 1001% | 0.01% | -0.04% | -0.11% | 100% | 99% |
| 2-5.2e | 0.02% | -0.01% | 0.05% | 100% | 100% | 0.01% | 0.04% | -0.04% | 100% | 100% |
| 2-5.3 | 0.01% | -0.07% | -0.02% | 100% | 100% | 0.02% | 0.13% | -0.32% | 99% | 99% |
| 2-5.4 | 0.02% | -0.04% | 0.01% | 100% | 100% | 0.00% | 0.02% | -0.14% | 100% | 100% |
| 2-5.5a | -0.06% | -0.07% | -0.08% | 101% | 101% | -0.02% | -0.13% | -0.12% | 100% | 101% |
| 2-5.5b | 0.00% | -0.04% | -0.02% | 100% | 100% | 0.10% | 0.07% | -0.07% | 100% | 99% |
| 2-5.5c | -0.05% | -0.11% | -0.12% | 100% | 100% | 0.02% | -0.02% | -0.13% | 99% | 99% |
| 2-5.6a | 0.02% | -0.05% | -0.04% | 100% | 100% | 0.01% | -0.12% | 0.03% | 99% | 101% |
| 2-5.6b | 0.00% | -0.08% | 0.04% | 100% | 100% | 0.02% | -0.02% | 0.10% | 100% | 99% |
| 2-5.6c | 0.00% | -0.04% | -0.01% | 100% | 99% | -0.02% | 0.03% | -0.25% | 100% | 101% |

Memory reduction is summarized in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Test#** | **Local storage**  **(bits per CTU: 36 bits per CPMV, 3 bits for CU width, 3 bits for CU height, 10 bits for CU top-left x and y, 1 bit for affine type)** | **Line buffer for**  **(bits per 8x8)** | **Additional logic** |
| VTM4.0 | 11072 = 128/8 \* (36\*3\*2+5+10+1) + 128/8 \* 2\*(36\*3\*2+3\*1+10+1) | 8 (3 bits for width, 5 bits for CU x position) |  |
| 2-5.1a | 1165 = (5\*(36\*3\*2+3\*2+10+1)) | 0 bit | Affine HMVP table update |
| 2-5.1b | 1165 = (5\*(36\*3\*2+3\*2+10+1)) | Same | Affine HMVP table update |
| 2-5.2a | 11072 =128/8 \* (36\*3\*2+5+10+1) + 128/8 \* 2\*(36\*3\*2+3\*1+10+1) | Same | No |
| 2-5.2b | 3152 = ((128/8\*2+2) \* 36\*2)+128/8 \* (5+10+1) + 128/8 \* 2\*(3\*1+10+1) | Same | No |
| 2-5.2c | 3152 = ((128/8\*2+2) \* 36\*2)+128/8 \* (5+10+1) + 128/8 \* 2\*(3\*1+10+1) | Same | No |
| 2-5.2d | 3152 = ((128/8\*2+2) \* 36\*2)+128/8 \* (5+10+1) + 128/8 \* 2\*(3\*1+10+1) | Same | No |
| 2-5.2e | 1648 = (128/16\*2+2) \* 36\*2)+128/16 \* (5+10+1) + 128/16 \* 2\*(3\*1+10+1) | 8 per 16x16 | No |
| 2-5.3 | 4160 =128/8 \* (36\*2+5+10+1) + 128/8 \* 2\*(36\*2+3\*1+10+1) | Same | No |
| 2-5.4 | 3072 = 48\*(8\*4\*2) | Same | No |
| 2-5.5a | 11392 = 320 + 128/8 \* (36\*3\*2+5+10+1) + 128/8 \* 2\*(36\*3\*2+3\*1+10+1) | Same | Affine HMVP table update (no pruning |
| 2-5.5b | 320 = (10\*4\*8) | 0 | Affine HMVP table update (no pruning |
| 2-5.5c | 320 = (10\*4\*8) | Same | Affine HMVP table update (no pruning |
| 2-5.6a | Same | 0 | No |
| 2-5.6b | Same |  |  |
| 2-5.6c | Same | 0 | No |

The current VTM 4 requires about 50% extra memory (~10k bits / 1384 bytes) of local buffer for affine CPMV storage in addition to what is needed for motion data storage without affine. The number would be larger for software implementations ~7888 bytes of local cache, perhaps 75% rather than 50%.

Additionally, 2-5.1a, 2-5.5b and 2-5.6x remove usage of some information about the above CTU, which may reduce line buffering storage, depending on implementation.

Some proposals have extra logic introduced.

This was further discussed after offline study of the following:

* Three alternatives to each other (these alternatives try to reduce in-CTU MV storage):
  + 2-5.2b or a variant that removes the 2-5.2a part of it was suggested for focus. It reduces the memory needed and was suggested to have a consistent structure.
  + 2-5.5c was also suggested for focus. It has a larger memory reduction but has some additional logic, increasing the number of candidates and availability checks.
  + 2-5.1b was also suggested for focus, as it has a larger memory reduction than 2-5.2b and was said to have less additional logic than 2-5.5c.
* An orthogonal concept (these alternatives try to reduce line buffer storage): 2-5.6a or b

It was also said that the current design is acceptable and “clean”/consistent, so no action may really be needed. The amount of memory reduction available from these schemes is not especially large relative to total requirements.

This was further discussed in track B on 25 March 2019 1720-2025, chaired by Y. Ye.

Based on offline discussion, it was commented that the storage for affine CPMV is 10% of the total required local storage for all MVs. This includes subblock MV buffer for current VPDU, TMVP buffer, line buffer for local (within CTU) subblock MV, and local CPMV buffer. One VPDU contains 16x16 motion information units (MV, pred\_mode, and ref\_idx, etc), one TMVP buffer is 16x16 motion information units. Two of each of VPDU and TMVP buffers are required. Subblock MV storage is (128/4)\*2+1 motion information units. Local CPMV buffer is (128/8)\*2+1 CPMV data units. The total required local storage for all MVs is about 10K bytes.

It was commented that for software implementation, byte-aligned implemention is generally used. It was reported that the total required local (within CTU) storage for all MVs for software implementation can be as large as 33K bytes.

For reduction of in-CTU MV storage, one hardware expert commented that such storage does not seem to be critical.

The proponent of CE2-5.2.b (and the variant of it as noted above) reports that their solution reduces 600 bytes of hardware storage, and has neglible coding loss. The variant of 2-5.2b minus 2-5.2a reduces the spec text by 4 lines. The proponent of N0752 test 1 (which was suggested for focus in discussion instead of CE2-5.5c) reports that their solution reduces 1K bytes of hardware storage, and has no coding loss. The proponent of CE2-5.1b reports that their solution reduces 900 bytes of hardware storage, and has 0.03% for RA and 0.05% for LDB.

The proponent of CE2-5.2.b reports that the the noted variant has additional benefits: 1) unify the operation between within-CTU and on CTU boundary; 2) removes 4 lines of spec text; 3) reduces memory for software implementation as well.

It was commented that unification of within CTU and on CTU boundary operations seems to be a good thing to have.

It was commented that if we change the current method in VVC draft 4, then the unification method is more preferable.

One expert commented that the current method is conceptually clearer, but some other experts commented that the proposed unificiation is conceptually clearer.

The proponent suggested that the proposed unification can be implemented with minor changes to hardware implementation of the current design. This was agreed.

It was commented that with the current method in VVC draft 4, the spacing of CPMVs is full CU size, but in the proposed unification method, the spacing of CPMVs is reduced to half CU size, which decreases the affine parameter model precision, and could theoretically harm the coding performance. It was commented that the test results showed no loss.

The biggest loss of a class D non-CTC sequence BQSquare is reported to be 0.5% in LDB, but the affine gain of that sequence is reported to be 8% in LDB.

There was no consensus on whether to adopt the proposed unification in CE2-5.2b-CE2-5.2a.

No action was taken on this.

Discussion on line buffer reduction, as proposed in CE2-5.6a or b: the difference between the two tests is just whether the distance of two subblocks is set to 4 or 8 for 4-parameter affine. It was agreed to focus on CE2-5.6a, which sets the distance to 4. The proponent reported that the performance loss was negligible (0.02% for RA and 0.01% for LDB).

It was commented that the proposed method uses more conditional checks, but reduces the number of subblocks of the above-left CTU that can be accessed.

It was estimated that the storage saving due to method CE2-5.6a is approximately 512 bytes.

In terms of subblock accesses, the proponent reports that, in the current method, in the worst case, 96 subblocks of the above-left CTU need to be accessed; in the proposed method, that number is reduced to 35 subblocks.

However, it was noted that since all these subblocks are likely to be in cache, such accesses do not seem to be a problem.

It was further commented that the current affine inheritance method accesses 3 subblocks each time, and the proposed method reduces that to 2 subblocks.

It was further commented that the current affine inheritance process uses (width – 4), and this proposed method changes that to (width), which is the theoretically correct value. However, it was noted that this does not seem to bring any performance benefit.

No action was taken on this.

[JVET-N0068](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5788) CE2: On restriction of memory bandwidth consumption of affine mode (CE2-4.8) [M. Zhou (Broadcom)]

[JVET-N0075](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5795) CE2-2.1: Simplification of constructed affine merging candidate derivation [Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0076](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5796) CE2-5.3: Simplifications for inherited affine merging candidates [Y.-L. Hsiao, T.-D. Chuang, C.-W. Hsu, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0078](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5798) CE2-5.6: Simplifications for inherited affine merging candidates at CTU row boundaries [Y.-L. Hsiao, T.-D. Chuang, C.-W. Hsu, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek), K. Zhang, L. Zhang, H. Liu, J. Xu (Bytedance)]

[JVET-N0637](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6387) Crosscheck of JVET-N0078 (CE2-5.6: Simplifications for inherited affine merging candidates at CTU row boundaries) [H. Huang (Qualcomm)] [late]

[JVET-N0195](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5915) CE2: Memory bandwidth reduction for the affine mode (Test 2.4.3) [J. Li, C.-W. Kuo, C. S.Lim (Panasonic)]

[JVET-N0196](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5916) CE2: Using the shorter-tap filter for 4x4 sized partitions (Test 2.4.6) [J. Li, C.-W. Kuo, C. S. Lim (Panasonic)]

[JVET-N0860](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6615) Crosscheck of JVET-N0196 with affine sequences [X. Li (Tencent)] [late]

[JVET-N0210](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5930) CE2-4.9: Integer motion compensation for regular inter mode [X.W. Meng (PKU), X. Zheng (DJI), S.S. Wang, S.W. Ma (PKU)]

[JVET-N0253](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5974) CE2-4.7: Motion compensation with padded samples for small coding units [H. Liu, L. Zhang, J. Chon, H. Chuang, K. Zhang, J. Xu, Y. Wang (Bytedance)]

[JVET-N0256](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5977) CE2: Worst-case Memory Bandwidth Reduction for affine (Test 2.4.5) [H. Huang, L. Pham Van, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-N0257](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5978) CE2: Alignment of affine control-point motion vector and subblock motion vector (Test 2.5.2) [H. Huang, W.-J. Chien, V. Seregin, H. Wang, M. Karczewicz (Qualcomm)]

[JVET-N0616](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6357) Crosscheck of JVET-N0257 (CE2: Alignment of affine control-point motion vector and subblock motion vector (Test 2.5.2)) [H. Chen (Huawei)] [late]

[JVET-N0261](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5982) CE2-1.1: Interweaved Prediction for Affine Motion Compensation [K. Zhang (Bytedance)]

[JVET-N0687](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6438) Cross-check of JVET-N0261 (CE2-1.1d: Interweaved Prediction for Affine Motion Compensation) [J. Li, C.-W. Kuo, C. S.Lim (Panasonic)] [late]

[JVET-N0263](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5984) CE2-5.5: History-parameter-based affine model inheritance [K. Zhang (Bytedance)]

[JVET-N0272](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5993) CE2-5.4: Parameter-based affine model inheritance [K. Zhang (Bytedance)]

[JVET-N0319](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6040) CE2: Symmetric MVD for affine bi-prediction coding (CE2-1.2) [H. Yang, J. Luo, Y. He (InterDigital)]

[JVET-N0323](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6044) CE2: Reducing worst-case memory bandwidth of affine mode (CE2-4.2.a, CE2-4.2.b, CE2-4.2.c and CE2-4.2.d) [Y.-W. Chen, X. Wang (Kwai Inc.), H. Chen, T. Solovyev, H. Yang, J. Chen (Huawei)]

[JVET-N0377](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6099) CE2-5.1: Affine HMVP with modified affine inheritance [G. Li, X. Xu, X. Li, S. Liu (Tencent), J. Zhao, S. Kim (LGE)]

[JVET-N0378](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6100) CE2-2.2: Affine merge with prediction offset [G. Li, X. Xu, X. Li, S. Liu (Tencent)]

[JVET-N0379](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6101) CE2-4.10: Constraint on constructed affine MV range [G. Li, X. Xu, X. Li, S. Liu (Tencent)]

[JVET-N0529](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6257) Cross-check of JVET- N0379 (CE2-4.10: Constraint on constructed affine MV range) [J. Zhao (LGE)] [late]

[JVET-N0398](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6120) CE2-4.4: Affine block memory bandwidth reduction by MV clip [X. Li, G. Li, X. Xu, S. Liu (Tencent)]

## CE3: Intra prediction and mode coding (19)

Contributions in this category were discussed Wednesday 20 March 0900–1345 (Track A chaired by JRO).

[JVET-N0023](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6232) CE3: Summary Report on Intra Prediction and Mode Coding [G. Van der Auwera, L. Li, A. Filippov]

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

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

* CE3-1: Cross-component prediction (18 tests)
* CE3-2: Small block size restrictions (5 tests)
* CE3-3: MPM list harmonization (12 tests)
* CE3-4: Affine linear weighted intra prediction (2 tests)

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

CTC conditions as agreed at the 13th JVET meeting (Marrakech, MA) for SDR (JVET-M1010) are followed for the evaluation of objective performance. The anchor is the ‘VVC Test Model’ or VTM. Results are provided for the ‘All Intra’ and ‘Random Access’ test configurations for all sub-tests, and additionally the ‘Low Delay B’ configuration for sub-test CE3-2. The VTM version 4.0 software is used with ‘vtm’ configuration files to produce the VTM anchor. Tools are implemented into the VTM version 4.0 software.

In addition to VTM-4.0, a modified codebase is also used for evaluating the tests in CE3-3. In the codebase, a macro is added on top of VTM-4.0 to always include all MPMs (6 MPMs in VTM-4.0) for full encoder R-D checking in intra mode decision. For evaluating the coding performance of each CE3-3 test, following Test A and Test B results are reported:

* Test A:
  + Anchor: VTM-4.0
  + Tested: VTM-4.0 with test method
* Test B:
  + Anchor: Codebase
  + Tested: Codebase with test method

Separate test results (A and B) are provided for modifications to the encoder search algorithm other than the one described above.

Proposals are compared with respect to objective compression efficiency while complexity is also assessed.

3-1, category on CCLM simplifications:

|  |  |  |
| --- | --- | --- |
| **Test #** | **Short description** | **Doc. #** |
| 3-1.1.1 | Selection of the up to 6 samples is applied to the down-sampled luma samples | JVET-N0387 (Technicolor) |
| 3-1.2.1 | Reduction of reference samples to N points for CCLM (CCLM\_LT, CCLM\_T, and CCLM\_L), using an offset, with N being set according to the size of the block | JVET-N0131 (Xidian Univ., NPU, OPPO) |
| 3-1.2.2 | Reduction of reference samples to N points for CCLM (CCLM\_LT, CCLM\_T, and CCLM\_L), using an offset, with N being set fixed (i.e., uniform for all block sizes) |
| 3-1.3.1 | Skipping initial P reference samples for CCLM\_L and CCLM\_T, with P being set according to the size of the block | JVET-N0130 (NPU, Xidian Univ., OPPO) |
| 3-1.3.2 | Test 3-1.3.1 + Test 3-1.2.1 |
| 3-1.3.3 | Test 3-1.3.1 + Test 3-1.2.2 |
| 3-1.4.1 | CCLM parameter calculation with half number of reference samples | JVET-N0228 (LGE) |
| 3-1.4.2 | CCLM parameter calculation with half and upper-limited reference samples |
| 3-1.5 | CCLM model derived from four neighbouring luma samples | JVET-N0271 (Bytedance, Peking Univ.) |
| 3-1.6.1 | Identify the min/max luma samples without down-sampling process; apply the 6-taps filter on the identified min/max samples to generate the filtered (down-sampled) min/max luma samples for the derivation of α and β. | JVET-N0321 (Kwai) |
| 3-1.6.2 | Combination of test 3-1.6.1 with JVET-M0108 (test 3-1.1.1) |
| 3-1.6.3 | Combination of test 3-1.6.1 with JVET-M0211 (test 3-1.2.2) |
| 3-1.6.4 | Combination of test 3-1.6.1 with JVET-M0211+JVET-M0212 (test 3-1.3.3) |
| 3-1.6.5 | Combination of test 3-1.6.1 with JVET-M0219 (test 3-1.4.2) |
| 3-1.6.6 | Combination of test 3-1.6.1 with JVET-M0274 (test 3-1.5) |

An overview of the tested methods for reducing reference samples used in calculation of CCLM model parameters is provided in following table:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Test #** | **#ref samples LT\_CCLM** | **#ref\_samples T\_CCLM** | **#ref\_samples L\_CCLM** | **Locations** | **#comparison operations** |
| VTM4 | Up to 2\*min(W,H) (if avail.) | Up to 2\*W (if avail.) | Up to 2\*H (if avail.) | Note: W, H are chroma TB dimensions | 2\*#ref\_samples |
| 3-1.1.1 | 6 (3 top line, 3 left) | 3 | 3 | #ref samples LT\_CCLM = nS\_T + nS\_L  #ref\_samples T\_CCLM = nS\_T  #ref\_samples L\_CCLM = nS\_L  Top: (0, – 1), (nS\_T – 1, – 1), (nS\_T/2, – 1)  Left: (– 1, 0), (– 1, nS\_L – 1), (– 1, nS\_L/2) |  |
| 3-1.2.1 | 2 (min(W,H) == 2) or 4 | 2 (W == 2) or 4 | 2 (H == 2) or 4 | Example:  -Original reference samples number: ***L***=16  -Reduced reference samples number: ***N****=*4  -Sampling interval: =4  -Starting offset = /2 =2 | 4 (min(W,H) == 2) or 8 |
| 3-1.2.2 | 4 | 4 | 4 | 8 |
| 3-1.3.1 | Idem VTM4 | Up to ¾ (2\*W) | Up to ¾ (2\*H) | Skipping initial quarter of reference samples for CCLM\_L and CCLM\_T (VTM4) | -LT\_CCLM:  Idem VTM4  -L\_CCLM:  Up to 3W  -T\_CCLM:  Up to 3H |
| 3-1.3.2 | 4 | 2 (if after offset, #samples remaining is <4) or 4 | 2 (if after offset, #samples remaining is <4) or 4 | -LT\_CCLM: 4  -L\_CCLM and \_T\_CCLM:  Initial offset is set as the first quarter of the reference samples (skipped). Then, reference samples are selected according to the method in 3-1.2.1 | Up to 8 |
| 3-1.3.3 | 4 | 4 | 4 | -LT\_CCLM: 4  -L\_CCLM and \_T\_CCLM:  Initial offset is set as the first quarter of the reference samples (skipped). Then, reference samples are selected according to the method in 3-1.2.2 | 8 |
| 3-1.4.1 | Up to min(W,H) (if avail.) | Up to W (if avail.) | Up to H (if avail.) | Half of VTM4 reference samples are used | #ref\_samples |
| 3-1.4.2 | Up to min(W,H) (if avail.) (max. 8) | Up to W (if avail.) (max. 8) | Up to H (if avail.) (max. 8) | Half of VTM4 reference samples are used, up to 8 max. | #ref\_samples (up to 16) |
| 3-1.5 | 4 | 4 | 4 | * LT\_CCLM: W’=W, H’=H * T\_CCLM: W’=W+H * L\_CCLM: H’=H+W   4 samples are selected as:   * LT\_CCLM: S[W’/4, -1], S[3W’/4, -1], S[-1, H’/4], S[-1, 3H’/4] * T\_CCLM: S[W’/8, -1], S[3W’/8, -1], S[5W’/8, -1], S[7W’/8, -1] * L\_CCLM: S[-1, H’/8], S[-1, 3H’/8], S[-1, 5H’/8], S[-1, 7H’/8]   4 neighbouring luma samples at the selected positions are down-sampled and compared four times to find two smaller values: *x*0*A* and *x*1*A*, and two larger values: *x*0*B* and *x*1*B*. Corresponding chroma sample values are denoted as *y*0*A*, *y*1*A*, *y*0*B* and *y*1*B*. Then *xA*, *xB*, *yA* and *yB* are derived as for model calc.:  *xA*=(*x*0*A* + *x*1*A* +1)>>1; *xB*=(*x*0*B* + *x*1*B* +1)>>1; *yA*=(*y*0*A* + *y*1*A* +1)>>1; *yB*=(*y*0*B* + *y*1*B* +1)>>1. | 4 |
| 3-1.6.1 | Method applied to VTM4 | | | Reconstructed luma samples without down-sample filtering to find the min/max luma samples, followed by filtering before model parameter calc. | Same as VTM4 |
| 3-1.6.2 | Method applied to test 3-1.1.1 | | | Same as 3-1.1.1 |
| 3-1.6.3 | Method applied to test 3-1.2.2 | | | Same as 3-1.2.2 |
| 3-1.6.4 | Method applied to test 3-1.3.3 | | | Same as 3-1.3.3 |
| 3-1.6.5 | Method applied to test 3-1.4.2 | | | Same as 3-1.4.2 |
| 3-1.6.6 | Method applied to test 3-1.5 | | | Same as 3-1.5 |

Continuation of above table:

|  |  |  |
| --- | --- | --- |
| **Test #** | **# comparison operation in worst case** | **# downsampling samples in worst case** |
| VTM4 | 8 | 4 |
| 3-1.1.1 | 5 | 4 |
| 3-1.2.1 | 4 | 4 |
| 3-1.2.2 | 8 | 4 |
| 3-1.3.1 | 8 | 4 |
| 3-1.3.2 | 4 | 4 |
| 3-1.3.3 | 8 | 4 |
| 3-1.4.1 | 4 | 2 |
| 3-1.4.2 | 4 | 2 |
| 3-1.5 | 4 | 4 |
| 3-1.6.1 | 8 | 2 |
| 3-1.6.2 | 8 | 2 |
| 3-1.6.3 | 8 | 2 |
| 3-1.6.4 | 8 | 2 |
| 3-1.6.5 | 4 | 2 |
| 3-1.6.6 | 4 | 0 |

The worst case above relates to a unit of 2x2 chroma block.

This would also be resolved by disallowing 2x2 chroma blocks (as investigated in CE3-2).

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10 - Over VTM-4.0** | | | | | **Random Access Main10 - Over VTM-4.0** | | | | |
| **Test #** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 3-1.1.1 | 0.08% | 0.14% | 0.17% | 98% | 97% | 0.02% | -0.02% | 0.01% | 100% | 99% |
| 3-1.2.1 | -0.03% | -0.11% | -0.21% | 100% | 100% | -0.01% | -0.24% | -0.27% | 100% | 100% |
| 3-1.2.2 | -0.03% | -0.24% | -0.31% | 100% | 99% | -0.01% | -0.35% | -0.46% | 100% | 100% |
| 3-1.3.1 | -0.02% | -0.06% | -0.13% | 100% | 99% | -0.01% | -0.11% | -0.20% | 100% | 100% |
| 3-1.3.2 | -0.02% | 0.02% | -0.08% | 100% | 99% | 0.01% | -0.07% | -0.18% | 100% | 100% |
| 3-1.3.3 | -0.03% | -0.06% | -0.17% | 100% | 99% | -0.01% | -0.23% | -0.40% | 100% | 100% |
| 3-1.4.1 | 0.00% | 0.07% | 0.03% | 100% | 100% | 0.00% | 0.08% | -0.04% | 101% | 101% |
| 3-1.4.2 | 0.00% | 0.04% | 0.01% | 101% | 100% | 0.01% | 0.04% | -0.12% | 101% | 101% |
| 3-1.5 | -0.05% | -0.30% | -0.38% | 99% | 100% | -0.05% | -0.36% | -0.63% | 100% | 100% |
| 3-1.6.1 | 0.02% | 0.19% | 0.22% | 99% | 97% | 0.02% | 0.22% | 0.14% | 98% | 98% |
| 3-1.6.2 | 0.05% | 0.32% | 0.33% | 99% | 98% | 0.02% | 0.16% | 0.16% | 99% | 99% |
| 3-1.6.3 | -0.02% | -0.07% | -0.13% | 100% | 98% | 0.00% | -0.18% | -0.27% | 100% | 99% |
| 3-1.6.4 | -0.02% | 0.08% | -0.05% | 100% | 99% | 0.00% | -0.02% | -0.13% | 99% | 98% |
| 3-1.6.5 | 0.01% | 0.18% | 0.13% | 100% | 100% | 0.02% | 0.11% | 0.08% | 99% | 99% |
| 3-1.6.6 | 0.00% | 0.20% | 0.08% | 101% | 100% | 0.00% | 0.20% | -0.01% | 100% | 100% |

There is not really a problem in terms of complexity, but simplifying things and unifying logic across different block sizes may be desirable.

Switching to different logic for different block sizes may not always be desirable

There is an issue in VTM with large block sizes in that the number of comparisons scales up with the number of reference samples, which may not be necessary

3-1.2.2 and 3-1.5 are using the same (or at least similar) locations of filtering (4 positions), are unifications and simplifications according to the aspects above, where 3-1.2.2 has more comparisons, and 3-1.5 replaces some comparison by additional averaging operation. 3-1.5 has a very small gain.

3-1.6.1 through 3-1-6.5 switches min/max and filtering, which may be undesirable due to the fact that the result of min/max imposes which samples to access for filtering.

3-1.6.6 completely omits the filtering, and combines it with the averaging operation of 3.1.5. Some concern expressed this may not be desirable, as there is some indication of minor losses of 0.05%, and the filtering is very regular operation, no concern of complexity)

3-1.6.6 is the simplest solution (no filtering), 3-1.2.2 and 3.1.5 are also clear simplifications relative to current VTM, have comparable complexity.

3-1.5 is the best solution in this group (candidate for adoption).

Decision: Adopt JVET-N0271 (Cross-checker confirmed during JVET plenary the appropriateness of text and matching with software)

CE3-1, category on multi-model LM:

|  |  |  |
| --- | --- | --- |
| **Test #** | **Short description** | **Doc. #** |
| 3-1.7 | Multiple-model LM with small block size restriction | JVET-N0264 (Foxconn, Qualcomm) |
| 3-1.8.1 | Multiple-model LM using piecewise linear model and block size restriction | JVET-N0241 (Canon) |
| 3-1.8.2 | More stringent block size restriction on CCLMs with JVET-M0384 included. |

Summary of the tested methods:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | CCLM | CE3-1.7 | CE3-1.8.1 | CE3-1.8.2 |
| Signalling | 3 modes | 6 modes | 3 modes (CCLM or MMLM depending on block size) | 3 modes (CCLM or MMLM depending on block size) |
| Number of lines used for model derivation | Y: 2 lines above, 3 lines left, C: 1 line above and left); 1 line above at CTU boundary | idem | idem | idem |
| Chroma block sizes applicable | nSamples >= 4 (all block sizes) | CCLM: nSamples >= 4 (all sizes)  MMLM: nSamples > 16 | CCLM: 4 <= nSamples < 16  MMLM: nSamples >= 16 | CCLM: 16 <= nSamples < 64  MMLM: nSamples >= 64 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10 - Over VTM-4.0** | | | | | **Random Access Main10 - Over VTM-4.0** | | | | |
| **Test #** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 3-1.7 | -0.27% | -1.56% | -2.13% | 100% | 100% | -0.13% | -1.29% | -1.75% | 100% | 100% |
| 3-1.8.1 | -0.30% | -0.97% | -1.45% | 100% | 102% | -0.16% | -0.97% | -1.39% | 100% | 111% |
| 3-1.8.2 | -0.26% | -0.63% | -0.99% | 100% | 104% | -0.11% | -0.47% | -0.70% | 100% | 111% |

MMLM requires computation of two models, plus an additional classification of samples to determine the two groups of samples from which the models are computed.

Also during prediction, a classification is necessary to determine which model is applied to a given chroma sample.

To keep the worst case complexity, MMLM is only applied to larger blocks (larger than 16 in 3-1.7, larger/equal 16 in 3-1.8). 3-1.8 reuses the current signalling, enforces MMLM always to be used for larger blocks.

The additional gain over CCLM is not large enough to justify the additional complexity. No action on multi-model.

CE3-2: Small block size restrictions

|  |  |  |
| --- | --- | --- |
| **Test #** | **Short description** | **Doc. #** |
| 3-2.1.1 | Disable 2x2/4x2/2x4 in dual tree only | JVET-N0137 (Sharp) |
| 3-2.1.2 | Disable 2x2/4x2/2x4 in dual tree and use DC only for 2x2/4x2/2x4 intra chroma prediction |
| 3-2.1.3 | 3-2.1.1 + 3-2.2 | JVET-N0140 (Sharp, MediaTek) |
| 3-2.2 | Share reference samples for at least 16 chroma samples in both dual and shared tree | JVET-N0081 (MediaTek) |
| 3-2.3 | Disable intra chroma 2x2, 2x4 and 4x2 in dual tree. And use a 2x8 or 8x2 coefficient group size instead of a 2x2 coefficient group size on remaining intra chroma blocks which has width or height size as 2. | JVET-N0102 (Canon) |

Summary table of the methods per tree type:

|  |  |  |
| --- | --- | --- |
| **Test** | **Shared trees** | **Separated trees** |
| 3-2.1.1 |  | Disables 2x2, 2x4, and 4x2 |
| 3-2.1.2 | DC mode for small blocks | Disables 2x2, 2x4, and 4x2 |
| 3-2.1.3 | Shared reference sample in parallel regions with minimum size of 16 | Disables 2x2, 2x4, and 4x2 |
| 3-2.2 | Shared reference sample such that a region with minimum size of 16 can be processed in parallel | |
| 3-2.3 | Blocks of width or height of 2 use a 2x8 or 8x2 coefficient group size, respectively | Disables 2x2, 2x4, and 4x2 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10 - Over VTM-4.0** | | | | | **Random Access Main10 - Over VTM-4.0** | | | | |
| **Test #** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 3-2.1.1 | 0.02% | 0.37% | 0.49% | 100% | 100% | 0.01% | 0.30% | 0.36% | 101% | 101% |
| 3-2.1.2 | 0.02% | 0.37% | 0.49% | 100% | 100% | 0.10% | 0.61% | 0.74% | 100% | 101% |
| 3-2.1.3 | 0.02% | 0.37% | 0.49% | 101% | 101% | 0.06% | 0.46% | 0.62% | 101% | 102% |
| 3-2.2 | 0.03% | 0.30% | 0.33% | 100% | 101% | 0.06% | 0.29% | 0.48% | 101% | 101% |
| 3-2.3 | 0.02% | 0.33% | 0.47% | 96% | 94% | 0.02% | 0.24% | 0.32% | 100% | 99% |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Low Delay B Main10 - Over VTM-4.0** | | | | |
| **Test #** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 3-2.1.1 | 0.00% | 0.18% | 0.15% | 100% | 101% |
| 3-2.1.2 | 0.07% | 0.66% | 0.53% | 100% | 101% |
| 3-2.1.3 | 0.04% | 0.44% | 0.42% | 101% | 101% |
| 3-2.2 | 0.02% | 0.43% | -0.20% | 100% | 100% |
| 3-2.3 | -0.02% | 0.22% | 0.24% | 100% | 100% |

From the solutions investigated in CE, 3-2.1.3 is the best approach resolving the dependency issues of small chroma blocks. The compression loss would be in an acceptable range. There are however CE related contributions which might come with less loss.

After reviewing CE related contributions it was agreed that disabling the 2x2, 4x2 and 2x4 chroma block cases in dual tree is the right direction to go. However, for the single tree case, the CE related contributions provide simpler solutions than re-defining the reference samples for small block cases. .

Decision: Adopt from JVETN0137, test 3-2.1.1

CE3-3: Harmonization of MPM list

|  |  |  |
| --- | --- | --- |
| **Test #** | **Short description** | **Doc. #** |
| 3-3.1.1 | Unified MPM list generation with changed order to include tools such as MRL, intra sub-partition coding, etc. | JVET-N0184 (Huawei, LGE) |
| 3-3.1.2 | Harmonization of luma intra mode coding (including MRL, intra sub-partitioning, etc.) | JVET-N0451 (LGE, Huawei) |
| 3-3.2.1 | Simplification of MPM derivation | JVET-N0134 (ETRI) |
| 3-3.2.2 | Simplification of MPM derivation with changed order described in JVET-M0295 |
| 3-3.2.3 | Withdrawn |
| 3-3.3.1 | Unification of MPM list generation with prioritization of Planar mode in MPM list | JVET-N0393 (Tencent) |
| 3-3.3.2 | Unification of MPM list generation with Planar and DC modes being first two MPMs of zero reference line, each of the first two bins of MPM index is coded using one context |
| 3-3.3.3 | Unification of MPM list generation with Planar and DC modes being first two MPMs of zero reference line, the first bin of MPM index is coded using more than one context |
| 3-3.4.1 | Planar/DC coded as separate modes | JVET-N0436 (Sharp) |
| 3-3.4.2 | Same as previous test, but with modified encoder search described in JVET-M0528 |
| 3-3.4.3 | Planar/DC coded as separate modes, use 4MPMs described in JVET-M0494 |
| 3-3.5.1 | Explicitly signal Planar&DC  MPM list and intra\_luma\_ref\_idx signalling only for angular mode | JVET-N0104 (Fujitsu)  Comment: uploaded late on 17 Mar. |
| 3-3.5.2 | Test 3.3.5.1, use 4MPMs described in JVET-M0494 |

It was commented on the CE3 participants email list that full test results were due by T3 (4 March 2019), and the following is an overview of lateness as provided by one test proponent:

CE3-3.1.1: March 13 (9 days late), uploaded document

CE3-3.1.2: March 17 (13 days late), uploaded document

CE3-3.2: March 6 (2 days late), uploaded to gitlab; bug fixed version (Mar. 20).

CE3-3.3: March 10 (6 days late), uploaded to gitlab; bug fixed version (Mar. 20).

CE3-3.4: March 4 (on time), uploaded to gitlab

CE3-3.5: March 17 (13 days late), uploaded document

The following table provides a summary of some aspects of the CE3-3 methods.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **VTM-4.0** | **3.1.1** | **3.1.2** | **3.2.1** | **3.2.2** | **3.3.1** | **3.3.2** | **3.3.3** | **3.4.1** | **3.4.2** | **3.4.3** | **3.5.1** | **3.5.2** |
| # MPMs (regular) | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 2+6 | 2+6 | 2+4 | 2+4 | 2+4 |
| # MPMs (MRL) | 6 | 5 | 4 | 6 | 6 | 4 | 4 | 4 | 6 | 6 | 4 | 6 | 4 |
| # MPMs (ISP) | 6 | 6 | 5 | 6 | 6 | 5 | 5 | 5 | 1+6 | 1+6 | 1+4 | 1+5 | 1+4 |
| Re-index if fewer | No | Yes | Yes | No | No | Yes | Yes | Yes | NA | NA | NA | NA | NA |
| Context-coded | No | Yes  (\*)  (1st bin) | No | No | No | No | Yes  (\*)  (1st, 2nd bins) | Yes  (\*)  (1st, 2nd bins) | Yes  (\*\*) | Yes  (\*\*) | Yes  (\*\*) | Yes  (\*\*) | Yes  (\*\*) |
| # contexts added | - | 3 | - | - | - | - | 1+1 | 3+1 | 10+2 | 10+2 | 10+2 | 5+1 | 5+1 |

(\*) mpm\_idx

(\*\*) angular flags and planar\_or\_dc\_flag

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test #** | **All Intra Main10 - Over VTM-4.0** | | | | | **Random Access Main10 - Over VTM-4.0** | | | | |
| **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 3-3.1.1 | -0.08% | -0.05% | -0.07% | 101% | 100% | -0.04% | 0.00% | -0.09% | 101% | 99% |
| 3-3.1.2 | -0.04% | 0.02% | 0.00% | 98% | 99% | 0.01% | 0.00% | -0.08% | 100% | 99% |
| 3-3.2.1 | 0.10% | 0.12% | 0.10% | 102% | 100% | 0.03% | 0.01% | -0.05% | 100% | 100% |
| 3-3.2.2 | -0.05% | 0.03% | 0.00% | 102% | 100% | -0.02% | 0.00% | -0.09% | 100% | 100% |
| 3-3.3.1 | -0.02% | 0.04% | 0.02% | 99% | 100% | 0.01% | 0.00% | -0.09% | 99% | 100% |
| 3-3.3.2 | -0.07% | -0.01% | 0.00% | 99% | 100% | -0.02% | -0.02% | -0.04% | 99% | 100% |
| 3-3.3.3 | -0.11% | -0.08% | -0.05% | 100% | 100% | -0.02% | -0.05% | 0.00% | 99% | 100% |
| 3-3.4.1 | -0.11% | -0.08% | -0.09% | 99% | 101% | -0.02% | -0.02% | -0.13% | 100% | 100% |
| 3-3.4.2 | -0.29% | -0.20% | -0.17% | 103% | 100% | -0.08% | -0.01% | -0.07% | 100% | 100% |
| 3-3.4.3 | -0.05% | -0.05% | -0.02% | 97% | 100% | 0.00% | -0.01% | -0.04% | 99% | 99% |
| 3-3.5.1 | -0.09% | -0.06% | -0.07% | 100% | 98% | -0.03% | -0.01% | -0.07% |  |  |
| 3-3.5.2 | -0.05% | -0.05% | -0.02% | 100% | 98% |  |  |  |  |  |

Currently, three independent processes are defined in spec and software for constructing MPM in cases of regular, multi-line and ISP intra prediction. All proposals are unifying this to a single MPM list construction, but some aspects may still be different, e.g. substitutions.

All proposals are then making the MPM index coding in some regard different for the three cases, e.g. by using different number of indexes, re-indexing, separating DC/planar signalling.

Some of the proposals are introducing additional context coded bins, e.g. for the additional DC/planar flag, or for MPM index.

In terms of results, two versions were investigated: “Test A” (called VTM4 intra search), “Test B” (called VTM4 intra search + 6 MPM in full RD check list). However, the original intent of using exactly the same encoder search for all proposals turned out to be not easy to follow, as obviously the way of constructing and coding an MPM list, and the decision of which modes would not be checked are interrelated. The appropriate way of resolving this might have been full search which is not practical. Therefore, Test B was defined believing that it would be closer to full search, but there is some debate among proponents about this, because some believe that the additional MPMs are not necessarily optimum for their proposals. So far, it has not been analysed in detail to which extent proposal-specific encoder optimization was used, and to which extent proposals have used their own MPMs preferentially, etc.

From the current results in compression performance, it is difficult to draw conclusions.

Currently, no proposal on the table is fulfilling the desirable amount of harmonization.

Ideally, a harmonization should use identical method of MPM list construction and identical method of MPM coding for all three cases, and come with no loss in compression performance and no increase in complexity.

There are various non-CE proposals which are verbally claimed to provide better solutions. Necessary to continue this CE, but also with better definition of test conditions to make proposals comparable, and complexity assessment.

BoG (G.v.d.Auwera) to further discuss this, and review the related proposals.

CE3-4 Affine weighted intra prediction

|  |  |  |
| --- | --- | --- |
| **Test #** | **Short description** | **Doc. #** |
| 3-4.1 | Affine linear weighted intra prediction, i.e., to store all matrices and offsets needed, is restricted to be not more than 8 Kilobyte | JVET-N0217 (HHI) |
| 3-4.2 | Architectural variations of the affine linear weighted intra prediction will be studied which do not exceed the total memory requirement of 8 Kilobyte |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10 - Over VTM-4.0** | | | | | **Random Access Main10 - Over VTM-4.0** | | | | |
| **Test #** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 3-4.1 | -0.79% | -0.27% | -0.28% | 138% | 99% | -0.42% | -0.63% | -0.64% | 104% | 99% |
| 3-4.2 | -0.82% | -0.24% | -0.32% | 141% | 99% | -0.44% | -0.54% | -0.63% | 105% | 101% |

It is noted that 3-4.2 is further optimization that was not in the original CE description.

No more than 4 multiplications per sample

Most concerns of hardware experts seem to be resolved

Further review necessary, some experts would like to study this further, including text, software, etc.

To be clarified how the tables should be conveyed in the spec.

Presentation should also report result and method of reduced-complexity encoder version

Presentation was given in Sunday plenary

The presentation deck to be made available

Gain in AI 0.5% with less complex encoder, 10% run time increase. For RA this would be 0.39% with 2% run time increase.

Different matrices for different block sizes, and different matrices for different classes of block sizes, and different numbers of modes (less than 8 kByte memory to store the matrices)

It is commented that it would be desirable to reduce the word length of matrices lower than 10 bit.

It is offered that the training algorithm could be offered.

Software implementation should be cleaner, currently SIMD code which may not bring speedup.

Some concern is raised from hardware experts that the matrix multiply is a new building block that is not there for other intra prediction modes.

It is noted that there may be some interference with secondary transform.

Some experts raised concern that the method does not use the MPM list method.

It is asked if it also shows good performance with HDR.

In terms of complexity/performance tradeoff this is a cornercase.

It was suggested to adopt the proposal under the following conditions:

- Matrices to be specified and implemented with 8 bit precision

- The tool may be removed if the gain is significantly lower in combination with other tools as per AHG13 study

- Encoder search to be cleaned up

Training algorithm for matrices will be provided.

Decision: Adopt JVET-N0217, CTC with the fast encoder version

– adopt or stop further investigating it.

[JVET-N0081](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5801) CE3-2.2: Shared reference samples for multiple chroma intra CBs [Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0102](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5822) CE3-2.3: Chroma block coding and size restriction [C. Rosewarne, J. Gan (Canon)]

[JVET-N0104](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5824) CE3-3.5 Explicitly signal non angular modes in intra mode coding [J. Yao, J. Zhu, W. Cai, K. Kazui (Fujitsu)] [late]

[JVET-N0130](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5850) CE3: Reduced reference samples range for CCLM\_L and CCLM\_T (Tests 1.3.1, 1.3.2 and 1.3.3) [S. Wan (NPU), Q.-H. Ran, X.-W. Li, J.-Y. Huo, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.), Y.-F. Yu, Y. Liu (OPPO)]

[JVET-N0131](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5851) CE3: Offset-based reference sample reduction for CCLM (Tests 1.2.1 and 1.2.2) [J.-Y. Huo, X.-W. Li, J.-L. Wang, X.-Y. Chai, Y.-Z. Ma, F.-Z. Yang, B.-Z. Shen (Xidian Univ.), S. Wan (NPU), Y.-F. Yu, Y. Liu (OPPO)]

[JVET-N0134](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5854) CE3: Simplification of MPM derivation (CE3-3.2) [J. Lee, H. Lee, S.-C. Lim, J. Kang, H. Y. Kim (ETRI)]

[JVET-N0137](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5857) CE3-2.1: Intra chroma partitioning and prediction [[T. Zhou](mailto:zhou.tianyang@sharp.co.jp), [T. Ikai (Sharp)](mailto:ikai.tomohiro@sharp.co.jp)]

[JVET-N0140](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5860) CE3-2.1.3: Combination of CE3-2.1.1 and CE3-2.2 [T. Zhou, T. Ikai (Sharp), Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0184](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5904) CE3-3.1.1: Unified MPM list generation with changed order to include tools such as MRL, intra sub-partition coding, etc. [B. Wang, A. M. Kotra, S. Esenlik, H. Gao, J. Chen (Huawei), L. Li, J. Heo, J. Choi, S. Yoo, J. Lim, S. Kim (LGE)]

[JVET-N0217](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5937) CE3: Affine linear weighted intra prediction (CE3-4.1, CE3-4.2) [J. Pfaff, B. Stallenberger, M. Schäfer, P. Merkle, P. Helle, T. Hinz, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

[JVET-N0582](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6316) Crosscheck of JVET-N0217 (CE3: Affine linear weighted intra prediction (CE3-4.1, CE3-4.2)) [F. Racapé (Technicolor)] [late]

[JVET-N0228](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5948) CE3: Reduced number of reference samples for CCLM parameter calculation (CE3-1.4.1 and CE3-1.4.2) [J. Choi, J. Heo, S. Yoo, L. Li, J. Choi, J. Lim, S. Kim (LGE)]

[JVET-N0241](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5961) CE3: Results of Test CE3-1.8 on multiple model LM using piecewise linear model [C. Gisquet, G. Laroche, P. Onno, J. Taquet (Canon)]

[JVET-N0264](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5985) CE3-1.7: Multiple-model LM with small block size restriction [P.-H. Lin (Foxconn), A. K. Ramasubramonian, G. Van der Auwera, T. Hsieh, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-N0271](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5992) CE3-1.5: CCLM derived from four neighbouring samples [M. Wang, K. Zhang (Bytedance)]

[JVET-N0321](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6042) CE3: Simplification of LM mode (CE3-1.6) [Y.-W. Chen, H.-J. Jhu, X. Wang (Kwai Inc.)]

[JVET-N0577](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6311) Crosscheck of JVET-N0321: CE3: Simplification of LM mode (Tests CE3-1.6.3 and CE3-1.6.5) [L. Pham Van, G. Van der Auwera, A. K. Ramasubramonian, H. Huang, M. Karczewicz (Qualcomm)] [late]

[JVET-N0387](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6109) CE3: report of CE3-1.1 on reduction of the number of reference samples in CCLM mode [E. François (Technicolor)]

[JVET-N0393](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6115) CE3-3.3: MPM list harmonization [L. Zhao, X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-N0436](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6158) CE3-3.4.1, CE3-3.4.2, CE3-3.4.3: Results for unified MPM list construction process [F. Bossen, K. Misra (Sharp Labs of America)]

[JVET-N0451](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6173) CE3-3.1.2: Harmonization on MPM list [J. Heo, L. Li, J. Choi, J. Choi, S. Yoo, J. Lim, S. Kim (LGE)]

## CE4: Inter prediction and motion vector coding (18)

[JVET-N0024](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6365) CE4: Summary report on inter prediction and motion vector coding [H. Yang, G. Li, K. Zhang]

Discussed Wednesday 20 March 1115-1300 (GJS).

This contribution provides a summary report of Core Experiment 4 on inter prediction and motion vector coding. CE4 comprises 4 categories,

1. Merge mode signalling
2. STMVP
3. MMVD modification
4. TPM merge list modification

All techniques are implemented on top of and test against VTM-4.0. Simulation results and crosschecking reports of each test specified in this document are provided.

**CE4-1: Merge mode signaling**

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| **Test#** | **Source** | **Description** |
| 4-1.1 | JVET-N0141 | Signalling MMVD syntax elements when merge\_flag equal to 0. |
| 4-1.2.a | JVET-N0324 | Signal a regular merge flag right after the merge flag and skip flag to indicate whether the regular merge/skip mode is used by the current CU |
| 4-1.2.b | JVET-N0324 | Combination of test 4-1.2.a with 4-1.1 |
| 4-1.3 | JVET-N0237 | Change the MMVD flag position, and remove unnecessary syntax element |
| 4-1.4.a | JVET-N0252 | Signal a merge\_subblock\_flag and a merge\_triangle\_flag consecutively |
| 4-1.4.b | JVET-N0252 | Combination of test 4-1.4.a with 4-1.1 |
| 4-1.4.c | JVET-N0252 | Combination of test 4-1.4.a with 4-1.3 |
| 4-1.5.a | JVET-N0212 | Remove TMVP merge candidate for the block size with samples <= 32 |
| 4-1.5.b | JVET-N0212 | Remove TMVP merge candidate for the block size with samples <= 64 |
| 4-1.5.c | JVET-N0212 | Remove TMVP merge candidate for the block size of 4xN / Nx4 and 8x8 |

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|  | **Random Access Main 10** | | | | | **Low delay B Main10** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 4-1.1 | -0.03% | -0.01% | 0.02% | 99% | 101% | -0.06% | 0.02% | -0.15% | 102% | 101% |
| 4-1.2.a | -0.01% | -0.07% | -0.06% | 102% | 102% | -0.07% | 0.30% | 0.15% | 101% | 99% |
| 4-1.2.b | 0.09% | 0.07% | 0.15% | 100% | 101% | 0.04% | 0.31% | 0.17% | 101% | 99% |
| 4-1.3 | -0.02% | -0.17% | -0.11% | 101% | 100% | -0.01% | 0.08% | -0.29% | 101% | 100% |
| 4-1.4.a | -0.01% | -0.09% | -0.03% | 102% | 102% | -0.03% | 0.02% | -0.10% | 95% | 89% |
| 4-1.4.b | -0.01% | 0.06% | 0.06% | 102% | 102% | -0.05% | 0.01% | -0.05% | 96% | 87% |
| 4-1.4.c | -0.02% | -0.10% | -0.06% | 103% | 103% | -0.02% | -0.07% | -0.39% | 92% | 82% |
| 4-1.5.a | -0.01% | -0.04% | -0.06% | 104% | 98% | -0.01% | 0.11% | 0.03% | 81% | 100% |
| 4-1.5.b | -0.03% | -0.07% | -0.06% | 100% | 100% | 0.01% | 0.10% | -0.08% | 100% | 66% |
| 4-1.5.c | -0.03% | -0.06% | -0.04% | 100% | 102% | 0.04% | 0.04% | -0.26% | 81% | 97% |

Test 4-1.1 moves MMVD syntax from merge\_data() to coding\_unit(), trying to improve coding efficiency in high QP condition. As a coding efficiency proposal, the gain from this did not seem sufficient to justify a change. The proponent indicated that coding efficiency was not the main goal of this, but rather it is to reduce the maximum conditioning depth of branching conditions. Some other participants said that since MMVD is conceptually part of merging in an encoder, it would be less conceptually logical and confusing for encoder design to put the associated data somewhere else in the syntax. It was also commented that the maximum depth is not really a problem. So no action was taken on this.

Test 4-1.2 assigns shortest codeword to regular merge mode among all the 5 modes of merge candidates. The modified signalling order is: Regular merge, MMVD, subblock, CIIP, and TPM, rather than MMVD, subblock, CIIP, TPM, and then regular merge. The coding efficiency benefit from this was also very small, but it was commented that the test did verify that the most commonly chosen merge mode was not the one that had been first in the list. It was also commented that the current order is different from what would be expected in terms of wanting to put the modes that are most likely to be implemented/tested by an encoder first. It was commented that high-level disabling of features is another way to effectively remove entries in the list. This is a minor matter, but the current design does not seem logical. Decision (cleanup): Adopt.

Test 4-1.3 proposes removing mmvd\_merge\_flag and its context model, and the parsing of MMVD syntax being conditioned on merge\_idx being equal to 0 or 1.

There is an assumption in the current MMVD design that the merge list has at least two candidates, otherwise parsing mmvd\_merge\_flag is a waste. However, there is no checking to ensure this. The proposal removes this unnecessary syntax. This is a minor matter, but the current design does not seem logical. However, it was commented that there may be other “corner case” aspects that should be considered – for example, when considering the interaction between the triangle mode and regular merge candidates (which is discussed in some non-CE contributions). This can be further discussed in relation to some other such issues.

Test 4-1.4 divides all merge candidates into to three groups, CU merge candidates, subblock merge candidates, and triangle merge candidates, according to the type of block partitioning for motion compensation. It is proposed to put together the syntax of each group, and reorder the syntax of the three groups as subblock candidates, triangle candidates, and CU candidates. This has an interaction with the action taken on Test 4-1.2. With the action taken on 4-1.2, there is a grouping, although in a different order. So no action was needed on 4-1.4.

Test 4-1.5 proposes not using TMVP in merge for small CUs. Three criteria for identifying small CUs are tested. With the action taken in response to CE2, 4x4 inter CUs are no longer in the design and therefore don’t need to be considered. The motivation for this was said to be for improving hardware throughput by skipping some of the logic needed for list construction when small blocks are used. Different sizes were tested and that coding efficiency benefit remained negligible. It was initially planned to adopt 4-1.5.c, until further discussion was held as recorded for the BoG report N0809.

It was said that 4-1.5b and 4-1.5c have some interaction with work to simplify the MV list construction for triangle mode, since some of these are based on trying to use a similar process as in regular merge list construction with spatial and TMVP candidates. See notes of further discussion for BoG report N0809.

Discussion adjourned at 1300 and was then resumed at 1430.

**CE4-2: STMVP**

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| **Test#** | **Source** | **Description** |
| 4-2.2.a | JVET-N0285 | STMVP merge candidate, consisting in an averaged motion vector between the TMVP merge candidate and some other motion vectors predictors. |

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|  | **Random Access Main 10** | | | | | **Low delay B Main10** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 4-2.2.a | -0.13% | -0.10% | -0.10% | 101% | 101% | 0.00% | 0.23% | 0.07% | 102% | 103% |

A single STMVP (spatial and temporal averaged) motion vector candidate, if available, is proposed to be put into regular merge list before the top-left spatial motion vector candidate. The derivation of the STMVP candidate uses one temporal candidate and up to two spatial candidates in the regular merge list construction. This is a proposed additional candidate for the merge list. The coding efficiency benefit for this change seemed too small to justify the change.

**CE4-3: MMVD modification**

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| **Test#** | **Source** | **Description** |
| 4-3.1.b | JVET-N0125 | Binarization method change |
| 4-3.1.c | JVET-N0125 | Multiple distance list concept |
| 4-3.1.d | JVET-N0125 | Multiple distance list concept + binarization method change |
| 4-3.3.a | JVET-N0441 | MMVD distance table is reduced 4 and is refined based on the resolution of base motion vectors |
| 4-3.3.b | JVET-N0441 | 4-3.3.a + 4-3.4.a |
| 4-3.3.c | JVET-N0441 | 4-3.3.a + 4-1.1 |
| 4-3.3.d | JVET-N0441 | 4-3.3.b + 4-1.1 |
| 4-3.4.a | JVET-N0142 | Diagonal direction candidate for MMVD |
| 4-3.4.b | JVET-N0142 | 4-3.4.a + 4-1.1 |

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|  | **Random Access Main 10** | | | | | **Low delay B Main10** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 4-3.1.b | -0.02% | -0.12% | -0.12% | 100% | 98% | 0.00% | 0.13% | -0.28% | 100% | 101% |
| 4-3.1.c | -0.01% | -0.02% | -0.02% | 98% | 95% | 0.00% | 0.01% | -0.05% | 103% | 102% |
| 4-3.1.d | -0.02% | -0.13% | -0.12% | 100% | 98% | 0.00% | 0.10% | -0.28% | 100% | 103% |
| 4-3.3.a | 0.01% | 0.07% | 0.05% | 96% | 101% | 0.01% | 0.19% | 0.00% | 96% | 101% |
| 4-3.3.b | -0.08% | 0.09% | 0.10% | 97% | 101% | -0.05% | 0.25% | 0.21% | 96% | 100% |
| 4-3.3.c | -0.02% | 0.13% | 0.13% | 96% | 101% | -0.03% | 0.25% | 0.02% | 97% | 101% |
| 4-3.3.d | -0.11% | 0.11% | 0.17% | 97% | 101% | -0.12% | 0.20% | 0.05% | 98% | 101% |
| 4-3.4.a | -0.07% | 0.00% | 0.03% | 100% | 100% | -0.03% | 0.31% | 0.25% | 100% | 100% |
| 4-3.4.b | -0.11% | 0.02% | 0.12% | 100% | 101% | -0.08% | 0.13% | -0.14% | 101% | 100% |

Test 4-3.1.b changes the binarization of mmvd\_distance\_idx, making the codeword shorter for larger MVDs. The coding efficiency change was negligible and the change did not seem desirable for sufficient other reasons.

Test 4-3.1.c replaces the tile group header flag tile\_group\_fpel\_mmvd\_enabled\_flag by a syntax symbol that could represent 4 alternative resolutions of MMVD distance instead of 2 in the current VTM design. The coding efficiency change was negligible and the change did not seem desirable for sufficient other reasons.

Test 4-3.3.a proposes reducing the number of candidates in distance list from 8 to 4, keeping the first four smaller MVD offsets. In addition, the decoded distance is further modified according to the resolution of the base motion vector. If base MV falls on the grid of 2-pel resolution, the distance is enlarged 4x. If base mv falls on the grid of integer-pel resolution, the distance is enlarged 2x. The coding efficiency change was very small and the change did not seem desirable for sufficient other reasons.

Test 4-3.4.a proposes diagonal direction MVD offsets. With this modification, four points with the same MMVD distance index forms a diamond shape. The proposed method doubles the number of MVDs. The coding efficiency change was very small and the change did not seem desirable for sufficient other reasons.

**CE4-4: TPM merge list modification**

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| **Test#** | **Source** | **Description** |
| 4-4.1.a | JVET-N0083 | Use regular merge mode candidate list and two signaled indices. Candidate 1 select L0 MV if exist; otherwise select L1 MV. Candidate 2 select L1 MV if exist; otherwise select L0 MV. |
| 4-4.1.c | JVET-N0083 | 4-4.1.a + MV pruning and adding offset MV if necessary |
| 4-4.2.a | JVET-N0128 | Use first 3 candidates of regular merge candidate list for triangle list construction |
| 4-4.2.b | JVET-N0128 | Use first 4 candidates of regular merge candidate list for triangle list construction |
| 4-4.2.c | JVET-N0128 | 4-4.2.a + spatial temporal candidate only restriction |
| 4-4.2.d | JVET-N0128 | 4-4.2.c + simplified pruning |
| 4-4.2.e | JVET-N0128 | Use regular merge list with spatial temporal restriction |
| 4-4.2.f | JVET-N0128 | 4-4.2.e + simplified pruning |
| 4-4.3.a | JVET-N0322 | Share regular merge candidate list for triangle partition merge prediction. For RA, L0 and L1 motion vectors from the regular candidate list are selected in an interleaving manner. For LDB, L0 motion vectors are selected, followed by uni-prediction zero vectors. |
| 4-4.3.b | JVET-N0322 | Share regular merge candidate list for triangle partition merge prediction. For RA, L0 and L1 motion vectors from the regular candidate list are selected in an interleaving manner. For LDB, L0 motion vectors are selected, followed by L1 motion vectors. |
| 4-4.4.a | JVET-N0269 | Partial of the regular merge list construction process is reused. |
| 4-4.5.a | JVET-N0226 | Reduce the pruning operations in TPM merge list construction |
| 4-4.5.b | JVET-N0226 | Remove the pruning operations in TPM merge list construction |
| 4-4.6.a | JVET-N0454 | Derive triangular merge list based on the candidates of regular merge list, using same scan order. If candidate is bi-predictive, L0 part is used. |
| 4-4.6.b | JVET-N0454 | Derive triangular merge list based on the candidates of regular merge list, using same scan order. If candidate is bi-predictive, pruning is applied. |
| 4-4.7.c | JVET-N0197 | The reference index of L1 is set equal to be the same as that of L0, mirroring process is applied after offset addition |
| 4-4.7.d | JVET-N0197 | The reference index of L1 is set equal to be the same as that of L0, mirroring process is applied before offset addition |
| 4-4.8.a | JVET-N0211 | Reuse regular merge list derivation for triangle merging candidate list construction |
| 4-4.8.b | JVET-N0211 | Use candidates before HMVP in the regular merge list as the candidates for triangle merging candidate list construction |
| 4-4.9.a | JVET-N0418 | Derive merge list based on the regular list, bi-MV is split into uni-MVs and pruning is applied. |
| 4-4.9.b | JVET-N0418 | 4-4.9.a with no pruning in the final TPM merge list. |
| 4-4.9.c | JVET-N0418 | Merge list is derived based on the spatial and temporal MV candidates from the regular merge list, bi-MV is split into uni-MVs and pruning is applied |
| 4-4.9.d | JVET-N0418 | 4-4.9.c with no pruning in the final TPM merge list. |

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|  | **Random Access Main 10** | | | | | **Low delay B Main10** | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| 4-4.1.a | 0.06% | 0.00% | 0.06% | 101% | 100% | 0.15% | 0.19% | -0.01% | 100% | 100% |
| 4-4.1.c | 0.05% | 0.04% | 0.07% | 101% | 99% | 0.11% | 0.08% | -0.08% | 100% | 100% |
| 4-4.2.a | -0.03% | -0.07% | -0.11% | 100% | 100% | 0.08% | 0.12% | -0.28% | 100% | 100% |
| 4-4.2.b | -0.01% | -0.10% | -0.09% | 100% | 100% | -0.01% | -0.10% | -0.19% | 100% | 100% |
| 4-4.2.c | -0.03% | -0.04% | -0.06% | 100% | 100% | 0.04% | 0.01% | -0.09% | 100% | 100% |
| 4-4.2.d | -0.01% | -0.03% | 0.00% | 100% | 100% | 0.16% | 0.28% | -0.05% | 100% | 100% |
| 4-4.2.e | -0.03% | -0.04% | -0.09% | 100% | 100% | 0.05% | 0.16% | -0.08% | 100% | 101% |
| 4-4.2.f | 0.00% | -0.01% | 0.02% | 100% | 100% | 0.13% | 0.11% | 0.25% | 100% | 99% |
| 4-4.3.a | -0.02% | -0.09% | -0.06% | 101% | 99% | 0.16% | 0.33% | 0.03% | 100% | 100% |
| 4-4.3.b | -0.02% | -0.09% | -0.07% | 101% | 101% | 0.17% | 0.29% | 0.20% | 99% | 99% |
| 4-4.4.a | -0.02% | -0.09% | -0.11% | 100% | 100% | 0.09% | 0.20% | -0.19% | 100% | 100% |
| 4-4.5.a | 0.01% | -0.01% | 0.01% | 100% | 100% | 0.02% | 0.19% | -0.15% | 101% | 100% |
| 4-4.5.b | 0.03% | 0.01% | 0.02% | 100% | 100% | 0.14% | 0.37% | -0.04% | 101% | 101% |
| 4-4.6.a | 0.12% | 0.10% | 0.16% | 101% | 102% | 0.16% | 0.19% | 0.18% | 101% | 103% |
| 4-4.6.b | 0.00% | -0.07% | -0.09% | 101% | 102% | 0.11% | 0.12% | -0.01% | 101% | 103% |
| 4-4.7.c | 0.07% | 0.03% | 0.06% | 102% | 100% | 0.05% | -0.11% | -0.22% | 103% | 101% |
| 4-4.7.d | 0.06% | 0.03% | 0.08% | 103% | 100% | 0.05% | -0.11% | -0.22% | 104% | 100% |
| 4-4.8.a | 0.07% | 0.03% | 0.06% | 96% | 109% | 0.04% | 0.27% | 0.00% | 101% | 111% |
| 4-4.8.b | -0.03% | -0.04% | -0.09% | 96% | 110% | 0.05% | 0.16% | -0.08% | 101% | 111% |
| 4-4.9.a | -0.04% | -0.14% | -0.14% | 100% | 100% | -0.03% | 0.10% | -0.01% | 100% | 101% |
| 4-4.9.b | -0.01% | -0.08% | -0.06% | 100% | 100% | 0.31% | 0.48% | 0.06% | 100% | 102% |
| 4-4.9.c | -0.02% | -0.04% | -0.04% | 100% | 100% | 0.13% | 0.19% | 0.08% | 100% | 101% |
| 4-4.9.d | 0.00% | -0.05% | -0.07% | 101% | 101% | 0.34% | 0.45% | 0.30% | 100% | 101% |

In VTM4.0 TPM, the MV candidate list construction comprises two steps.

**Step 1. Construct the source candidate list**

* Obtain regular motion candidates from 5 spatial neighbouring blocks with full pruning.
* Obtain regular merge candidates from two temporal blocks.

**Step 2. Construct the TPM candidate list with uni-directional MVs, with full pruning**

* Loop #1: For each regular motion candidates, if it is uni-prediction (either from list 0 or list 1), it is directly added to the merge list as a TPM candidate.
* Loop #2: For each motion candidate, if it is bi-prediction, the motion information from list 0 is added as a new TPM candidate.
* Loop #3: For each motion candidate, if it is bi-prediction, the motion information from list 1 is added as a new TPM candidate.
* Loop #4: For each motion candidates, if it is bi-prediction, the motion information of list 1 is firstly scaled to list 0 reference picture, and the average of the two MVs is added as a new TPM candidate.
* Add default motion vector candidates.

The complexity is higher than regular merge candidate list construction. All tests target at reducing complexity of TPM list construction.

Most of the tests construct the regular merge list, full or partial, and use it as the source list. This is referred to as stage 1 of TPM list construction. Tests differs in stage 2 where a uni-prediction candidate list is constructed, trying to reduce the complexity in three ways, 1) reduce the number of iterations when checking the source candidate list, 2) reduce the number potential candidates, and 3) reduce the number of prunings when adding a new candidate to the list.

Test 4-4.5 is different from others in that regular merge list is not used in stage 1 TPM list construction.

Test 4-4.7 is different from others in that it firstly construct a TPM list with bi-pred MVs, by converting a uni-pred MV to a bi-pred one. And then derive a pair of uni-pred MVs from two signaled TPM candidates. Additional syntax indicating prediction direction is signaled. It removes operations in motion data storage stage by deriving bi-pred MV in the stage of TPM list construction.

A few tests do not even construct a TPM list in stage 2, and remove the complexity regarding stage 2 list construction. These tests are 4-4.1.a, 4-4.1.c, 4-4.6.a, 4-4.7.c, 4-4.7.d.

All tests are summarized below according to key elements in the design.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Test #** | **Stage 1 of TPM list construction** | | | **Stage 2 of TPM list construction** | | |  |
|  | **Candidate derivation** | **Number of candidates** | **Candidate pruning** | **Source list checking iterations** | **Conversion of Bi-pred MV** | **Candidate pruning** | **Others** |
| 4-4.1.a | Regular merge | 5 | Regular merge | - | - | - | - |
| 4-4.1.c | Regular merge | 5 | Regular merge | - | - | 1 | Add MV offsets conditionally |
| 4-4.2.a | Regular merge | 3 | Regular merge | 4 | Same as VTM4 | Full | - |
| 4-4.2.b | Regular merge | 4 | Regular merge | 4 | Same as VTM4 | Full | - |
| 4-4.2.c | Regular merge (spatial, temporal candidates) | 4 (max) | Regular merge | 4 | Same as VTM4 | Full | - |
| 4-4.2.d | Regular merge (spatial, temporal candidates) | 4 (max) | Regular merge | 4 | Same as VTM4 | Simplified pruning to only the last one | - |
| 4-4.2.e | Regular merge (spatial, temporal candidates) | 5 (max) | Regular merge | 4 | Same as VTM4 | Full | - |
| 4-4.2.f | Regular merge (spatial, temporal candidates) | 5 (max) | Regular merge | 4 | Same as VTM4 | Simplified pruning to only the last one | - |
| 4-4.3.a | Regular merge | 5 | Regular merge | 1 | Split to L0 and L1 MV | No | Different handling for RA and LDB |
| 4-4.3.b | Regular merge | 5 | Regular merge | 1 (RA)  2 (LDB) | Split to L0 and L1 MV | No | Different handling for RA and LDB |
| 4-4.4.a | Regular merge (spatial, temporal, HMVP candidates) | 5 (max) | Regular merge | 1 | Split to L0 and L1 MV | Simplified pruning, controlled by a threshold | - |
| 4-4.5.a | TPM source list | 7 (max) | Simplified pruning | 4 | Same as VTM4 | Simplified | - |
| 4-4.5.b | TPM source list | 7 (max) | Simplified pruning | 4 | Same as VTM4 | No | - |
| 4-4.6.a | Regular merge | 5 | Regular merge | 1 | Use L0 MV only | No | - |
| 4-4.6.b | Regular merge | 5 | Regular merge | 1 | Split to L0 and L1 MV | L0 vs. L1 pruning | - |
| 4-4.7.c | Regular merge | 4 | Regular merge | 1 | - | No | - |
| 4-4.7.d | Regular merge | 4 | Regular merge | 1 | - | No | - |
| 4-4.8.a | Regular merge | 6 | Regular merge | 4 | Same as VTM4 | Full | - |
| 4-4.8.b | Regular merge (spatial, temporal candidates) | 5 (max) | Regular merge | 4 | Same as VTM4 | Full | - |
| 4-4.9.a | Regular merge | 6 | Regular merge | 1 | Split to L0 and L1 MV | Full | - |
| 4-4.9.b | Regular merge | 6 | Regular merge | 1 | Split to L0 and L1 MV | No | - |
| 4-4.9.c | Regular merge (spatial, temporal candidates) | 5 (max) | Regular merge | 1 | Split to L0 and L1 MV | Full | - |
| 4-4.9.d | Regular merge (spatial, temporal candidates) | 5 (max) | Regular merge | 1 | Split to L0 and L1 MV | No | - |

Complexity analysis of list construction

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test#** | **Merge list size** | **Max number of potential candidates (stage1+stage2)** | **Max number of candidate comparison (stage1+stage2)** | **Max number of MV scaling (stage1+stage2)** | **Max number of temporal candidates (stage1+stage2)** | **Max number of MV average (stage1+stage2)** | **Max number of encoder MCs (stage1+stage2)** | **Others** |
| Regular merge | 6 | 13 | 9 | 2 | 2 | 2 | 12 |  |
| TPM | 5 | 28 (7+21) | 84 (10+74) | 11 (4+7) | 2 (2+0) | 7 (0+7) | 5 |  |
| 4-4.1.a | 5 | 13 | 9 | 2 | 2 | 2 | 10 |  |
| 4-4.1.c | 5 | 13 | 10 (9+1) | 2 | 2 | 2 | 10 | One additional MV addition (adding (1/4, 0) on second candidate) |
| 4-4.2.a | 5 | 22 (13+9) | 35 | 5 | 2 | 5 | 5 |  |
| 4-4.2.b | 5 | 25 (13+12) | 47 | 6 | 2 | 6 | 5 |  |
| 4-4.2.c | 5 | 19 (7+12) | 43 | 6 | 2 | 4 | 5 |  |
| 4-4.2.d | 5 | 19 (7+12) | 16 | 6 | 2 | 4 | 5 |  |
| 4-4.2.e | 5 | 25 (7+18) | 67 | 8 | 2 | 6 | 5 |  |
| 4-4.2.f | 5 | 25 (7+18) | 22 | 8 | 2 | 8 | 5 |  |
| 4-4.3.a | 5 | 13 | 9 | 2 | 2 | 2 | 5 |  |
| 4-4.3.b | 5 | 13 | 9 | 2 | 2 | 2 | 5 |  |
| 4-4.4.a | 5 | 15 (5+10) | 12 (9+3) | 1 | 1 | 0 | 5 |  |
| 4-4.5.a | 5 | 28 (+0) | 6+46 (-4-28) | 4+7 (+0+0) | 2 (+0) | 7 (+0) | 5 (+0) | / |
| 4-4.5.b | 5 | 28 (+0) | 6+0 (-4-74) | 4+7 (+0+0) | 2 (+0) | 7 (+0) | 5 (+0) | / |
| 4-4.6.a | 5 | 13 (13+0) | 9 (9+0) | 2 | 2 | 2 | 5 |  |
| 4-4.6.b | 5 | 23 (13+10) | 13 (9+4) | 2 | 2 | 2 | 5 |  |
| 4-4.7.c | 4 | 13 (13+0) | 9 | 2 | 2 | 2 | 8 | No mapping logic |
| 4-4.7.d | 4 | 13 (13+0) | 9 | 2 | 2 | 2 | 8 | No mapping logic |
| 4-4.8.a | 6 | 31 (13+18) | 71 (9+62) | 8 (2+6) | 2 (2+0) | 8 (2+6) | 5 |  |
| 4-4.8.b | 5 | 22 (7+15) | 55 (5+50) | 7 (2+5) | 2 (2+0) | 5 (0+5) | 5 |  |
| 4-4.9.a | 5 | 25 (13+12) | 47 (9+38) | 2 (2+0) | 2 (2+0) | 2 (2+0) | 5 |  |
| 4-4.9.b | 5 | 25 (13+12) | 9 (9+0) | 2 (2+0) | 2 (2+0) | 2 (2+0) | 5 |  |
| 4-4.9.c | 5 | 17 (7+10) | 35 (5+30) | 2 (2+0) | 2 (2+0) | 2 (2+0) | 5 |  |
| 4-4.9.d | 5 | 17(7+10) | 5 (5+0) | 2 (2+0) | 2 (2+0) | 2 (2+0) | 5 |  |

To prune the number of variants to consider, it was agreed to rule out those with 4 source list checking iterations. And 4-4.9.b, 4-4.9.d, 4-4.6.a, 4-4.1.a for coding efficiency loss in LB without sufficient other rationale. 4-4.3.a, 4-4.3.b also had some loss in LB but were suggested to further consider due eliminating pruning.

4-4.7c and 4-4.7d add additional syntax and additional encoder motion compensations (resulting in 3-4% encoder runtime increase), but reduce some decoder logic associated with MV storage. Thus, these were ruled out.

4-4.1.c was also eliminated, due to having more motion compensations than any of the other remaining variants and also showing some (small) loss.

4-4.1.c was also eliminated, due to having more motion compensations than any of the other remaining variants and also showing some (small) loss.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Test #** | **Stage 1 of TPM list construction** | | | **Stage 2 of TPM list construction** | | |  |
|  | **Candidate derivation** | **Number of candidates** | **Candidate pruning** | **Source list checking iterations** | **Conversion of Bi-pred MV** | **Candidate pruning** | **Others** |
| 4-4.3.a | Regular merge | 5 | Regular merge | 1 | Split to L0 and L1 MV | No | Different handling for RA and LDB |
| 4-4.3.b | Regular merge | 5 | Regular merge | 1 (RA)  2 (LDB) | Split to L0 and L1 MV | No | Different handling for RA and LDB |
| 4-4.4.a | Regular merge (spatial, temporal, HMVP candidates) | 5 (max) | Regular merge | 1 | Split to L0 and L1 MV | Simplified pruning, controlled by a threshold | - |
| 4-4.6.b | Regular merge | 5 | Regular merge | 1 | Split to L0 and L1 MV | L0 vs. L1 pruning | - |
| 4-4.9.a | Regular merge | 6 | Regular merge | 1 | Split to L0 and L1 MV | Full | - |
| 4-4.9.c | Regular merge (spatial, temporal candidates) | 5 (max) | Regular merge | 1 | Split to L0 and L1 MV | Full | - |

4-4.3.b has decoder logic that treats low-delay (i.e., all reference pictures are temporally preceding) as a special case, which was suggested to be undesirable customization. However, it was noted that there is logic for this already in the current standard (used for TMVP and BCW).

It was commented that there are relevant non-CE proposals as well (esp. JVET-N0340). There was general agreement that none of the remaining 6 variants may be as good as a non-CE proposal, so further discussion of them was not needed.

[JVET-N0083](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5803) CE4-4.1: Simplification of triangle merging candidate list derivation [T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0125](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5845) CE4-3.1: MMVD binarization [S. Jeong, M. W. Park, K. Choi (Samsung)]

[JVET-N0128](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5848) CE4-4.2: Triangle Prediction Mode Harmonization [A. Tamse, M. W. Park, K. Choi (Samsung)]

[JVET-N0584](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6318) Cross-check of JVET-N0128: CE4-4.2: Triangle Prediction Mode Harmonization [H. Wang (Qualcomm)] [late]

[JVET-N0141](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5861) CE4-1.1: Syntax Change of MMVD [E. Sasaki, T. Chujoh, T. Ikai (Sharp)]

[JVET-N0142](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5862) CE4-3.4: Diagonal direction candidate for MMVD [T. Hashimoto, E. Sasaki, T. Ikai (Sharp)]

[JVET-N0197](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5917) CE4: Triangle merge candidate list simplification (Test 4.4.7) [J. Li, C.-W. Kuo, C. S.Lim (Panasonic)]

[JVET-N0211](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5931) CE4-4.8: Triangle merge candidate list derivation simplification [X.W. Meng (PKU), X. Zheng (DJI), S.S. Wang, S.W. Ma (PKU)]

[JVET-N0688](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6439) Cross-check of JVET-N0211 (CE4-4.8b: Simplification of triangle prediction merging candidate list derivation) [J. Li, C.-W. Kuo, C. S.Lim (Panasonic)] [late]

[JVET-N0212](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5932) CE4-1.5: Remove TMVP merge candidate for the specified blocksizes [S.H. Wang (PKU), X. Zheng (DJI), S.S. Wang, S.W. Ma (PKU)]

[JVET-N0226](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5946) CE4-4.5: Pruning reduction in Triangle Merge mode [A. Robert, T. Poirier, F. Le Léannec, F. Galpin (Technicolor)]

[JVET-N0237](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5957) CE4-1.3: Modification of merge data syntax [G. Ko, D. Kim, J. Jung, J. Son, J. Kwak (WILUS)]

[JVET-N0252](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5973) CE4-1.4: Syntax changes of merge data [Y. Ahn, D. Sim (Digital Insights)]

[JVET-N0269](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5990) CE4-4.4: Merge list construction for triangular prediction mode [L. Zhang (Bytedance)]

[JVET-N0285](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6006) CE4-2.2: Pairwise extension with STMVP [F. Le Léannec, A. Robert, T. Poirier (Technicolor)]

[JVET-N0322](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6043) CE4: Triangle prediction merge list construction (CE4-4.3) [X. Wang, Y.-W. Chen (Kwai Inc.)]

[JVET-N0585](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6319) Cross-check of JVET-N0322: CE4: Triangle prediction merge list construction (CE4-4.3) [H. Wang (Qualcomm)] [late]

[JVET-N0324](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6045) CE4: Regular merge flag coding (CE4-1.2.a and CE4-1.2.b) [Y.-W. Chen, X. Wang (Kwai Inc.)]

[JVET-N0418](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6140) CE4: Using regular merge candidate list for triangular PU mode (CE4-4.9) [H. Wang, V. Seregin, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-N0635](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6384) Cross-check of JVET-N0418 (CE4-4.9: Using regular merge candidate list for triangular PU mode) [X. Wang (Kwai Inc.)] [late]

[JVET-N0441](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6163) CE4-3.3: Candidates optimization on MMVD [N. Park, H. Jang, J. Nam, J. Lim, S. Kim (LGE)]

[JVET-N0454](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6176) CE4-4.6: Simplification for merge list derivation in triangular prediction mode [T. Solovyev, S. Esenlik, S. Ikonin, J. Chen (Huawei)]

## CE5: Adaptive loop filtering (4)

Contributions in this category were discussed Friday 22 March 1445–1600 and 1800-1830 (Track A chaired by JRO).

[JVET-N0025](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6411) CE5: Summary Report on Adaptive Loop Filter [V. Seregin, C.-Y. Chen]

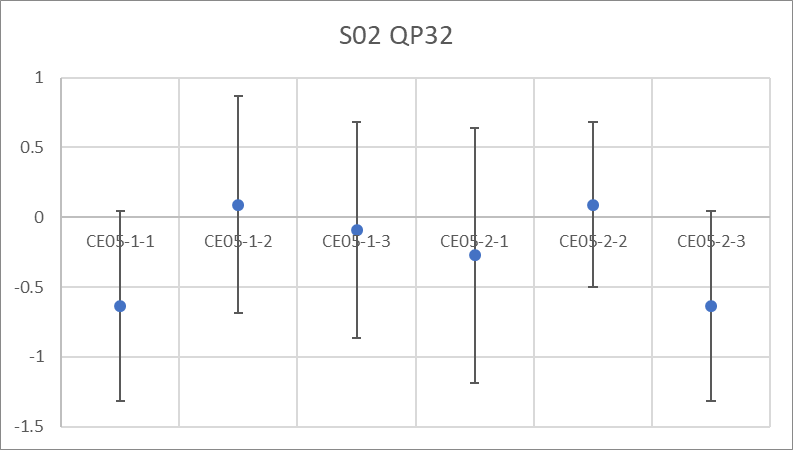
This document provides a summary report of Core Experiment 5 on Adaptive Loop Filter (ALF). There are two categories of the tests: line buffer reduction (CE5-1 and CE5-2) and coding efficiency improvement (CE5-3 and CE5-4). The subjective testing for the line buffer reduction category is required.

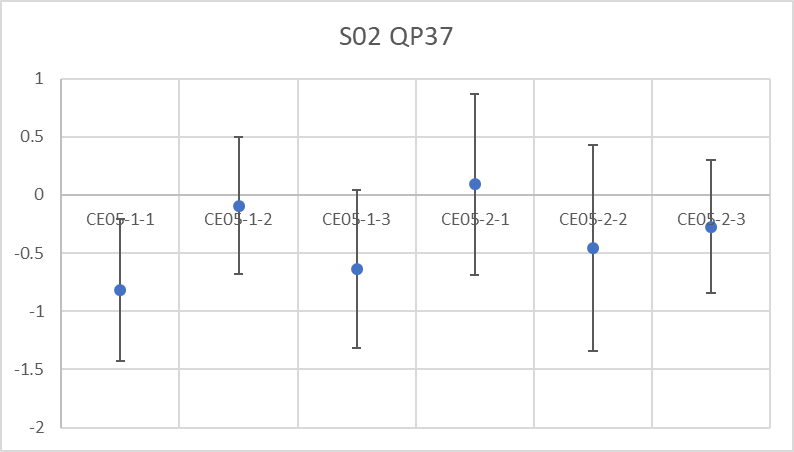
|  |  |  |
| --- | --- | --- |
| **Test#** | **Description** | **Document#** |
| CE5-1.1 | Virtual boundary processing with padding samples/gradients only | JVET-N0088 |
| CE5-1.2 | Virtual boundary processing with padding samples/gradients and weighted averaging | JVET-N0088 |
| CE5-1.3 | Virtual boundary processing with padding samples/gradients, weighted averaging and adaptive on/off control | JVET-N0088 |
| CE5-2.1 | Virtual boundary processing with padding samples and truncated filtering without adaptive on/off control | JVET-N0180 |
| CE5-2.2 | Virtual boundary processing with padding samples and truncated filtering with adaptive on/off control | JVET-N0180 |
| CE5-2.3 | Virtual boundary processing with padding samples and weighted averaging and adaptive on/off control | JVET-N0180 |
| CE5-3.1 | Non-linear ALF (NL-ALF) as in JVET-M0385. | JVET-N0242 |
| CE5-3.2 | Test CE5-3.1 + additional NL-ALF signaling + encoder optimization. | JVET-N0242 |
| CE5-3.3 | Test CE5-3.1 + reduced number of clipping operations for NL-ALF. | JVET-N0242 |
| CE5-3.4 | TestCE5-3.1 + reduced number of overall operations and line buffer for NL-ALF. | JVET-N0242 |
| CE5-4.1 | VTM with temporal filters mimicking APS | JVET-N0415 |
| CE5-4.2 | Luma CTBs with ALF on can switch among 1 tile group level signaled filter set, 16 fixed filter sets and those available sets in APS. All chroma CTBs with ALF on in a picture can only use the tile group level signaled filter or one temporal filter | JVET-N0415 |
| CE5-4.3 | Test CE5-4.2 with QP = 12, 17, 22 and 27 | JVET-N0415 |
| CE5-4.4 | Test CE5-4.2 without fixed filters | JVET-N0415 |
| CE5-4.5 | Test CE5-4.2 without temporal filters | JVET-N0415 |
| CE5-4.6 | Test CE5-4.5 with QP = 12, 17, 22 and 27 | JVET-N0415 |

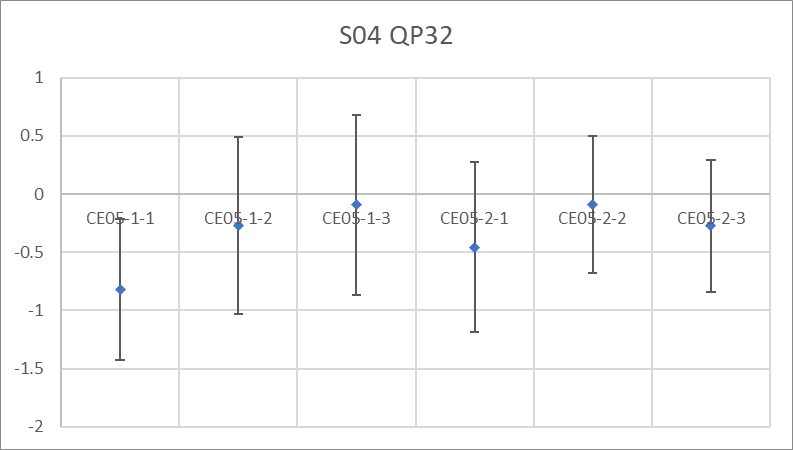
PSNR results

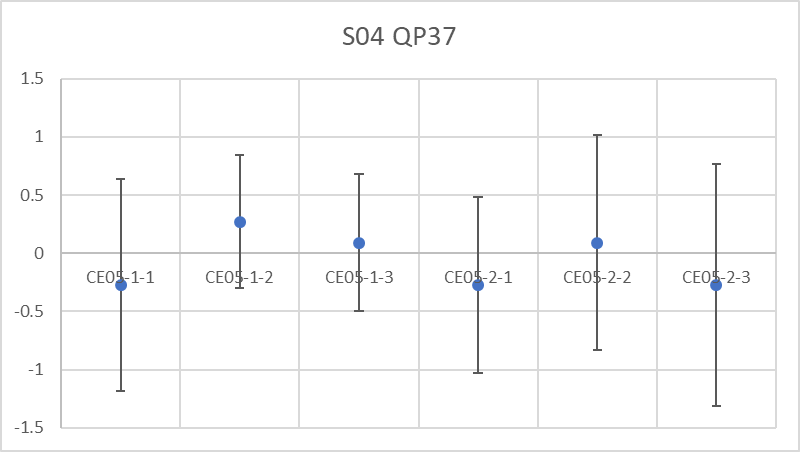
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | | | **Random Access** | | | | | | | | | **Low Delay B** | | | | | | | | |
| **Test#** | **Y** | **U** | **V** | **EncT** | | **DecT** | **Y** | | **U** | | **V** | | **EncT** | | **DecT** | **Y** | | **U** | | **V** | | **EncT** | | **DecT** |
| CE5-1.1 | 0.08 | 0.04 | 0.05 | 100% | 102% | | 0.08 | -0.03 | | 0.01 | | 100% | | 103% | | 0.10 | 0.05 | | -0.17 | | 100% | | 103% | |
| CE5-1.2 | 0.07 | 0.11 | 0.11 | 100% | 103% | | 0.09 | 0.02 | | 0.02 | | 100% | | 102% | | 0.09 | 0.14 | | -0.03 | | 100% | | 103% | |
| CE5-1.3 | 0.07 | 0.11 | 0.11 | 100% | 103% | | 0.10 | 0.04 | | 0.01 | | 100% | | 103% | | 0.11 | 0.18 | | 0.07 | | 100% | | 104% | |
| CE5-2.1 | 0.06 | 0.07 | 0.07 | 100% | 101% | | 0.10 | 0.06 | | 0.03 | | 100% | | 102% | | 0.09 | 0.18 | | 0.09 | | 100% | | 102% | |
| CE5-2.2 | 0.06 | 0.09 | 0.09 | 100% | 101% | | 0.10 | 0.04 | | 0.08 | | 100% | | 101% | | 0.06 | 0.10 | | 0.10 | | 100% | | 101% | |
| CE5-2.3 | 0.07 | 0.11 | 0.11 | 100% | 100% | | 0.09 | 0.02 | | 0.03 | | 100% | | 100% | | 0.08 | 0.45 | | 0.05 | | 101% | | 102% | |
| CE5-3.1 | -0.45 | -0.35 | -0.60 | 101% | 103% | | -0.67 | -0.96 | | -1.08 | | 100% | | 104% | | -0.73 | -0.37 | | -0.77 | | 103% | | 101% | |
| CE5-3.2 | -0.45 | -0.35 | -0.59 | 101% | 102% | | -0.68 | -1.01 | | -1.12 | | 100% | | 103% | | -0.75 | -0.52 | | -0.86 | | 104% | | 102% | |
| CE5-3.3 | -0.35 | -0.39 | -0.62 | 100% | 100% | | -0.50 | -0.96 | | -0.99 | | 99% | | 99% | | -0.51 | -0.51 | | -0.33 | | 101% | | 99% | |
| CE5-3.4 | 0.12 | -0.43 | -0.68 | 99% | 99% | | 0.17 | -1.01 | | -1.09 | | 98% | | 99% | | 0.00 | -0.37 | | -0.90 | | 100% | | 97% | |
| CE5-4.1 | 0.00 | 0.00 | 0.00 | 100% | 100% | | -0.14 | -0.16 | | -0.17 | | 100% | | 100% | | -0.38 | -0.19 | | -0.07 | | 100% | | 100% | |
| CE5-4.2 | -0.15 | -0.04 | -0.04 | 100% | 100% | | -0.52 | -0.14 | | -0.21 | | 100% | | 101% | | -0.62 | -0.27 | | -0.32 | | 100% | | 100% | |
| CE5-4.3 | -0.02 | 0.00 | 0.00 | 99% | 99% | | -0.26 | -0.11 | | -0.22 | | 99% | | 100% | | -0.29 | -0.25 | | -0.38 | | 100% | | 100% | |
| CE5-4.4 | 0.00 | 0.00 | 0.00 | 100% | 100% | | -0.33 | -0.20 | | -0.19 | | 100% | | 100% | | -0.53 | -0.53 | | -0.26 | | 100% | | 99% | |
| CE5-4.5 | -0.15 | -0.04 | -0.04 | 100% | 98% | | -0.35 | 0.04 | | 0.01 | | 100% | | 100% | | -0.43 | -0.16 | | -0.03 | | 100% | | 100% | |
| CE5-4.6 | -0.02 | 0.00 | 0.00 | 99% | 99% | | -0.13 | 0.03 | | -0.02 | | 99% | | 99% | | -0.15 | -0.14 | | -0.15 | | 99% | | 100% | |

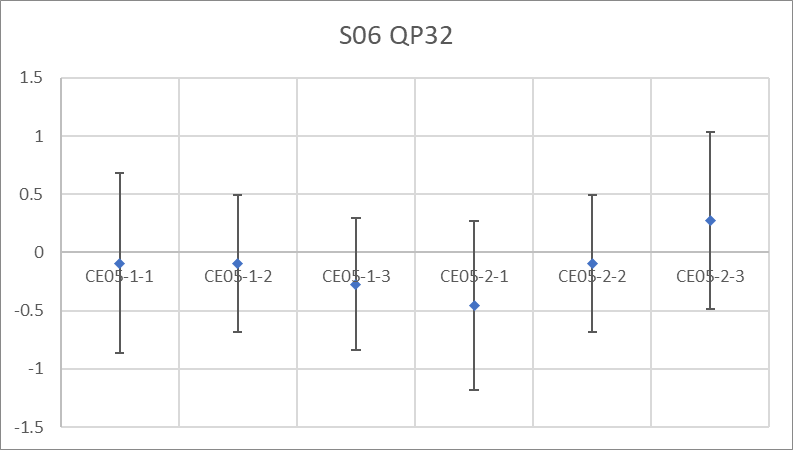
Results of subjective tests:

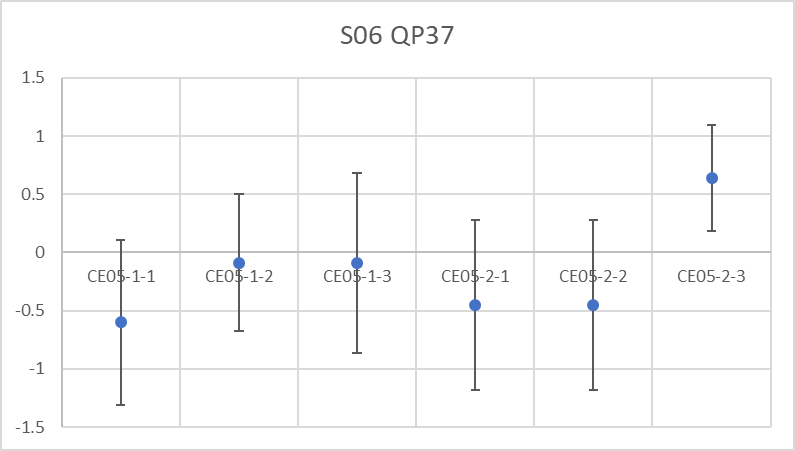












|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Test | Operations of classification process per luma sample | | Operations of filtering process per luma sample | | Operations of filtering process per chroma sample | | Frequency change of filters  (Y, Cb, Cr) | Line buffer size  (L, C) | memory for storing filters,  bytes | Additional operations per other units |
| Anchor | Add | 15.125 | Add | 25 | Add | 13 | 4x4 (Y)  tile group (Cb)  tile group (Cr) | 7 (L)  4 (C) | 10,624 | loading 332 bytes per tile group |
| Comp | 4.9375 | Comp | 4 | Comp | 1 |
| Mult | 0.125 | Mult | 13 | Mult | 7 |
| Shift | 2.5625 | Shift | 1 | Shift | 1 |
| CE5-1.1 | Gradient computation is skipped for 2 lines when compared with the anchor for the blocks near VB  two conditions to check avobe or below VB | | as anchor | | as anchor | | as anchor | 0 (L) 0 (C) | as anchor |  |
| CE5-1.2 | Gradient computation is skipped for 2 lines when compared with the anchor for the blocks near VB  two conditions to check avobe or below VB | | \*samples w VB:  Add 27 Comp 4 Mult 14 Shift 3   \*samples wo VB: as anchor | | \*samples w VB: Add 15 Comp 1 Mult 8 Shift 3  \*samples wo VB: as anchor | | as anchor | 0 (L) 0 (C) | as anchor | 1 Comp per sample line for 4x4 blcok with VB;  the numbers of luma and chroma lines filtered by VB are 6 and 4 in one CTB |
| CE5-1.3 | Gradient computation is skipped for 2 lines when compared with the anchor for the blocks near VB  two conditions to check avobe or below VB | | \*samples w VB:  Add 27 Comp 4 Mult 14 Shift 3  \*samples wo VB: as anchor | | \*samples w VB: Add 15 Comp 1 Mult 8 Shift 3  \*samples wo VB: as anchor | | as anchor  (luma on/off unit is 4x1 samples unit) | 0 (L) 0 (C) | + 50 bits for filtering on/off | As in CE5-1.2 and  Add: 29  Mul: 12  Comp: 6  Shift: 1  per luma filter |
| CE5-2.1 | Gradient computation is skipped for 2 lines when compared with the anchor for the blocks near VB, two conditions to check avobe or below VB  Otherwise, as anchor | | \*samples with VB: (based on the distance from VB)  line 0:  Add 23 Comp 6 Mult 12 Shift 1  line 1:  Add 17 Comp 4 Mult 10 Shift 3  line 2:  Add 7 Comp 4 Mult 4 Shift 3  \*samples w/o VB: as anchor | | \*samples with VB: (based on the distance from VB)  line 0:  Add 11 Comp 3 Mult 6 Shift 1  line 1:  Add 5 Comp 1 Mult 3 Shift 1 | | For the blocks at VB, filter is swithced for each 4 luma samples.  For chroma, filter is switched for CU line. | 0 (L) 0 (C) | For the blocks at VB, pre computed filters use 975 bytes=  25 x 3 x 13 for luma, and plus 21 = 3x7 bytes for chroma |  |
| CE5-2.2 | Gradient computation is skipped for 2 lines when compared with the anchor for the blocks near VB, two conditions to check avobe or below VB.  Otherwise, as anchor | | Same as CE5-2.1 | | Same as CE5-2.1 | | Same as CE 5-2.1 | 0 (L) 0 (C) | as in CE5-2.1  + 100 bits for filtering on/off | For filter on/off:  Add 29  Mul: 12  Comp: 6 Shift: 1  per luma filter per 4 luma samples in the line |
| CE5-2.3 | Gradient computation is skipped for 2 lines when compared with the anchor for the blocks near VB, two conditions to check avobe or below VB.  Otherwise, as anchor. | | \*samples w VB:  Add 27 Comp 4 Mult 14 Shift 3  \*samples wo VB: as anchor | | \*samples w VB: Add 15 Comp 1 Mult 8 Shift 3  \*samples wo VB: as anchor | | as anchor  (luma on/off unit is 4x1 samples unit) | 0 (L) 0 (C) | as in CE5-2.1  + 50 bits for filtering on/off | As in CE5-1.2 and in CE5-2.2 together |
| CE5-3.1 | as anchor | | |  |  | | --- | --- | | Add | 49 | | Comp | 52 | | Mult | 12 | | Shift | 1 | | | |  |  | | --- | --- | | Add | 25 | | Comp | 25 | | Mult | 6 | | Shift | 1 | | | as anchor | as anchor | 12,224 | as anchor |
| CE5-3.2 | as anchor | | as CE5-3.1 | | as CE5-3.1 | | as anchor | as anchor | as CE5-3.1 | as anchor |
| CE5-3.3 | as anchor | | |  |  | | --- | --- | | Add | 49 | | Comp | 20 | | Mult | 12 | | Shift | 1 | | | |  |  | | --- | --- | | Add | 25 | | Comp | 17 | | Mult | 6 | | Shift | 1 | | | as anchor | as anchor | as anchor | as anchor |
| CE5-3.4 | as anchor | | |  |  | | --- | --- | | Add | 25 | | Comp | 28 | | Mult | 6 | | Shift | 1 | | | |  |  | | --- | --- | | Add | 25 | | Comp | 25 | | Mult | 6 | | Shift | 1 | | | as anchor | 4 (L) 4 (C) | as anchor, when method is not used, otherwise  6,240 | as anchor |
| CE5-4.1 | as anchor | | as anchor | | as anchor | | as anchor | as anchor | as anchor | as anchor |
| CE5-4.2 | as anchor | | as anchor | | as anchor | | as anchor | as anchor | 11,756 | loading 332 bytes per CTU |
| CE5-4.3 | as anchor | | as anchor | | as anchor | | as anchor | as anchor | 11,756 | loading 332 bytes per CTU |
| CE5-4.4 | as anchor | | as anchor | | as anchor | | as anchor | as anchor | as anchor | loading 332 bytes per CTU |
| CE5-4.5 | as anchor | | as anchor | | as anchor | | as anchor | as anchor | 1,132 | loading 332 bytes per CTU |
| CE5-4.6 | as anchor | | as anchor | | as anchor | | as anchor | as anchor | 1,132 | loading 332 bytes per CTU |

5-1.1 is just padding, 5-1.2 additionally weighted averaging

5-2.1 could also be implemented by padding, but a more complex one.

5-1.x and 5-2.x:

- all proposals reduce the number of lines to be stored down to zero, which is the main aspect

- there are different degrees of complexity that try to prevent possible subjective impact, in terms of objective results they are almost equivalent

- 5-1.1 is the simplest solution, but has some quality problems, there are cases where it was judged worse than the anchor, according to the results of the visual test.

- 5-1.2 and 5-2.1 would both solve the problem, where 5-1.2 has slightly better MOS average, however all confidence intervals are overlapping, such that they would be assessed as visually indistinguishable

- More complexity analysis to be done on these two proposals, one of them to be adopted.

BoG (V. Seregin) to analyse this.

5-3.x Non-linear ALF

Clipping is applied to samples that deviate by more than a threshold from the current sample. Clipping parameters transmitted per filter shape. Number of clipping operations is as large as the number of samples. 5-3.3 is reducing the number of clipping operations by more than half, but this is position dependent and undesirable in hardware.

Gain of 5-3.1 and 5-3.2 is 0.67%/0.68% in RA, 0.45% in AI, >0.7% in LB

In terms of complexity, increase of runtime small (dec. 3-4%), manageable in hardware implementation.

Decision: Adopt JVET-N0242, version 5-3.2

It was later confirmed that text and SW are matching by cross-checkers and text editor - the requested change to make computation is dependent on bit depth was included in v3.

5-4.x CTU adaptive ALF

5-4.2 is a solution which includes a set of fixed filters, signals shich of those are applied in current together with adaptive filters, signaled per tile group, with reference to the APS index of current tile group. The gain over 5-4.1 (which is VTM with “simulated” APS signalling, i.e. the version which should be the true imlementation of VTM4) is 0.38%. Without fixed filters, this would drop by approx. half. No encoder/decoder runtime increase, no low-level complexity increase. Should also not be a problem combining with the adoption of 5-3.2.

Decision: Adopt JVET-N0415, version 5-4.2

It was later confirmed that text and SW are matching by cross-checkers. Some further alignment with APS might be necessary by text editor.

[JVET-N0088](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5808) CE5.1: Adaptive loop filter with virtual boundary processing [C.-Y. Chen, T.-D. Chuang, C.-Y. Lai, Z.-Y. Lin, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0180](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5900) CE5-2: Loop filter line buffer reduction [A. M. Kotra, S. Esenlik, J. Chen, B. Wang, H. Gao (Huawei)]

[JVET-N0242](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5962) CE5: Results of tests CE5-3.1, CE5-3.2, CE5-3.3 and CE5-3.4 on Non-Linear Adaptive Loop Filter [J. Taquet, P. Onno, C. Gisquet, G. Laroche (Canon)]

[JVET-N0415](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6137) CE5: Coding tree block based adaptive loop filter (CE5-4) [N. Hu, V. Seregin, H. E. Egilmez, M. Karczewicz (Qualcomm)]

## CE6: Transforms and transform signalling (4)

Contributions in this category were discussed Wednesday 20 March 1500–1650 (Track A chaired by JRO).

[JVET-N0026](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6235) CE6: Summary Report on Transforms and Transform Signaling [X. Zhao, H.E. Egilmez]

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

(1) CE6-1: Unification between MTS and Transform Skip mode (4 tests, 3 tests withdrawn)

(2) CE6-2: Reduced transform candidates of MTS (13 tests, 3 tests withdrawn)

(3) CE6-3: Secondary transform (5 tests)

In this CE all experiments were done using based on the VTM-4.0 SW. This document summarizes the test results, brief experiment definition, cross-check reports and complexity measurements, and also related contributions.

Core experiments (CEs) are organized according to the following five categories, and the following table lists all the experiments in each category, and the corresponding input document to the Geneva meeting. In total 16 tests were studied in this CE, and 6 tests were withdrawn from the original CE6 plan.

The 16 tests reported in this CE6 summary are listed below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test #** | **Doc #** | **Description** | **Tester** | **Cross-checker** |
| CE6-1.1a | JVET-N0360 | One dimensional TS (IDT used as horizontal or vertical transform) is applied up to 32-point. | X. Zhao (Tencent) | T. Tsukuba (Sony) |
| CE6-2.1a | JVET-N0053 | 2-mode MTS without implicit transform selection, Allowed intra picture 64x64 CU splits: QT, TT, BT | J. Lainema (Nokia) | C. Hollmann (Ericsson) |
| CE6-2.1b | 2-mode MTS without implicit transform selection, Allowed intra picture 64x64 CU splits: QT, TT | J. Lainema (Nokia) | C. Hollmann (Ericsson) |
| CE6-2.1c | 2-mode MTS without implicit transform selection, Allowed intra picture 64x64 CU splits: QT | J. Lainema (Nokia) | C. Hollmann (Ericsson) |
| CE6-2.2a | JVET-N0208 | Non-normative change with 3 modes | K. Choi (Samsung) | X. Zhao (Tencent) |
| CE6-2.2b | Non-normative change with 2 modes | K. Choi (Samsung) | X. Zhao (Tencent) |
| CE6-2.2c | Normative change with 3 modes | K. Choi (Samsung) | X. Zhao (Tencent) |
| CE6-2.2d | Normative change with 2 modes | K. Choi (Samsung) | X. Zhao (Tencent) |
| CE6-2.3a | JVET-N0490 | Simplified transform selection with reduced modes and no size-32 DCT-8, Number of evaluated candidates: 3 | C. Hollmann (Ericsson) | J. Lainema (Nokia) |
| CE6-2.3b | Simplified transform selection with reduced modes and no size-32 DCT-8, Number of evaluated candidates: 4 | C. Hollmann (Ericsson) | J. Lainema (Nokia) |
| CE6-2.3c | Simplified transform selection with reduced modes and no size-32 DCT-8, Number of evaluated candidates: 5 | C. Hollmann (Ericsson) | J. Lainema (Nokia) |
| CE6-3.1a | JVET-N0193 | ( 4 transform sets. 2 transforms per set ) | M. Koo (LGE) | P. Philippe (Orange) |
| CE6-3.1b | ( 4 transform sets. 2 transforms per set )  + (Secondary transform uses at most maximum 8 multiplications/sample ) | M. Koo (LGE) | P. Philippe (Orange) |
| CE6-3.1c | ( 4 transform sets. 2 transforms per set )  + ( Secondary transform uses at most maximum 8 multiplications/sample )  + ( Secondary transform is disabled for 4x4 TU ) | M. Koo (LGE) | P. Philippe (Orange) |
| CE6-3.1d | ( 4 transform sets. 2 transforms per set )  + ( Secondary transform uses at most maximum 8 multiplications/sample )  + ( 16x48 matrices are employed instead of 16x64 ones ) | M. Koo (LGE) | P. Philippe (Orange) |
| CE6-3.1e | ( 4 transform sets. 1 transforms per set ) | M. Koo (LGE) | P. Philippe (Orange) |

The following table summarizes the results of CE6 tests using CTC configuration and VTM-4.0 as anchor.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **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 | 0.19% | -0.20% | -0.21% | 95% | 99% | 0.08% | -0.13% | -0.12% | 100% | 100% | 0.04% | -0.04% | 0.18% | 100% | 101% |
| CE6-2.1a | -0.32% | -1.81% | -1.83% | 107% | 100% | 0.04% | -0.72% | -0.83% | 98% | 99% | 0.16% | -0.07% | -0.47% | 99% | 100% |
| CE6-2.1b | -0.02% | -1.48% | -1.51% | 89% | 100% | 0.11% | -0.78% | -0.74% | 97% | 100% | 0.17% | -0.04% | -0.65% | 99% | 100% |
| CE6-2.1c | 0.20% | -0.25% | -0.26% | 75% | 100% | 0.18% | -0.13% | -0.25% | 97% | 100% | 0.14% | 0.34% | -0.31% | 99% | 99% |
| CE6-2.2a\* | 0.00% | 0.00% | 0.00% | 99% | 101% | 0.00% | -0.02% | -0.06% | 100% | 101% | 0.01% | 0.04% | -0.12% | 101% | 100% |
| CE6-2.2b\* | 0.11% | -0.06% | -0.08% | 87% | 101% | 0.05% | -0.12% | -0.06% | 100% | 101% | 0.03% | 0.06% | -0.42% | 100% | 101% |
| CE6-2.2c\* | 0.00% | 0.01% | 0.02% | 99% | 101% | 0.00% | -0.08% | -0.07% | 100% | 101% | -0.04% | 0.12% | -0.14% | 100% | 101% |
| CE6-2.2d\* | 0.09% | -0.08% | -0.11% | 87% | 100% | 0.04% | -0.05% | -0.15% | 98% | 100% | 0.04% | 0.16% | 0.15% | 99% | 100% |
| CE6-2.3a | -0.03% | -0.01% | 0.03% | 100% | 100% |  |  |  |  |  |  |  |  |  |  |
| CE6-2.3b | -0.02% | -0.01% | -0.01% | 90% | 100% |  |  |  |  |  |  |  |  |  |  |
| CE6-2.3c | -0.02% | -0.01% | -0.03% | 90% | 100% |  |  |  |  |  |  |  |  |  |  |
| CE6-3.1a | -1.56% | -0.64% | -1.09% | 124% | 96% | -0.84% | -1.35% | -1.89% | 110% | 98% | -0.27% | -0.37% | -0.95% | 107% | 98% |
| CE6-3.1b | -1.40% | -0.51% | -1.04% | 125% | 98% | -0.73% | -1.25% | -1.81% | 111% | 99% | -0.24% | -0.50% | -1.09% | 108% | 99% |
| CE6-3.1c | -1.28% | -0.35% | -0.80% | 123% | 98% | -0.68% | -1.03% | -1.59% | 111% | 99% | -0.23% | -0.71% | -0.78% | 107% | 99% |
| CE6-3.1d | -1.34% | -0.40% | -0.87% | 126% | 98% | -0.69% | -1.13% | -1.75% | 111% | 99% | -0.22% | -0.19% | -0.83% | 108% | 99% |
| CE6-3.1e | -1.21% | 0.13% | -0.17% | 101% | 96% | -0.61% | -0.90% | -1.35% | 105% | 98% | -0.19% | -0.06% | -0.40% | 104% | 98% |

\*Results provided after contribution deadline.

CE6-1 shows loss for natural video, but come gain -0.8%,-0.6% for AI/RA in TGM screen content. Compared to gains shown by other SCC tools, this is very small gain, whereas the loss in natural is of some concern. No action.

CE6-2.1x intends to show the benefit of reducing number of transforms to 2. For AI, this reduces encoder complexity, or gives small gain when increasing complexity. For RA and LDB, luma losses are observed, probably due to the abandoning of DCT-VIII. For decoder implementation, no real advantage, as DCT-VIII and DST-VII are practically the same (flipped basis).

For SBT, the proposal substituted DCT-VIII by DCT-II.

Benefit not clear with diverging results in intra and inter cases. No action.

CE6-2.2x is targeting reduction of encoder runtime by a non-normative change of testing less modes. 6-2.2b reaches comparable encoder runtime for AI as 6-2.1b (though the modes tested are not the same as the ones that 6-2.1b would leave in a normative change). For RA and LB, less luma losses are observed than for the normative change of 6-2.1b. The luma loss in AI is 0.1%. It is discussed if it would be useful to adopt this to CTC for AI (as faster encoder), some experts expressed support for that. However, the AI simulations are not the most critical bottleneck. For real-world implemetations of fast AI encoders, this might be useful, no action for CTC

CE6-2.3x (JVET-N0490) had a very late update (03-20) after making a bug fix, RA data are not available yet. No cross-check available yet. The number of combinations that can be signalled is reduced, e.g. no combination of DCT-VIII/DCT-VIII, disallowing DCT-VIII for length 32. Results show no gain and no encoder run time reduction for CTC, but when compared against another non-CTC encoder which checks more modes, some 10% encoder runtime reduction is reported for AI. No clear benefit.

CE6-3 is abot secondary transform. CE6-3.1a and CE6-3.1e have worst case 16 mul/sample, the other versions have 8 mul/sample. Memory requirements for transform coefficient tables and other complexity aspects are analysed as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Operation counts | Primary transform: Same as VTM  Secondary transform: RST4x4: 256 (M), 240(A), 16(S)  RST8x8: 1024 (M), 960(A), 64(S)  Worst Case multiplication per sample: 16 | Primary transform: Same as VTM  Secondary transform: RST4x4: 256 (M), 240(A), 16(S)  RST8x8: 1024 (M), 960(A), 64(S)  Worst Case multiplication per sample: 8 | Primary transform: Same as VTM  Secondary transform: RST4x4: 256 (M), 240(A), 16(S)  RST8x8: 1024 (M), 960(A), 64(S)  Worst Case multiplication per sample: 8 | Primary transform: Same as VTM  Secondary transform: RST4x4: 256 (M), 240(A), 16(S)  RST8x8: 768 (M), 720(A), 48(S)  Worst Case multiplication per sample: 8 | Primary transform: Same as VTM  Secondary transform: RST4x4: 256 (M), 240(A), 16(S)  RST8x8: 1024 (M), 960(A), 64(S)  Worst Case multiplication per sample: 16 |
| Memory requirements | RST8x8:  16\*64\*8 /(8\*1024)= 1 KB per kernel  RST4x4:  16\*16\*8/(8\*1024)= 0.25 KB per Kernel  Total = 2\*4\*(1+ 0.25) = 10 KB | RST8x8:  16\*64\*8 /(8\*1024)= 1 KB per kernel  RST4x4:  16\*16\*8/(8\*1024)= 0.25 KB per Kernel  Total = 2\*4\*(1+ 0.25) = 10 KB | RST8x8:  16\*64\*8 /(8\*1024)= 1 KB per kernel  RST4x4:  16\*16\*8/(8\*1024)= 0.25 KB per Kernel  Total = 2\*4\*(1+ 0.25) = 10 KB | RST8x8:  16\*48\*8 /(8\*1024)= 0.75 KB per kernel  RST4x4:  16\*16\*8/(8\*1024)= 0.25 KB per Kernel  Total = 2\*4\*(0.75+ 0.25) = 8 KB | RST8x8:  16\*64\*8 /(8\*1024)= 1 KB per kernel  RST4x4:  16\*16\*8/(8\*1024)= 0.25 KB per Kernel  Total = 4\*(1+ 0.25) = 5 KB |
| Bit-precision to represent transform coefficients | 8 bits | 8 bits | 8 bits | 8 bits | 8 bits |
| Precision of arithmetic operations during transform computation | 8 bits x 16 bits mult. | 8 bits x 16 bits mult. | 8 bits x 16 bits mult. | 8 bits x 16 bits mult. | 8 bits x 16 bits mult. |
| Bit-precision for storing intermediate data representation | Same as VTM | Same as VTM | Same as VTM | Same as VTM | Same as VTM |
| Specify if a transform requires multiple iterations where transform output is fed back as input to the transform logic, and multiple iterations are required to produce final transform output. If yes, report the number of arithmetic operation required in each iteration, and if they can be computed in parallel. | No | No | No | No | No |
| Other operations and memory requirements | N/A | N/A | N/A | N/A | N/A |
| List of all combinations of transform types | Two RST Kernel combined with primary transform in VTM | Two RST Kernel combined with primary transform in VTM | Two RST Kernel combined with primary transform in VTM | Two RST Kernel combined with primary transform in VTM | One RST Kernel combined with primary transform in VTM |
| List of all combinations of transforms block size and transform type used for secondary transformation | For blocks with min(W,H)<8 : RST4x4  For blocks with min(W,H)>=8 : RST8x8 | For blocks with min(W,H)<8 : RST4x4  For blocks with min(W,H)>=8 : RST8x8  For simplification (option (B), 8 mult/sample):  for 4x4 block: Half RST4x4  for 8x8 block: Half RST8x8  for 4\*8 and 8\*4: only apply on one 4x4 corner | For blocks with min(W,H)<8 : RST4x4  For blocks with min(W,H)>=8 : RST8x8  For simplification (option (B), 8 mult/sample):  for 4x4 block: No RST  for 8x8 block: Half RST8x8  for 4\*8 and 8\*4: only apply on one 4x4 corner | For blocks with min(W,H)<8 : RST4x4  For blocks with min(W,H)>=8 : RST8x8  For simplification (option (B), 8 mult/sample):  for 4x4 block: Half RST4x4  for 8x8 block: Half RST8x8  for 4\*8 and 8\*4: only apply on one 4x4 corner | For blocks with min(W,H)<8 : RST4x4  For blocks with min(W,H)>=8 : RST8x8 |
| Provide analysis of implementation and arithmetic commonalities of proposed transforms. (e.g., stating which transforms are implemented using matrix multiplications, addition-only butterflies, or Givens rotations). | Primary transform: Same as VTM  Secondary transform: Reduced matrix multiplications | Primary transform: Same as VTM  Secondary transform: Reduced matrix multiplications | Primary transform: Same as VTM  Secondary transform: Reduced matrix multiplications | Primary transform: Same as VTM  Secondary transform: Reduced matrix multiplications | Primary transform: Same as VTM  Secondary transform: Reduced matrix multiplications |
| If the proposal requires additional computations at the encoder or decoder (e.g., additional transforms, or partial transforms along block boundaries), then the additional operations should be reported together with the other complexity metrics. | N/A | N/A | N/A | N/A | N/A |

Among the different versions, 6-3.1d appears to have the best complexity/performance tradeoff, though it has a larger requirement for storage compared to e, the worst case number of multiplications is reduced.

It is noted that the secondary transform does not have impact on decoder latency (as the inverse transform can be performed out of loop); however an encoder might face some latency issue depending on its implementation, and would also not be required to use it.

It provides 1.3% rate reduction for AI with 25% encoder runtime increase, and 0.7% with 11% encoder runtime increase for RA. For LB, the gain of 0.2% does not justify an increase of 8% encoder runtime.

Decision: Adopt JVET-N0193, version from CE6-3.1d. CTC for AI and RA, not LB.

It was suggested that the specification should be amended by introducing clipping at the output of the secondary transform (software has it). Cross-checkers later confirmed the matching of software and specification text, including the transform table.

High-level flag for disabling. There should be a better name than “secondary transform”, since it is the first transform executed after decoding the transform coefficients.

A BoG (H. Egilmez) was mandated to perform an initial review of CE related contributions, and identify the aspects to be investigated in the upcoming CE.

[JVET-N0053](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5773) CE6: 2-mode MTS (CE6-2.1) [J. Lainema (Nokia)]

[JVET-N0193](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5913) CE6: Reduced Secondary Transform (RST) (CE6-3.1) [M. Koo, M. Salehifar, J. Lim, S. Kim (LGE)]

[JVET-N0360](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6081) CE6-1: Unification between MTS and Transform Skip mode [X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-N0490](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6212) CE6: Transform Simplification (CE6-2.3a-c) [C. Hollmann, D. Saffar, J. Ström, P. Wennersten (Ericsson)]

## CE7: Quantization and coefficient coding (4)

Contributions in this category were discussed Wednesday 20 March 1700–1815 (Track A chaired by JRO).

[JVET-N0027](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6385) CE7: Summary report on quantization and coefficient coding [H. Schwarz, M. Coban]

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

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Tester** | **Tool** | **Cross checker** |
| CE7-1 | Jani Lainema (Nokia) | Joint coding of Cb and Cr residual | H. Schwarz (HHI) |
| CE7-2 | Xin Zhao (Tencent) | Reduced number of context-coded bins | Y. Piao (Samsung) |
| CE7-3 | Yinji Piao (Samsung) | Template-based unified Rice parameter derivation | Y.-H. Chao (Qualcomm) |
| CE7-4 | Yung-Hsuan Chao (Qualcomm) | Template based Rice parameter derivation for coding of abs\_remainder | Y. Piao (Samsung) |

|  |  |  |
| --- | --- | --- |
| **document** | **author(s)** | **title** |
| JVET-N0054 | J. Lainema (Nokia) | CE7: Joint coding of chrominance residuals (CE7-1) |
| JVET-N0188 | Y. Piao, K. Choi (Samsung) | CE7-7.3: Unified Rice parameter derivation for coefficient level coding |
| JVET-N0345 | Y.-H. Chao, M. Coban, M. Karczewicz (Qualcomm) | CE7: Template based Rice parameter derivation for coding of abs\_remainder (CE7-4) |
| JVET-N0361 | X. Zhao, X. Li, S. Liu (Tencent) | CE7-2: Reduced number of context-coded bins |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **CE 7** | | **Common test conditions** | | | | | **low QPs (2, 7, 12, 17)** | | | | |
| Y | U | V | encT | decT | Y | U | V | encT | decT |
|  |  |  |  |  |  |  |  |  |  |  |  |
| **Joint residual coding for Cb and Cr** | | | | | | | | | | | |
| **AI** | **CE7-1** | -0.38% | -0.49% | -1.52% | 103% | 100% | -0.28% | 0.57% | 0.27% | 108% | 99% |
| **RA** | **CE7-1** | -0.26% | -0.81% | -0.92% | 101% | 100% | -0.19% | 0.24% | -0.10% | 102% | 100% |
| **LD** | **CE7-1** | -0.07% | -2.99% | -4.76% | 100% | 100% | -0.18% | 0.09% | -0.58% | 103% | 100% |
|  |  |  |  |  |  |  |  |  |  |  |  |
| **Reduction of number of context-coded bins** | | | | | | | | | | | |
| **AI** | **CE7-2** | 0.03% | 0.07% | 0.04% | 99% | 100% | 0.11% | 0.16% | 0.16% | 99% | 99% |
| **RA** | **CE7-2** | 0.01% | -0.03% | -0.10% | 100% | 99% | 0.15% | 0.22% | 0.24% | 100% | 100% |
| **LD** | **CE7-2** | 0.02% | 0.36% | 0.00% | 100% | 99% | 0.13% | 0.22% | 0.19% | 101% | 100% |
|  |  |  |  |  |  |  |  |  |  |  |  |
| **Unification of Rice parameter derivation** | | | | | | | | | | | |
| **AI** | **CE7-3** | 0.00% | 0.01% | 0.00% | 102% | 101% | 0.00% | -0.02% | -0.02% | 102% | 102% |
| **CE7-4** | 0.00% | 0.02% | 0.03% | 103% | 100% | -0.02% | -0.02% | -0.01% | 104% | 103% |
| **RA** | **CE7-3** | -0.02% | 0.03% | -0.11% | 101% | 100% | 0.00% | -0.01% | -0.02% | 102% | 103% |
| **CE7-4** | 0.00% | -0.05% | -0.10% | 101% | 100% | 0.01% | -0.01% | 0.00% | 103% | 122% |
| **LD** | **CE7-3** | -0.01% | 0.19% | -0.20% | 100% | 100% | 0.00% | -0.01% | 0.00% | 102% | 102% |
| **CE7-4** | -0.04% | -0.01% | 0.23% | 101% | 101% | 0.02% | 0.02% | 0.03% | 103% | 101% |

CE7-1 is introducing a mode signalled per TB where Cb and Cr are jointly coded, and the reconstructed residual samples of the two components are just sign inverted against each other. This might exploit a similar effect as cross-component prediction (which also would give roughly similar as as per previous tool/core experiments). However, the new method has the advantage that it allows non-sequential decoding.

Slight increase of encoding time due to the need of checking that mode. Some fast decision is already used.

It is noted that at low QPs there might be a small drop of chroma PSNR, but still clear evidence of bit rate reduction.

There are CE related contributions (JVET-N0282, JVET-N0347) which seem to be extensions of this method rather than replacements.

Decision: Adopt JVET-N0054. Cross-checker confirmed that it is matching the implementation.

CE7-2 targets reducing the number of context coded bins in transform coding from 32 per 4x4 subblock to 30, which is achieved by formulating the budget of the limit differently for different subblock position, but in a way that it never exceeds Nx30, where N is the number of subblocks in a given transform block. In total, this may reduce the worst case number of context coded bins by around 5%, which does not appear to give a big deal. On the other hand, the definition of the limitation becomes more complicated, as it would be variable for different subblocks. There is only small loss in CTC, and some loss slightly above 0.1% average for low QP range.

No action, as the benefit is very low, and the specification text would be slightly more complicated.

CE7-3 and CE7-4 target some unification between the methods of bypass coding and remainder coding (by using the absolute value sum of the neighborhood template. CE7-3 has a minor advantage in compression (in the range of 0.01-0.05%, depending on class).

Decision: Adopt JVET-N0188. Alignment between text and software confirmed by cross-checker.

[JVET-N0054](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5774) CE7: Joint coding of chrominance residuals (CE7-1) [J. Lainema (Nokia)]

[JVET-N0188](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5908) CE7-7.3: Unified Rice parameter derivation for coefficient level coding [Y. Piao, K. Choi (Samsung)]

[JVET-N0345](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6066) CE7: Template based Rice parameter derivation for coding of abs\_remainder (CE7-4) [Y.-H. Chao, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-N0361](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6082) CE7-2: Reduced number of context-coded bins [X. Zhao, X. Li, S. Liu (Tencent)]

## CE8: Screen content coding tools (9)

Contributions in this category were discussed Wednesday 20 March 1830–2215 (8-1, 8-2, and 8-4) and Thursday 21 March 0900-0930 (8-3 and 8-5) (Track A chaired by JRO).

[JVET-N0028](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6272) CE8: Summary Report on Screen Content Coding Tools [X. Xu, Y.-C. Chao, Y.-C. Sun, J. Xu]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test** | **Tester** | **Document** | **Tool description** | **Cross checker** |
| CE8-1.1a | J. Nam  (LGE) | JVET-N0457 | Block vector prediction for merge mode and AMVP mode using default positions | X. Xu  (Tencent) |
| CE8-1.1b | J. Nam  (LGE) | JVET-N0457 | Block vector prediction for merge mode and AMVP mode using default positions with pruning invalid candidates | X. Xu  (Tencent) |
| CE8-1.2b | J. Nam  (LGE) | JVET-N0458 | Change binarization process for abs\_mvd\_minus2 syntax | K. Choi  (Samsung) |
| CE8-1.2c | J. Nam  (LGE) | JVET-N0458 | Add context models for abs\_mvd\_greater0\_flag[] and/or abs\_mvd\_greater1\_flag[] syntaxes | K. Choi  (Samsung) |
| CE8-1.2d | J. Nam  (LGE) | JVET-N0458 | Combination of 8.1.2b + 8.1.2c | K. Choi  (Samsung) |
| CE8-1.3a | Y. Li  (Wuhan U.) | JVET-N0255 | IBC with integer MMVD offsets | G. Venugopal  (HHI) |
| CE8-1.3b | Y. Li  (Wuhan U.) | JVET-N0255 | IBC with integer MMVD offsets and negative directions | G. Venugopal  (HHI) |
| CE8-2.1 | Y.-H. Chao  (Qualcomm)  Y.-C. Sun  (Alibaba) | JVET-N344 | Palette mode in HEVC SCC (except that separate palettes are used in case of separate luma/chroma trees) | R. Chernyak (Huawei) |
| CE8-2.2a | Y.-C. Sun  (Alibaba) Y.-H. Chao  (Qualcomm)  R. Chernyak  (Huawei) | JVET-N0404 | Separate palette coding for luma and chroma | B. Bross (HHI) |
| CE8-2.2c | Y.-C. Sun  (Alibaba) | JVET-N0404 | Palette mode and simplified intra mode combination | C.-Y. Lai  (MediaTek) |
| CE8-2.2e | Y.-C. Sun  (Alibaba) Y.-H. Chao  (Qualcomm)  R. Chernyak  (Huawei) | JVET-N0404 | Combine 8.2.2a and 8.2.2c | S. Yoo (LGE) |
| CE8-3.1a | F. Henry  (Orange)  T. Nguyen (HHI)  X. Li  (Tencent) | JVET-N0280 | Block-DPCM with H/V predictor from JVET-M0058 with residual coding from JVET-M0464 and context coded bins limitation from JVET-M0449 (max 2 context coded bins/sample) | P. Onno  (Canon) |
| CE8-3.1b | F. Henry  (Orange)  T. Nguyen (HHI)  X. Li  (Tencent) | JVET-N0280 | Block-DPCM with H/V predictor from JVET-M0058 with residual coding from JVET-M0464 and context coded bins limitation from JVET-M0449 (max 3 context coded bins/sample) | P. Onno  (Canon) |
| CE8-4.1a | S. Yoo  (LGE) | JVET-N0428 | Rearrangement of the residual block according to intra mode for transform skip by flipping | B. Bross (HHI) |
| CE8-4.1b | S. Yoo  (LGE) | JVET-N0428 | Rearrangement of the residual block of transform skip by rotating | X. Zhao (Tencent)  K. Choi (Samsung) |
| CE8-4.1c | S. Yoo  (LGE) | JVET-N0428 | Rearrangement of the residual block adaptively between rotation and flip for transform skip | M. Ikeda (Sony) |
| CE8-4.2a | S. Yoo  (LGE) | JVET-N0429 | Residual coding for transform skip including context coded sign information  and bitstream restriction for context coded bins limitation with max  2 context coded bins per sample | F. Henry (Orange) |
| CE8-4.2b | S. Yoo  (LGE) | JVET-N0429 | Residual coding for transform skip including context coded sign information  and bitstream restriction for context coded bins limitation with max  3 context coded bins per sample | Y.-C. Sun (Alibaba) |
| CE8-4.3a | T. Nguyen  (HHI) | JVET-N0280 | Residual coding for transform skip  and bitstream restriction for context coded bins limitation with max  2 context coded bins per sample | X. Xu  (Tencent) |
| CE8-4.3b | T. Nguyen  (HHI) | JVET-N0280 | Residual coding for transform skip  and bitstream restriction for context coded bins limitation with max  3 context coded bins per sample | X. Xu  (Tencent) |
| CE8-4.4a | T. Nguyen  (HHI)  X. Li  (Tencent) | JVET-N0280 | Residual coding for transform skip  and context coded bins limitation from JVET-M0449 with max  2 context coded bins per sample | S. Yoo  (LGE) |
| CE8-4.4b | T. Nguyen  (HHI)  X. Li  (Tencent) | JVET-N0280 | Residual coding for transform skip  and context coded bins limitation from JVET-M0449 with max  3 context coded bins per sample | Y.-C. Sun  (Alibaba) |
| CE8-5.1a | F. Henry  (Orange)  B. Bross (HHI)  X. Li  (Tencent) | JVET-N0214 | Combination of CE8-3.1a and CE8-4.4a (both use max 2 context coded bins per sample) | A. Filippov  (Huawei) |
| CE8-5.1b | F. Henry  (Orange)  B. Bross (HHI)  X. Li  (Tencent) | JVET-N0214 | Combination of CE8-3.1b and CE8-4.4b (both use max 3 context coded bins per sample) | S. Yoo (LGE) |

Results with IBC enabled:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **AI Over VTM-4.0** | | | | | **RA Over VTM-4.0** | | | | |
|  | **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CTC | CE8-1.1a | 0.00% | 0.00% | -0.02% | 101% | 99% | -0.03% | -0.04% | -0.08% | 102% | 101% |
| CE8-1.1b | -0.04% | -0.03% | -0.06% | 103% | 103% | -0.04% | -0.06% | -0.03% | 103% | 100% |
| CE8-1.2b | -0.01% | -0.01% | 0.00% | 100% | 99% | 0.00% | 0.02% | 0.00% | 100% | 100% |
| CE8-1.2c | 0.00% | -0.01% | -0.02% | 100% | 99% | 0.00% | 0.04% | -0.07% | 100% | 100% |
| CE8-1.2d | -0.01% | -0.02% | -0.03% | 100% | 99% | 0.00% | -0.03% | -0.04% | 99% | 99% |
| CE8-1.3a | -0.02% | -0.06% | -0.04% | 108% | 100% | -0.01% | -0.02% | -0.10% | 102% | 100% |
| CE8-1.3b | -0.01% | -0.04% | -0.02% | 108% | 100% | 0.00% | 0.07% | -0.02% | 101% | 100% |
| CE8-2.1 | 0.06% | 0.02% | 0.05% | 103% | 104% | 0.04% | -0.02% | -0.04% | 103% | 102% |
| CE8-2.2a | 0.06% | 0.02% | 0.05% | 101% | 98% | 0.05% | 0.02% | 0.00% | 102% | 99% |
| CE8-2.2c | 0.06% | 0.02% | 0.04% | 105% | 103% | 0.04% | -0.08% | -0.03% | 102% | 100% |
| CE8-2.2e | 0.06% | 0.02% | 0.04% | 106% | 102% | 0.04% | -0.04% | -0.02% | 101% | 98% |
| CE8-3.1a | -0.04% | -0.02% | -0.02% | 106% | 102% | 0.02% | 0.03% | -0.10% | 101% | 101% |
| CE8-3.1b | -0.04% | -0.01% | -0.03% | 106% | 102% | 0.02% | -0.07% | 0.00% | 101% | 100% |
| CE8-4.1a | -0.02% | -0.01% | 0.00% | 100% | 100% | -0.02% | -0.05% | -0.02% | 100% | 99% |
| CE8-4.1b | -0.07% | -0.05% | -0.02% | 100% | 99% | -0.04% | 0.04% | -0.11% | 99% | 99% |
| CE8-4.1c | -0.08% | -0.08% | -0.01% | 100% | 99% | -0.03% | -0.08% | -0.07% | 100% | 100% |
| CE8-4.2a | -0.12% | -0.04% | 0.01% | 101% | 105% | -0.02% | -0.06% | 0.00% | 101% | 102% |
| CE8-4.2b | -0.13% | -0.03% | 0.02% | 101% | 103% | -0.04% | -0.03% | -0.08% | 102% | 102% |
| CE8-4.3a | -0.11% | -0.02% | 0.02% | 100% | 102% | -0.02% | 0.01% | -0.08% | 100% | 101% |
| CE8-4.3b | -0.12% | -0.03% | 0.02% | 100% | 101% | -0.02% | -0.03% | -0.01% | 100% | 101% |
| CE8-4.4a | -0.12% | -0.03% | 0.02% | 100% | 101% | -0.02% | 0.02% | -0.05% | 100% | 100% |
| CE8-4.4b | -0.12% | -0.02% | 0.02% | 100% | 101% | -0.03% | -0.02% | -0.05% | 100% | 101% |
| CE8-5.1a | -0.12% | -0.03% | 0.03% | 106% | 102% | 0.02% | 0.00% | -0.03% | 101% | 100% |
| CE8-5.1b | -0.12% | -0.04% | 0.05% | 106% | 102% | 0.02% | 0.03% | 0.05% | 101% | 99% |
| Class F | CE8-1.1a | 0.02% | -0.03% | -0.09% | 101% | 100% | -0.02% | -0.04% | -0.08% | 100% | 100% |
| CE8-1.1b | -0.20% | -0.22% | -0.32% | 102% | 100% | -0.18% | -0.27% | -0.31% | 101% | 99% |
| CE8-1.2b | -0.21% | -0.17% | -0.15% | 100% | 100% | -0.21% | -0.28% | -0.26% | 100% | 100% |
| CE8-1.2c | -0.10% | -0.05% | -0.18% | 101% | 100% | -0.15% | -0.22% | -0.19% | 100% | 101% |
| CE8-1.2d | -0.32% | -0.36% | -0.38% | 100% | 101% | -0.26% | -0.44% | -0.33% | 100% | 100% |
| CE8-1.3a | -0.03% | -0.03% | -0.08% | 111% | 101% | -0.04% | -0.03% | -0.19% | 103% | 101% |
| CE8-1.3b | -0.01% | -0.07% | -0.19% | 108% | 101% | -0.08% | -0.09% | -0.13% | 102% | 101% |
| CE8-2.1 | -2.38% | -2.20% | -2.28% | 100% | 102% | -1.44% | -2.13% | -2.07% | 103% | 101% |
| CE8-2.2a | -2.38% | -2.20% | -2.28% | 98% | 96% | -1.44% | -1.97% | -1.89% | 100% | 98% |
| CE8-2.2c | -2.63% | -2.73% | -2.87% | 106% | 100% | -1.79% | -2.61% | -2.61% | 105% | 101% |
| CE8-2.2e | -2.63% | -2.73% | -2.87% | 106% | 96% | -1.75% | -2.44% | -2.30% | 105% | 101% |
| CE8-3.1a | -2.63% | -1.72% | -1.70% | 104% | 100% | -1.74% | -1.26% | -1.29% | 101% | 101% |
| CE8-3.1b | -2.78% | -1.74% | -1.84% | 104% | 100% | -1.81% | -1.45% | -1.35% | 101% | 101% |
| CE8-4.1a | -0.37% | -0.20% | -0.36% | 100% | 100% | -0.34% | -0.37% | -0.23% | 100% | 100% |
| CE8-4.1b | -0.58% | -0.30% | -0.42% | 100% | 100% | -0.47% | -0.27% | -0.28% | 100% | 100% |
| CE8-4.1c | -0.74% | -0.47% | -0.48% | 100% | 101% | -0.57% | -0.33% | -0.51% | 100% | 101% |
| CE8-4.2a | -2.03% | -0.82% | -0.79% | 104% | 104% | -1.10% | -0.32% | -0.27% | 103% | 104% |
| CE8-4.2b\* | -2.91% | -1.55% | -1.71% | 103% | 105% | -1.92% | -1.22% | -1.10% | 103% | 105% |
| CE8-4.3a | -1.83% | -0.75% | -0.79% | 101% | 96% | -0.96% | -0.18% | -0.35% | 100% | 98% |
| CE8-4.3b | -2.67% | -1.41% | -1.56% | 100% | 96% | -1.77% | -1.05% | -1.01% | 100% | 100% |
| CE8-4.4a | -2.57% | -1.39% | -1.36% | 99% | 96% | -1.74% | -0.99% | -0.92% | 99% | 100% |
| CE8-4.4b | -2.79% | -1.52% | -1.70% | 99% | 98% | -1.93% | -1.22% | -1.18% | 99% | 100% |
| CE8-5.1a | -3.77% | -2.26% | -2.31% | 103% | 100% | -2.65% | -1.71% | -1.77% | 101% | 102% |
| CE8-5.1b | -3.94% | -2.38% | -2.59% | 104% | 101% | -2.80% | -1.82% | -1.96% | 101% | 101% |
| SCC TGM | CE8-1.1a | 0.02% | -0.01% | -0.01% | 100% | 100% | -0.06% | -0.01% | 0.00% | 99% | 99% |
| CE8-1.1b | -0.72% | -0.67% | -0.68% | 101% | 101% | -0.51% | -0.45% | -0.54% | 100% | 98% |
| CE8-1.2b | -0.58% | -0.55% | -0.54% | 100% | 100% | -0.25% | -0.21% | -0.25% | 100% | 100% |
| CE8-1.2c | -0.24% | -0.27% | -0.25% | 100% | 100% | -0.12% | -0.11% | -0.08% | 100% | 100% |
| CE8-1.2d | -0.85% | -0.80% | -0.81% | 100% | 100% | -0.35% | -0.20% | -0.32% | 100% | 101% |
| CE8-1.3a | -0.16% | -0.17% | -0.17% | 112% | 101% | -0.06% | 0.00% | -0.04% | 105% | 100% |
| CE8-1.3b | -0.16% | -0.17% | -0.17% | 110% | 100% | -0.12% | -0.05% | -0.06% | 104% | 100% |
| CE8-2.1 | -6.85% | -5.66% | -5.29% | 91% | 94% | -3.30% | -3.16% | -3.03% | 100% | 100% |
| CE8-2.2a | -6.85% | -5.66% | -5.29% | 90% | 93% | -3.18% | -2.80% | -2.52% | 98% | 97% |
| CE8-2.2c | -8.09% | -6.55% | -6.16% | 99% | 94% | -3.87% | -3.62% | -3.48% | 102% | 100% |
| CE8-2.2e | -8.09% | -6.55% | -6.16% | 99% | 91% | -3.68% | -3.36% | -3.01% | 101% | 98% |
| CE8-3.1a | -3.51% | -2.25% | -2.20% | 103% | 99% | -1.61% | -0.81% | -0.87% | 100% | 101% |
| CE8-3.1b | -3.78% | -2.41% | -2.35% | 102% | 99% | -1.68% | -0.92% | -0.92% | 100% | 101% |
| CE8-4.1a | -0.45% | -0.30% | -0.30% | 100% | 100% | -0.38% | -0.22% | -0.21% | 100% | 101% |
| CE8-4.1b | -0.57% | -0.34% | -0.33% | 100% | 99% | -0.31% | -0.07% | -0.07% | 100% | 100% |
| CE8-4.1c | -0.74% | -0.48% | -0.48% | 100% | 100% | -0.53% | -0.18% | -0.19% | 100% | 100% |
| CE8-4.2a | -2.13% | -0.04% | -0.16% | 106% | 99% | -1.05% | 0.67% | 0.72% | 102% | 100% |
| CE8-4.2b\* | -4.38% | -2.03% | -2.13% | 104% | 102% | -2.78% | -0.87% | -0.82% | 102% | 102% |
| CE8-4.3a | -1.85% | 0.14% | 0.01% | 103% | 99% | -0.90% | 0.74% | 0.81% | 99% | 100% |
| CE8-4.3b | -4.00% | -1.77% | -1.84% | 101% | 99% | -2.58% | -0.72% | -0.64% | 99% | 101% |
| CE8-4.4a | -3.87% | -1.71% | -1.81% | 100% | 99% | -2.67% | -0.74% | -0.63% | 98% | 101% |
| CE8-4.4b | -4.37% | -2.12% | -2.19% | 100% | 100% | -2.96% | -0.98% | -0.97% | 98% | 101% |
| CE8-5.1a | -5.83% | -3.24% | -3.25% | 102% | 98% | -3.54% | -1.23% | -1.13% | 99% | 101% |
| CE8-5.1b | -6.23% | -3.63% | -3.63% | 102% | 97% | -3.77% | -1.56% | -1.48% | 99% | 101% |

Table 4: CE8 test results with VTM-4.0+IBC=0

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **AI Over VTM-4.0** | | | | | **RA Over VTM-4.0** | | | | |
|  | **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CTC | CE8-2.1 | 0.06% | 0.06% | 0.04% | 102% | 105% | 0.04% | -0.04% | -0.03% | 104% | 104% |
| CE8-2.2a | 0.06% | 0.06% | 0.04% | 102% | 103% | 0.04% | -0.04% | -0.03% | 102% | 102% |
| CE8-2.2c | 0.06% | 0.06% | 0.04% | 102% | 107% | 0.03% | 0.00% | 0.02% | 105% | 105% |
| CE8-2.2e | 0.06% | 0.06% | 0.04% | 102% | 105% | 0.03% | 0.00% | 0.02% | 103% | 102% |
| CE8-3.1a | -0.06% | -0.01% | 0.03% | 109% | 101% | 0.02% | 0.03% | -0.10% | 101% | 101% |
| CE8-3.1b | -0.06% | -0.01% | 0.00% | 109% | 102% | 0.01% | -0.01% | -0.13% | 102% | 101% |
| CE8-4.1a | -0.03% | -0.04% | -0.03% | 100% | 100% | -0.02% | -0.06% | -0.03% | 101% | 101% |
| CE8-4.1b | -0.08% | -0.03% | -0.06% | 100% | 100% | -0.04% | -0.02% | -0.08% | 100% | 100% |
| CE8-4.1c | -0.08% | -0.02% | -0.06% | 100% | 101% | -0.04% | -0.02% | -0.22% | 101% | 101% |
| CE8-4.2a | -0.12% | -0.05% | -0.02% | 100% | 103% | -0.02% | -0.03% | -0.13% | 103% | 103% |
| CE8-4.2b\* | -0.13% | -0.05% | -0.05% | 99% | 98% | -0.02% | -0.03% | -0.02% | 100% | 99% |
| CE8-4.3a | -0.12% | -0.04% | -0.01% | 100% | 99% | -0.03% | -0.04% | -0.10% | 99% | 99% |
| CE8-4.3b | -0.13% | -0.04% | -0.03% | 100% | 99% | -0.03% | -0.02% | -0.10% | 99% | 99% |
| CE8-4.4a | -0.13% | -0.05% | -0.03% | 100% | 100% | -0.04% | 0.00% | -0.04% | 99% | 99% |
| CE8-4.4b | -0.13% | -0.04% | -0.02% | 100% | 100% | -0.02% | -0.01% | -0.06% | 99% | 98% |
| CE8-5.1a | -0.14% | 0.00% | 0.02% | 109% | 102% | 0.02% | 0.01% | -0.13% | 101% | 100% |
| CE8-5.1b | -0.14% | -0.01% | 0.02% | 109% | 102% | 0.01% | 0.00% | -0.12% | 101% | 100% |
| Class F | CE8-2.1 | -8.58% | -7.71% | -7.86% | 94% | 99% | -6.72% | -7.66% | -7.47% | 103% | 103% |
| CE8-2.2a | -8.58% | -7.71% | -7.86% | 94% | 96% | -6.72% | -7.52% | -7.22% | 103% | 101% |
| CE8-2.2c | -8.79% | -7.85% | -8.08% | 103% | 101% | -7.22% | -8.13% | -7.97% | 105% | 103% |
| CE8-2.2e | -8.79% | -7.85% | -8.08% | 103% | 98% | -7.21% | -7.96% | -7.75% | 105% | 101% |
| CE8-3.1a | -5.90% | -4.52% | -4.51% | 109% | 97% | -4.04% | -3.48% | -3.29% | 102% | 100% |
| CE8-3.1b | -6.26% | -4.90% | -4.82% | 108% | 98% | -4.37% | -3.76% | -3.69% | 102% | 100% |
| CE8-4.1a | -1.06% | -0.93% | -0.85% | 100% | 100% | -0.88% | -0.73% | -0.60% | 101% | 101% |
| CE8-4.1b | -0.86% | -0.66% | -0.70% | 100% | 100% | -0.68% | -0.43% | -0.42% | 101% | 101% |
| CE8-4.1c | -1.11% | -1.01% | -0.99% | 98% | 102% | -0.88% | -0.64% | -0.55% | 101% | 102% |
| CE8-4.2a | -3.80% | -2.36% | -2.33% | 106% | 102% | -2.12% | -1.37% | -1.20% | 103% | 103% |
| CE8-4.2b | -5.52% | -3.87% | -3.90% | 104% | 100% | -3.60% | -2.59% | -2.40% | 104% | 103% |
| CE8-4.3a | -3.47% | -2.19% | -2.25% | 103% | 98% | -1.96% | -1.30% | -1.22% | 101% | 101% |
| CE8-4.3b | -5.25% | -3.64% | -3.70% | 102% | 96% | -3.41% | -2.56% | -2.35% | 101% | 101% |
| CE8-4.4a | -4.70% | -2.98% | -3.14% | 101% | 97% | -2.94% | -2.08% | -1.78% | 101% | 101% |
| CE8-4.4b | -5.48% | -3.84% | -3.85% | 101% | 96% | -3.65% | -2.69% | -2.44% | 100% | 101% |
| CE8-5.1a | -7.19% | -5.37% | -5.42% | 108% | 94% | -4.95% | -3.92% | -3.77% | 101% | 99% |
| CE8-5.1b | -7.80% | -5.97% | -5.94% | 108% | 96% | -5.50% | -4.37% | -4.26% | 101% | 99% |
| SCC TGM | CE8-2.1 | -27.12% | -25.34% | -25.16% | 75% | 81% | -13.17% | -13.41% | -13.18% | 99% | 100% |
| CE8-2.2a | -27.12% | -25.34% | -25.16% | 75% | 81% | -13.19% | -12.80% | -12.27% | 99% | 98% |
| CE8-2.2c | -29.14% | -26.79% | -26.63% | 87% | 83% | -14.51% | -14.35% | -14.25% | 101% | 100% |
| CE8-2.2e | -29.14% | -26.79% | -26.63% | 87% | 81% | -14.55% | -13.85% | -13.47% | 101% | 98% |
| CE8-3.1a | -15.10% | -12.15% | -12.24% | 108% | 93% | -7.09% | -5.25% | -5.29% | 101% | 99% |
| CE8-3.1b | -16.09% | -13.20% | -13.29% | 106% | 94% | -7.72% | -5.89% | -5.86% | 100% | 99% |
| CE8-4.1a | -2.19% | -1.90% | -1.92% | 100% | 98% | -1.17% | -1.00% | -0.98% | 101% | 101% |
| CE8-4.1b | -1.84% | -1.68% | -1.67% | 99% | 99% | -0.77% | -0.72% | -0.72% | 101% | 101% |
| CE8-4.1c | -2.20% | -2.00% | -1.99% | 97% | 100% | -1.11% | -0.98% | -0.97% | 100% | 101% |
| CE8-4.2a | -9.61% | -6.94% | -7.24% | 109% | 96% | -4.28% | -2.36% | -2.36% | 102% | 100% |
| CE8-4.2b | -14.31% | -10.94% | -11.16% | 106% | 94% | -7.12% | -4.77% | -4.73% | 102% | 100% |
| CE8-4.3a | -8.75% | -6.33% | -6.59% | 107% | 92% | -3.81% | -2.08% | -2.09% | 100% | 99% |
| CE8-4.3b | -13.76% | -10.44% | -10.68% | 104% | 92% | -6.81% | -4.44% | -4.47% | 100% | 98% |
| CE8-4.4a | -12.60% | -9.23% | -9.46% | 101% | 89% | -6.27% | -3.93% | -3.90% | 99% | 99% |
| CE8-4.4b | -14.35% | -10.94% | -11.15% | 101% | 91% | -7.27% | -4.88% | -4.88% | 99% | 100% |
| CE8-5.1a | -17.91% | -14.15% | -14.34% | 107% | 90% | -9.29% | -6.39% | -6.41% | 99% | 99% |
| CE8-5.1b | -19.10% | -15.39% | -15.56% | 106% | 91% | -10.08% | -7.25% | -7.25% | 99% | 98% |

\* Results are updated after contribution deadline.

Discussion in context of CE review for CE8-1

CE8-1.x are all targeting improvement of compression performance of IBC vector coding, but do not achieve much (relatively) compared to the overall compression benefit of IBC for SC sequences (0.8% compared to > 40% for TGM class).

The question is if the main design goal of IBC specific coding of vectors should be simplification or (significant) improvement of compression (or both). It is agreed that the main design goal should be significant simplification, without affecting or (if possible) increasing compression. However, methods that would significantly increase compression without overly adding complexity would also be considered. In the context of SC sequences (in partcular TGM class) significant probably means several percent. The current proposals in CE8-1 do not fulfill these criteria.

As a matter of fact, and aspects that might be relevant to consider in that context

- IBC has clear benefit from 4x4 blocks (whereas motion comp is currently giving up 4x4 in regular inter mode) (for example, it is reported informally by one expert that disallowing 4x4, 4x8 and 8x4 in IBC would increase the average rate by approx. 18% for the TGM class).

- There is a recursive dependency in IBC vector coding (in merge and prediction stages), which is currently solved by using shared merge lists

- Is the merge list derivation more complicated than MPM derivation in conventional intra (where the same kind of recursion occurs, but is not seen as a problem). If not, we do not urgently need to target simplification.

- The sample prediction itself is not a problem, as it is integer based (simpler than other intra modes)

- Possibly, if a sufficiently simplified merge would be designed, the sharing concept could be given up (provided that it provides benefit in terms of compression performance)

It is noted that nobody knows if there is impact of merge list sharing for IBC performance in screen content. This aspect should be investigated in next CE if there would be a target of simplified coding methods. See further notes under the BoG report.

CE8-2: Palette mode

8-2.2a is implementing separate palettes for luma and chroma, regardless if it is combined or separate luma/chroma trees. The results indicate that this has a loss (not very significant) in particular for chroma in random access, compared to the default palette mode of 8-2.1 (for intra, it is identical, because separate trees are used by default). This seems to indicate that separate palettes for luma and chroma are not beneficial in case of combined tree. This behaviour is independent from enabling or disabling IBC.

8-2.2c is using a special palette entry that indicates to copy a sample from a neighbored block, where a CU level flag indicates whether this sample is the boundary of the same row in the left neighbor block, or the same column in the block above. This provides an additional gain of 1.2%/0.7% for TGM class and 0.25%/0.35% for class F, compared to 8-2.1 in AI/RA configuration, for the case where IBC is enabled. Decoder-complexity wise this is simple, but encoder runtime increases compared to 8-2.1.

8-2.2e is combination of 8-2.2a/c, which does not show benefit over c standalone

As a general conclusion, palette mode is a non-insignificant additional building block which should be justified by significant improvement of compression performance. The best version currently known (CE8-2.2c) provides 2.6%/1.8% for class F, and 8%/3.9% for TGM, in AI/RA mode. This is asserted to be not sufficient to justify inclusion. It is however noted that contributions in the context of 4:4:4 support indicate that palette mode has much bigger advantage in combination with IBC, when operated on 4:4:4 screen content.

It is noted that the gains are somewhat higher in low QP range which was tested additionally

The discussion on 4:4:4 aspects was later conducted in the plenary and in CE related discussion in track B. It was decided to include testing of 4:4:4 in the next version of CE8.

8-3 is using a modified residual coding from 8-4.4 proposal, and therefore will be discussed after

About the different 8-4 variants:

8-4.1a is using VTM TS residual coding, but performs flipping of 4x4 blocks based on intra prediction mode, either hor, or vert, or not.

8-4.1b is using VTM TS residual coding, but performs 180 rotation (always), similar as HEVC but for all block sizes.

8-4.1c is combining a/b, where 4x4 blocks are rotated if they have not been flipped, Other blocks are always rotated.

8-4.2a/b is based on 8-4.3a/b, but it can switch to another method of sign coding based on the number of nonzero coefficients.

8-4.3a/b is the proposal for alternative coding of TS residual as from JVET-M0464, with restriction of average number of context coded bins per sample, implemented as bitstream restriction

8-4.4a/b is derived from 8-4.3a/b, where however the bitstream restriction is replaced by a counter based limitation (from JVET-M0449), where a decoder would know that bypass coding is used as soon as the counter limit is reached.

a/b above means that the limit is 2 resp. 3 context coded bins per sample (for 8-4.2 through 8-4.4). This limit applies per TU.

The differences compared to VTM are:

- no last signif. Position

- modification of subblock CBF inference

- context coding of sign flag

- sign coded at beginning

- scan direction is changed (forward)

Benefit is observed only for screen content, so it should be considered as SCC tool. However, it would be undesirable if different residual coding would be used for TS in screen and natural content. There are no losses (and perhaps some small gain such as 0.1% for AI) for natural content as well.

Gain is 4.3%/3% for AI/RA in TGM, and 2.8%/1.9% in class F (with IBC enabled). This is for the max 3 context coded bins. For 2 context coded bins, the gain is 3.8%/2.6% for AI/RA class TGM, 2.5%/1.7% for class F. (these results relate to CE8-4.4, which is the conceptually best solution w.r.t limitation of CC bins)

The method uses similar building blocks as the current TS (resp. transform coeff.) coding, also similar level of complexity (at least for the case of max two context coded bins). The necessary modifications for implementing this additionally are quite common, such as replacing bypass by context coding, changing scan orders, etc. All this seems acceptable complexity-wise, and the gain is in an interesting range for the screen content cases.

Decision: Adopt JVET-N0280, method 8-4.4a, counter-based limitation with 2 context coded bins. It was later reported by the cross-checker that there were initially some misalignments between text and software, which were however resolved in the upload JVET-N0280v3.

8-3.1x is using the method from 8-4.4x for BDPCM, but uses VTM residual coding for TS. 8-5.1x uses 8-4.4x for both BDPCM and TS residual. Therefore, only 8-5.1a is relevant after adoption of 8-4.4.a

The additional benefit of BDPCM over the new method of residual coding of TS is 1.2%/0.9% in class F, and 2%/0.9% in class TGM, for AI/RA cases. No benefit for conventional video / CTC.

The method requires pixel-recursive processing, where either lines or columns can be processed in parallel. In case of 4xN and Nx4 blocks, a subdivision of blocks is applied such that better parellelism can be achieved. The process would not cause an additional latency problem. However, it would be a new building block which cannot reuse much of current intra prediction logic. Considering the fact that it has only benefit for screen content, and the gain it gives over 8-4.4a is relatively low, this method should not be considered for adoption.

It is noted that it might be more beneficial in case of 4:4:4 content.

BoG (X. Xu) to make an initial review of CE related contributions, and identify the aspects to be investigated in the upcoming CE. The BoG should also discuss an update of CTC for the SC classes.

It is noted that potentially it could be interesting to test screen content with 4K resolution (so far, everything is 1080p or lower).

[JVET-N0214](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5934) CE8: BDPCM with harmonized residual coding and CCB limitation (CE8-3.1a, CE8-3.1b, CE8-5.1a, CE8-5.1b) [G. Clare (bcom), F. Henry (Orange), B. Bross, T. Nguyen, P. Keydel, H. Schwarz, D. Marpe, T. Wiegand (HHI), M. Xu, X. Li, X. Xu, M. Gao, S. Liu (Tencent)]

[JVET-N0255](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5976) CE8: Combination of MMVD and IBC mode (test 1.3a and 1.3b) [Y. Li, Z. Chen (Wuhan Univ.), X. Xu, X. Li, S. Liu (Tencent)]

[JVET-N0527](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6254) Crosscheck of JVET-N0255 (CE8-1.3a and CE8-1.3b) [G. Venugopal (HHI)] [late]

[JVET-N0280](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6001) CE8: Residual Coding for Transform Skip Mode (CE8-4.3a, CE8-4.3b, CE8-4.4a, and CE8-4.4b) [B. Bross, T. Nguyen, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

[JVET-N0344](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6065) CE8: Palette Mode in HEVC (CE8-2.1) [Y.-H. Chao, V. Seregin, M. Karczewicz (Qualcomm), Y.-C. Sun, T.-S. Chang, J. Lou (Alibaba)]

[JVET-N0404](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6126) CE8: Palette Mode Improvements (CE8-2.2) [Y.-C. Sun, T.-S. Chang, J. Lou (Alibaba), Y.-H. Chao, V. Seregin, M. Karczewicz (Qualcomm), R. Chernyak, S. Ikonin, J. Chen (Huawei)]

[JVET-N0428](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6150) CE8-4.1: Rearrangement of the residual block for transform skip [S. Yoo, J. Choi, J. Heo, J. Choi, L. Li, J. Lim, S. Kim (LGE)]

[JVET-N0429](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6151) CE8-4.2: Residual Coding for transform skip with various maximum context coded bins [S. Yoo, J. Choi, J. Heo, J. Choi, J. Lim, S. Kim (LGE)]

[JVET-N0596](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6333) Cross-chreck of JVET-N0429 (CE8-4.2: Residual Coding for transform skip with various maximum context coded bins) [F. Henry (Orange)] [late]

[JVET-N0457](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6179) CE8-1.1: Block vector prediction for IBC [J. Nam, J. Lim, S. Kim (LGE)]

[JVET-N0458](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6180) CE8-1.2: Block vector coding for IBC [J. Nam, J. Lim, S. Kim (LGE)]

## CE9: Decoder motion vector derivation (7)

[JVET-N0029](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6444) CE9: Summary report on decoder motion vector derivation [S. Esenlik, X. Xiu]

This was discussed in Track B Wednesday 20 March 1645 (GJS).

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: DMVR Specific Simplification (3 tests)
* CE9-2: BDOF Specific Simplification (9 tests)

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

**CE9-1: DMVR simplifications**

|  |  |  |
| --- | --- | --- |
| **#** | **Description** | **Document** |
| CE9-1.1a | Disable 8x8/4xN CUs for DMVR | [JVET-N0407](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6129) |
| CE9-1.1b | CE9-1.1.a + Remove boundary padding process | [JVET-N0407](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6129) |
| CE9-1.2 | Impact of bit-depth restriction applied to interpolated samples used for refinement in DMVR. | [JVET-N0291](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6012) |

Summary of results

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Test** | **Description** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE9-1.1a | Disable 8x8/4xN CUs for DMVR. | 0.04% | 0.07% | 0.03% | 100% | 99% |
| CE9-1.1b | CE9-1.1.a + Remove boundary padding process | 0.04% | 0.04% | 0.05% | 99% | 99% |
| CE9-1.2 | Impact of bit-depth restriction applied to interpolated samples used for refinement in DMVR | -0.01% | -0.04% | -0.04% | 101% | 101% |

CE9-1.1b somewhat increases average memory access. There was discussion of whether the worst case is affected (vs 8x16 biprediction). In hardware the padding is probably preferable, whereas in software the padding may impose an extra burden. Padding is also used in BDOF. The argument for eliminating the padding is primarily design consistency (not having some different process for MC prediction depending on whether it’s for DMVR or not). The opinions about this were mixed – seemingly a matter of hardware versus software perspectives – so this aspect was retained as in the existing draft (i.e., keep the padding).

Decision (complexity reduction): Adopt CE-9-1.1a (draft text in JVET-N0407).

CE9-1.2 uses 8-bit SAD rather than 10-bit SAD (just discarding two LSBs), motivated by the belief that this would be easier in SIMD. It was commented that this is not so helpful for newer devices (AVX2 and various DSP chips), as they have support for wider bit depths.

The cross-checker said that the SIMD code had not been modified to take advantage of the bit depth reduction.

There was no loss observed, which was suggested to be because the LSBs are noisy.

Aside from reduced computation, this was said to have a reduced memory requirement – e.g., 40 bytes in hardware (not very much).

The potential benefit from this seemed very small, so no action was taken.

**CE9-2: BDOF simplifications**

|  |  |  |
| --- | --- | --- |
| **#** | **Description** | **Document** |
| CE9-2.1 | Disable SAD based early termination | [JVET-N0177](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5897) |
| CE9-2.2a | The SAD region is divided for each 16x16 sub-blocks for 1st stage of early termination. | [JVET-N0187](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5907) |
| CE9-2.2b | The SAD region is divided for each 16x16 sub-blocks for 1st stage of early termination. And an early termination for 2nd stage (4x4 block level) is disabled. | [JVET-N0187](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5907) |
| CE9-2.2c | The early termination for 1st stage (CU level) is disabled. | [JVET-N0187](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5907) |
| CE9-2.3a | When a CU contains more than 256 luma samples, it is split into multiple sub-blocks with 256 luma samples and BDOF is performed for each sub-block. | [JVET-N0270](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5991) |
| CE9-2.3b | SAD is calculated only for 4 corners (instead of all 16 luma samples) of each 4x4 sub-block. | [JVET-N0270](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5991) |
| CE9-2.4 | Implicitly split BDOF application region along 16x16 boundaries | [JVET-N0178](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5898) |
| CE9-2.5 | Simplification of BDOF’s optical flow parameter derivation | [JVET-N0198](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5918) |
| CE9-2.6 | CE9.2.1 + CE9.2.4 | [JVET-N0178](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5898) |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Test** | **Description** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CE9-2.1 | Disable SAD based early termination | -0.02% | -0.01% | 0.00% | 101% | 104% |
| CE9-2.2a | The SAD region is divided for each 16x16 sub-blocks for 1st stage of early termination. | 0.03% | -0.01% | -0.03% | 100% | 102% |
| CE9-2.2b | The SAD region is divided for each 16x16 sub-blocks for 1st stage of early termination. And an early termination for 2nd stage (4x4 block level) is disabled. | 0.03% | 0.00% | -0.02% | 101% | 102% |
| CE9-2.2c | The early termination for 1st stage (CU level) is disabled. | 0.00% | -0.01% | 0.01% | 101% | 103% |
| CE9-2.3a | When a CU contains more than 256 (luma samples, it is split into multiple sub-blocks with 256 luma samples and BDOF is performed for each sub-block. | 0.01% | -0.01% | -0.02% | 100% | 100% |
| CE9-2.3b | SAD is calculated only for 4 corners (instead of all 16 luma samples) of each 4x4 sub-block. | 0.01% | -0.03% | -0.03% | 99% | 100% |
| CE9-2.4 | Implicitly split BDOF application region along 16x16 boundaries | 0.01% | 0.00% | -0.01% | 101% | 100% |
| CE9-2.5 | Simplification of BDOF optical flow parameter derivation | 0.10% | 0.04% | 0.06% | 99% | 100% |
| CE9-2.6 | CE9.2.1 + CE9.2.4 | 0.00% | 0.00% | -0.01% | 102% | 104% |

The current design is not compatible with the VPDU concept, which was considered a significant problem and is why some of these “simplification” proposals have increased runtimes. All of the proposals fix that problem except CE9-2.5, which is addressing a different issue.

CE9-2.5 was considered unrelated to the others; and it was agreed to discuss the others first.

It was suggested to focus on CE9-2.1 and CE9-2.4. (It was remarked that CE9-2.4 includes the basic concept of CE9-2.2.)

CE9-2.2a is only implicitly splitting the SAD computation region, whereas 2.4 is splitting the whole BDOF application region (e.g., applying padding around 16x16 padding), following the same splitting as when BDOF is applied after DMVR. It was remarked (and seemed generally agreed) that CE9-2.4 makes the BDOF design more consistent with DMVR. CE9-2.4 has two early termination stages – at the 16x16 and 4x4 levels. Some participants suggested removing one of the early termination stages but not both of them. The relationship to the SAD performed at the 16x16 level for DMVR was also discussed, with the suggestion to use that SAD measure for the early termination.

JVET-N0097, JVET-N0148, JVET-N0158, JVET-N0296 and JVET-N0507 are related non-CE contributions.

It was suggested to focus on JVET-N0296, which removes the 4x4-level early termination and uses the SAD for DMVR for 16x16-level early termination when DMVR is enabled, and when DMVR is not enabled, does not use 16x16-level early termination. It seemed odd that if an encoder chooses not to use DMVR, the decoder would not benefit from early termination.

JVET-N0097 has some similarities while keeping a form of early termination with DMVR disabled, but uses a different sample source for the SAD calculation in that case. There was discussion of whether it was desirable to need to support the different SAD for that case.

C9-2.3 was discussed, but the irregularity of the memory access was questioned.

Decision (complexity/cleanup): Adopt CE9-2.4.

CE9-2.5 modifies the BDOF equations by replacing multiplies with adds and subtracts. It was commented that there are many other multiplies needed in the design since BDOF is built upon conventional biprediction (which requires a substantial number of multiplies) and the savings is not so much to justify doing something different in this part. Also some loss was observed (as much as 0.48% on some sequences, although averaging 0.1%). So no action was taken on this.

[JVET-N0177](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5897) CE9: Disabling SAD based early termination of BDOF (CE9-2.1) [S. Esenlik, B. Wang, A. M. Kotra, H. Gao, J. Chen (Huawei), K. Kondo, M. Ikeda, T. Suzuki (Sony)]

[JVET-N0178](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5898) CE9: Implicit splitting of BDOF application region (CE9-2.4 and CE9-2.6) [H. Chen, X. Ma, S. Esenlik, H. Yang, J. Chen (Huawei)]

[JVET-N0187](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5907) CE9-2.2: On early termination of BDOF [K. Kondo, M. Ikeda, T. Suzuki (Sony)]

[JVET-N0198](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5918) CE9: Simplification of BDOF’s optical flow parameter derivation (Test 9.2.5) [J. Li, C.-W. Kuo, C. S.Lim (Panasonic)]

[JVET-N0270](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5991) CE9-2.3: Modifications on BDOF [H. Liu, L. Zhang (Bytedance)]

[JVET-N0291](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6012) CE9: Results of DMVR related Tests CE9-1.2 [S. Sethuraman (Ittiam)]

[JVET-N0407](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6129) CE9: Removal of 4xN/8x8 CUs and Boundary Padding Process from DMVR (Test 9.1.1) [C.-C. Chen, W.-J. Chien, M. Karczewicz (Qualcomm)]

## CE10: Combined intra/inter prediction (X)

[JVET-N0030](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6294) CE10: Summary Report on Combined Inter and Intra Prediction [C.-W. Hsu, M. Winken]

This report was discussed in Track B on Thursday 21 March 0900 (GJS)

A summary of Core Experiment 10 (CE10) on combined inter and intra prediction is reported. One sub CE was created to investigate combined inter and intra prediction techniques on top of VTM-4.0, as follows:

* CE10-1: Combined inter and intra prediction (CIIP) with weight modifications.

There are 2 tests for the sub CE. All tests are evaluated based on the common test conditions defined in JVET-M1010. All tests and crosscheck results are integrated in this report.

|  |  |  |  |
| --- | --- | --- | --- |
| Proposal Document # | Corresponding Tests | Title | Author(s) |
| JVET-N0302 | CE10-1.1 | CE10: CIIP with position-independent weights (Test CE10-1.1) | [L. Pham Van](mailto:lphamvan@qti.qualcomm.com), [G. Van der Auwera](mailto:geertv@qti.qualcomm.com), [A. K. Ramasubramonian](mailto:aramasub@qti.qualcomm.com),[V. Seregin](mailto:vseregin@qti.qualcomm.com), [M. Karczewicz (Qualcomm)](mailto:martak@qti.qualcomm.com) |
| JVET-N0298 | CE10-1.2 | CE10: CIIP using explicit signaling of weights (CE10-1.2) | [A. Seixas Dias](mailto:andre.seixasdias@bbc.co.uk), [G. Kulupana](mailto:gosala.kulupana@bbc.co.uk), [S. Blasi (BBC)](mailto:saverio.blasi@bbc.co.uk) |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| # | Proposal | Supported intra modes | Weight scheme | Weight sets  (wIntra, wInter) |
|  |  |  |  |  |
| VTM-4.0 |  | 4: DC, PL, VER, HOR | PL, DC: equal weights | (4, 4) |
|  |  |  | VER, HOR: position dependent weights, four regions | (6, 2), (5,3), (3,5), (2, 6) |
| CE10-1.1 | JVET-N0302 | 1: PL | Implicit weight assignment | 2: (3, 1)  1: (2, 2)  0: (1, 3) |
|  |  |  | (number of intra-coded left and top neighbors) |  |
| CE10-1.2 | JVET-N0298 | 1: PL | Explicit weight signalling | 0: (4, 4)  10: (2, 6)  11: (6, 2) |
|  |  |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| # | Proposal | Config. |  |  | VTM |  |  |
|  |  |  | Y | U | V | EncT | DecT |
| CE10-1.1 | JVET-N0302 | RA | -0.05% | -0.02% | 0.02% | 98% | 100% |
|  |  | LB | -0.03% | 0.20% | 0.07% | 98% | 100% |
| CE10-1.2 | JVET-N0298 | RA | -0.04% | 0.04% | 0.05% | 100% | 99% |
|  |  | LB | -0.01% | 0.16% | -0.01% | 101% | 98% |

The proposals are both substantially simpler than the current design (removing position-dependent weighting and an MPM list derivation). It was commented that it may also be desirable to consider a pure simplification of just removing the DC, horizontal and vertical modes. Estimated results for that are ~0.01% loss in RA and ~0.1% loss in LB with equal weights. Hypothetically, having weights determined by RA vs LB would reduce the loss in LB for that to about 0.03%.

It was commented that the explicit weight method of CE10-1.2 would enable additional gain if the encoder did more searching. The estimated benefit of that was about 0.09% overall and 0.17% in Class A1 for 3% encoder runtime (for a straightforward approach). The CE10-1.2 test did not use more full RD tests than the VTM anchor, but performed 12 SATD checks, whereas the CE10-1.1 scheme performed 4 SATD checks (where the anchor used 7 SATD checks, so one scheme decreased encoder runtime and the other one slightly reduced encoder runtime). The difference in decoder complexity between the two proposed methods did not seem substantial.

For the explicit signalling method, the first flag indicating whether a non-equal weight is bypass coded and the second flag is context coded. It was commented that the bypass coding of the first bin means that the encoder would be forced to check both possibilities to avoid wasting signalling bits. It was then commented that there could be some flag to turn off the low-level signalling. Another discussed possibility was to use a context for coding the first bin as well as the second one.

It was commented that since the encoder resources are higher for the CE10-1.2 scheme and the additional gain available for an even better encoder is quite limited, the CE10-1.1 scheme seemed preferable.

Decision (complexity reduction/cleanup): Adopt CE10-1.1 scheme.

[JVET-N0298](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6019) CE10: CIIP using explicit signaling of weights (CE10-1.2) [A. Seixas Dias, G. Kulupana, S. Blasi (BBC)]

[JVET-N0302](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6023) CE10: CIIP with position-independent weights (Test CE10-1.1) [L. Pham Van, G. Van der Auwera, A. K. Ramasubramonian, V. Seregin, M. Karczewicz (Qualcomm)]

## CE11: Deblocking (4)

Contributions in this category were discussed Friday 22 March 1900–2015 (Track A chaired by JRO).

[JVET-N0031](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6473) CE11: Summary Report on Deblocking [A. Norkin, A. M. Kotra]

|  |  |  |
| --- | --- | --- |
| **Test#** | **Description** | **Document#** |
| 11-1.1 | Very strong deblocking filtering with conditional activation signalling | [JVET-N0595](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6332) |
| 11-2.1 | Deblocking for 4xN, Nx4 and 8xN and Nx8 block boundaries not aligned with 8x8 grids | [JVET-N0098](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5818) |
| 11-2.2 | Disable deblocking filter for 4xN for vertical edge and Nx4 for Horizontal edge on 4x4 grid | [JVET-N0463](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6185) |
| 11-2.3 | Disabling of sub-pu deblocking | [JVET-N0181](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5901) |

CE11-1.1 increases worst-case complexity in case of intra slice:

Luma:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Tests** | **Samples from block bound. modified** | **Samples from block bound. deblocking decision** | **Max num. oper for filtering per line (add/mult/compar/shift)** | **Max number of oper. for decision for 8-sample boundary (add/mult/compar/shift)** | **Max number of operations including filtering and decision (Per \*Sample\*)**  **(add/mult/compar/shift)** | **Num. line buffers** | **Worst case complexity increased (Y/N)** |
| VTM4.0 | 7+7, 7+5, 5+7, 5+5, 7+3, 3+7, 5+3, 3+5 | 8+8, 8+6, 6+8, 6+6, 8+4, 4+8, 6+4, 4+6 | 120 (46,24,28,22) | 21 (43,0,24,15)/4 |  | 4 | N |
| CE11-1.1 | VTM (Inter), 3+3...16+16 (Intra) | VTM | Intra slice: 288 (96/96/64/32), Inter slice: VTM | VTM |  | VTM | Intra slice: Y  Inter slice: N |

Chroma:

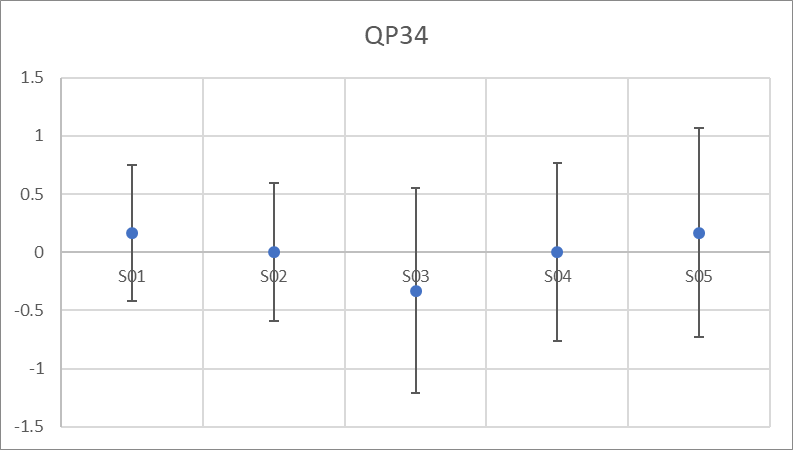
|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Tests** | **Samples from block boundary modified** | **Samples from block boundary for deblocking decision** | **Max number of operations for filtering per line (add/mult/compar/shift)** | **Max number of oper. for decision for 8-sample boundary (add/mult/compar/shift)** | **Max number of operations including filtering and decision (Per \*Sample\*)**  **(add/mult/compar/shift)** | **Number of line buffers** | **Worst case complexity increased (Y/N)** |
| VTM4.0 | 3+3 | 4+4 | 64 (36,2,12,14) | 17 (17, 0, 12, 5)/2 per line |  | 2 | Y |
| CE11-1.1 | VTM (Inter), 1+1...8+8 (Intra) | VTM | Intra slice: 144 (48/48/32/16), Inter slice: VTM | VTM |  | VTM | Intra slice: Y  Inter slice: N |

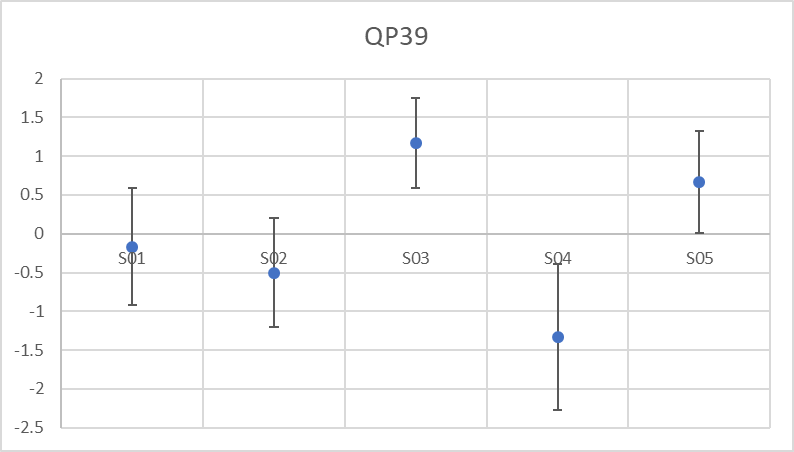
In terms of objective criteria, no benefit.

Some discussion was performed on the approach: It is selectively applied (signalled) on a TU basis, where only the side of the current TU is strong deblocked. The implementation is such that it requires two passes (first strong deblocking is applied, and in a second pass the conventional deblocking is applied on the remaining blocks). For a real implementation, it should only be one pass (which would however have other results)

Viewing results from document JVET-N0835

Results from subjective testing on CE11-1, ALF on:





The subjective viewing did not show any differences for QP34, for QP39 the results were diverging (sometimes better, sometimes worse).

It is claimed by proponents that they believe it has benefit for Sunset Beach (HLG), but it is mentioned by other experts that other tools like the luma adaptive deblocking (not in CTC but in standard) likely helps there as well.

No action.

CE11-2: Deblocking 4x4 boundaries

Luma complexity:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Tests** | **Samples from block bound. Modified** | **Samples from block bound. for deblocking decision** | **Max num. oper for filtering per line (add/mult/compar/shift)** | **Max number of oper. for decision per line (add/mult/compar/shift)** | **Max number of operations including filtering and decision (per \*sample\*)**  **(add/mult/compar/shift)** | **Num. line buffers** | **Worst case complexity increased (Y/N)** |
| CE11-2.1 | All 4x4: 1+1 | All 4x4: 3+3 | All 4x4: 14 (6/2/5/1) | VTM (all 4x4 : 1.25 (11/0/5/4) /4 ) | All 4x4: 4.75 (2.1875/0.5/1.5625/0.5) | 4 | N |
| CE11-2.2 | All 4x4: 0  4xN : 3+3  Other: VTM | All 4x4 : 0  4xN : 3+3  Other: VTM | All 4x4 : 0  4xN : VTM  Other: VTM | All 4x4 : 0  4xN : VTM  Other: VTM | All 4x4 : 0  4xN : VTM  Other : VTM | 4 | N |
| CE11-2.3 | Same as VTM | Same as VTM | Same as VTM | Same as VTM | Same as VTM | 4 | N |

Chroma complexity:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Tests** | **Samples from block bound. modified** | **Samples from block bound. for deblocking decision** | **Max num. oper for filtering per line (add/mult/compar/shift)** | **Max number of oper. for decision for 8-sample boundary (add/mult/compar/shift)** | **Max number of operations including filtering and decision (per \*sample\*)**  **(add/mult/compar/shift)** | **Num. line buffers** | **Worst case complexity increased (Y/N)** |
| CE11-2.1 | VTM | VTM | VTM | VTM | VTM | VTM | N |
| CE11-2.2 | VTM | VTM | VTM | VTM | VTM | VTM | N |
| CE11-2.3 | VTM | VTM | VTM | VTM | VTM | VTM | N |

Even though in terms of computation operations no increase over VTM occurs, the worst case number of edges is doubling in CE11-2.1/2, and this may be some concern in hardware implementation. In CE11-2.2, the number of edges is doubling in both luma and chroma.

Objective results with ALF on

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test** | **AI** | | | | | **RA** | | | | |
| **Y** | **U** | **V** | **EncT (%)** | **DecT (%)** | **Y** | **U** | **V** | **EncT (%)** | **DecT (%)** |
| CE11-2.1 | 0.05% | 0.00% | 0.00% | 90% | 102% | 0.03% | -0.06% | -0.06% | 102% | 102% |
| CE11-2.2 | -0.05% | 0.22% | 0.14% | 99% | 98% | -0.02% | 0.28% | 0.19% | 100% | 98% |
| CE11-2.3 | 0.00% | 0.00% | 0.00% | 100% | 100% | 0.04% | -0.05% | 0.00% | 100% | 98% |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test** | **LD-B** | | | | | **LD-P** | | | | |
| **Y** | **U** | **V** | **EncT (%)** | **DecT (%)** | **Y** | **U** | **V** | **EncT (%)** | **DecT (%)** |
| CE11-2.1 | -0.05% | 0.04% | 0.17% | 95% | 102% | -0.15% | -0.26% | -0.20% | 99% | 101% |
| CE11-2.2 | -0.04% | -0.06% | -0.39% | 100% | 99% | 0.00% | -0.26% | -0.39% | 99% | 98% |
| CE11-2.3 | 0.10% | 0.08% | -0.21% | 100% | 97% | 0.06% | -0.05% | -0.04% | 100% | 98% |

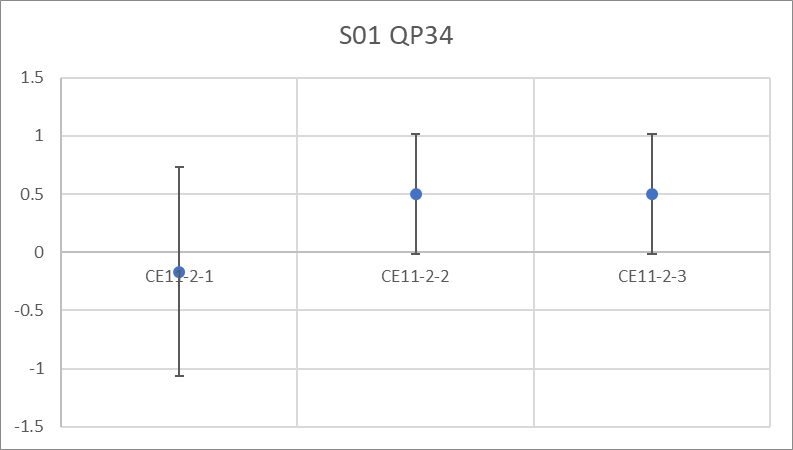
Objective results with ALF off

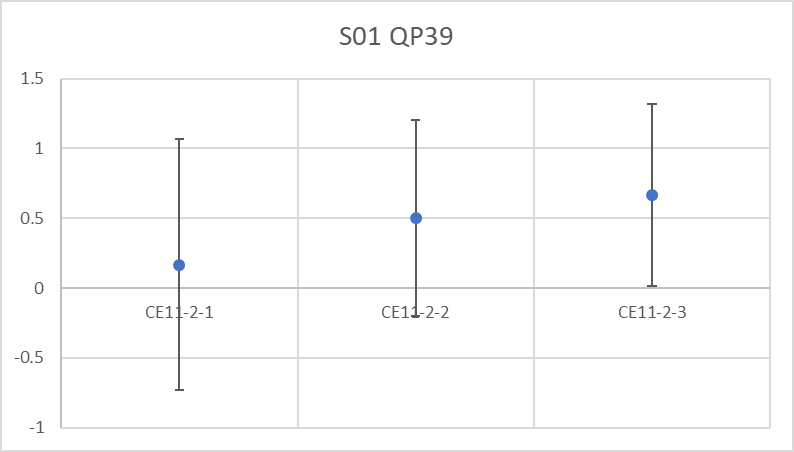
|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test** | **AI** | | | | | **RA** | | | | |
| **Y** | **U** | **V** | **EncT (%)** | **DecT (%)** | **Y** | **U** | **V** | **EncT (%)** | **DecT (%)** |
| CE11-2.1 | -0.03% | 0.00% | 0.00% | 100% | 102% | -0.12% | -0.08% | -0.06% | 100% | 101% |
| CE11-2.2 | -0.01% | -0.27% | -0.47% | 100% | 98% | 0.00% | 0.60% | 0.47% | 100% | 99% |
| CE11-2.3 | 0.00% | 0.00% | 0.00% | 100% | 100% | 0.06% | -0.01% | 0.00% | 100% | 100% |

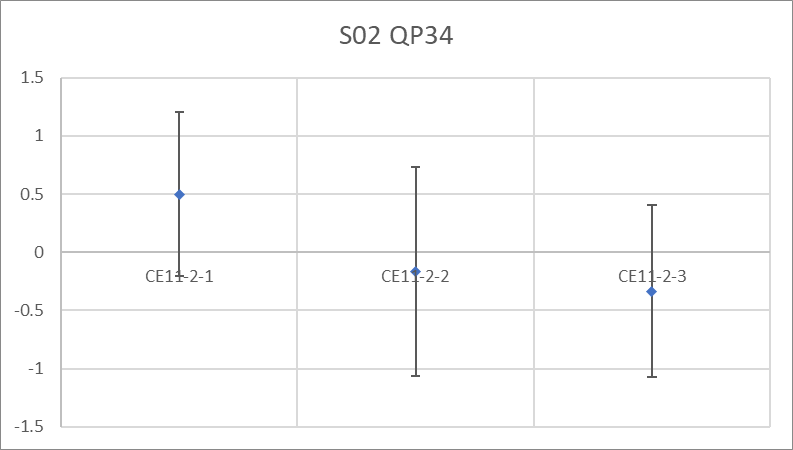
|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test** | **LD-B** | | | | | **LD-P** | | | | |
| **Y** | **U** | **V** | **EncT (%)** | **DecT (%)** | **Y** | **U** | **V** | **EncT (%)** | **DecT (%)** |
| CE11-2.1 | -0.08% | -0.02% | -0.01% | 100% | 103% | -0.53% | -0.24% | -0.18% | 100% | 102% |
| CE11-2.2 | -0.01% | -0.17% | -0.31% | 100% | 99% | 0.02% | -0.17% | -0.31% | 100% | 99% |
| CE11-2.3 | 0.08% | -0.11% | -0.13% | 100% | 100% | 0.13% | -0.04% | -0.05% | 100% | 100% |

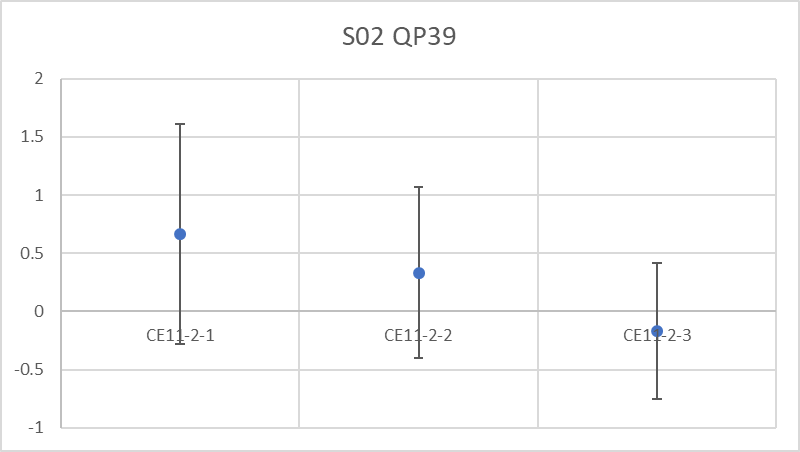
It is pointed out that CE11-2.1 deblocks all subblock transform boundaries, whereas VTM does not deblock even 8x8 subblock transform boundaries, but there is a bug in the implementation such that it is not performed.

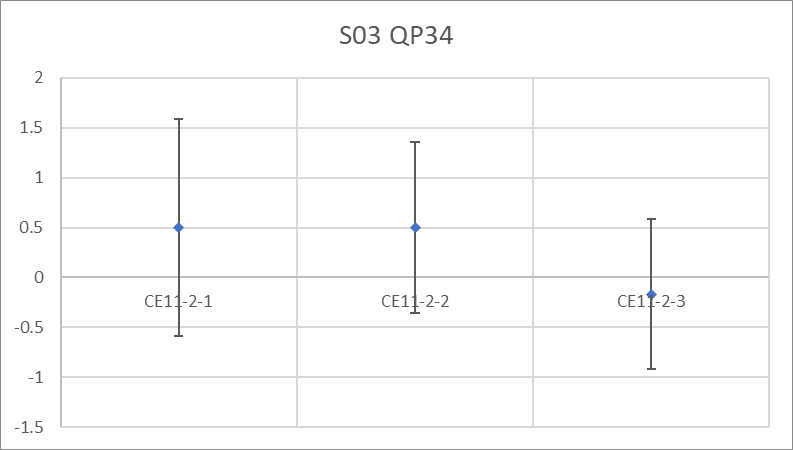
Results of subjective testing for CE11-2, ALF on:

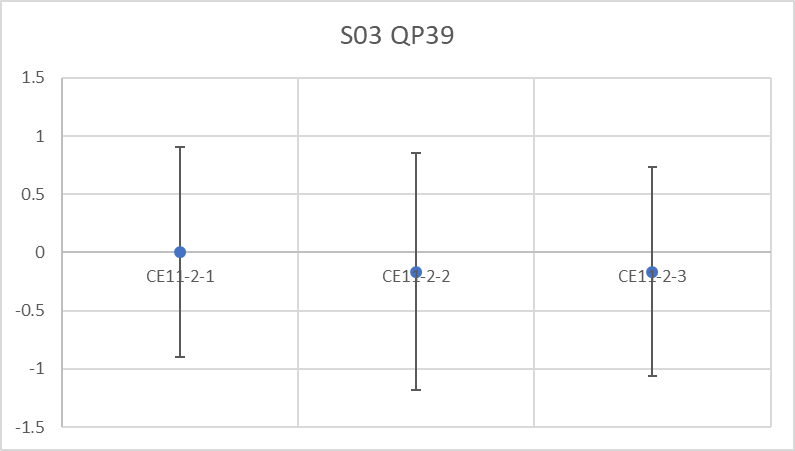


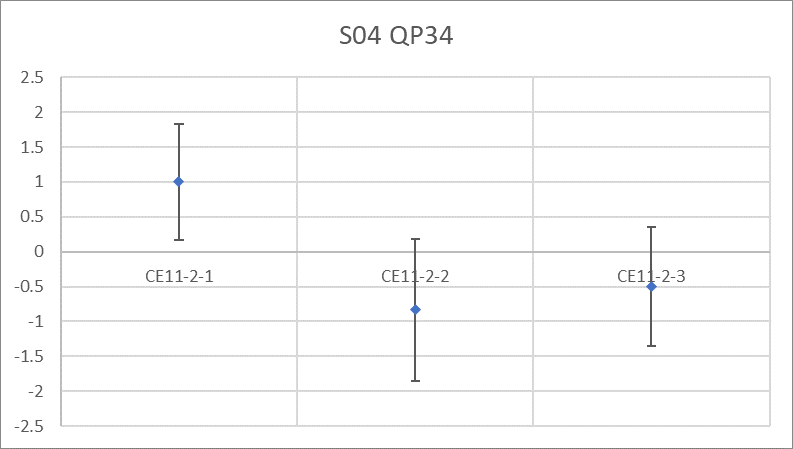


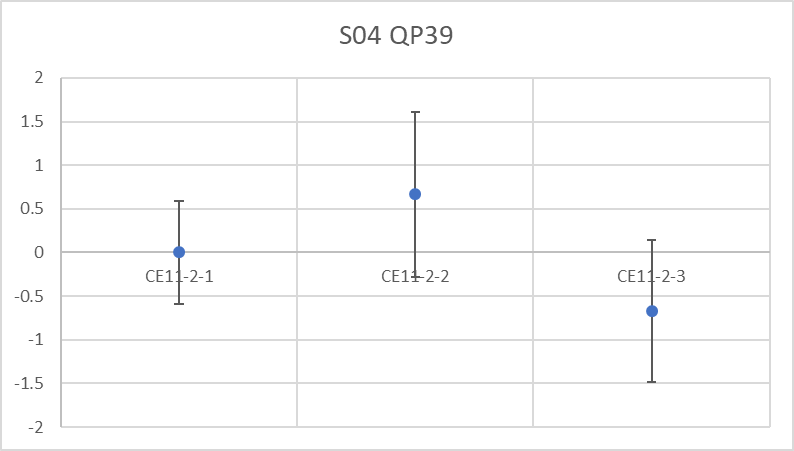






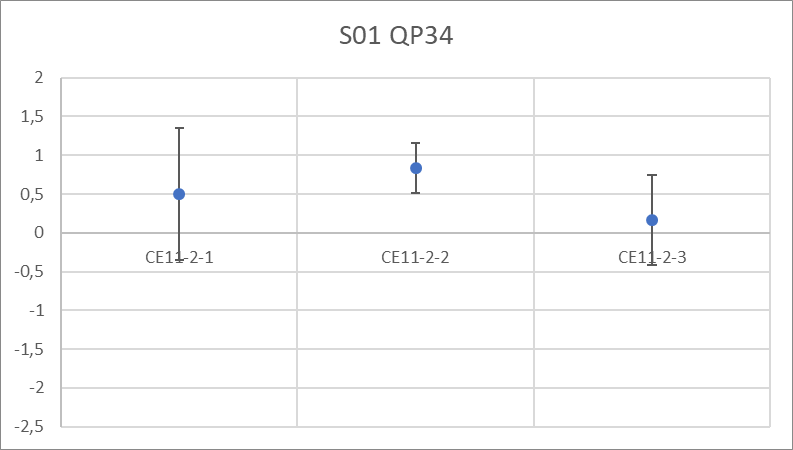


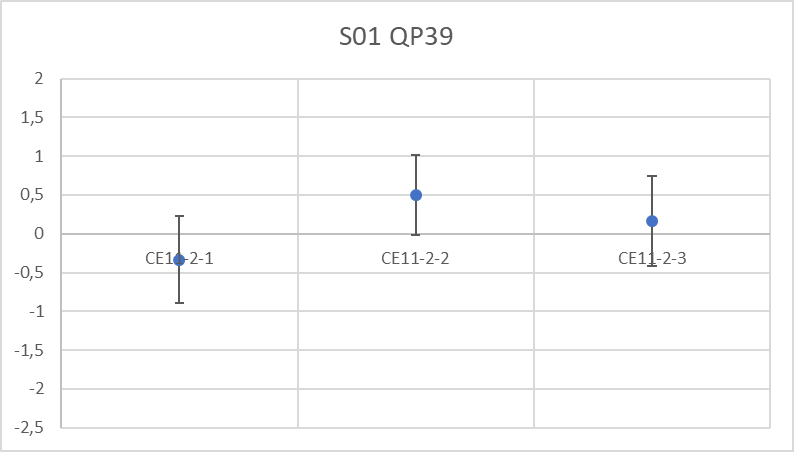


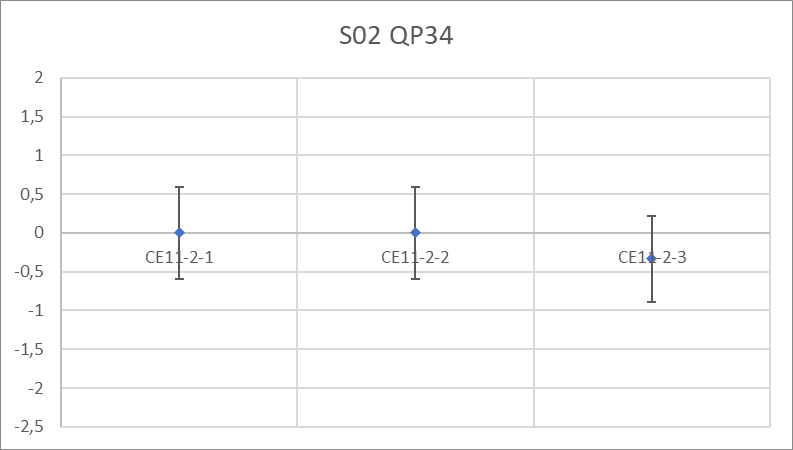


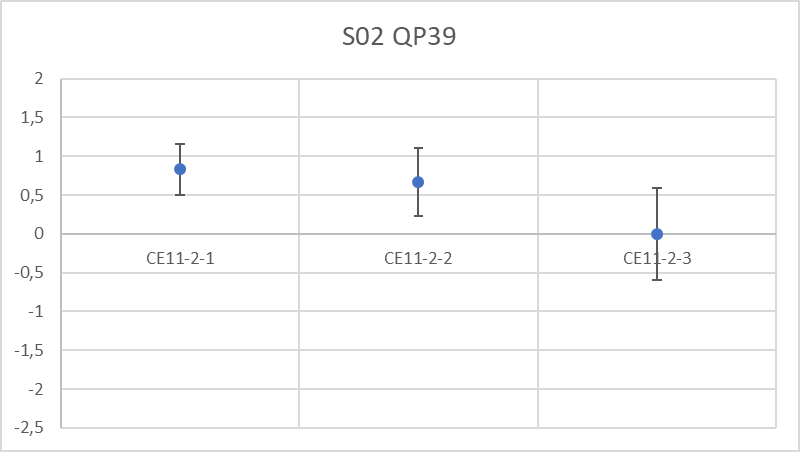
Visual tests with ALF on are not fully conclusive. Sometimes CE11-2.3 (which is even doing less deblocking than VTM) behaves better, sometimes one of the other two. There is only one clear case of CE11-2.1 (and a few corner cases of others as well) where a visual benefit over VTM4 could be shown with statistical significance.

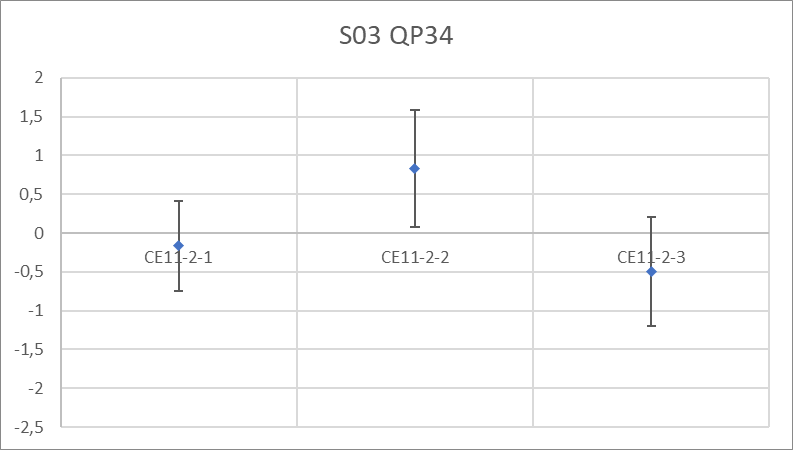
It was therefore decided to run another round of subjective tests with ALF off on CE11-2 to see if a more clear tendency can be determined.

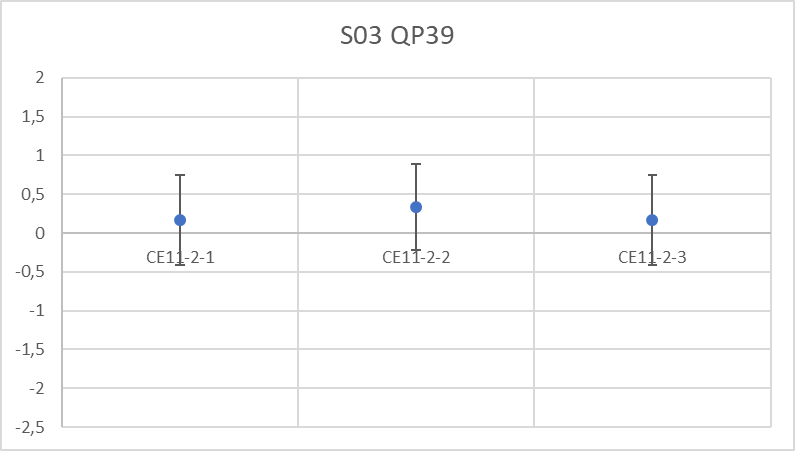


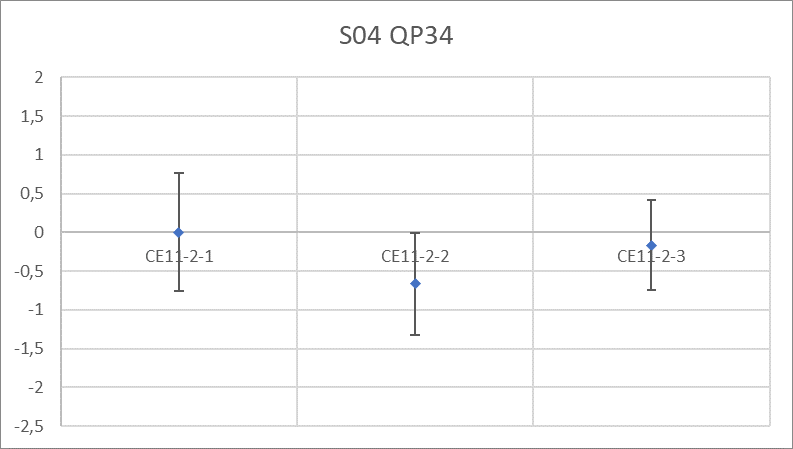


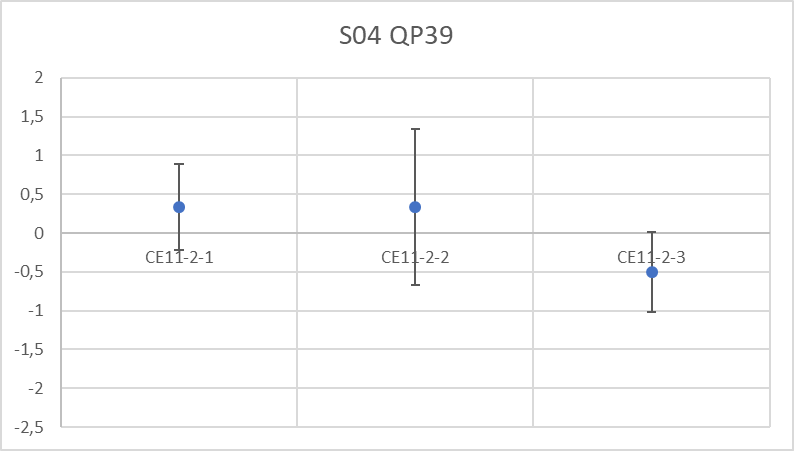












From the results above, it becomes more evident that proposals whch perform deblocking at more boundaries (CE11-2.1 and CE11-2.2) have visual advantage over the proposal with less deblocking (CE11-2.3The proposal CE11-2.2 has two out of four cases with better visual quality than VTM4 at QP34, which would still be a reasonable quality in the normal application range. CE11-2.1 ha another case in ALF on configuration where it performed better than VTM4 at QP34.

It is further noted that CE11-2.2 does not deblock SBT and ISP boundaries (which VTM4 also did not do, because it was a kind of bug from the last meeting), whereas CW11-2.1 already corrected this bug, and some aspects of its quality may be due to this.

It is confirmed by proponents of CE11-2.2 that the proposal has full capability of parallel processing, as a 4x4 block would not be deblocked, if the next block is again at a distance 4.

Another aspect is that CE11-2.2 is also deblocking the chroma blocks aligned with the modified boundaries of the luma blocks. CE11-2.1 does not do that and leaves the deblocking of the chroma on a fixed 8x8 grid. It seems to be a reasonable design choice to deblock the chroma aligned with the luma.

It was initially suggested to adopt the JVET-N0098 method for deblocking of 4x4 boundaries, including the bug fix on ISP and SBT, in combination with the aspect from JVET-N0463 of deblocking chroma at boundaries that are aligned with luma.

In a follow-up discussion, it was identified that a straightforward combination of the two methods is not possible, as JVET-N0098 in extreme case would deblock all 4x4 block boundaries (with shorter filter), and the corresponding chroma boundaries would be 2x2. In terms of worst case number of boundaries, JVET-N0098 doubles for luma and keeps chroma unchanged relative to VTM4. JVET-N0463 keeps the worst case number for luma unchanged, but doubles for chroma. Both approaches increase the number, but effectively for the case of 4:2:0 the increase is larger for JVET-N0098, as luma has more samples than chroma. (As suggested in some other discussion by hardware experts, the number of boundaries is of larger concern than the multiplications necessary for length of the filters, as decisions have to determined at each boundary). Further study is necessary to identify whether there is benefit to actually deblock small blocks (JVET-N0463 does not deblock any blocks at their 4xN or Nx4 boundaries, i.e. only the longer side of such blocks is deblocked. It however deblocks larger blocks where the boundary is not aligned with an 8x8 grid). The CE should be continued to better identify

- How much benefit comes due to the 4xN and Nx4 deblocking of JVET-N0098

- How much benefit comes from the additional chroma deblocking of JVET-N0463

Further investigation should also be performed on the aspect if 4:4:4 material should be deblocked differently from 4:2:0, as this would also have impact to decide which of the wo methods is more complex (1080p is sufficient for that).

The additional aspect from JVET-N0098 of adapting the MV threshold should also be independently studied in CE.

[JVET-N0098](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5818) CE11-2.1: Deblocking for 4xN, Nx4 and 8xN and Nx8 block boundaries not aligned with 8x8 grids [K. Andersson, J. Enhorn, Z. Zhang, R. Sjöberg (Ericsson), A. M. Kotra, J. Chen, S. Esenlik, B. Wang, H. Gao, Y. Zhao (Huawei), C.-M. Tsai, C.-W. Hsu, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0181](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5901) CE11-2.3: Disabling of sub-pu deblocking [A. M. Kotra, S. Esenlik, J. Chen, B. Wang, H. Gao (Huawei)]

[JVET-N0463](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6185) CE11-2.2 Disable deblocking filter for 4xN for vertical edge and Nx4 for Horizontal edge on 4x4 grid [H. Jang, J. Nam, J. Lim, S. Kim (LGE)]

[JVET-N0595](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6332) CE11-1.1: Further information on conditionally signaled very strong deblocking [C. Helmrich (HHI)] [late]

## CE12: Tile set boundary motion compensation handling (2)

[JVET-N0032](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6460) CE12: Summary report on Tile Set Boundary Handling [Hendry, R. Skupin, W. Wan]

This report was discussed in Track B on Thursday 21 March 1000 (GJS)

A summary of Core Experiment 12 (CE12) on Tile Boundary Handling is reported. Two tests were defined in CE12:

* CE12-1: Handling all tile group boundaries as picture boundaries which includes padding to the tile group boundaries and allowing motion vectors to point to samples outside the tile group boundaries in the reference pictures and TMVP and ATMVP handling boundaries of temporally independent tile groups similar to picture boundaries.
* CE12-2: Encoder-side restrictions of tile groups to not use samples or motion vector candidates from outside the tile group.

All tests were evaluated based on test conditions defined in JVET-M0870. All tests and crosscheck results are integrated in this report.

As described in JVET-M0870, the 360° video test sequences SkateboardInLot, ChairLift, KiteFlite, Harbor, Trolley and GasLamp are used in CMP format with a face size of 1536x1536 and a total resolution of 4608x3072 equivalent to 6k.

Two tiling setups were investigated, namely 6x4 and 12x8 uniformly sized tiles, which results in tile sizes of 768x768 (i.e. 24 tiles) or 384x384 (i.e. 96 tiles) respectively.

In order to avoid the implementation burden for CE12-1, tests were run with one encoder per tile group. As ALF and reshaper result in very different operation points when optimized over the whole picture or just a sub-picture, it was agreed amongst participants to disable ALF and LMCS for all tests and the anchor. Furthermore, runtimes are reported as cumulative runtimes of sequential en-/decoders.

|  |  |  |  |
| --- | --- | --- | --- |
| Proposal Document # | Corresponding Tests | Title | Author(s) |
| JVET-N0109 | CE12-1 | CE12/AHG12: Treating boundaries of independent tile groups as picture boundaries | Hendry, S. Hong, J. Chen, Y.-K. Wang (Huawei) |
| JVET-N0356 | CE12-2 | CE12-2: Encoder-side tile group restriction | R. Skupin, Y. Sanchez, V. George, K. Suehring, T. Schierl (HHI) |

**CE12-1: Handling independently decodable tile group boundaries as picture boundaries**

In CE12-1, the goal is to investigate the coding efficiency of independently decodable tile groups when tile set boundaries are handled as picture boundaries for motion compensation, i.e. boundary extension.

The test results for this aspect are summarized as follows:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| # | Proposal | Config. |  |  | VTM |  |  |
|  |  |  | Y | U | V | EncT\* | DecT\* |
| CE12-1 | JVET-N0109 | RA  6x4 Tiles | 2.64% | 3.24% | 3.35% | 131% | 63% |
| RA  12x8 Tiles | 10.00% | 11.90% | 12.34% | 124% | 63% |

\* The runtimes for CE12-1 may not be accurate since it is the sum of runtimes multiple encoders and decoders so there are overhead of initializing encoders and decoders.

**CE12-2: Encoder-side tile group restriction**

In CE12-2, the goal is to investigate the coding efficiency of independently decodable tile groups when encoder-side restrictions are employed in motion compensation.

The test results for this aspect are summarized as follows:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| # | Proposal | Config. |  |  | VTM |  |  |
|  |  |  | Y | U | V | EncT | DecT |
| CE12-2 | JVET-N0356 | RA  6x4 Tiles | 6.77% | 7.04% | 7.28% | 110% | 61% |
| RA  12x8 Tiles | 16.46% | 18.24% | 18.86% | 102% | 61% |

It was not clear why the decoding times were reduced in either subtest.

The worst case penalty with 96 tiles for method 2 is 34% (versus 19% for method 1).

The worst case penalty with 24 tiles for method 2 is 14% (versus 7% for method 1).

The RD percentage penalty is larger at lower bit rates. It was commented that the relevant applications would tend to use relatively high fidelity.

It was commented that it is important to limit the amount of decoder special treatment to enable the related applications (which are more than just 360° video – e.g., high-resolution parallel encoding for ordinary video, region-of-interest decoding, multi-way videoconferencing, gradual decoder refresh, and point clouds). It was commented that if we take action on method 1, we should avoid “scope creep” to add additional complicated optimization for the use case.

The changes needed for the reference software for method 1 had not been done. Method 2 is already supported in the VTM. It was commented that the software changes for method 1 are more localized than for method 2 (basically only affecting two functions).

For hardware, method 1 was said not to be a substantial burden. It also seemed doable for software, although it makes the pre-padding approach basically infeasible.

Review of related contributions was then done (at 1115), and further discussion was held at 1215.

The syntax of the method 1 CE uses a flag for each tile group in the PPS (also proposed in N0124), only for rectangular tile groups.

The group was inclined to adopt method 1, but felt that VTM software should be available before action. So this will be considered at the next meeting when software is expected to become available and the quality of the software and its speed can be confirmed. No CE was planned on this topic.

[JVET-N0109](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5829) CE12/AHG12: Treating boundaries of independent tile groups as picture boundaries [Hendry, S. Hong, J. Chen, Y.-K. Wang (Huawei)]

[JVET-N0356](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6077) CE12-2: Encoder-side tile group restriction [R. Skupin, Y. Sanchez, V. George, K. Sühring, T. Schierl (HHI)] [late]

## CE13: Neural-network based loop filtering (5)

Contributions in this category were discussed Thursday 21 March 0930–1130 (Track A chaired by JRO).

[JVET-N0033](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6303) CE13: 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 13 on neural network based filter for video coding. 22 tests have been tested in CE13 in between JVET-M and JVET-N 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. Crosschecking results for the performed tests are integrated in this contribution.

the following tests in table 1 are performed in CE13.

Table 1: Summary of tests performed in CE13

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test #** | **Description** | **Document** | **Tester** | **Cross checker** |
| CE13-1.1a | Loop filter chain: DBF + SAO + ALF + NN filter. NN filter follows the description in M0159 | JVET-N0110 | Y.-L. Hsiao (Mediatek) | H. Yin (Intel) |
| ~~CE13-1.1b~~ | ~~Loop filter chain: NN filter only. NN filter follows the description in M0159~~ | ~~JVET-N0110~~ | ~~Y.-L. Hsiao (Mediatek)~~ |  |
| CE13-1.2a | Loop filter chain: DBF + SAO + ALF + NN filter. NN filter follows the description in M0566 | JVET-N0480 | H. Yin (Intel) | Y.-L. Hsiao (Mediatek) |
| ~~CE13-1.2b~~ | ~~Loop filter chain: NN filter only. NN filter follows the description in M0566~~ | ~~JVET-N0480~~ | ~~H. Yin (Intel)~~ |  |
| CE13-2.1a | DBF + NN filter + SAO + ALF, NN filter follows the description in M0351 | JVET-N0169 | C. Lin (Hikvision) | Y. Wang (Wuhan Univ.) |
| CE13-2.1b | NN filter only, NN filter follows the description in M0351 | JVET-N0169 | C. Lin (Hikvision) | Y. Wang (Wuhan Univ.) |
| CE13-2.1c | NN filter + ALF, NN filter follows the description in M0351 | JVET-N0169 | C. Lin (Hikvision) | Y. Wang (Wuhan Univ.) |
| CE13-2.2a | DBF + NN filter + SAO + ALF, NN filter follows the description in M0508 | JVET-N0254 | Y. Wang (Wuhan Univ.) | C. Lin (Hikvision) |
| CE13-2.2b | NN filter only, NN filter follows the description in M0508 | JVET-N0254 | Y. Wang (Wuhan Univ.) |  |
| CE13-2.2c | NN filter + ALF, NN filter follows the description in M0508 | JVET-N0254 | Y. Wang (Wuhan Univ.) |  |
| CE13-2.3a | CTC QP for training, CTC QP for testing (the same as CE13-2.2.a) | JVET-N0254 | Y. Wang (Wuhan Univ.) |  |
| CE13-2.3b | CTC QP for training, CTC QP + 2 for testing | JVET-N0254 | Y. Wang (Wuhan Univ.) |  |
| CE13-2.3c | CTC QP for training, CTC QP - 2 for testing | JVET-N0254 | Y. Wang (Wuhan Univ.) |  |
| CE13-2.4a | DBF + NN filter + SAO + ALF, NN filter follows the description in M0510 | JVET-N0513 | Y. Dai (USTC) | Y. Wang (Wuhan Univ.) |
| CE13-2.4b | NN filter only, NN filter follows the description in M0510 | JVET-N0513 | Y. Dai (USTC) |  |
| CE13-2.4c | NN filter + ALF, NN filter follows the description in M0510 | JVET-N0513 | Y. Dai (USTC) |  |
| CE13-2.5a | CTC QP for training, CTC QP for testing(the same as CE13-2.4.a) | JVET-N0513 | Y. Dai (USTC) |  |
| CE13-2.5b | CTC QP for training, CTC QP + 2 for testing | JVET-N0513 | Y. Dai (USTC) |  |
| CE13-2.5c | CTC QP for training, CTC QP - 2 for testing | JVET-N0513 | Y. Dai (USTC) |  |
| CE13-2.6a | DBF + NN filter + SAO + ALF, NN filter follows the description in M0872 | JVET-  N710 | K. Kawamura (KDDI) |  |
| CE13-2.6b | NN filter only, NN filter follows the description in M0872 | JVET-  N710 | K. Kawamura (KDDI) |  |
| CE13-2.6c | NN filter + ALF, NN filter follows the description in M0872 | JVET-  N710 | K. Kawamura (KDDI) |  |
| CE13-2.7a | NN filter adaptive on/off in CTU level | JVET-  N710 | K. Kawamura (KDDI) |  |
| CE13-2.7b | NN filter always on in CTU level | JVET-  N710 | K. Kawamura (KDDI) |  |

It comprises 2 categories,

* CE 13.1: Topics on top of sequence-adaptive (two-pass) methods
* CE 13.2: Topics on top of sequence-independent (one-pass) methods

Each category will investigate the following problems:

* The impact of NN filter position in the filter chain.
* The benefit of the CTU/block level NN filter adaptive on/off.
* The generalization capability of the NN filter when the test QP is not the same as the training QP.

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 +/- 2

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

Table 1: CE13 test results with VTM-4.0+ Test Condtion1 (CTC)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **AI Over VTM-4.0** | | | | | **RA Over VTM-4.0** | | | | |
|  | **Test#** | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** |
| CTC Full test | CE13-1.1a |  |  |  |  |  | -1.36% | -14.96% | -14.91% | 100% | 142% |
| CE13-1.2a |  |  |  |  |  | -0.58% | -10.91% | -10.69% | 103% | 127% |
| CE13-2.1a | -3.48% | -5.18% | -6.77% | 142% | 38414% |  |  |  |  |  |
| CE13-2.1b | -4.14% | -5.49% | -6.70% | 140% | 38411% |  |  |  |  |  |
| CE13-2.1c | -4.65% | -6.73% | -7.92% | 139% | 37956% |  |  |  |  |  |
| CE13-2.2a | -1.52% | -2.12% | -2.73% | 107% | 4667% | -1.45% | -4.37% | -4.27% | 106% | 7156% |
| CE13-2.4a | -0.87% | -0.44% | -0.56% | 106% | 1912% | -0.49% | -0.23% | -0.33% | 124% | 468% |
| CE13-2.6a |  |  |  |  |  |  |  |  |  |  |

Table 2: CE13 test results with VTM-4.0+Test Condtion2

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | |  | **AI Over VTM-4.0** | | | | | **RA Over VTM-4.0** | | | | |
|  |  | **Test#** | | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** | |
| Test Condition  #2 | Filter chain | CE13-2.2a | |  |  |  |  |  | -1.62% | -4.51% | -4.42% | 106% | 7559% | |
| CE13-2.2b | |  |  |  |  |  | 1.51% | 1.21% | 1.80% | 105% | 9910% | |
| CE13-2.2c | |  |  |  |  |  | -0.65% | -2.18% | -1.60% | 105% | 9937% | |
| Filter chain | CE13-2.4a | |  |  |  |  |  | -0.53% | -0.23% | -0.43% | 90% | 349% | |
| CE13-2.4b | |  |  |  |  |  | 5.73% | 6.09% | 6.07% | 95% | 610% | |
| CE13-2.4c | |  |  |  |  |  | 1.14% | 2.52% | 2.65% | 90% | 497% | |
| Filter chain | CE13-2.6a | |  |  |  |  |  | -1.70% | -2.84% | -4.09% | 139% | 63166% | |
| CE13-2.6b | |  |  |  |  |  | 2.26% | 3.86% | 2.09% | 138% | 66303% | |
| CE13-2.6c | |  |  |  |  |  | -0.80% | -1.21% | -2.59% | 138% | 66626% | |
| CTU adaptive on/off | CE13-2.7a | |  |  |  |  |  | -1.70% | -2.84% | -4.09% | 139% | 63166% | |
| CE13-2.7b | |  |  |  |  |  | -1.68% | -2.79% | -4.05% | 138% | 69946% | |

Table 3: CE13 test results with VTM-4.0+Test Condtion3

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | |  | **AI Over VTM-4.0** | | | | | **RA Over VTM-4.0** | | | | |
|  |  | **Test#** | | **Y** | **U** | **V** | **EncT** | **DecT** | **Y** | **U** | **V** | **EncT** | **DecT** | |
| Test Condition  #3 | generalization capability (QP) | CE13-2.3a | |  |  |  |  |  | -1.62% | -4.51% | -4.42% | 106% | 7559% | |
| CE13-2.3b | |  |  |  |  |  | -1.88% | -4.81% | -4.33% | 107% | 8008% | |
| CE13-2.3c | |  |  |  |  |  | -1.37% | -4.57% | -4.04% | 105% | 6794% | |
| generalization capability (QP) | CE13-2.5a | |  |  |  |  |  | -0.53% | -0.23% | -0.43% | 90% | 349% | |
| CE13-2.5b | |  |  |  |  |  | -0.52% | -0.31% | -0.48% | 98% | 378% | |
| CE13-2.5c | |  |  |  |  |  | -0.46% | -0.33% | -0.40% | 113% | 422% | |

For the understanding of network, e.g., complexity, the following information is provided.

Table 4: CE13 test results with complexity analysis

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **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) |
| CE13-1.1 | 3 | 0 | NA | 1506 | 6-bit/32-bit (I) | 0.001282 | 0.344 (128x128, CTU based) |
| CE13-1.2 | 2 | 0 | NA | 692x3 (Luma)  402x3 (Chroma) | 6-bit/32-bit (I) | 0.0028 | 0.0448(128x128, CTU based) |
| CE13-2.1 | 8 | 0 | Caffe | 224960 | 32-bit (F) | 0.86 | 1846.95(192x152, block based) |
| CE13-2.2 | 21 | 0 | PyTorch | 22371 | 32-bit (F) | 0.09 | 196.23(pixels num. < 80000, block based) |
| CE13-2.4 | 10 | 0 | Tensorflow | 7521 | 32-bit (F) | 0.029 | 10.06(128\*128,CTU based) |
| CE13-2.6 |  |  |  |  |  |  |  |

Generally, the performance/complexity tradeoff indicates that the NN technology currently is not mature enough to be included in a standard. The main purpose of this CE had been to provide answers to following questions:

The impact of NN filter position in the filter chain: The results indicate that with a very complex deep network architecture the same or better objective performance can be achieved even if the notwork is run standalone rather than combining it with the conventional filters. This is shown in CE13-2.1, however only for AI configuration. CE13-2.2, CE13-2.4 and CE13-2.6 which are less complex and also run in RA configuration were not able to fully compensate for the gain of conventional filters if those were disabled. It is asked if this would also translate into subjective benefit. An informative session should be prepared during the meeting. Results from experiment 13-2.2 (and if possible 13-2.4) are of particular interest here, because by comparing AI and RA also effects of pure post processing (for AI) or in-loop processing (for RA) could be compared. Best using QP 32 and 37.

The benefit of the CTU/block level NN filter adaptive on/off. This was investigated in CE13-2.7 (a is adaptive, b is always on). The objective gain of adapive is minor, but it would be useful to confirm if it has subjective benefit. Include 13-2.7 in the informal viewing.

The generalization capability of the NN filter when the test QP is not the same as the training QP: This is investigated in CE13-2.3 and CE13-2.5. a is the case where training and test QP are identical. For example, the network in CE13-2.3 was trained in a way that the actual QP is one input parameter of the network. In test a, the network is then run with inputting the true QP, and in cases b and c the actual QP was higher and lower than the one input to the network. However, the difference was not large. Results indicate that the difference is minor, however there is some tendency that the network performs better when the rate is lower (or the actual quality is worse) than in training.

CE13-2.6/7 were only trained with QP37 examples, and the weight by which the difference signal generated by the network was superimposed is decreased for the cases of lower QP.

It can be concluded that there need to be some mechanisms that guarantee that the network is operating differently for different QP values. 13-2.4 and 13-2.5 trained different CNN for every QP value. The effect of CNN filters is probably largest for high QP. Further investigation on this aspect is necessary, also the complexity impact of QP dependent networks should be studied, e.g. the need to load new filter weights.

Another question that should be deeper investigated is the aspect of in-loop or post filter operation. This requires running RA configuration with both in-loop and post processing, and also more to take into account possible subjective impact.

Continue CE. BoG (Y. Li) to review the two CE related contributions, prepare viewing session, and discuss preparation of the upcoming CE

It is mentioned that there is an MPEG standardization activity on neural network compression. Would there be any need for coordination? For future clarification and study.

[JVET-N0110](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5830) CE13-1.1: 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-N0653](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6403) Crosscheck of JVET-N0110 (CE13-1.1: Convolutional neural network loop filter) [H. Yin, R. Yang, X. Fang, S. Ma (??)] [late]

[JVET-N0169](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5889) CE13-2.1: Convolutional Neural Network Filter (CNNF) for Intra Frame [?? (??)]

[JVET-N0254](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5975) CE13: Dense Residual Convolutional Neural Network based In-Loop Filter (Test 2.2 and 2.3) [Y. Wang, Z. Chen, Y. Li (Wuhan Univ.), L. Zhao, S. Liu, X. Li (Tencent)]

[JVET-N0480](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6202) CE13-1.2: Adaptive convolutional neural network loop filter [H. Yin, R. Yang, X. Fang, S. Ma (??)]

[JVET-N0513](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6239) CE13: Experimental results of CNN-based In-Loop Filter [Y. Dai, D. Liu, N. Yan, F. Wu (USTC)] [late]

[JVET-N0710](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6464) CE13-2.6/CE13-2.7: Evaluation results of CNN based in-loop filtering [K. Kawamura, Y. Kidani, S. Naito (KDDI)] [late]

# Non-CE Technology proposals

## CE1 related – Post-prediction and post-reconstruction filtering (10)

Contributions in this category were discussed Thursday 21 March 1150–1400 (Track A chaired by JRO).

[JVET-N0144](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5864) Non-CE1: Simplification of division calculation in local illumination compensation [Y. Yasugi, T. Ikai (Sharp)]

This contribution proposes a method to reduce the table size in scale value derivation in local illumination compensation (LIC). In CE4, the LIC scale value derivation is division free with the 16-bit inverse value multiplication. However the multiplication requires an operation with up to 28 bits and a table of 1024 bits. The proposed method reduces the bit width to 10 bits and the table size to 64 bits. The experimental result reportedly show the luma BD rate performance on average are -0.42% and -0.39% for RA and LB configuration, respectively.

The algorithm of the proposed method is basically as same as the scaling method in CCLM of VTM-4.0, which was originally proposed in JVET-M0064.

The method corresponds to the “1-5.1a” results of CE1 which is not the desirable solution. Relative to that, the loss is 0.04%.

Table has 4 bit instead of three in CCLM.

The unification with CCLM is probably going into the right direction, but here only one part of it is used. Furthermore, currently LIC does not seem to have enough benefit for making it a candidate for VVC (as per results of CE1).

[JVET-N0556](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6285) Crosscheck of JVET-N0144 (Non-CE1: Simplification of division calculation in local illumination compensation) [K. Abe (Panasonic)] [late]

[JVET-N0171](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5891) CE1-related: Combination of LIC and affine [H. Chen, X. Ma, H. Yang, J. Chen (Huawei)]

This contribution proposes unification methods for affine and LIC. Unidirectional illumination compensation in JVET-M0500 is extended to affine coded CU. It is asserted that the BD-rate can be improved by enabling affine with LIC. In LIC, the linear model parameters are estimated based on the reconstructed neighbor samples of the current CU and their corresponding reference samples. In this contribution, 3 methods are proposed for fetching the reference samples of affine coded CU.

In method one, the top-left sub-block motion vector (MV) of the affine coded CU is used for fetching the reference samples of the whole CU. In method two, the central sub-block MV is used. In method three, the reference samples in the top template are fetched by each sub-block MVs in top row and the reference samples in the left template are fetched by each sub-block MVs in left column.

For method one, the simulation results reportedly show on average 0.67%/0.45% luma BD-rate saving with 118%/116% encoding time in RA/LDB configurations over VTM4.0.

For method two, the simulation results reportedly show on average 0.63%/0.48% luma BD-rate saving with 118%/116% encoding time in RA/LDB configurations over VTM4.0.

For method three, the simulation results reportedly show on average 0.72%/0.47% luma BD-rate saving with 118%/116% encoding time in RA/LDB configurations over VTM4.0.

The method corresponds to the “1-5.1a” results of CE1 which is not the desirable solution. Relative to that, the loss is 0.04%.

It is interesting to note that the combination with affine improves the performance of LIC. The solution suggested here is computing LIC at CU level, which could be manageable complexity-wise. Would be interesting to see which loss would be observed if it was operated with the CE1-5.1b restriction. It is also suggested that in case of large CUs, it could also be practical to subdivide and perform LIC on the 16x16 block level.

The method three is the most practical solution, as it ony uses samples that are fetched anyway in affine.

Further study in CE. Combination with CE1-5.1b, and also test in combination with the min/max based parameter derivation from JVET-N0716 (see further notes there). Also, the aspect of determining LIC parameters on a 16x16 grid for larger CUs (as previously tested in CE1-5.7b) should be included in the test.

[JVET-N0720](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6475) Crosscheck of JVET-N0171 (CE1-related: Combination of LIC and affine) [H. Huang (Qualcomm)] [late]

[JVET-N0206](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5926) CE1-related: Improvement of the neighboring reference samples restriction on LIC test [K. Abe, T. Toma (Panasonic)]

This contribution is a follow-up contribution to JVET-N0205 and CE1-5 tests described in JVET-M1021. LIC tests of CE1-5 are conducted with/without the neighboring reference samples constraint. However, large loss was observed with this constraint. This contribution provides test results of LIC tests of CE1-5 using the improved algorithm of the constraint method. Simulation results reportedly show that base LIC (CE1-5.1) with proposed constraint method provides -0.37% BD-rate for RA, -0.37% BD-rate for LDB, and 16x16 unit processing LIC (CE1-5.7) with proposed constraint method provides -0.31% BD-rate for RA, -0.30% BD-rate for LDB.

The benefit over the current CE1-5.xb method is only marginal, and the method may require some additional checks in reference sample access, and requires an additional division. No need for action.

[JVET-N0570](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6304) Crosscheck of JVET-N0206 (CE1-related: Improvement of the neighboring reference samples restriction on LIC test) [V. Seregin (Qualcomm)] [late]

[JVET-N0304](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6025) CE1-related: combined bi-directional LIC and post-reconstruction filters mutually exclusive [P. Bordes, F. Urban, F. Galpin (Technicolor)]

This contribution proposes to combine LIC and post-reconstruction filtering in mutual exclusive way. Then the decoder pipeline worst case is unchanged compared to implementation of LIC or post-reconstruction filtering only.

It is reported the proposed combination of LIC with Bilateral post-reconstruction filtering implemented on top of CE1-5.4b and CE1-5.5b achieves the following gains (YUV):

* CE1-5.4b: -0.82%,-0.43%, -0.41% (RA) and -0.90%, 0.18%, 0.01% (LDB)
* CE1-5.5b: -0.68%,-0.27%, -0.20% (RA) and -0.87%, 0.38%, 0.06% (LDB)

It is reported the proposed combination of LIC with Hadamard post-reconstruction filtering implemented on top of CE1-5.4b and CE1-5.5b achieves the following gains (YUV):

* CE1-5.4b: -0.79%,-0.40%, -0.39% (RA) and -0.90%,0.47%, 0.07% (LDB)
* CE1-5.5b: -0.66%,-0.29%, -0.24% (RA) and -XX%,-XX%, -XX% (LDB)

As the separate technologies were no adopted, the same applies for the combination. It is however interesting to see that gains are additive.

[JVET-N0552](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6281) Crosscheck of JVET-N0304 (CE1-related: combined bi-directional LIC and post-reconstruction filters mutually exclusive) [T. Chujoh, T. Ikai (Sharp)] [late]

[JVET-N0620](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6362) Crosscheck of JVET-N0304 (CE1-related: combined bi-directional LIC and post-reconstruction filters mutually exclusive) [C.-M. Tsai (MediaTek)] [late]

[JVET-N0718](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6472) Crosscheck of JVET-N0304 (CE1-related: combined bi-directional LIC and post-reconstruction filters mutually exclusive) [S. Ikonin (Huawei)] [late]

[JVET-N0306](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6027) non-CE1: simplification of LIC parameters derivation [P. Bordes, F. Urban, F. Galpin (Technicolor)]

This contribution proposes to simplify the derivation of the LIC parameters. The current method is based on LMS and quadratic sum terms operations whereas the proposal is based on linear sum terms operations. It is reported the proposed method reduces the number of operations (number of multiplications) with small loss (0.05% in RA and 0.04% in LDB).

Interesting simplification, but not for free in terms of compression.

JVET-N0410 and JVET-N0716 are other approaches with more reduction of complexity.

[JVET-N0538](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6266) Crosscheck of JVET-N0306 (non-CE1: simplification of LIC parameters derivation) [Y. He (InterDigital)] [late]

[JVET-N0307](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6028) CE1-related: on LIC reference samples selection [P. Bordes, F. Urban, F. Galpin (Technicolor)]

This contribution proposes to adapt the selection of the reconstructed samples values used to derive the LIC parameters to follow the constraint of not using reconstructed intra coded samples.

In the common LIC software used in CE1 experiments (CE1-5.1b), the reconstructed intra coded samples in the L-shape are replaced with the co-located reference sample values. However, this may reduce the LIC efficiency by biasing the LIC parameters to default (1:0) LIC values.

In this proposal, it is proposed to replace the reconstructed samples of the L-shape which are intra coded, with inter-coded reconstructed samples of the L-shape.

It is reported the proposed method achieves BD-rate Luma gains on uni-directional LIC (CE1-5.1b) of -0.04% in RA and -0.01% in LDB, and BD-rate Luma gains on bi-prediction LIC (CE1-5.4b) of -0.04% in RA and -0.05% in LDB.

Similar to N0206, but instead of omitting the missing samples, they are replaced by duplicates of other inter reference samples. As the number of samples stays a number of two, the division can be a shift. At the same time, the corresponding reconstructed samples are also replaced.

The method requires additional buffer accesses and copying. It is not clear if this was justified by the compression benefit. This would be more at the level of fine-tuning once a clear LIC concept would be in VVC (which we currently don’t have)

[JVET-N0410](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6132) CE1-related: Simplification of LIC parameter derivation and its unification with CCLM [A. Filippov, V. Rufitskiy, J. Chen (Huawei)]

No need to present, included in JVET-N0716

[JVET-N0787](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6542) Crosscheck of JVET-N0410 (CE1-related: Simplification of LIC parameter derivation and its unification with CCLM) [K. Abe (Panasonic)] [late]

[JVET-N0648](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6398) Cross-check of JVET-N0410 (CE1-related: Simplification of LIC parameter derivation and its unification with CCLM) [J. Chen (Alibaba)] [late]

[JVET-N0663](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6414) Cross-check of JVET-N0410 (CE1-related: Simplification of LIC parameter derivation and its unification with CCLM) [S.-C. Lim, H. Lee, J. Lee, J. Kang (ETRI)] [late]

[JVET-N0679](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6430) Crosscheck of JVET-N0410 (CE1-related: Simplification of LIC parameter derivation and its unification with CCLM) [J. Lainema (Nokia)] [late]

[JVET-N0717](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6471) Crosscheck of JVET-N0410 (CE1-related: Simplification of LIC parameter derivation and its unification with CCLM) [S.-T. Hsiang (MediaTek)] [late]

[JVET-N0727](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6482) Crosscheck of JVET-N0410 (CE1-related: Simplification of LIC parameter derivation and its unification with CCLM) [N. Choi (Samsung)] [late]

[JVET-N0817](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6572) Crosscheck of JVET-N0410 (CE1-related: Simplification of LIC parameter derivation and its unification with CCLM) [K. Unno (KDDI)] [late]

[JVET-N0479](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6201) CE1-related: Hadamard transform domain in-loop filter also using bottom/right reconstructed samples [S. Ikonin, V. Stepin, A. Karabutov, J. Chen (Huawei)]

This document is a follow-up contribution to JVET-N0478 and test CE1-2.3 in which Hadamard transform domain in-loop filter was tested having access to top and left neighboring reconstructed samples within current CTU. However, for in-loop filters bottom and right samples are also available. This contribution reports results of Hadamard transform domain in-loop filter also having access to bottom/right reconstructed samples.

The simulation over VTM-4.0 shows -0.41%/-0.64% of the luma BD-rate change with 106%/103% of encoding time and 104%/101% of decoding time for AI/RA configurations correspondingly.

This contribution also considers aspect of using reconstructed samples from other than current CTU.

From the partial results, it appears that most of the gain disappears when RDO is not used (in the CE1-2.3 case, it even showed loss). The question would be if still a gain would be observed when the adjacent deblocking filter would also be taken into account in the RDO decision (software for that is available in VTM, but turned off in CTC). It is known that an RDO-optimized deblocking gives comparable or higher gain, so only by considering both together it could be judged if the hadamard filter would have benefit by itself as additional element in the loop.

Further results employing this filter + deblocking with joint RDO opt. against a non-CTC anchor enabling the RDO-optimized deblocking would be welcome.

[JVET-N0625](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6374) Crosscheck of JVET-N0479 (CE1-related: Hadamard transform domain in-loop filter also using bottom/right reconstructed samples) [K. Zhang (Bytedance)] [late]

[JVET-N0482](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6204) CE1-related: Additional test results for CE1-1.7 tests [D. Rusanovskyy, K. Reuze, M. Karczewicz (Qualcomm)]

This document presents additional results for CE1-1.7 tests. An alternative, LUT-free implementation of the bilateral filter design of CE1-1.7 is proposed in this document. The CE1-1.7 method with proposed implementation (and a bug-fix) provides:

**Constraints A**: -0.38% BD-Rate for RA, -0.41% BD-Rate for LDB

**Constraints C**: -0.32% BD-Rate for RA, -0.39% BD-Rate for LDB

It is claimed, that reported results indicates that proposed parametrization (with higher accuracy approximation) provides better bd-rate reduction then alternative BIF methods. It is also argued, that observed improvement to the BIF parametrization can be applicable for other BIF filtering methods, e.g. placed in the loop-filter chain.

Compared to the CE, the method has 1 add, 1 shift and 1 comp more, and also requires a larger ROM table than 1-1.1. Compared in the ”c” case (which would be the desirable solution), the compression increases by 0.01% for RA, and 0.08% for LDB.

No need for action.

[JVET-N0634](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6383) Crosscheck of JVET-N0482 (CE1-related: Additional test results for CE1-1.7 tests) [M. Abdoli, T. Guionnet (ATEME)] [late]

[JVET-N0493](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6215) CE1-related: Multiplication-free bilateral loop filter [J. Ström, P. Wennersten, J. Enhorn, R. Sjöberg (Ericsson)]

This contribution presents a version of the bilateral filter as a loop filter, placed directly before deblocking. It is reported that the shape of the filter is 3×3 samples, and that it uses five 16-item-long LUT tables, that together need 60 bytes of storage. It is stated that 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. BDR figures for luma are -0.46% / -0.61% for AI / RA respectively over VTM-4.0.

In terms of number of samples used, it is higher than 1-1.3 (the simplest solution from CE), but does not require multiplications. In terms of memory requirements it is also lower, similar now to the Hadamard filter.

It also uses samples from right and bottom now (similar to JVET-N0479 for Hadamard LF).

Gain is increased compared to CE1-1.5, similar range as JVET-N0479.

It is commented by cross-checkers that generally this filter seems to provide better gain for low resolution.

Further results employing this filter + deblocking with joint RDO opt. against a non-CTC anchor enabling the RDO-optimized deblocking would be welcome, to understand if such an additional processing element in the loop would have benefit by itself.

It was also suggested by other experts to think about enabling/disabling at low level.

[JVET-N0785](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6540) Cross-check of JVET-N0493: CE1-related: Multiplication-free bilateral loop filter, with additional tests on RDO [K. Reuze, D. Rusanovskyy (Qualcomm)] [late]

[JVET-N0716](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6470) CE1-related: Simplified and robust LIC parameter derivation unified with CCLM [A. Filippov, V. Rufitskiy, J. Chen (Huawei), C. Helmrich, H. Schwarz, D. Marpe, T. Wiegand (HHI)] [late]

This contribution proposes to use CCLM MinMax method to derive linear model parameters for LIC. It is also proposed to improve performance of both LIC and CCLM by calculating average values and slope of linear model with extended set of input data.

It is reported the proposed method reduce the number of sequential computations, simplifies VVC specification draft and reduces hardware complexity.

Powerpoint deck not uploaded.The powerpoint deck has complete results, the document should be updated.

It is tried to use a unified approach for determing parameters both for LIC and CCLM (it is noted that this is not urgently necessary – the more relevant aspect is the complexity reduction for LIC)

If the CCLM method is applied (test 0), LIC loses 0.15% for RA, compared to the CE1-5.1b

The modified method applied to CCLM provides 0.1% gain in AI (from test 2)

The modified method applied only to LIC loses 0.1% for RA, compared to CE1-5.1b

The modified method is somewhat more complex than the CCLM method, but less complex than current LIC

Further investigate in CE, together with the combination affine/LIC, only test 0 and test 1

Test 2 could be investigated in the context of CE3.

[JVET-N0788](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6543) Crosscheck of JVET-N0716 (CE1-related: Simplified and robust LIC parameter derivation unified with CCLM) [K. Abe (Panasonic)] [late]

[JVET-N0791](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6546) Cross-check of JVET-N0716 (CE1-related: Simplified and robust LIC parameter derivation unified with CCLM) [S.-C. Lim, H. Lee, J. Lee, J. Kang (ETRI)] [late]

[JVET-N0818](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6573) Crosscheck of JVET-N0716 (CE1-related: Simplified and robust LIC parameter derivation unified with CCLM) [K. Unno (KDDI)] [late]

[JVET-N0836](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6591) Crosscheck of JVET-N0716 (CE1-related: Simplified and robust LIC parameter derivation unified with CCLM) [S. Blasi (BBC)] [miss\_endmeeting] [late]

## CE2 related – Subblock motion compensation (19)

Contributions in this category were discussed XXday XX March XXXX–XXXX (chaired by XXXqq).

[JVET-N0079](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5799) CE2-related: Applying SMR to subblock-based merging candidate list [Y.-C. Lin, C.-C. Chen, M.-S. Chiang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0599](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6339) Crosscheck of JVET-N0079 (CE2-related: Applying SMR to subblock-based merging candidate list) [Y. Han, W.-J. Chien (Qualcomm)] [late]

[JVET-N0199](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5919) CE2-related: combined test of affine memory bandwidth complexity reduction (Test2.4.6+Test2.4.8) [J. Li, C.-W. Kuo, C. S.Lim (Panasonic), M. Zhou (Broadcom)]

[JVET-N0623](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6372) Crosscheck of JVET-N0199 (CE2-related: Combined test of affine memory bandwidth complexity reduction (Test2.4.6+Test2.4.8)) [K. Zhang (Bytedance)] [late]

[JVET-N0235](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5955) CE2-related: Symmetric MVD signalling [J. Luo, Y. He (InterDigital)]

[JVET-N0618](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6360) Crosscheck of JVET-N0235 on improvements on bi-directional optical flow [X. Li (Tencent)] [late]

[JVET-N0769](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6524) Crosscheck of JVET-N0235 (non-CE4: Symmetric MVD signaling) [H. Chen (Huawei)] [late]

[JVET-N0236](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5956) CE2-related: Prediction refinement with optical flow for affine mode [J. Luo, Y. He (InterDigital)]

[JVET-N0626](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6375) Crosscheck of JVET-N0236 (CE2-related: Prediction refinement with optical flow for affine mode) [K. Zhang (Bytedance)] [late]

[JVET-N0651](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6401) Crosscheck of JVET-N0236 (CE2-related: Prediction refinement with optical flow for affine mode) test 1-2 [G. Li (Tencent)] [late]

[JVET-N0736](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6491) Crosscheck of JVET-N0236 test 6 (CE2-related: Prediction refinement with optical flow for affine mode) [T. Ikai (Sharp)] [late]

[JVET-N0266](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5987) CE2-related: Disabling bi-prediction or inter prediction for small blocks [H. Liu, L. Zhang (Bytedance)]

[JVET-N0645](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6395) Cross-chreck of JVET-N0266 (CE2-related: Disabling bi-prediction or inter prediction for small blocks) [J. Chen (Alibaba)] [late]

[JVET-N0268](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5989) CE2-related: Remove above-left affine inherited motion vector predictor [H. Huang, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-N0546](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6275) Crosscheck of JVET-N0268 (CE2-related: Remove above-left affine inherited motion vector predictor) [H. Chen (Huawei)] [late]

[JVET-N0273](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5994) CE2-related: Affine motion compensation using 2x2 subblock [H. Huang, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-N0547](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6276) Crosscheck of JVET-N0273 (CE2-related: Affine motion compensation using 2x2 subblock) [H. Chen (Huawei)] [late]

[JVET-N0334](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6055) CE2/4/9-related: Overflow prevention in motion field storage [X. Xiu, Y.-W. Chen, T.-C. Ma, X. Wang (Kwai Inc.)]

[JVET-N0681](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6432) Crosscheck of JVET-N0334 (CE2/4/9-related: Overflow prevention in motion field storage) [P. Hanhart (InterDigital)] [late]

[JVET-N0335](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6056) CE2/4-related: unification of MV rounding [X. Xiu, Y.-W. Chen, T.-C. Ma, X. Wang (Kwai Inc.)]

[JVET-N0621](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6363) Crosscheck of JVET-N0335 (CE2/4-related: unification of MV rounding) [C.-M. Tsai (MediaTek)] [late]

[JVET-N0336](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6057) CE2/4-related: On motion field storage reduction for spatial motion prediction [X. Xiu, Y.-W. Chen, T.-C. Ma, X. Wang (Kwai Inc.)]

[JVET-N0515](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6241) Crosscheck of JVET-N0336 (CE2/4-related: On motion field storage reduction for spatial motion prediction) [Y.-L. Hsiao (MediaTek)] [late]

[JVET-N0721](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6476) Crosscheck of JVET-N0336 (CE8-related: Modified limitation on context coded bins for CE8-4.3a and CE8-5.1a) [G. Clare, F. Henry (Orange)] [late]

[JVET-N0369](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6090) CE2-related: On restriction of memory bandwidth consumption of affine mode (2x2 variant) [M. Zhou (Broadcom)]

[JVET-N0575](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6309) Crosscheck of JVET-N0369 (CE2-related: On restriction of memory bandwidth consumption of affine mode (2x2 variant)) [K. Zhang (Bytedance)] [late]

[JVET-N0399](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6121) CE2-related: Simplifications of interweaved affine mode [X. Li, G. Li, X. Xu, S. Liu (Tencent)]

[JVET-N0624](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6373) Crosscheck of JVET-N0399 (CE2-related: Simplifications of interweaved affine mode) [K. Zhang (Bytedance)] [late]

[JVET-N0456](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6178) CE2-related: Affine motion model derivation method for affine merge mode [W. Chen, J. Luo, Y. He (InterDigital)]

[JVET-N0481](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6203) Non-CE2: Gbi inheritance for constructed affine merge candidate [J. Chen, R.-L. Liao, Y. Ye (Alibaba)]

[JVET-N0655](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6405) Crosscheck of JVET-N0481 (Non-CE2: Gbi inheritance for constructed affine merge candidate) [H. Liu (Bytedance)] [late]

[JVET-N0659](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6409) Crosscheck of JVET-N0481: Non-CE2: Gbi inheritance for constructed affine merge candidate [J. Luo (InterDigital)] [late]

[JVET-N0504](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6227) CE2-related: simplification of 2x2 subblock based affine motion compensation [H. Huang, W.-J. Chien, M. Karczewicz (Qualcomm)] [late]

[JVET-N0597](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6336) Crosscheck of JVET-N0504 (CE2-related: Simplified prediction refinement for affine motion compensation) [R.-L. Liao (Alibaba)] [late]

[JVET-N0510](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6236) CE2-related: Phase-variant affine subblock motion compensation [T.-D. Chuang, C.-Y. Chen, C.-Y. Lai, Y.-W. Huang, S.-M. Lei (MediaTek)] [late]

[JVET-N0676](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6427) Crosscheck of JVET-N0510 (CE2-related: Phase-variant affine subblock motion compensation) [Y.-C. Sun (Alibaba)] [late]

[JVET-N0709](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6463) CE2-related: Computation reductions of interweaved affine mode [K. Kawamura, S. Naito (KDDI)] [late]

[JVET-N0737](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6492) Non-CE2: Combination of affine MV clip and prediction refinement with optical flow [X. Li, G. Li, X. Xu, S. Liu (Tencent)] [late]

[JVET-N0752](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6507) CE2-related: Supplementary results for CE2-5.5.c [K. Zhang, L. Zhang, H. Liu, J. Xu, Y. Wang (Bytedance)] [late]

[JVET-N0821](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6576) CE2: Additional result for JVET-N0196 [J. Li, C.-W. Kuo, C.S.Lim (Panasonic)] [late]

[JVET-N0856](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6611) Cross-check of JVET-N0821 (CE2-related: Combination test of JVET-N0196 and JVET-N0266 (test 2)) [M. Zhou (Broadcom)] [late]

## CE3 related – Intra prediction and mode coding (54)

Contributions in this category were discussed XXday XX March XXXX–XXXX (chaired by XXXqq).

[JVET-N0082](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5802) CE3-related: Constrained partitioning of chroma intra CBs [Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0693](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6445) Crosscheck of JVET-N0082 (CE3-related: Constrained partitioning of chroma intra CBs) [C. Rosewarne (Canon)] [late]

[JVET-N0129](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5849) Non-CE3: PDPC simplification [N. Choi, M. W. Park, K. Choi (Samsung)]

[JVET-N0644](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6394) Cross-check of JVET-N0129 (Non-CE3: PDPC simplification) [A. K. Ramasubramonian (Qualcomm)] [late]

[JVET-N0132](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5852) Non-CE3: Simplification of DC Prediction [J.-Y. Huo, J.-L. Wang, X.-W. Li, Y.-Z. Ma, W. Zhang, F.-Z. Yang (Xidian Univ.), S. Wan (NPU), Y.-F. Yu, Y. Liu (OPPO)]

[JVET-N0657](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6407) Cross-check of JVET-N0132 (Non-CE3: Simplification of DC Prediction) [X. Ma (Huawei)] [late]

[JVET-N0139](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5859) CE3-related: Intra Angular Prediction and Modified PDPC Based on Two Reference Lines [D. Jiang, J. Lin, F. Zeng, C. Fang (Dahua)]

(no presenter available during BoG or Track A Sat. evening, and Monday afternoon and Wednesday afternoon)

[JVET-N0143](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5863) Non-CE3: Simplification of multi-line intra [T. Hashimoto, E. Sasaki, T. Ikai (Sharp)]

[JVET-N0758](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6513) Cross check of Non-CE3: Simplification of multi-line intra (JVET-N0143) [S. Jeong, K. Choi (Samsung)] [late]

[JVET-N0151](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5871) CE3-related: Modified Chroma Derived Mode [D. Jiang, J. Lin, F. Zeng, C. Fang (Dahua)]

(no presenter available during BoG or Track A Sat. evening, and Monday afternoon and Wednesday afternoon)

[JVET-N0154](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5874) Non-CE3: Chroma Intra Default Modes Modification Based on Order of Luminance Modes [[D. Jiang](mailto:jiang_dong@dahuatech.com), [J. Lin](mailto:lin_jucai@dahuatech.com), [F. Zeng](mailto:zeng_feiyang@dahuatech.com), C. Fang (Dahua)]

(no presenter available during BoG or Track A Sat. evening, and Monday afternoon and Wednesday afternoon)

[JVET-N0155](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5875) Non-CE3: Chroma Intra Default Modes Modification Based on Statistics of Luminance Modes [D. Jiang, J. Lin, F. Zeng, C. Fang (Dahua)]

(no presenter available during BoG or Track A Sat. evening, and Monday afternoon and Wednesday afternoon)

[JVET-N0157](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5877) Non-CE3: MPM List Modification for Zero Reference Line [D. Jiang, J. Lin, F. Zeng, C. Fang (Dahua)]

(no presenter available during BoG or Track A Sat. evening, and Monday afternoon and Wednesday afternoon)

[JVET-N0159](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5879) Non-CE3: Relaxation method of processing dependency in ISP for small blocks [K. Unno, K. Kawamura, Y. Kidani, S. Naito (KDDI)]

[JVET-N0767](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6522) Cross-check of JVET-N0159 (Non-CE3: Relaxation method of processing dependency in ISP for small blocks) [S. De-Luxán-Hernández (HHI)] [late]

[JVET-N0164](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5884) CE3-related: Size restriction for CCLM [F. Chen, L. Wang (Hikvision)]

[JVET-N0563](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6295) Crosscheck of JVET-N0164 (CE3-related: Size restriction for CCLM) [J. Choi (LGE)] [late]

[JVET-N0170](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5890) CE3-related: Explicitly signal non angular modes with encoding changes [J. Yao, J. Zhu, W. Cai, K. Kazui (Fujitsu)] [late]

[JVET-N0745](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6500) Crosscheck of JVET-N0170 (CE3-related: Explicitly signal non angular modes with encoding changes) [S. Iwamura (NHK)] [late]

[JVET-N0183](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5903) Non-CE3: Shared MPM list [A. M. Kotra, S. Esenlik, J. Chen, B. Wang, H. Gao (Huawei)]

[JVET-N0641](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6391) Crosscheck of JVET-N0183 (AHG16/Non-CE3: Shared MPM list) [Y.-C. Lin (MediaTek)] [late]

[JVET-N0185](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5905) CE3-related: A unified MPM list for intra mode coding [B. Wang, A. M. Kotra, S. Esenlik, H. Gao, J. Chen (Huawei)]

[JVET-N0750](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6505) Crosscheck of JVET-N0185 (CE3-related: A unified MPM list for intra mode coding) [M. G. Sarwer (MediaTek)] [late]

[JVET-N0186](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5906) CE3-related: Simplification on Intra sub-partition coding mode [B. Wang, A. M. Kotra, S. Esenlik, H. Gao, J. Chen (Huawei)]

[JVET-N0728](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6483) Crosscheck of JVET-N0186 (AHG16/Non-CE3: Simplification on Intra sub-partition coding mode) [Y.-W. Chen (Kwai Inc.)] [late]

[JVET-N0215](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5935) Non-CE3: Intra prediction mode restriction in small blocks [D. Y. Lee, T. H. Kim, G. H. Park (KHU)]

[JVET-N0660](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6410) Cross check of Non-CE3: Intra prediction mode restriction in small blocks (JVET-N0215) [M. W. Park (Samsung)] [late]

[JVET-N0216](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5936) Non-CE3: Determination of wide-angle mode using the size of a coding block [D. Kim, J. Jung, G. Ko, J. Son, J. Kwak (WILUS)]

[JVET-N0218](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5938) CE3-related: Chroma Intra Mode Coding with Lumped Luma Directions and Replacement for DM mode [J. Park, B. Jeon (SKKU)]

[JVET-N0723](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6478) Cross check of JVET-N0218 (CE3-related: Chroma Intra Mode Coding with Lumped Luma Directions and Replacement for DM mode) [N. Choi (Samsung)] [late]

[JVET-N0222](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5942) CE3-related: CIIP intra mode propagation to intra block [L. Li, J. Nam, J. Heo, J. Lim, S. Kim (LGE)]

[JVET-N0862](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6617) Crosscheck of JVET-N0222 (CE3-related: CIIP intra mode propagation to intra block) [B. Wang (Huawei)] [late]

[JVET-N0223](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5943) CE3-related: reference sample filtering simplification [L. Li, J. Heo, J. Lim, S. Kim (LGE)]

[JVET-N0229](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5949) Non-CE3: CCLM prediction for 4:2:2 and 4:4:4 color format [J. Choi, J. Heo, J. Lim, S. Kim (LGE)]

[JVET-N0230](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5950) Non-CE3: Simplified intra mode candidates for ISP [J. Choi, J. Heo, S. Yoo, L. Li, J. Choi, J. Lim, S. Kim (LGE)]

[JVET-N0665](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6416) Crosscheck of JVET-N0230 (Non-CE3: Simplified intra mode candidates for ISP) [J. Lee, S.-C. Lim, H. Lee, J. Kang (ETRI)] [late]

[JVET-N0248](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5968) Non-CE3: Combined-Hypothesis Intra-Prediction with Unified Intra Mode Coding [G. Kulupana, A. Seixas Dias, S. Blasi (BBC)]

[JVET-N0774](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6529) Crosscheck of JVET-N0248 (Non-CE3: Combined-Hypothesis Intra-Prediction with Unified Intra Mode Coding) [S. Nemoto (NHK)] [late]

[JVET-N0303](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6024) CE3-related: Simplified unified luma intra mode coding [S. Blasi, A. Seixas Dias, G. Kulupana (BBC)]

[JVET-N0764](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6519) Cross check of JVET-N0303 [K. Misra (Sharp Labs of America)] [late]

[JVET-N0766](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6521) Cross check of JVET-N0303 (Non-CE6: Further cost reduction for primary transform) [K. Choi (Samsung)] [late]

[JVET-N0305](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6026) CE3-related: Luma intra mode coding with restricted MPM derivation [S. Blasi, A. Seixas Dias, G. Kulupana (BBC)]

[JVET-N0531](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6259) Crosscheck of JVET-N0305 (CE3-related: Luma intra mode coding with restricted MPM derivation) [S. De-Luxán-Hernández (HHI)] [late]

[JVET-N0308](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6029) AHG16/Non-CE3: Restriction of the maximum CU size for ISP to 64x64 [S. De-Luxán-Hernández, B. Bross, T. Nguyen, V. George, B. Stabernack, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

[JVET-N0672](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6423) Cross-check of JVET-N0308 (AHG16/Non-CE3: Restriction of the maximum CU size for ISP to 64x64) [X. Cao (Hikvision)] [late]

[JVET-N0313](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6034) CE3-related: Low latency intra sub-partitions [R. Vanam, Y. He (InterDigital)]

[JVET-N0719](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6474) Crosscheck of JVET-N0313 (Low latency intra sub-partitions) [R. Jullian (Technicolor)] [late]

[JVET-N0330](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6051) Non-CE3: Intra sub-partition coding without thin partitions [T.-C. Ma, X. Xiu, Y.-W. Chen, X. Wang (Kwai Inc.)]

[JVET-N0832](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6587) Crosscheck of JVET-N0330 (Non-CE3: Intra sub-partition coding without thin partitions) [M. G. Sarwer (MediaTek)] [late]

[JVET-N0846](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6601) Crosscheck of JVET-N0330 (Non-CE3: Intra sub-partition coding without thin partitions) [E. Sasaki (Sharp)] [late]

[JVET-N0333](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6054) CE3-related: MMLM only cross-component prediction [H.-J. Jhu, Y.-W. Chen, X. Wang (Kwai Inc.)]

[JVET-N0607](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6348) Cross-check of JVET-N0333, "CE3-related: MMLM only cross-component prediction" [?? (??)][late]

[JVET-N0339](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6060) Non-CE3: Unification on WAIP for normal and ISP intra prediction [T.-C. Ma, X. Xiu, Y.-W. Chen, X. Wang (Kwai Inc.)]

[JVET-N0581](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6315) Crosscheck of JVET-N0339 (Non-CE3: Unification on WAIP for normal and ISP intra prediction) [J. Heo, H. Jang, J. Lim, S. Kim (LGE)] [late]

[JVET-N0342](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6063) Non-CE3: Decoder-side Intra Mode Derivation with Prediction Fusion [M. Abdoli, E. Mora, T. Guionnet, M. Raulet (ATEME)]

[JVET-N0590](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6324) Crosscheck of JVET-N0342 (Decoder-side Intra Mode Derivation with Prediction Fusion) [?? (??)][late]

[JVET-N0358](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6079) Non-CE3: Harmonization of CBF coding for intra sub-partition coding mode [Z. Zhang, K. Andersson, R. Sjöberg (Ericsson)]

[JVET-N0820](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6575) Crosscheck of JVET-N0358 (Non-CE3: Harmonization of CBF coding for intra sub-partition coding mode) [Biao Wang (Huawei)] [late]

[JVET-N0371](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6093) Non-CE3: directional intra prediction with varying angle [G. Rath, F. Urban, F. Racapé (Technicolor)]

[JVET-N0591](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6325) Crosscheck of JVET-N0371 (Non-CE3: directional intra prediction with varying angle) [P. Merkle (HHI)] [late]

[JVET-N0372](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6094) Non-CE3: ISP with independent sub-partitions for certain block sizes [S. De-Luxán-Hernández, B. Bross, T. Nguyen, V. George, B. Stabernack, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

[JVET-N0536](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6264) Crosscheck of JVET-N0372 (Non-CE3: ISP with independent sub-partitions for certain block sizes) [X. Zhao (Tencent)] [late]

[JVET-N0376](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6098) AHG16/CE3-related: CCLM mode restriction for increasing decoder throughput [J.-Y. Jung, Y.-L. Lee (Sejong Univ.), D.-Y. Kim, W. J. Jeong (Chips&Media), S.-C. Lim, J. Kang (ETRI)]

[JVET-N0705](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6458) Cross-check of JVET-N0376 (AHG16/CE3-related: CCLM mode restriction for increasing decoder throughput) [G. Laroche (Canon)] [late]

[JVET-N0390](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6112) AHG16/non-CE3: Study of CCLM restrictions in case of separate luma/chroma tree [E. François, F. Galpin, F. Le Léannec, T. Poirier (Technicolor)]

[JVET-N0792](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6547) Crosscheck of JVET-N0390 (AHG16/non-CE3: Study of CCLM restrictions in case of separate luma/chroma tree) [A. Filippov, V. Rufitskiy (Huawei)] [late]

[JVET-N0394](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6116) CE3-related: Unified MPM list based on CE3-3.3 and CE3-3.5.1 [L. Zhao, X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-N0583](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6317) Cross-check of JVET-N0394: CE3-related: Unified MPM list based on CE3-3.3 and CE3-3.5.1 [X. Xiu (Kwai Inc.)] [late]

[JVET-N0396](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6118) CE3-related: Enabling parallel reconstruction of small intra-coded blocks [L. Pham Van, G. Van der Auwera, A. K. Ramasubramonian, V. Seregin, H. Huang, M. Karczewicz (Qualcomm)]

[JVET-N0682](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6433) Crosscheck of JVET-N0396 (CE3-related: Enabling parallel reconstruction of small intra-coded blocks) [?? (??)][late]

[JVET-N0401](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6123) Non-CE3/Non-CE8: Enable Transform Skip in CUs using ISP [S. De-Luxán-Hernández, T. Nguyen, B. Bross, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

[JVET-N0629](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6378) Crosscheck of JVET-N0401 (Non-CE3/Non-CE8: Enable Transform Skip in CUs using ISP) [T.-C. Ma (Kwai Inc.)] [late]

[JVET-N0412](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6134) CE3-related: Modification on the intra luma mode coding process [Y. Kidani, K. Kawamura, K. Unno, S. Naito (KDDI)]

[JVET-N0749](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6504) Crosscheck of JVET-N0412 (CE3-related: Modification on the intra luma mode coding process) [S. Iwamura (NHK)] [late]

[JVET-N0786](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6541) Cross check of JVET-N0412 [K. Misra (Sharp Labs of America)] [late]

[JVET-N0426](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6148) Non-CE3: History-based intra MPM default angular modes derivation [Z. Zhang, P. Wennersten, R. Yu, J. Ström, R. Sjöberg (Ericsson)]

[JVET-N0790](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6545) Cross check of JVET-N0426 [K. Misra (Sharp Labs of America)] [late]

[JVET-N0427](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6149) CE3-related: Harmonization between ISP and WAIP [L. Zhao, X. Zhao, X. Li, S. Liu (Tencent)] [late]

[JVET-N0627](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6376) Crosscheck of JVET-N0427 (CE3-related: Harmonization between ISP and WAIP) [T.-C. Ma (Kwai Inc.)] [late]

[JVET-N0432](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6154) AHG16/Non-CE3: On 1xN and 2xN subpartitions in intra subpartition coding [A. K. Ramasubramonian, G. Van der Auwera, T. Hsieh, V. Seregin, L. Pham Van, M. Karczewicz]

[JVET-N0726](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6481) Crosscheck of JVET-N0432 (AHG16/Non-CE3: On 1xN and 2xN subpartitions in intra subpartition coding) [N. Choi (Samsung)] [late]

[JVET-N0433](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6155) CE3-related: Unification of MPM derivation for luma intra modes [A. K. Ramasubramonian, G. Van der Auwera, L. Pham Van, M. Karczewicz (Qualcomm)]

[JVET-N0562](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6293) Crosscheck of JVET-N0433 (CE3-related: Unification of MPM derivation for luma intra modes) [M. G. Sarwer (MediaTek)] [late]

[JVET-N0435](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6157) Non-CE3: Harmonization between WAIP and intra smoothing filters [P.-H. Lin, Y.-C. Yang (Foxconn)]

[JVET-N0777](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6532) Crosscheck of JVET-N0435 (Non-CE3: Harmonization between WAIP and intra filters) [C.-H. Yau, C.-C. Kuo, C.-C. Lin (ITRI)] [late]

[JVET-N0437](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6159) Non-CE3: On allowing non-MPM modes for ISP and non-zero reference line [F. Bossen, K. Misra (Sharp Labs of America)]

[JVET-N0802](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6557) Crosscheck of JVET-N0437 (Non-CE3: On allowing non-MPM modes for ISP and non-zero reference line) [Z. Zhang (Ericsson)] [late]

[JVET-N0450](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6172) CE3-3.4-related: unified MPM list construction [F. Bossen, K. Misra (Sharp)]

[JVET-N0704](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6457) Crosscheck of JVET-N0450 (CE3-3.4-related: unified MPM list construction) [S. Blasi, A. Seixas Dias, G. Kulupana (BBC)] [late]

[JVET-N0452](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6174) Non-CE3: Harmonization between WAIP and ISP [J. Heo, H. Jang, L. Li, J. Choi, J. Lim, S. Kim (LGE)]

[JVET-N0628](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6377) Crosscheck of JVET-N0452 (Non-CE3: Harmonization between WAIP and ISP) [T.-C. Ma (Kwai Inc.)] [late]

[JVET-N0453](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6175) AHG16/Non-CE3: on chroma 2xN and Nx2 intra prediction in single tree [Y. Zhao, A. Karabutov, H. Yang, J. Chen (Huawei)]

[JVET-N0686](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6437) Crosscheck of JVET-N0453 Test 1 (AHG16/Non-CE3: on chroma 2xN and Nx2 intra prediction in single tree) [C. Rosewarne (Canon)] [late]

[JVET-N0814](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6569) Crosscheck of JVET-N0453 (AHG16/Non-CE3: on chroma 2xN and Nx2 intra prediction in single tree) [Z.-Y. Lin (MediaTek)] [late]

[JVET-N0465](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6187) CE3-related: Restrict 2xN, Nx2 chroma processing for dual tree structure [H. Jang, J. Nam, N. Park, J. Lim, S. Kim (LGE)]

[JVET-N0588](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6322) Crosscheck of JVET-N0465 (CE3-related: Restrict 2xN, Nx2 chroma processing for dual tree structure) [T. Zhou (Sharp)] [late]

[JVET-N0469](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6191) CE3-related: Disable ISP mode for 128xN, Nx128 Block [H. Jang, J. Heo, J. Nam, J. Lim, S. Kim (LGE)]

[JVET-N0475](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6197) Non-CE3/6: Enabling Transform Skip for ISP [T.-C. Ma, X. Xiu, Y.-W. Chen, X. Wang (Kwai Inc.)]

[JVET-N0849](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6604) Cross-check of JVET-N0475 (Non-CE3/6: Enabling Transform Skip for ISP) [S. De-Luxán-Hernández (HHI)] [late]

[JVET-N0524](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6250) Non-CE3: Modified beta derivation in CCLM [M. Ikeda, T. Suzuki (Sony)] [late]

[JVET-N0694](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6446) Crosscheck of JVET-N0524 (Non-CE3: Modified beta derivation in CCLM) [Y. Kidani, K. Kawamura, K. Unno, S. Naito (KDDI)] [late]

## CE4 related – Inter prediction and motion vector coding (40)

Contributions in this category were discussed XXday XX March XXXX–XXXX (chaired by XXXqq).

[JVET-N0084](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5804) CE4-related: Motion compression for HMVP buffers and MV line buffer [Y.-L. Hsiao, T.-D. Chuang, C.-W. Hsu, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0824](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6579) Crosscheck of JVET-N0084 (Motion compression for HMVP buffers and MV line buffer) [F. Bossen (Sharp)] [late]

[JVET-N0085](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5805) CE4-related: MV rounding unification [T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0578](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6312) Cross-check of JVET-N0085: CE4-related: MV rounding unification [X. Xiu (Kwai Inc.)] [late]

[JVET-N0086](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5806) CE4-related: Reduction of interactions between bi-prediction coding tools [C.-C. Chen, M.-S. Chiang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0539](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6267) Crosscheck of JVET-N0086: CE4-related: Reduction of interactions between bi-prediction coding tools [X. Xu (Tencent)] [late]

[JVET-N0586](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6320) Cross-check of JVET-N0086: CE4-related: Reduction of interactions between bi-prediction coding tools [H. Wang (Qualcomm)] [late]

[JVET-N0087](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5807) CE4-related: Simplification of triangle merging candidate list derivation on top of CE4-4.1c [T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0126](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5846) CE4-related: Signaling MMVD syntax elements [S. Jeong, M. W. Park, K. Choi (Samsung)]

[JVET-N0810](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6565) Crosscheck of JVET-N0126 (CE4-related: Signaling MMVD syntax elements) [M. Koo (LGE)] [late]

[JVET-N0127](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5847) CE4-related: MMVD enabling signaling in SPS [S. Jeong, M. Park, K. Choi (Samsung)]

[JVET-N0811](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6566) Crosscheck of JVET-N0127 (CE4-related: MMVD enabling signaling in SPS) [M. Koo (LGE)] [late]

[JVET-N0165](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5885) CE4-related: On spatial candidate list construction [L. Xu, F. Chen, L. Wang (Hikvision)]

[JVET-N0656](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6406) Crosscheck of JVET-N0165 (Non-CE4: On spatial candidate list construction) [S. H. Wang (PKU)] [late]

[JVET-N0166](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5886) CE4-related: Advanced Multi-hypothesis Inter Prediction for bandwidth reduction in B frame [Y. Sun, F. Chen, L. Wang (Hikvision)]

[JVET-N0699](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6451) Crosscheck of JVET-N0166 (Non-CE4: Advanced multi-hypothesis inter prediction for bandwidth reduction in B frame) [M.-S. Chiang (MediaTek)] [late]

[JVET-N0167](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5887) CE4-related: Advanced Multi-hypothesis Inter Prediction [Y. Sun, F. Chen, L. Wang (Hikvision)]

[JVET-N0700](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6452) Crosscheck of JVET-N0167 (Non-CE4: Advanced multi-hypothesis inter prediction) [M.-S. Chiang (MediaTek)] [late]

[JVET-N0168](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5888) CE4-related: AMVR cost calculation modification in motion estimation stage [Y. Sun, F. Chen, L. Wang (Hikvision)]

[JVET-N0795](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6550) Cross-check of JVET-N0168 (Non-CE4: AMVR cost calculation modification in motion estimation stage) [M. Winken (HHI)] [late]

[JVET-N0200](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5920) Non-CE4: Simplification of inter MVP list generation for 4x4 block [J. Li, C.-W. Kuo, C. S.Lim (Panasonic)]

[JVET-N0557](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6288) Crosscheck of JVET-N0200 (Non-CE4: Simplification of inter MVP list generation for 4x4 block) [Y. Yasugi (Sharp)] [late]

[JVET-N0203](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5923) Non-CE4: Modification of the temporal merging candidate for the inter merge mode [G. Lee, G. Kim, S. Cha, D. Nam, J. Han (Sejong University)]

[JVET-N0567](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6300) Crosscheck of JVET-N0203 (Non-CE4: Modification of the temporal merging candidate for the inter merge mode) [H. Lee, S. -C. Lim, J. Lee, J. Kang (ETRI)] [late]

[JVET-N0213](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5933) CE4-related: Remove TMVP merge and AMVP candidate for the specified blocksizes [S. H. Wang (PKU), X. Zheng (DJI), S. S. Wang, S. W. Ma (PKU)] [placeholder] [late]

[JVET-N0650](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6400) Crosscheck of JVET-N0213 (CE4-related: Remove TMVP merge and AMVP candidate for the specified block sizes) [G. Li (Tencent)] [late]

[JVET-N0240](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5960) Non-CE4: Simplification of merge MVD derivation [G. Ko, D. Kim, J. Jung, J. Son, J. Kwak (WILUS)]

[JVET-N0572](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6306) Crosscheck of JVET-N0240 (Non-CE4: Simplification of merge MVD derivation) [Y.-W. Chen (Kwai Inc.)] [late]

[JVET-N0265](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5986) CE4-related: Simplification of HMVP in AMVP mode [H. Huang, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-N0756](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6511) Crosscheck of JVET-N0265 (CE4-related: Simplification of HMVP in AMVP mode) [Franck Galpin (Technicolor)] [late]

[JVET-N0267](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5988) Non-CE4: shared merge list without double HMVP tables [L. Zhang (Bytedance)]

[JVET-N0542](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6270) Crosscheck of JVET-N0267: Non-CE4: shared merge list without double HMVP tables [X. Xu (Tencent)] [late]

[JVET-N0277](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5998) Non-CE4: Parallel friendly pair-wise merge candidate derivation [K. Zhang (Bytedance)]

[JVET-N0560](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6291) Crosscheck of JVET-N0277 (Non-CE4: Parallel-friendly pairwise average merge candidate derivation) [T. Hashimoto (Sharp)] [late]

[JVET-N0286](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6007) CE4-related: Simplified coding of the BPWA index [F. Le Léannec, Y. Chen, T. Poirier, A. Robert (Technicolor)]

[JVET-N0517](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6243) Crosscheck of JVET-N0286 (CE4-related: Simplified coding of the BPWA index) [S.-T. Hsiang (MediaTek)] [late]

[JVET-N0287](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6008) CE4-related: Simplified coding of the MVP index [F. Le Léannec, Y.Chen, T. Poirier, A. Robert (Technicolor)]

[JVET-N0602](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6343) Crosscheck of JVET-N0287 (CE4-related: Simplified coding of the MVP index) [Y. Han, W.-J. Chien (Qualcomm)] [late]

[JVET-N0309](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6030) Non-CE4: Switched half-pel interpolation filter [A. Henkel, B. Bross, M. Winken, P. Keydel, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

[JVET-N0707](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6461) Crosscheck of JVET-N0309 (Non-CE4: Switched half-pel interpolation filter) [N. Hu (Qualcomm)] [late]

[JVET-N0332](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6053) Non-CE4: MVD scaling issue for LTRPs [Y.-W. Chen, X. Xiu, T.-C. Ma, X. Wang (Kwai Inc.)]

[JVET-N0680](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6431) Crosscheck of JVET-N0332 (Non-CE4: MVD scaling issue for LTRPs) [G. Ko, D. Kim, J. Jung, J. Son, J. Kwak (WILUS)] [late]

[JVET-N0340](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6061) CE4-related: An improved method for triangle merge list construction [X. Wang, Y.-W. Chen, X. Xiu, T.-C. Ma (Kwai Inc.)]

This was discussed in Track B Wednesday 20 March 1625 (GJS).

In this contribution, a method is proposed to derive uni-prediction merge list for triangle prediction. In this method, regular merge candidate list is re-used for triangle partition merge prediction with no extra motion vector pruning. For each merge candidate in the regular merge candidate list, one and only one of its L0 or L1 motion vector is used for triangle prediction. In addition, the order of selecting the L0 vs. L1 motion vector is based on its merge index parity. With the proposed scheme, the regular merge list can be directly used and there is no need to explicitly generate the uni-prediction merge candidate list for triangle prediction. Simulation results based on CTC reportedly show that the proposed scheme incurs an average 0.01% and 0.09% luma coding efficiency loss respectively for random access and low delay B configuration, and no chroma coding efficiency loss relative to VTM-4.0.

Complexity properties equivalent to what was collected for the CE are shown in the table below:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Merge list size** | | **Max number of potential candidates** | **Max number of candidate comparison** | **Max number of MV scaling** | **Max number of temporal candidates** | **Others** |
| 5 | 13 | 9 | 2 | 2 | – | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **Random Access** |  |  |
|  |  |  | **Over VTM-4.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.02% | -0.08% | 0.00% | 99% | 98% |
| Class A2 | -0.05% | -0.06% | 0.01% | 98% | 98% |
| Class B | 0.00% | -0.08% | -0.21% | 101% | 101% |
| Class C | 0.04% | 0.09% | -0.06% | 102% | 103% |
| Class E |  |  |  |  |  |
| **Overall** | 0.01% | -0.03% | -0.08% | 100% | 100% |
| Class D | 0.00% | 0.08% | 0.26% | 101% | 102% |
| Class F | 0.07% | 0.08% | 0.02% | 102% | 103% |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **Low Delay B** |  |  |
|  |  |  | **Over VTM-4.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | 0.05% | 0.00% | -0.15% | 101% | 103% |
| Class C | 0.12% | 0.27% | -0.08% | 99% | 97% |
| Class E | 0.13% | -0.43% | 0.08% | 96% | 98% |
| **Overall** | 0.09% | -0.02% | -0.07% | 99% | 100% |
| Class D | 0.20% | 0.38% | -0.24% | 100% | 104% |
| Class F | 0.04% | -0.15% | -0.04% | 101% | 99% |

Decision (complexity reduction / cleanup): Adopt.

[JVET-N0587](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6321) Cross-check of JVET-N0340: CE4-related: An improved method for triangle merge list construction [H. Wang (Qualcomm)] [late]

[JVET-N0373](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6095) Non-CE4: HMVP unification between the Merge and MVP list [H. Lee, J. Kang, S.-C. Lim, J. Lee, H. Y. Kim (ETRI)]

[JVET-N0674](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6425) Crosscheck of JVET-N0373 (Non-CE4: HMVP unification between the Merge and MVP list) [R. Yu (Ericsson)] [late]

[JVET-N0380](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6102) CE4-related: Fix of MMVD signalling [G. Li, X. Li, X. Xu, S. Liu (Tencent)]

[JVET-N0760](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6515) Cross check of CE4-related: Fix of MMVD signalling (JVET-N0380) [S. Jeong, K. Choi (Samsung)] [late]

[JVET-N0385](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6107) CE4-related: modification of HMVP update process inside the shared merging candidate list region [X. Xu, X. Li, G. Li, S. Liu (Tencent)]

[JVET-N0606](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6347) Crosscheck of JVET-N0385 (Non-CE4: modification of HMVP update process inside the shared merging candidate list region) [N. Zhang, H. Liu (Bytedance)] [late]

[JVET-N0400](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6122) CE4-related: Signaling of maximum number of triangle candidates [X. Li, G. Li, X. Xu, S. Liu (Tencent)]

[JVET-N0647](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6397) Crosscheck of JVET-N0400 (CE4-related: Signaling of maximum number of triangle candidates) [Y.-J. Chang (Qualcomm)] [late]

[JVET-N0834](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6589) Crosscheck of JVET-N0400 (CE4-related: Signaling of maximum number of triangle candidates) [Y.-W. Chen (Kwai Inc.)] [late]

[JVET-N0434](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6156) Non-CE4: Unified context model of AMVR and Affine AMVR [Y.-C. Yang, P.-H. Lin (Foxconn)]

[JVET-N0751](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6506) Crosscheck of JVET-N0434 (Non-CE4: Unified context model of AMVR and Affine AMVR) [Z.-Y. Lin (MediaTek)] [late]

[JVET-N0439](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6161) CE4-related: supplementary information regarding CE4-4.4 [L. Zhang, K. Zhang, H. Liu, J. Xu, Y. Wang (Bytedance)]

[JVET-N0447](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6169) Non-CE4: On triangle merge mode [Y.-J. Chang, C.-C. Chen, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-N0622](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6364) Crosscheck of JVET-N0447 on triangle merge mode [X. Li (Tencent)] [late]

[JVET-N0448](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6170) Non-CE4: On MMVD signaling [Y.-J. Chang, W.-J. Chien, C.-C. Chen, M. Karczewicz (Qualcomm)]

[JVET-N0761](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6516) Cross check of Non-CE4: On MMVD signaling (JVET-N0448) [S. Jeong, K. Choi (Samsung)] [late]

[JVET-N0449](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6171) CE4-related: Simplification on MMVD distance table [Y. Zhang, Y.-J. Chang, C.-C. Chen, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-N0670](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6421) Crosscheck of JVET-N0449 (CE4-related: Simplification on MMVD distance table) [T.-H. Li, Y.-C. Yang (Foxconn)] [late]

[JVET-N0462](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6184) Non-CE4: Mismatch between text specification and reference software on inter prediction mode [J. Nam, H. Jang, N. Park, J. Lim, S. Kim (LGE)]

[JVET-N0775](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6530) Crosscheck of JVET-N0462 (Non-CE4: Mismatch between text specification and reference software on inter prediction mode) [Y. Ahn (Digital Insights)] [late]

[JVET-N0471](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6193) Non-CE4: Simplication of decoding process for SMVD reference indices [H. Lee, J. Kang, S.-C. Lim, J. Lee, H. Y. Kim (ETRI)]

[JVET-N0770](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6525) Crosscheck of JVET-N0471 (non-CE4: Simplification of decoding process for SMVD reference indices) [W. Chen (InterDigital)] [late]

[JVET-N0476](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6198) Non-CE4: Constraints of picture size in VVC [Y.-W. Chen, X. Xiu, T.-C. Ma, X. Wang (Kwai Inc.)]

[JVET-N0483](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6205) Non-CE4: Simplification of triangle partition and SBT combination [R.-L. Liao, Y. Ye, J. Chen (Alibaba)]

[JVET-N0598](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6338) Crosscheck of JVET-N0483: Non-CE4: Simplification of triangle partition and SBT combination [C.-H. Hung, W.-J. Chien (Qualcomm)] [late]

[JVET-N0486](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6208) CE4-related: Simplification for share merge list and HMVP harmonization process [S. H. Wang (PKU), X. Zheng (DJI), S. S. Wang, S. W. Ma (PKU)]

[JVET-N0643](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6393) Crosscheck of JVET-N0486 (CE4-related: Simplification for shared merge list and HMVP harmonization process) [Y.-C. Lin (MediaTek)] [late]

[JVET-N0487](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6209) CE4-related: Further simplification of triangle prediction merging candidate list derivation [X.W. Meng (PKU), X. Zheng (DJI), S.S. Wang, S.W. Ma (PKU)]

[JVET-N0738](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6493) Crosscheck of JVET-N0487 (CE4-related: Further simplification of triangle prediction merging candidate list derivation) [F. Chen (Hikvision)] [late]

[JVET-N0499](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6221) CE4-related: Simplification for merge list derivation in triangular prediction mode on top of test CE4-4.6.b [T. Solovyev, S. Esenlik, S. Ikonin, J. Chen (Huawei)]

[JVET-N0500](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6222) Non-CE4: Restrictions on triangular merge list size [T. Solovyev, S. Esenlik, S. Ikonin, J. Chen (Huawei)] [late]

[JVET-N0525](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6252) CE4-related: CE4-4.5 pruning reduction in TPM using regular merge candidates [A. Robert, T. Poirier, F. Le Léannec, F. Galpin (Technicolor)] [late]

[JVET-N0851](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6606) CE4-related: On merge list construction [C.-W. Hsu, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek), Y.-J. Chang, C.-C. Chen, W.-J. Chien, M. Karczewicz (Qualcomm)] [late]

## CE5 related – Adaptive loop filtering (3)

Contributions in this category were discussed Friday 22 March 2020–2115 (Track A chaired by JRO).

[JVET-N0243](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5963) Non-CE5: Complementary results of tests CE5-3 on Non-Linear ALF [J. Taquet, P. Onno, C. Gisquet, G. Laroche (Canon)]

This contribution proposes to extend the Non-Linear ALF concept that was introduced in JVET-M0385. More precisely, this contribution proposes to add some syntax elements to enable the use of alternative ALF Luma filter sets and alternative Chroma filters, and to select them on a per filter, per CTU basis. For each CTU, if the ALF filtering is enabled on Luma component, an additional Luma filter set alternative index is signalled for each ALF Luma filter index. Similarly, for each CTU, for each Chroma component on which ALF filtering is enabled, an alternative Chroma filter index is signalled to select a given filter for the Chroma components.

It is reported that against the VTM4.0, the average Luma/Cb/Cr BDR gains are:   
with **Test-1** -0.37%/-1.22%/-1.81% for AI, -0.85%/-2.90%/-3.24% for RA, -1.23%/-3.78%/-4.46% for LB, -1.69%/-4.94%/-4.89% for LP;   
with **Test-2** -0.37%/-1.22%/-1.81% for AI, -0.78%/-2.94%/-3.27% for RA, -1.04%/-3.98%/-4.58% for LB, -1.52%/-4.92%/-5.07% for LP; and   
with **Test-3** -0.27%/-1.24%/-1.82% for AI, -0.64%/-2.89%/-3.19% for RA, -0.96%/-3.74%/-4.35% for LB, -1.39%/-4.99%/-5.22% for LP.

This proposal takes up the general idea of CE5-4 and combines it with CE5-3.2 (test 1 and test 2 are related to 5.3.2). It however uses a smaller fixed filter set (which could be the reason for relative smaller gain in luma), but applies a similar adaptation on CTU basis for chroma filters as well (which id the likely reason for higher gains in chroma). Another aspect is that filters from different sets defined at tile group level can be mixed in a CTU specific set.

Further study in CE. Reference for comparison should be the straightforward combination of the two adopted methods of CE5-3 and CE5-4 with proper APS implementation. Beyond further harmonization, the most intersting aspects to be investigated are the mixing of filters and the chroma part.

Revisit in plenary (general comment, not specific on this proposal but important for CE): Clarify with HLS experts who will implement the APS. ALF experts should study the current APS implementation of VTM software to identify how usable it is in the CE.

[JVET-N0662](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6413) Cross-check of JVET-N0243 (Non-CE5: Complementary results of tests CE5-3 on Non-Linear ALF) [S.-C. Lim, H. Lee, J. Lee, J. Kang (ETRI)] [late]

[JVET-N0416](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6138) CE5-related: Unification of picture boundary and line buffer handling for ALF [N. Hu, V. Seregin, M. Karczewicz (Qualcomm)]

In CE5, the concept of virtual boundaries is used to remove the line buffer requirement of adaptive loop filter in VTM4. In this contribution, the method is extended to picture boundaries.

At picture boundaries, more complicated processing (as investigated in CE5-1 and CE5-2) is not necessary, because there is no danger to see a CTU boundary effect. Padding (as currently done) is the most simple and straightforward solution.

No action necessary.

[JVET-N0545](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6274) Crosscheck of JVET-N0416 (CE5-related: Unification of picture boundary and line buffer handling for ALF) [C.-Y. Chen (MediaTek)] [late]

[JVET-N0488](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6210) CE5-related: Syntax redundancy removal in adaptive loop filter [X.W. Meng (PKU), X. Zheng (DJI), C.M. Jia, S.S. Wang, S.W. Ma (PKU)]

This contribution proposes to remove syntax redundancy for adaptive loop filter coefficient signalling in VTM-4.0. The proposed method removes the **alf\_luma\_coeff\_delta\_idx** when the syntax **alf\_luma\_num\_filters\_signalled\_minus1** equals to NumAlfFilters-1. It is reported that as compared to VTM-4.0, 0.00% coding performance changed is observed. And compared to worst case anchor, it can achieve 0.04%, 0.38% and 0.99% coding gain in all intra, random access and low delay B configuration respectively.

It is discussed that if that signalling would be reused, something else would need to be specified to avoid wrong usage in bitstream or wrong interpretation. Rather than introducing ambiguities in the specification, it is better to keep this syntax element. In normal operation, the saving of bit rate is irrelevant. No action.

[JVET-N0569](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6302) Crosscheck of JVET-N0488 (CE5-related: Syntax redundancy removal in adaptive loop filter) [W. Choi (Samsung)] [late]

## CE6 related – Transforms and transform signalling (27)

Contributions in this category were discussed XXday XX March XXXX–XXXX (chaired by XXXqq).

[JVET-N0089](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5809) CE6-related: Unified implicit MTS between ISP mode and regular intra mode [M.-S. Chiang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0565](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6297) Crosscheck of JVET-N0089 (CE6-related: Unified implicit MTS between ISP mode and regular intra mode) [Y. Sun, F. Chen, L. Wang (Hikvision)] [late]

[JVET-N0105](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5825) CE6-related: RST binarisation [C. Rosewarne, J. Gan (Canon)]

[JVET-N0813](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6568) Crosscheck of JVET-N0105 (CE6-related: RST binarisation) [M. Koo (LGE)] [late]

[JVET-N0121](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5841) Non-CE6: MTS simplification [T. Tsukuba, Y. Yagasaki, T. Suzuki (Sony)]

[JVET-N0747](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6502) Crosscheck of JVET-N0121 (Non-CE6: MTS simplification) [S. Iwamura (NHK)] [late]

[JVET-N0122](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5842) CE6/CE8-related: Alternative implementation of residual rearrangement for transform skipped blocks [T. Tsukuba, M. Ikeda, T. Suzuki (Sony)] [placeholder] [late]

[JVET-N0778](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6533) Crosscheck of JVET-N0122 (CE6/CE8-related: Alternative Implementation of residual rearrangement for transform skipped blocks) [K. Abe (Panasonic)] [late]

[JVET-N0123](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5843) Non-CE6/CE8: Chroma Transform Skip [T. Tsukuba, M. Ikeda, T. Suzuki (Sony)]

[JVET-N0534](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6262) Crosscheck of JVET-N0123 (AHG13/Non-CE6/CE8: Chroma Transform Skip) [X. Zhao (Tencent)] [late]

[JVET-N0160](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5880) CE6-related: Simplification on transform selection for Intra Sub-Partitions [X. Cao, L. Xu, F. Chen, L. Wang (Hikvision)]

[JVET-N0535](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6263) Crosscheck of JVET-N0160 (Non-CE6: Simplification on transform selection for Intra Sub-Partitions) [X. Zhao (Tencent)] [late]

[JVET-N0161](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5881) CE6-related: Implicit transform selection based on intra mode [X. Cao, F. Chen, L. Wang (Hikvision)]

[JVET-N0731](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6486) Cross-check of JVET-N0161 (Non-CE6: Implicit transform selection based on intra mode) [S. De-Luxán-Hernández (HHI)] [miss\_endmeeting] [late]

[JVET-N0172](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5892) Non-CE6: Unification of Implicit Transform Core Selection [H. Gao, S. Esenlik, B. Wang, A. M. Kotra, J. Chen (Huawei)]

[JVET-N0807](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6562) Crosscheck of JVET-N0172 (Non-CE6: Unification of Implicit Transform Core Selection) [H.E. Egilmez (Qualcomm)] [late]

[JVET-N0190](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5910) Non-CE6: Modifications on sub-block transform [J. Jung, D. Kim, G. Ko, J. Son, J. Kwak (WILUS)]

[JVET-N0713](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6467) Crosscheck of JVET-N0190 (Non-CE6: Modifications on sub-block transform) [X. Zhao (Tencent)] [late]

[JVET-N0208](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5928) CE6-6.2: Simplification related to MTS with reduced modes [K. Choi, M. Park, M. W. Park, W. Choi (Samsung)]

[JVET-N0338](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6059) Non-CE6: Unified transform selection for implicit MTS [T.-C. Ma, X. Xiu, Y.-W. Chen, X. Wang (Kwai Inc.)]

[JVET-N0833](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6588) Crosscheck of JVET-N0338 (Non-CE6: Unified transform selection for implicit MTS) [M.-S. Chiang (MediaTek)] [late]

[JVET-N0362](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6083) Non-CE6: Configurable max transform size in VVC [X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-N0729](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6484) Cross-check of JVET-N0362 (Non-CE6: Configurable max transform size in VVC) [S. De-Luxán-Hernández (HHI)] [late]

[JVET-N0363](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6084) CE6-related: Modified encoder decision for transform skip [X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-N0667](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6418) Cross-check of JVET-N0363 (CE6-related: Modified encoder decision for transform skip) [X. Cao (Hikvision)] [late]

[JVET-N0364](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6085) Non-CE6: Further cost reduction for primary transform [X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-N0365](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6086) CE6-related: MPM based non-separable secondary transform [X. Zhao, X. Li, S. Liu (Tencent)]

[JVET-N0518](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6244) Crosscheck of JVET-N0365 (CE6-related: MPM based non-separable secondary transform) [P. Philippe (Orange bcom)] [late]

[JVET-N0375](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6097) Non-CE6: Simplification on implicit transform selection in ISP mode [S.-C. Lim, J. Kang, J. Lee, H. Lee, H. Y. Kim (ETRI)]

[JVET-N0678](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6429) Crosscheck of JVET-N0375 (Non-CE6: Simplification on implicit transform selection in ISP mode) [J. Lainema (Nokia)] [late]

[JVET-N0388](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6110) Non-CE6: Shape Adaptive Transform Selection for ISP, SBT and MTS [K. Naser, T. Poirier, F. Le Léannec (Technicolor)]

[JVET-N0743](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6498) Crosscheck of JVET-N0388 (Non-CE6: Shape Adaptive Transform Selection for ISP, SBT and MTS) [P. Philippe (Orange bcom)] [late]

[JVET-N0804](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6559) Cross-check of JVET-N0388 (Non-CE6: Shape Adaptive Transform Selection for ISP, SBT and MTS) [M. Salehifar (LGE)] [late]

[JVET-N0419](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6141) Non-CE6: A Simplification of Implicit MTS [H. E. Egilmez, A. Said, N. Hu, C.-H. Hung, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-N0850](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6605) Cross-check of JVET-N0419 (Non-CE6: A Simplification of Implicit MTS) [S. De-Luxán-Hernández (HHI)] [miss\_endmeeting] [late]

[JVET-N0420](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6142) Non-CE6: A Simplification of Implicit Transform Selection in Intra-subblock Partitioning [H. E. Egilmez, A. K. Ramasubramonian, A. Said, N. Hu, V. Seregin, G. Van der Auwera, M. Karczewicz (Qualcomm)]

[JVET-N0730](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6485) Cross-check of JVET-N0420 (Non-CE6: A Simplification of Implicit Transform Selection in Intra-subblock Partitioning) [S. De-Luxán-Hernández (HHI)] [late]

[JVET-N0424](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6146) CE6-related: Simplification of MTS for intra-CUs [C.-H. Hung, H. E. Egilmez, N. Hu, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-N0519](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6245) Crosscheck of JVET-N0424 (CE6-related: An Explicit MTS Design with Fast Encoder) [P. Philippe (Orange bcom)] [late]

[JVET-N0445](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6167) Non-CE6: MTS kernel derivation for efficient memory usage [S. Shrestha, A. Kumar, B. Lee (Chosun Univ.), Y. Lee, J. Park (Humax)]

[JVET-N0668](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6419) Crosscheck of JVET-N0445 (Non-CE6: MTS kernel derivation for efficient memory usage) [J. Kim (??)] [late]

[JVET-N0485](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6207) Non-CE6: Efficient separable Multi-Transform-Signalling (MTS) without zero-out [A. Said, H.E. Egilmez, Y.-H. Chao, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-N0762](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6517) Crosscheck of JVET-N0485 (Non-CE6: Efficient separable Multi-Transform-Selection (MTS) without zero-out) [P. Philippe (Orange bcom)] [late]

[JVET-N0491](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6213) CE6-related: Transform Candidate Ordering [[C. Hollmann](mailto:christopher.hollmann@ericsson.com), [D. Saffar](mailto:davood.saffar@ericsson.com), [J. Ström](mailto:jacob.strom@ericsson.com), [P. Wennersten (Ericsson)](mailto:per.wennersten@ericsson.com)]

[JVET-N0509](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6234) CE6-Related: NSST with 8 Coefficients Computation [K. Naser, G. Rath, P. de Lagrange (Technicolor)] [late]

[JVET-N0695](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6447) Crosscheck of JVET-N0509 (CE6-Related: NSST with 8 Coefficients Computation) [?? (??)][late]

[JVET-N0555](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6284) CE6-related: Simplification of the Reduced Secondary Transform [M. Siekmann, M. Winken, H. Schwarz, D. Marpe, T. Wiegand (HHI)] [late]

[JVET-N0812](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6567) Crosscheck of JVET-N0555 (CE6-related: Simplification of the Reduced Secondary Transform) [M. Koo (LGE)] [late]

[JVET-N0808](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6563) Non-CE6: Joint proposal on configurable max transform size of JVET-N0362 and JVET-N0227 [X. Zhao, X. Li, S. Liu (Tencent), L. Li, M. Koo, J. Heo, J. Lim, S. Kim (LGE)] [late]

[JVET-N0866](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6621) Non-CE6: Combined Test of JVET-N0172/JVET-N0375/JVET-N0419/JVET-N0420 on Unification of Implicit Transform Selection [H. Gao, S. Esenlik, B. Wang, A. M. Kotra, J. Chen (Huawei), H. E. Egilmez, A. K. Ramasubramonian, A. Said, N. Hu, V. Seregi, G. Van-der Auwera, M. Karczewicz (Qualcomm), S.-C. Lim, J. Kang, J. Lee, H. Lee, H. Y. Kim (ETRI)] [late]

In VVC Draft 4.0, two separate implicit transform selection methods based on intra mode and block-shape are introduced for ISP and implicit MTS, respectively. This joint contribution describes the unified design adopted in the 14th JVET meeting, where the components of the unified design are independently proposed and tested in JVET-N0172, JVET-N0375, JVET-N0419 and JVET-N0420:

- The implicit MTS part of the adoption is proposed and tested in JVET-N0172 and JVET-N0419.

- The transform derivation for ISP is proposed and tested in JVET-N0172, JVET-N0375 and JVET-N0420.

The adopted unified method provides -0.01%, 0.00%, and -0.01% coding efficiency over VTM4.0 for AI, RA, and LDB cases under CTC, respectively. As compared to the current implicit MTS design in VTM-4.0, -0.11%, -0.02%, and 0.02% are achieved for AI, RA, and LDB cases, respectively.

Was presented in Track A Tue 26 morning

Text in v2 was presented and confirmed to be simplified as suggested.

Decision: Adopt JVET-N0866

## CE7 related – Quantization and coefficient coding (11)

Contributions in this category were discussed Thursday 21 March 1600–1945 (Track A chaired by JRO).

[JVET-N0090](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5810) CE7-related: Support of signalling default and user-defined scaling matrices [O. Chubach, C.-Y. Lai, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

In this contribution, it is proposed to add support for signalling the default and user-defined scaling matrices on top of VTM4.0. The proposal is conforming to the bigger size range for the blocks (from 4×4 to 64×64 for luma, from 2×2 to 32×32 for chroma), rectangular transform blocks (TBs), dependent quantization, multiple transform selection (MTS), large transform with zeroing-out high frequency coefficients, intra subblock partitioning (ISP), and intra block copy (IBC, also known as current picture referencing, CPR). The proposed method of signalling scaling matrices has been implemented on top of VTM4.0.

The general approach is similar to HEVC for larger blocks: Using 8x8 as basis, and extending it by duplicating samples. This is modified for non-square blocks. It is described as first interpolating to a square size, and then decimating to the size of the shorter block side. It is suggested to better describe this as a one-step. Same applies to the case when coefficient are zeroed out in a Nx64|32 or 64|32xN block.

A related proposal JVET-N0204 also proposes quant matrices, but the difference is that it does not propose different matrices for MTS, and proposes to disable in case of TS generally (current VTM software has some code for quant matrices and disables them for TS in cases of larger than 4x4).

Further study is needed to investigate whether it is necessary to use different matrices for MTS, and how it would work together with the secondary transform.

It is agreed that the mechanism for quant. matrices should be included in VVC

There is no need to transfer the default matrices from HEVC, as it is unclear that they are practically used – default should be flat matrices.

Proponents of JVET-N0090 and JVET-N0204 should work on designing a basic description text for supporting quantization matrices for square and rectangular block sizes of VVC as described above, default flat, and disabled for blocks that use TS or secondary transform. The proponents are also mandated to generate the software (or combine them from the two implementations).

See further notes under JVET-N0847.

[JVET-N0782](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6537) Cross-check of JVET-N0090: CE7-related: Support of signalling default and user-defined scaling matrices [M. Coban (Qualcomm)] [late]

[JVET-N0204](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5924) AHG18: Support of quantization matrices [T. Toma, K. Abe (Panasonic), S.-C. Lim, J. Kang (ETRI)]

This contribution proposes to support quantization matrices in VTM. The proposed signaling method of quantization matrices is HEVC based design as proposed in JVET-L0121 [1]. Quantization matrices for square CU are signaled and those for rectangular CU are derived by down-sampling from the matrices for square CU. This method is implemented in VTM 4.0.

See notes above.

[JVET-N0631](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6380) Crosscheck of JVET-N0204 (AHG18: Support of quantization matrices) [H. Sakurai, M.Ikeda (Sony)] [late]

[JVET-N0091](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5811) CE7-related: TB-level constraints on context-coded bins for coefficient coding [T.-D. Chuang, S.-T. Hsiang, Z.-Y. Lin, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

In the VTM4.0 coefficient coding, a coefficient subblock-level maximum number of context-coded bins is imposed. The averaged maximum number of context-coded bins per 16 samples is increased by 28% compared with that in HEVC. In this contribution, it is proposed to use a transform block (TB) level constraint for maximum number of context-coded bins instead of coefficient subblock-level constraint. For a luma TB, the maximum allowed number of context-coded bin is equal to tb\_width\*tb\_height\*1.75. For a chroma TB, the maximum allowed number of context-coded bin is equal to tb\_width\*tb\_height\*1.25. The averaged maximum number of context-coded bins per 16 samples is only increased by 1.3% compared with that in HEVC. Simulation results reportedly show that the average luma BD-rates are 0.03%, 0.01%, and 0.07% in AI, RA, and LB cases, respectively.

Was also tested at low QPs, does also not introduce loss.

Generally agreed that an approach in this direction is reasonable, as it can be expected that the number of context coded bins is unequally distributed in case of large TUs.

It is suggested to study this in CE. Also investigate the effect on number of context coded bins using the software of JVET-N0049. The CE should also investigate which percentage of overall context coded bins is consumed by the residual coding (in dependency of QP). Low QP range shall be investigated as well. For this purpose, it may not be necessary to study LB performance. The CE should also impose the same constraint for the TS case (which has a constraint at block level, which needs to be modified to the same number)

[JVET-N0638](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6388) Crosscheck of JVET-N0091 (CE7-related: TB-level constraints on context-coded bins for coefficient coding) [H. Huang (Qualcomm)] [late]

[JVET-N0092](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5812) CE7-related: Unified Rice parameter derivation of abs\_remainder and dec\_abs\_level syntax elements [M. G. Sarwer, O. Chubach, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

In this proposal, a unified template-based Rice parameter derivation process is applied for coding both abs\_remainder and dec\_abs\_level syntax elements. In addition to Rice parameter derivation, the syntax element abs\_remainder and its associated sign value (i.e. coeff\_sign\_flag) are jointly coded using a joint syntax element abs\_remainder\_with\_sign. In addition, in the proposed method, the decoding of coeff\_sign\_flag is moved to the second pass. Therefore, the number of coding passes in residual levels coding is reduced from three to two (i.e., pass 1: context coding; pass 2: bypass coding). It is reported that in AI condition this proposal can achieve -0.06%/-0.02%/-0.04% Y/Cb/Cr BD-rate for VTM4.0. In RA condition, the BD-rate is -0.05%/-0.10%/-0.12% for Y/Cb/Cr. Encoding time and decoding time of this proposal are similar to those of VTM4.0.

The aspect of template-based Rice parameter derivation is resolved (due to adoption from CE7-3.1). Though it is not identical, that aspect does not need to be considered any more. The remaining aspect would be the combined decoding of sign and abs\_remainder which is currently done in two passes, which is shown to provide some small coding gain. In combination with sign data hiding, it seems however more straightforward to keep the current design.

[JVET-N0732](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6487) Cross-check of JVET-N0092 (CE7-related: Unified Rice parameter derivation of abs\_remainder and dec\_abs\_level syntax elements) [A. K. Ramasubramonian (Qualcomm)] [late]

[JVET-N0103](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5823) CE7-related: Coefficient group size harmonisation [C. Rosewarne, J. Gan (Canon)]

Prior to VTM-4.0 two coefficient group sizes were present in the design, 2x2 and 4x4 for chroma and always 4x4 for luma. VTM-4.0 includes intra sub partitions, which introduces additional coefficient group sizes in luma, 1x16, 2x8, 8x2, and 16x1. The selection of coefficient group sizes becomes dependent upon the TB size and the channel type (luma or chroma). This contribution proposes to set the coefficient group size based upon TB size only, i.e., remove the dependency on channel type. As a consequence, the above-mentioned 2x8 and 8x2 sizes become available in chroma. Moreover, sizes of 2x4 and 4x2 also become available for TBs of these sizes. The resulting BD-rate impact for AI is 0.00%, -0.04%, -0.05%, for RA is -0.09%, 0.05%, -0.01%, and for LDB is 0.00%, 0.14%, -0.12% in Y, Cb, and Cr channels, respectively.

The reported gain is somewhat random and mainly comes from class C in RA. However, the goal is not coding efficiency improvement.

It is generally agreed that this would be a desirable harmonization (e.g. having same definition of coefficient group for any blocks of 16 samples). However, in the discussion it was expressed that it would be even more desirable to only have two coefficient group sizes: 4 coefficients or 16 coefficients, and in case of 4x2/2x4 use two groups of 4 samples (as in current VTM) instead of defining a new size of 8.

Generally, this adoption was supported. It was requested that the text should be updated with the requested modifications above. Results and text were shown in Track A Tuesday 26 morning. In the modified version with coeff group sizes 4 and 16, there is no relevant change in compression compression performance relative to VTM4.

Decision(cleanup): Adopt JVET-N0103, updated method with text in v3.

[JVET-N0864](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6619) Crosscheck of JVET-N0103 (CE3/7-related: Coefficient group size harmonization) [H. Schwarz (Fraunhofer HHI)] [late]

[JVET-N0106](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5826) CE7-related: TU level limits on context-coded bins for coefficient coding [M. Coban, M. Karczewicz (Qualcomm)]

This document proposes to limit the total number of context-coded bins for coefficient coding at TU-level. The limit is set to number of non-zero coded coefficient groups in a TU times the existing regular coded bin count limit at coefficient group level (2 bins/coefficient). The simulations results show -0.05% AI, -0.03% RA, -0.04% LB BD-Rate versus the VTM-4.0 anchor under common test conditions.

It is commented that the method of JVET-N0091 might be simpler to implement. Study in CE.

[JVET-N0765](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6520) Crosscheck of JVET-N0106 (CE7-related: TU level limits on context-coded bins for coefficient coding) [C.-Y. Lai (MediaTek)] [late]

[JVET-N0783](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6538) Crosscheck of JVET-N0106 (CE7-related: TU level limits on context-coded bins for coefficient coding) [H. Schwarz (Fraunhofer HHI)] [late]

[JVET-N0194](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5914) CE6/7-related: Context selection of last non-zero coefficient position coding based on reduced TU size (related to JVET-M0297 and JVET-M0251/M0257) [M. Koo, J. Choi, M. Salehifar, J. Lim, S. Kim (LGE)]

In 13th JVET meeting, reduced 32-point MTS (RMTS32) based on skipping high frequency coefficients was adopted in order to reduce computational complexity of 32-point DST-7/DCT-8. Moreover, it was also agreed that the proposed residual coding change should be accompanied considering all types of zero-out (those of JVET-M0297 and JVET-M0251/M0257).

During in-between VVC working draft editing period, all the related proponents provided their spec text where contexts of last non-zero coefficient position coding is selected based on original TU size, which is aligned with the current VTM4.0 SW. But, it was questioned if this context selection should be performed based on reduced TU size, which was commented to be more consistent. Therefore, it was proposed that it could be decided at the next meeting based on experimental results which TU size should be involved during the context selection.

In this contribution, the experimental results based on reduced TU size are presented. It is reportedly shown that luma BD-rate/encoding time/decoding time changes of all configurations are 0.10%/101%/103% (AI), 0.05%/XXX%/XXX% (RA), and -0.02%/XXX%/XXX% (LD), respectively, but BD-rate loss for high resolution sequences on AI configuration is substantial (up-to 0.24%).

Presentation deck not available in latest upload.

Decision(BF): The problem that this contribution raises is recognized. The text should be aligned with the method imlemented in VTM, as the latter seems to have better performance (to be done by text editor).

[JVET-N0796](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6551) Crosscheck of JVET-N0194 (CE6-related: Context selection of last non-zero coefficient position coding based on reduced TU size (related to JVET-M0297 and JVET-M0251/M0257) [H. Gao (Huawei)] [late]

[JVET-N0189](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5909) Non-CE7: Unified last position coding for 32-point transforms [Y. Piao, K. Choi (Samsung)]

This contribution suggests a unified last position coding for different type of transforms. Due to 16-point zero-out approach for 32-point MTS, last positions in range of 12 to 15 are represented by different binarizations in MTS, sub-block transform, DCT2 and TransformSkip mode. To simply the logic in parsing stage, a unified binarizations for last position within block size of 32 is suggested regardless of the selected transform type. Only 0.02% and 0.01% BD-rate loss is observed with the unified solution in AI and RA configurations, respectively.

Several experts expressed that there is no problem and no need for unification. Beyond that, if the suggested modification would be made, a bitstream restriction would need to be formulated that a last coefficient position shall not be in the zeroed-out area.

No action.

[JVET-N0533](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6261) Crosscheck of JVET-N0189 (Non-CE7: Unified last position coding for 32-point transformsNon-CE7: Unified last position coding for 32-point transforms) [X. Zhao (Tencent)] [late]

[JVET-N0281](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6002) CE7-related: Constraint on the number of regular bins per subblock [S.-T. Hsiang, T.-D. Chuang, S.-M. Lei (MediaTek)]

In VVC Draft 4, the constraint on the maximum allowed number of context-coded bins is defined for the 1st subblock coding pass. The total number of the context-coded bins may exceed the constraint value by 1 for coding a subblock when the syntax element coded\_sub\_block\_flag is present in the current subblock. In this contribution, we propose to enforce the constraint value on the maximum allowed number of regular bins for coding a subblock, further counting the regular bin for coding coded\_sub\_block\_flag. The regular bin budget for the 1st subblock coding pass is decremented by 1 when coded\_sub\_block\_flag is present in the current subblock. The proposed method reportedly generates 0.00%, 0.00, and -0.02% luma BD-rates for the AI, RA and LB settings, respectively, under the JVET CTCs.

Presentation deck not available in latest upload.

This aspect is noted, but in the current situation is not of prior importance to take action. To some extent the number of the constraint is random, and it does not matter too much if the coded subblock flag is included in the count. A CE is planned which allows further reduction of the number of context coded bins by imposing constraints at block level rather than subblock.

[JVET-N0592](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6326) Cross-check of JVET-N0281 (CE7-related: Constraint on the number of regular bins per subblock) [[F. Le Léannec](mailto:fabrice.leleannec@technicolor.com), [T. Poirier (Technicolor)](mailto:tangi.poirier@technicolor.com)] [late]

[JVET-N0282](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6003) CE7-related: Joint chroma residual coding with multiple modes [C. Helmrich, C. Rudat, T. Nguyen, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

In this contribution, an extension of the joint chroma residual coding suggested in JVET-M0305 is proposed. In contrast to JVET-M0305, in which the addition of one joint chroma residual coding mode (given by Cr = −Cb) was suggested, this contribution proposes three modes for joint chroma residual coding with different mixing factors (given by Cr = ±Cb/2, Cr = ±Cb, Cb = ±Cr/2). The sign used for deriving the second chroma residual is coded in the tile group header. The usage of a joint chroma coding mode is indicated by a TU-level flag and the selected mode is implicitly indicated by the chroma coded block flags.

The following average results are reported for the common test conditions relative to VTM 4.0:

AI: −0.58% (Y), −0.76% (Cb), −1.13% (Cr) at 103% enc. and approximately 100% dec. time;  
RA: −0.34% (Y), −2.53% (Cb), −1.74% (Cr) at 102% enc. and approximately 100% dec. time;  
LD: −x.xx% (Y), −x.xx% (Cb), −x.xx% (Cr) at 102% enc. and approximately 100% dec. time.

In addition, results for an alternative design of the chroma residual coding modes are reported. In this version, one of the three modes is replaced by a mode in which two chroma channels are coded that represent the transform coefficients of a Hadamard transform across the chroma components. For this version, the following average results are reported:

AI: −0.67% (Y), −0.67% (Cb), −1.12% (Cr) at 107% enc. and approximately 98% dec. time;  
RA: −0.37% (Y), −2.28% (Cb), −1.68% (Cr) at 104% enc. and approximately 100% dec. time;  
LD: −x.xx% (Y), −x.xx% (Cb), −x.xx% (Cr) at 103% enc. and approximately 100% dec. time.

Presentation deck is not provided in latest upload.

For method A, Luma gain is 0.2% in AI, less than 0.1% for RA compared to the CE7-1 method. No increase in encoder run time, but some encoder speed-ups are used.

Study in CE.

[JVET-N0794](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6549) Cross check of JVET-N0282 [K. Misra (Sharp Labs of America)] [late]

[JVET-N0326](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6047) Non-CE7: Simplification of cbf coding [Y.-W. Chen, X. Xiu, T.-C. Ma, X. Wang (Kwai Inc.)]

In current VVC, the intra sub-partition flag, cbf of previous sub-partition and transform depth are utilized to select one out of four contexts for coding the cbf of a luma block. The transform depth is utilized to select one out of two contexts for coding the cbf of a Cb block while the cbf of the corresponding Cb block is utilized to select one out of the two contexts for coding the cbf of the Cr block. In this proposal, it is proposed to remove the context selection based on intra sub-partition flag, cbf of previous sub-partition and transform depth. In the proposed simplification, only one context is used by the luma cbf coding and only one context is used by the Cb cbf coding. Two contexts are still used by Cr cbf coding which is the same as current VVC. In summary, the context selection for cbf coding of luma and Cb blocks are totally removed and the CABAC contexts for cbf coding are reduced by four. The simulation results reportedly show that the proposed simplifications shows {0.04%, 0.01%, 0.00%} and {-0.01%, 0.63%, -0.10%} BD-rates changes on Y, Cb and Cr components for AI and RA over VTM-4.0.

Presentation deck is not provided in latest upload.

The presentation has more results than in the uploaded proposal.

The first aspect (removing the ISP dependent context condition) is regarded as reasonable by several experts, and might be adopted.

The second aspect introduces higher losses on Cb (likely due to the fact that context dependency is only modfied for luma and Cb). This approach seems to be questionable.

Specification text for the first aspect was provided, and confirmed to be matching with the software implementation by the cross-checkers.

As however this may have some impact in combination with other adoptions of the meeting (e.g. combination of ISP with DC, and the implicit transform choices, it is suggested to be further studied (CE) if that aspect would still be applicable without loss.

[JVET-N0652](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6402) Crosscheck of JVET-N0326 (Non-CE7: Simplification of cbf coding) [G. Li (Tencent)] [late]

[JVET-N0347](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6068) CE7-related: Joint coding of chroma residuals [G. Van der Auwera, A. K. Ramasubramonian, M. Coban, M. Karczewicz (Qualcomm)]

This contribution builds upon the joint chroma residual coding method that is tested in CE7-1. It is claimed that the CE7-1 method may result in chroma artifacts due to the approximation of the Cb and Cr residuals, because the approximation error is not further coded and, therefore, the lost chroma information can not be recovered. The proposed method processes the Cb and Cr residuals in an invertible manner, which is only lossy due to rounding, and is similar to jointly applying a 1D 2-point transform to the residuals. The Cb and Cr residuals are processed in the rescaled chroma domain before transforms, quantization, entropy coding. At the decoder-side, in case the signalled joint chroma residual coding mode is enabled for the transform block, the reconstruction of a Cb transform block consists of adding the two decoded Cb and Cr residuals to the predicted Cb block, while the reconstruction of a Cr transform block consists of subtracting the decoded Cb residual and adding the decoded Cr residual to the predicted Cr block. While the CE7-1 method signals a specific Qp offset value for the joint mode, which may be an encoder burden to determine this value, the proposed method does not require a specific Qp offset value.

The average BD-rates and runtimes are as follows:

* Qp values {22, 27, 32, 37}:
  + AI: -0.29% (Y), 0.20% (U), -0.01% (V) with runtimes 104% (EncT) and 102% (DecT)
  + RA: -0.21% (Y), 0.15% (U), 0.39% (V) with runtimes 102% (EncT) and 100% (DecT)
  + LDB: -0.14% (Y), 1.10% (U), -0.14% (V) with runtimes 102% (EncT) and 102% (DecT)
* Low-Qp values {2, 7, 12, 17}, for 100 frames:
  + AI: -0.11% (Y), 0.14% (U), 0.07% (V) with runtimes x% (EncT) and x% (DecT)
  + RA: -0.11% (Y), 0.27% (U), 0.30% (V) with runtimes x% (EncT) and x% (DecT)
  + LDB: -0.12% (Y), 0.24% (U), 0.18% (V) with runtimes x% (EncT) and x% (DecT)

The average BD-rates and runtimes are as follows with lambda tuning included that is identical to CE7-1:

* Qp values {22, 27, 32, 37}:
  + AI: -0.46% (Y), 0.69% (U), 0.44% (V) with runtimes x% (EncT) and x% (DecT)
  + RA: -0.33% (Y), 0.48% (U), 0.67% (V) with runtimes x% (EncT) and x% (DecT)
  + LDB: -0.16% (Y), 0.44% (U), -1.18% (V) with runtimes x% (EncT) and x% (DecT)
* Low-Qp values {2, 7, 12, 17}, for 100 frames:
  + AI: -0.28% (Y), 0.56% (U), 0.48% (V) with runtimes x% (EncT) and x% (DecT)
  + RA: -0.18% (Y), 0.40% (U), 0.44% (V) with runtimes x% (EncT) and x% (DecT)
  + LDB: -0.16% (Y), 0.28% (U), 0.07% (V) with runtimes x% (EncT) and x% (DecT)

It is reported that the highest coding gains are observed for sequence classes A and F.

It is suggested that the CE7-1 method might cause coding artifacts if wrongly, which would not occur here.

Gain compared to CE7-1 is somewhat lower than for JVET-N0282, which includes this as one of the modes.

Study in CE, should also include study if the methods are still useful with HDR CTC.

[JVET-N0573](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6307) Crosscheck of JVET-N0347 (CE7-related: Joint coding of chroma residuals) [Y.-W. Chen (Kwai Inc.)] [late]

[JVET-N0725](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6480) Crosscheck of JVET-N0347 (CE7-related: Joint coding of chroma residuals) [N. Choi (Samsung)] [late]

[JVET-N0492](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6214) CBF flags signalling in VVC [R. Chernyak, Y. Zhao, S. Ikonin, J. Chen (Huawei)]

This contribution proposes a modification of VVC 4 specification and VTM 4.0.1 SW aimed to remove inconsistency in part of CBF flags signalling between them. The contribution consists of two aspects. The first aspect proposes to remove hierarchical chroma CBF signalling based on Transform Unit depth from the VTM SW, which is not presented in the specification; and include to the specification missing luma cbf flag deriving methods for normal TU and SBT TU based on chroma CBF flags, which is presented in the SW. The second aspect is proposed on top of the first and assumes unified design of all existing luma cbf flag deriving methods. Both aspects provide negligible coding performance difference in respect to VTM 4.0.1.

Document should be updated with the results shown in the powerpoint deck.

The first part of the proposal points out two issues (elements which is in SW but not described in text):

- Luma CBF deriving - if implemented without (as per text) would result in 0.1% loss in RA.

- Hierarchical CBF – if implemented without (as per text) no difference.

It is suggested to align software and text, such that

- hierarchical CBF would be removed from software (as it does not give gain, but would make the text more complicated),

- describe luma CBF deriving in text and keep it in software.

Decision(BF/Text/SW): Adopt this aspect of JVET-N0492 as described above.

The second part of the proposal suggests to use the method of luma CBF deriving that is used in ISP for the case of maximum-size TUs. This however does not give gain.

Related to the second aspect, some experts suggested that rather than adding the method to the case 64 TBs, a more consistent unification would be tom remove it from ISP (provided it would not result in loss, which nobody knows). There is no real need for a unification here, as it would make the case of maximum-size TB more complicated without benefit.

[JVET-N0685](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6436) Crosscheck of JVET-N0492 (CBF flags signalling in VVC) [P. Hanhart (InterDigital)] [late]

[JVET-N0847](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6602) CE7-related: Support of signalling default and user-defined scaling matrices [O. Chubach, C.-Y. Lai, C.-Y. Chen, T.-D. Chuang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek), T. Toma, K. Abe (Panasonic), S.-C. Lim, J. Kang (ETRI)] [late]

(include abstract)

The text was reviewed in Track A Tue 03-26 morning; it is implementing the concept as previously sugessted, i.e. use the 4x4 matrix for block sizes 4x4, 4x2, 2x4, and the 8x8 matrix for all other cases, where decimation is applied for 1|2|4xN and Nx1|2|4, and otherwise the HEVC concept of interpolation per direction.

Decision: Adopt JVET-N0847. Some minor text improvements are left to the discretion of the editor.

## CE8 related – Screen content coding tools (41)

Contributions in this category were discussed XXday XX March XXXX–XXXX (chaired by XXXqq).

[JVET-N0093](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5813) CE8-related: Disallowing coexistence of regular merge and IBC merge in SMR [Y.-C. Lin, C.-C. Chen, M.-S. Chiang, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0601](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6341) Crosscheck of JVET-N0093 (CE8-related: Disallowing coexistence of regular merge and IBC merge in SMR) [Y. Han, W.-J. Chien (Qualcomm)] [late]

[JVET-N0094](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5814) CE8-related: Context modelling of transform skip mode [M. G. Sarwer, O. Chubach, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0768](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6523) Crosscheck of JVET-N0094 (CE8-related: Context modelling of transform skip mode associated Resources) [B. Wang (Huawei)] [late]

[JVET-N0095](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5815) CE8-related: Unified method for coding BVD and MVD [S.-T. Hsiang, S.-M. Lei (MediaTek)]

[JVET-N0677](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6428) Crosscheck of JVET-N0095 (CE8-related: Unified method for coding BVD and MVD) [Y.-C. Sun (Alibaba)] [late]

[JVET-N0096](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5816) CE8-related: A fixed updating order for IBC reference memory [C.-Y. Lai, T.-D. Chuang, C.-Y. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0702](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6454) Crosscheck of JVET-N0096 (CE8-related: A fixed updating order for IBC reference memory) [T.-S Chang (Alibaba)] [late]

[JVET-N0173](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5893) Non-CE8: IBC Reference Area Rearrange [H. Gao, S. Esenlik, B. Wang, A. M. Kotra, J. Chen (Huawei)]

[JVET-N0611](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6352) Cross-check of JVET-N0173 [?? (??)] [late]

[JVET-N0174](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5894) Non-CE8: Exclusive Regular Merge and IBC Merge in One Shared Merge List Area [H. Gao, S. Esenlik, B. Wang, A. M. Kotra, J. Chen (Huawei)]

[JVET-N0640](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6390) Crosscheck of JVET-N0174 (Non-CE8: Exclusive regular merge and IBC merge in one shared merge list area) [Y.-C. Lin (MediaTek)] [late]

[JVET-N0175](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5895) Non-CE8: IBC Reference Memory for Arbitrary CTU Size [H. Gao, S. Esenlik, B. Wang, A. M. Kotra, J. Chen (Huawei)]

[JVET-N0540](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6268) Crosscheck of JVET-N0175: Non-CE8: IBC Reference Memory for Arbitrary CTU Size [X. Xu (Tencent)] [late]

[JVET-N0176](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5896) Non-CE8: IBC Merge List Simplification [H. Gao, S. Esenlik, B. Wang, A. M. Kotra, J. Chen (Huawei)]

[JVET-N0683](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6434) Crosscheck of JVET-N0176 (Non-CE8: IBC Merge List Simplification) [J. Nam, J. Lim, S. Kim (LGE)] [late]

[JVET-N0201](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5921) Non-CE8: IBC modifications [J. Li, C.-W. Kuo, C. S.Lim (Panasonic)]

[JVET-N0516](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6242) Crosscheck of JVET-N0201 (Non-CE8: IBC modifications) [S.-T. Hsiang (MediaTek)] [late]

[JVET-N0202](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5922) AHG16/non-CE8: Report on conformance check failures of IBC block vectors [J. Li, C.-W. Kuo, C. S.Lim (Panasonic)] late]

[JVET-N0249](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5969) Non-CE8: An alternative search area for IBC [J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)]

[JVET-N0798](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6553) Crosscheck of JVET-N0249 (Non-CE8: An alternative search area for IBC) [H. Gao (Huawei)] [late]

[JVET-N0250](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5971) Non-CE8: Reference memory reduction for intra block copy [J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)]

[JVET-N0684](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6435) Crosscheck of JVET-N0250 (Non-CE8: Reference memory reduction for intra block copy) [J. Nam, J. Lim, S. Kim (LGE)] [late]

[JVET-N0251](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5972) Non-CE8: Intra block copy clean-up [J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)]

[JVET-N0541](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6269) Crosscheck of JVET-N0251: Non-CE8: Intra block copy clean-up [X. Xu (Tencent)] [late]

[JVET-N0258](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5979) CE8-related: Palette Mode Coding [W. Zhu, L. Zhang, J. Xu, K. Zhang, H. Liu, Y. Wang (Bytedance)]

[JVET-N0701](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6453) Crosscheck of JVET-N0258 (CE8-related: Palette Mode Coding) [T.-S. Chang (Alibaba)] [late]

[JVET-N0259](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5980) CE8-related: compound palette mode [W. Zhu, J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)]

[JVET-N0799](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6554) Crosscheck of JVET-N0259 (CE8-related: compound palette mode) [H. Gao (Huawei)] [late]

[JVET-N0260](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5981) Non-CE8: Disabling fractional MVD search in DMVR for SCC [W. Zhu, H. Liu, K. Zhang, L. Zhang, J. Xu, Y. Wang (Bytedance)]

[JVET-N0739](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6494) Crosscheck of JVET-N0260 (Non-CE8: Disabling fractional MVD search in DMVR for SCC) [S. Ye (Hikvision)] [late]

[JVET-N0289](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6010) CE8-Related: On MVD Coding [M. Salehifar, S. Paluri, S. Kim (LGE)]

[JVET-N0722](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6477) Crosscheck of JVET-N0289 (CE8-Related: On MVD Coding) [Y. Han, W.-J. Chien (Qualcomm)] [late]

[JVET-N0316](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6037) CE8-related: Default Processing for IBC Mode [Y. Han, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-N0558](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6289) Crosscheck of JVET-N0316 (CE8-related: Default Processing for IBC Mode) [T. Zhou (Sharp)] [late]

[JVET-N0317](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6038) CE8-related: Simplification on IBC Merge/Skip Mode [Y. Han, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-N0593](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6327) Cross-check of JVET-N0317 (CE8-related: Simplification on IBC Merge/Skip Mode) [F. Le Léannec, A. Robert (Technicolor)] [late]

[JVET-N0318](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6039) CE8-related: Block Size Limitation for IBC Mode [Y. Han, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-N0642](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6392) Crosscheck of JVET-N0318 (CE8-related: block size limitation for IBC mode) [Y.-C. Lin (MediaTek)] [late]

[JVET-N0329](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6050) CE8-related: Encoder improvements on IBC search [X. Xiu, Y.-W. Chen, T.-C. Ma, X. Wang (Kwai Inc.)]

[JVET-N0543](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6271) Crosscheck of JVET-N0329: CE8-related: Encoder improvements on IBC search [X. Xu (Tencent)] [late]

[JVET-N0337](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6058) CE8-related: Adaptive disabling of intra sample interpolation for screen content coding [X. Xiu, Y.-W. Chen, T.-C. Ma, X. Wang (Kwai Inc.)]

[JVET-N0661](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6412) Crosscheck of JVET-N0337 (CE8-related: Adaptive disabling of intra sample interpolation for screen content coding) [H. Yang (InterDigital)] [late]

[JVET-N0346](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6067) Non-CE8: Palette Mode in HEVC for YUV4:4:4 format [Y.-H. Chao, H. Wang, W.-J. Chien, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-N0690](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6441) Crosscheck of JVET-N0346 (Non-CE8: Palette Mode in HEVC for YUV4:4:4 format) [C.-Y. Lai (MediaTek)] [late]

[JVET-N0789](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6544) Crosscheck of JVET-N0346 (Non-CE8: Palette Mode in HEVC for YUV4:4:4 format) [Y.-C. Sun (Alibaba)] [late]

[JVET-N0357](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6078) CE8-related: Context Modelling of Sign for TS Residual Coding [B. Bross, T. Nguyen, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

[JVET-N0781](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6536) Cross-check of JVET-N0357: CE8-related: Context Modelling of Sign for TS Residual Coding [M. Coban (Qualcomm)] [late]

[JVET-N0366](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6087) CE8-related: Modified limitation on context coded bins for CE8-3.1a and CE8-5.1a [X. Zhao, X. Li, X. Xu, S. Liu (Tencent)] [placeholder] [late]

[JVET-N0382](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6104) CE8-related: unified IBC block vector prediction [X. Xu, X. Li, S. Liu (Tencent)]

[JVET-N0520](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6246) Crosscheck of JVET-N0382 (CE8-related: unified IBC block vector prediction) [C.-C. Chen (MediaTek)] [late]

[JVET-N0383](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6105) Non-CE8: IBC search range adjustment for implementation consideration [X. Xu, X. Li, S. Liu (Tencent)]

[JVET-N0610](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6351) Cross-check of JVET-N0383 [?? (??)][late]

[JVET-N0384](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6106) Non-CE8: IBC search range increase for small CTU sizes [X. Xu, X. Li, S. Liu (Tencent)]

[JVET-N0797](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6552) Crosscheck of JVET-N0384 (Non-CE8: IBC search range increase for small CTU sizes) [H. Gao (Huawei)] [late]

[JVET-N0405](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6127) CE8-related: Palette Mode Simplification [Y.-C. Sun, T.-S. Chang, J. Lou (Alibaba), Y.-H. Chao, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-N0608](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6349) Crosscheck of JVET-N0405 (CE8-related: Palette Mode Simplification) [W. Zhu (Bytedance)] [late]

[JVET-N0413](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6135) CE8-related: Quantized residual BDPCM [M. Karczewicz, M. Coban (Qualcomm)]

[JVET-N0703](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6455) Crosscheck of JVET-N0413 (CE8-related: Quantized residual BDPCM) [T.-S Chang (Alibaba)] [late]

[JVET-N0430](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6152) CE8-related: Transform skip restriction [J. Choi, J. Heo, S. Yoo, J. Choi, J. Lim, S. Kim (LGE)]

[JVET-N0455](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6177) CE8-related: Sign context modelling and level mapping for TS residual coding [M. Karczewicz, M. Coban (Qualcomm)]

[JVET-N0594](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6328) Cross-chreck of JVET-N0455 (CE8-related: Sign context modelling and level mapping for TS residual coding) [F. Le Léannec, T. Poirier (Technicolor)] [late]

[JVET-N0609](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6350) Crosscheck of JVET-N0455: CE8-related: Sign context modelling and level mapping for TS residual coding [T. Nguyen (HHI)] [late]

[JVET-N0459](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6181) CE8-related: Modified block vector coding for IBC [J. Nam, H. Jang, J. Choi, J. Heo, J. Lim, S. Kim (LGE)]

[JVET-N0800](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6555) Crosscheck of JVET-N0459 (CE8-related: Modified block vector coding for IBC) [Y. Han, W.-J. Chien (Qualcomm)] [late]

[JVET-N0460](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6182) CE8-related: Default candidates for IBC merge mode [J. Nam, H. Jang, J. Lim, S. Kim (LGE)]

[JVET-N0801](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6556) Crosscheck of JVET-N0460 (CE8-related: Default candidates for IBC merge mode) [Y. Han, W.-J. Chien (Qualcomm)] [late]

[JVET-N0461](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6183) CE8-related: Signaling on maximum number of candidates for IBC merge mode [J. Nam, H. Jang, J. Lim, S. Kim (LGE)]

[JVET-N0630](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6379) Crosscheck of JVET-N0461: CE8-related: Signaling on maximum number of candidates for IBC merge mode [L. Pham Van (Qualcomm)] [late]

[JVET-N0464](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6186) Non-CE8: MMVD Motion vector rounding for SCC [H. Jang, J. Nam, N. Park, J. Lim, S. Kim (LGE)]

[JVET-N0576](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6310) Crosscheck of JVET-N0464: Non-CE8: MMVD Motion vector rounding for SCC [X. Xu (Tencent)] [late]

[JVET-N0466](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6188) Non-CE8: The corner case handling regarding mv derivation for Chroma IBC in dual tree structure [H. Jang, J. Nam, N. Park, J. Lim, S. Kim (LGE)]

[JVET-N0603](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6344) Crosscheck of JVET-N0466 (Non-CE8: The corner case handling regarding mv derivation for Chroma IBC in dual tree structure) [Y. Han, W.-J. Chien (Qualcomm)] [late]

[JVET-N0467](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6189) Non-CE8: Experimental result for various size of IBC block with optimized syntax signaling [H. Jang, J. Nam, N. Park, J. Lim, S. Kim (LGE)]

[JVET-N0604](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6345) Crosscheck of JVET-N0467 (Non-CE8: Experimental result for various size of IBC block with optimized syntax signaling) [Y. Han, W.-J. Chien (Qualcomm)] [late]

[JVET-N0472](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6194) Non-CE8: On IBC reference buffer design [J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)]

[JVET-N0837](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6592) Crosscheck of JVET-N0472 (Non-CE8: On IBC reference buffer design) [J. Nam, J. Lim, S. Kim (LGE)] [late]

This was a report of a check of decodability of an alternative decoding method for the same encoded content, using software provided by the proponent (a bit different from a usual cross-check).

[JVET-N0550](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6279) CE8-related: Subblock based Palette Mode [Y.-H. Chao, T. Hsieh, M. Karczewicz (Qualcomm)] [late]

[JVET-N0580](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6314) Cross-check of JVET-N0550: CE8-related: Line-based CG Palette Mode [X. Xiu (Kwai Inc.)] [late]

[JVET-N0742](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6497) CE8-related: Joint test of JVET-N0094 and CE8-4.1 [M. G. Sarwer, O. Chubach, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek), S. Yoo, J. Choi, J. Heo, J. Choi, L. Li, J. Lim (LGE)] [late]

[JVET-N0829](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6584) Cross check of JVET-N0742 (CE8-related: Joint test of JVET-N0094 and CE8-4.1) [T.-C. Ma (Kwai Inc.)] [late]

[JVET-N0763](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6518) CE8-related: Joint proposal for transform skip (CE8-4.1c, JVET-M0279 and JVET-N0094) [S. Yoo, J. Choi, J. Heo, J. Choi, J. Lim, S. Kim (LGE), M. G. Sarwer, O. Chubach, C. -W. Hsu, Y. -W. Huang, S.-M. Lei (MediaTek)] [late]

[JVET-N0822](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6577) Non-CE8: Combination of JVET-0173 and JVET-N0249 for improved IBC buffer utilization [H. Gao, S. Esenlik, B. Wang, A. M. Kotra, J. Chen (Huawei)] [late]

[JVET-N0843](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6598) CE8-related: Combination test of JVET-N0176/JVET-N0317/JVET-N0382 on simplification of IBC vector prediction [X. Xu, X. Li, S. Liu (Tencent), Y. Han, W.-J. Chien, M. Karczewicz (Qualcomm), H. Gao, S. Esenlik, B. Wang, A. M. Kotra, J. Chen (Huawei)] [late]

[JVET-N0844](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6599) Crosscheck of JVET-N0843: Combination test of JVET-N0176/JVET-N0317/JVET-N0382 on simplification of IBC vector prediction [Y.-C. Sun (Alibaba)] [late]

[JVET-N0853](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6608) CE8-related: Additional 4:4:4 results of palette mode improvements in HEVC (CE8-2.2c) [Y.-C. Sun, T.-S. Chang, J. Lou (Alibaba)] [late]

[JVET-N0854](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6609) Crosscheck of JVET-N0853 (CE8-related: Additional 4:4:4 results of palette mode improvements in HEVC (CE8-2.2c)) [Y.-H. Chao (Qualcomm)] [late]

## CE9 related – Decoder motion vector derivation (34)

Contributions in this category were discussed XXday XX March XXXX–XXXX (chaired by XXXqq).

[JVET-N0097](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5817) CE9-related: Simplification of cascading DMVR and BDOF processes [C.-Y. Chen, T.-D. Chuang, C.-C. Chen, C.-Y. Lai, Z.-Y. Lin, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0571](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6305) Crosscheck of JVET-N0097 (CE9-related: Simplification of cascading DMVR and BDOF processes) [Y.-W. Chen (Kwai Inc.)] [late]

[JVET-N0145](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5865) Non-CE9: Harmonization of DMVR and MMVD [E. Sasaki, T. Hashimoto, T. Chujoh, T. Ikai (Sharp)]

[JVET-N0759](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6514) Cross check of Non-CE9: Harmonization of DMVR and MMVD (JVET-N0145) [S. Jeong, K. Choi (Samsung)] [late]

[JVET-N0146](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5866) Non-CE9: On conditions for DMVR and BDOF [T. Chujoh, T. Ikai (Sharp)]

[JVET-N0522](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6248) Crosscheck of JVET-N0146 [P. Bordes (Technicolor)] [late]

[JVET-N0147](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5867) CE9-related: Simplification of BDOF [T. Chujoh, T. Ikai (Sharp)]

[JVET-N0673](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6424) Crosscheck of JVET-N0147 (CE9-related: Simplification of BDOF) [R. Yu (Ericsson)] [late]

[JVET-N0148](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5868) CE9-related: Early termination for BDOF [T. Chujoh, T. Ikai (Sharp)]

[JVET-N0549](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6278) Crosscheck of JVET-N0148 (CE9-related: Early termination for BDOF) [K. Kondo, M. Ikeda (Sony)] [late]

[JVET-N0152](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5872) Non-CE9: On motion refinement parameter derivation in BDOF [R. Yu, D. Liu (Ericsson)]

[JVET-N0654](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6404) Crosscheck of JVET-N0152 (Non-CE9: On motion refinement parameter derivation in BDOF) [H. Liu (Bytedance)] [late]

[JVET-N0153](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5873) Non-CE9: On DMVR and GBI [R. Yu, D. Liu (Ericsson)]

[JVET-N0566](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6299) Crosscheck of JVET-N0153 (non-CE9: on DMVR and GBI) [H. Lee, S. -C. Lim, J. Lee, J. Kang (ETRI)] [late]

[JVET-N0158](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5878) CE9-related: Alternative method of SAD based early termination for BDOF [K. Unno, K. Kawamura, S. Naito (KDDI)]

[JVET-N0551](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6280) Crosscheck of JVET-N0158 (CE9-related: Alternative method of SAD based early termination for BDOF) [T. Chujoh, T. Ikai (Sharp)] [late]

[JVET-N0162](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5882) CE9-related: Modified enabling condition for DMVR [F. Chen, L. Wang (Hikvision)]

[JVET-N0692](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6443) Crosscheck of JVET-N0162 (Non-CE9: Modified enabling condition for DMVR and BDOF) [S. Esenlik (Huawei)] [late]

[JVET-N0163](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5883) CE9-related: Simplified refinement process for DMVR [F. Chen, L. Wang (Hikvision)]

[JVET-N0819](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6574) Crosscheck of JVET-N0163 (Non-CE9: Simplified refinement process for DMVR) [Y. Wang, X. Zheng (DJI)] [late]

[JVET-N0179](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5899) Non-CE9: Reducing bi-linear interpolation buffer requirement for DMVR [S. Esenlik, H. Gao, A. M. Kotra, B. Wang, J. Chen (Huawei)]

[JVET-N0734](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6489) Crosscheck of JVET-N0179 (Non-CE9: Reducing bi-linear interpolation buffer requirement for DMVR) [C.-C. Chen, W.-J. Chien (Qualcomm)] [late]

[JVET-N0209](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5929) CE9-related: Simplification of BDOF based on CE9-2.5 [Y. Kato, K. Abe, T. Toma (Panasonic)]

[JVET-N0816](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6571) Cross-check of JVET-N0209 (CE9-related: Simplification of BDOF based on CE9-2.5) [S. Sethuraman (Ittiam)] [late]

[JVET-N0239](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5959) CE9-related: BDOF-BWA unification [F. Galpin, T. Poirier, P. Bordes (Technicolor)]

[JVET-N0658](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6408) Crosscheck of JVET-N0239: CE9-related: BDOF-BWA unification [J. Luo (InterDigital)] [late]

[JVET-N0262](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5983) CE9-related: Disable DMVR if BPWA is not using default weight [H. Huang, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-N0514](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6240) Crosscheck of JVET-N0262 (CE9-related: Disabling DMVR for non equal weight BPWA) [Y.-L. Hsiao (MediaTek)] [late]

[JVET-N0292](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6013) CE9-related: Reference sample access constraints at VPDU level for DMVR [S. Sethuraman (Ittiam)]

[JVET-N0294](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6015) CE9-related: Adaptive search pattern for DMVR [S. Sethuraman (Ittiam)]

[JVET-N0735](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6490) Crosscheck of JVET-N0294 (CE9-related: Adaptive search pattern for DMVR) [C.-C. Chen, W.-J. Chien (Qualcomm)] [late]

[JVET-N0295](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6016) CE9-related: Using extended samples during DMVR SAD cost evaluations [S. Sethuraman (Ittiam)]

[JVET-N0568](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6301) Crosscheck of JVET-N0295 (CE9-related: Using extended samples during DMVR SAD cost evaluations) [H. Lee, S. -C. Lim, J. Lee, J. Kang (ETRI)] [late]

[JVET-N0296](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6017) CE9-related: DMVR costs based early termination for BDOF in CE9-2.6 [S. Sethuraman (Ittiam)]

[JVET-N0708](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6462) Crosscheck of JVET-N0296 (CE9-related: DMVR costs based early termination for BDOF in CE9-2.6) [Y. Kato, K. Abe, T. Toma (Panasonic)] [late]

[JVET-N0312](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6033) CE9-related: A SIMD-friendly simplification for BDOF [S. Sethuraman (Ittiam)]

[JVET-N0711](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6465) Crosscheck of JVET-N0312 (CE9-related: A SIMD-friendly simplification for BDOF) [Y. Kato, K. Abe, T. Toma (Panasonic)] [late]

[JVET-N0314](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6035) CE9-related: Results for use of DMVR refined MVs from top and top-left CTUs for spatial MV prediction and CU boundary de-blocking [S. Sethuraman (Ittiam)]

[JVET-N0325](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6046) CE9-related: Improvements on bi-directional optical flow (BDOF) [X. Xiu, Y.-W. Chen, T.-C. Ma, X. Wang (Kwai Inc.)]

[JVET-N0328](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6049) Non-CE9: Mutually exclusive DMVR/BDOF at CU level [Y.-W. Chen, X. Xiu, T.-C. Ma, X. Wang (Kwai Inc.)]

[JVET-N0544](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6273) Crosscheck of JVET-N0328 (Non-CE9: Mutually exclusive DMVR/BDOF at CU level) [C.-Y. Chen (MediaTek)] [late]

[JVET-N0374](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6096) Non-CE9: On early termination for DMVR [H. Lee, S.-C. Lim, J. Lee, J. Kang, H. Y. Kim (ETRI)]

[JVET-N0740](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6495) Non-CE9: Cross-check of JVET-N0374 (Non-CE9: On early termination for DMVR) [S. Sethuraman (Ittiam)] [late]

[JVET-N0408](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6130) Non-CE9: Early Termination Techniques for DMVR [C.-C. Chen, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-N0771](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6526) Crosscheck of JVET-N0408 (Non-CE9: Early Termination Techniques for DMVR) [W. Chen (InterDigital)] [late]

[JVET-N0409](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6131) CE9-related: Horizontal and Vertical Boundary Padding Process of DMVR [C.-C. Chen, W.-J. Chien, M. Karczewicz (Qualcomm)]

[JVET-N0691](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6442) Crosscheck of JVET-N0409 (CE9-related: Horizontal and Vertical Boundary Padding Process of DMVR) [S. Esenlik (Huawei)] [late]

[JVET-N0440](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6162) CE9-related: Disabling DMVR and BDOF when underlying assumptions are false [H. Liu, L. Zhang, K. Zhang, J. Xu, W. Zhu, Y. Wang (Bytedance)]

[JVET-N0675](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6426) Crosscheck of JVET-N0440 (CE9-related: Disabling DMVR and BDOF when underlying assumptions are false) [R. Yu (Ericsson)] [late]

[JVET-N0442](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6164) Non-CE9: Conditions fix for DMVR and BDOF [N. Park, H. Jang, J. Nam, J. Lim, S. Kim (LGE)]

[JVET-N0553](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6282) Crosscheck of JVET-N0442 (Non-CE9: Conditions fix for DMVR and BDOF) [T. Chujoh, T. Ikai (Sharp)] [late]

[JVET-N0443](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6165) Non-CE9: BDOF processing considering assumption for the optical flow [N. Park, H. Jang, J. Nam, J. Lim, S. Kim (LGE)]

[JVET-N0589](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6323) Crosscheck of JVET-N0443 (Non-CE9: BDOF processing considering assumption for the optical flow) [?? (??)][late]

[JVET-N0444](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6166) Non-CE9: Mismatch beween test specification and reference software on BDOF and DMVR [N. Park, H. Jang, J. Nam, J. Lim, S. Kim (LGE)]

[JVET-N0484](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6206) Non-CE9: Simplification of DMVR and BDOF combination [R.-L. Liao, Y. Ye, J. Chen (Alibaba)]

[JVET-N0574](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6308) Crosscheck of JVET-N0484 (Non-CE9: Simplification of DMVR and BDOF combination) [Y.-W. Chen (Kwai Inc.)] [late]

[JVET-N0505](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6228) Non-CE9: Simplification of parametric motion vector refinement in DMVR [E. Sasaki, T. Zhou, T. Ikai (Sharp)] [late]

[JVET-N0748](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6503) Crosscheck of JVET-N0505 (Non-CE9: Simplification of parametric motion vector refinement in DMVR) [S. Iwamura (NHK)] [late]

[JVET-N0507](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6230) CE9-related: Early termination of BDOF with DMVR cost [K. Kondo, M. Ikeda (Sony)] [late]

[JVET-N0554](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6283) Crosscheck of JVET-N0507 (CE9-related: Early termination of BDOF with DMVR cost) [T. Chujoh, T. Ikai (Sharp)] [late]

[JVET-N0548](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6277) CE9-related: Additional experimental results of JVET-N0187 (CE9-2.2) [K. Kondo, M. Ikeda (Sony)] [late]

[JVET-N0757](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6512) CE9-related: combination of PROF for affine and BDOF-BWA [F. Galpin, T. Poirier (Technicolor), J. Luo, Y. He (InterDigital)] [late]

[JVET-N0868](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6623) Revised spec text for DMVR reconciling with software ticket 214 [S. Sethuraman (Ittiam)] [late]

TBP

## CE10 related – Combined intra/inter prediction (3)

Contributions in this category were discussed Tuesday 26 March 1430–XXXX (chaired by JRO).

[JVET-N0327](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6048) CE10-related: Simplification on combined inter and intra prediction (CIIP) [X. Xiu, Y.-W. Chen, T.-C. Ma, X. Wang (Kwai Inc.)]

In this contribution, two simplification methods are proposed to reduce the computational complexity of combined inter and intra prediction (CIIP) in the VVC working draft. In the first method, it is proposed to exclude decoder-side motion vector derivation (DMVR) and bi-directional optical flow (BDOF) when generating the inter prediction samples in the CIIP mode. In the second method, it is proposed to restrict the inter prediction of the CIIP mode to always be uni-prediction when generating the inter prediction samples. Compared to the VTM-4.0 anchors, the first method reportedly leads to {Y, U, V} BD-rate variations of {-0.01%, -0.02%, -0.05%} for RA configuration. The second method reportedly results in {Y. U, V} BD-rate variations of {-0.01%, -0.14%, -0.15%} and {-0.05%, 0.00%, -0.19%} for RA and LD configurations, respectively.

The gains of method 1 above were corrected to express the performance without some encoder bug fix.

Generally agreed that method 1 is a useful reduction in complexity. It is asked what would be the effect if only DMVR or only BDOF would be disabled, this is not known. It is noted that results from JVET-N0395 indicate that only disabling BDOF comes with no loss, and the same seems to be true for DMVR disabling from the current result.

As however during the discussion it turned out that there are some discrepancies in the reported results, and how much could be due to some encoder bug fixing, it is concluded to further study this in CE9, where other conditions on enabling/disabling DMVR and BDOF will be investigated.

[JVET-N0537](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6265) Crosscheck of JVET-N0327 (CE10-related: Simplification on combined inter and intra prediction (CIIP)) [L. Zhao (Tencent)] [late]

[JVET-N0395](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6117) CE10-related: Simplification and Improvement of combined intra-inter prediction mode [L. Zhao, X. Li, X. Zhao, S. Liu (Tencent)]

In this contribution, simplification and improvement for combined intra-inter prediction (CIIP) mode is proposed. Firstly, Bi-directional optical flow (BDOF) is disabled for CIIP mode to save decoder complexity. Secondly, a new mode, i.e., Inter-PDPC is added as an additional CIIP mode to improve the coding performance of CIIP. When CIIP mode is on, one flag, namely InterPdpc flag, is further signaled to indicate whether to use the newly added mode or not. When InterPdpc flag is true, PDPC filtering process is directly applied to the inter prediction samples indicated by merge index. It is reported that the first proposed method obtains 0.00% luma BD-rates for RA configuration with 101% and 100% encoding and decoding time. The combination of the first and second method obtain 0.11% and 0.28% coding gain for the RA and LDB configurations with 102% and 101% encoding time, and 101% and 101% decoding time respectively.

One aspect (removal of BDOF) is simplification (disabling BDOF, same as one aspect of JVET-N0327) This comes at no loss.

The other aspect adds PDPC to the CIIP process for the benefit of compression performance. It is via a flag either applied to intra prediction or to inter prediction. Currently, PDPC is always applied, now it would become switchable. It may depend on the implementation, if planar and PDPC pipelines are closely coupled. If yes, it would have the consequence that special PDPC logic would need to be implemented for the inter case.

Some concern is expressed that CIIP is already quite challenging for the hardware implementation in terms of pipelining, and more study is needed about possible problems when more switching options and possible additional logic is required. Proponents are requested to make a more detailed analysis about the pipelining aspects, an also about the possible amount of additional logic in case that the second PDPC would need to be operated in a different pipeline for inter prediction. Furthermore, it should be investigated how the method would perform together with the adoption of CE10-1.1.

There is no need to run a CE on this, if the analysis above is convincing, this method of aspect 2 could be adopted also as a non-CE proposal at the next meeting.

[JVET-N0579](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6313) Cross-check of JVET-N0395: CE10-related: Simplification and Improvement of combined intra-inter prediction mode [X. Xiu (Kwai Inc.)] [late]

[JVET-N0508](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6233) CE10-related: A combination of JVET-N0302 (CE10-1.1) and JVET-N0327 [L. Pham Van, G. Van der Auwera, A. K. Ramasubramonian, V. Seregin, M. Karczewicz (Qualcomm), X. Xiu, Y.-W. Chen, T.-C. Ma, X. Wang (Kwai Inc.)] [late]

In this contribution reports the results of the combination test of CE10-1.1 and JVET-N0327 on simplification for the combined inter and intra prediction (CIIP). In CE10-1.1, the number of intra modes allowed in CIIP is reduced from 4 to only 1, i.e., planar mode. In addition, an adaptive position-independent weight scheme based on the number of intra-coded neighbouring blocks is used. Test 1 of JVET-N0327 proposes to exclude decoder-side motion vector derivation (DMVR) and bi-directional optical flow (BDOF) when generating the inter prediction samples in the CIIP mode. Test 2 of JVET-N0327 proposes to restrict the inter prediction of the CIIP mode to always be uni-prediction when generating the inter prediction samples. The combination tests reportedly lead to {Y, U, V} BD-rate variations compared to VTM4.0 as follows:

* CE10-1.1+Test1: {-0.12%, -0.10%, -0.13%} and {-0.08%, 0.06%%, -0.19%} in RA and LDB, respectively.
* CE10-1.1+Test2: {-0.04% %, -0.11%, -0.13%} and {-0.06%, 0.09%, -0.22%} in RA and LDB, respectively.

Performance of JVET-N0327 on top of the CE10 adopted technology still has some additional gain, and simplifies.

It is however observed that better performance is also achieved in LDB configuration, which should not be the case as neither BDOF nor DMVR would be used there. The proponents report that additional gain is achieved by an encoder bug fix. Therefore, the results are not conclusive

[JVET-N0803](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6558) Crosscheck of JVET-N0508 : CE10-related: A combination of JVET-N0302 (CE10.1.1) and JVET-N0327 [A. Konda, C. Pujara (Samsung)] [late]

[JVET-N0825](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6580) Cross check of CE10-related: A combination of JVET-N0302 (CE10.1.1) and JVET-N0327 (JVET-N0508) [S. Jeong, K. Choi (Samsung)] [late]

[JVET-N0845](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6600) Crosscheck of JVET-N0508 (CE10-related: A combination of JVET-N0302 (CE10.1.1) and JVET-N0327) [T.-S. Chang (Alibaba)] [late]

## CE11 related – Deblocking (3)

Contributions in this category were discussed 0y 22 March 2115–2215 (Track A chaired by JRO).

[JVET-N0182](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5902) CE11-related: Simplification of sub-pu deblocking and longer tap filter [A. M. Kotra, S. Esenlik, J. Chen, B. Wang, H. Gao (Huawei)]

This contribution proposes two simplifications to the existing deblocking filter design in VTM-4.0. The first simplification suggests to not apply longer tap filter for any of the implicit transform unit edges. The second simplification proposes to disable deblocking of the first and last sub-pu edges aligning on the 8 x 8 sample grid for a given coding unit which use sub-pu tools like Affine, ATMVP or CIIP tools. These two simplifications reportedly result in reduced number of conditional checks in the deblocking filter design.

Objective results are as follows

Over VTM-4.0 Anchor with ALF ON (AI, RA, LDB, LDP): Luma BD-Rate of 0.00%, 0.03%, 0.05%, 0.01% is reported with no change in EncT and DecT

Internal subjective evaluation reportedly shows no visual degradation when compared to VTM-4.0

Further study in CE.

[JVET-N0619](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6361) Crosscheck of JVET-N0182 (CE11-related: Simplification of sub-pu deblocking and longer tap filter) [C.-M. Tsai (MediaTek)] [late]

[JVET-N0359](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6080) CE11-related: On MV threshold for deblocking [K. Andersson, J. Enhorn (Ericsson)]

This contribution proposes the use of a sub-sample MV component difference threshold for determination of boundary strength in deblocking instead of the luma sample threshold currently used in VVC. The motivation is too avoid passing block artifacts without deblocking. The modification is on top of fixing deblocking of SBT boundaries which not are filtered in VTM-4.0. The proposal gives a benefit in subjective video quality.

Not clear why the modified threshold would be necessary in VVC.

The proposal shows some objective loss (0.13% in RA), which should be justified by improving the subjective quality. Study in CE, also with other values such as ½ instead of ¼ sample.

[JVET-N0473](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6195) Non-CE11: On ISP transform boundary deblocking [K. Misra, A. Segall (Sharp Labs of America), M. Ikeda, T. Suzuki (Sony)]

In the VTM software and VVC WD, transform boundaries inside an intra sub partition (ISP) luma coding block do not undergo deblocking while transform boundaries resulting from an equivalent BT partitioning do undergo deblocking. It is asserted to be desirable that the deblocking of ISP partitioning and regular binary tree (BT) partitioning be consistent. This contribution proposes that transform boundaries inside an ISP luma coding block aligned with the 8x8 deblocking grid should also undergo deblocking.

In revision 1 of the document objective results and md5sums of decoded YUVs are reported.

The BD-Rate number for Y/U/V reportedly shows 0.0%/0.0%/0.0% at AI, 0.0%/-0.1%/-0.1% at RA, 0.0%/0.1% /-0.1% at LDB and 0.0%/0.0%/-0.2% at LDP over VTM-4.0 with ALF switched on, respectively. When ALF is switched off, the BD-Rate results for Y/U/V reportedly shows 0.0%/0.0%/0.0% at AI, 0.0%/0.0%/0.0% at RA, 0.0%/-0.1%/-0.4% at LDB and 0.0%/0.0%/-0.2% at LDP, respectively.

General agreement: Subblock transform and ISP boundaries should be treated like other transform boundaries in deblocking, as long as they are on an 8x8 grid. This complements the alreading existing practice that subblock MC boundaries and handled like other PUs as long as they are on an 8x8 grid.

As currently K. Andersson is still working on text integration of long tap deblocking filters and that needs some coordination about what counts as a block size where this should be applied, this clarification is important. Even though it was decided in the last meeting that ISP boundaries are not to be deblocked (at least it was not in the proposal), and the decision to deblock subblock transform boundaries was somewhat vague, this should now be corrected. K. Anderson and K. Misra should work offline and coordinate with B. Bross towards a text specification. For software, it should be checked if some pieces of CE11-2.1 can be reconfigured such that ISP and SBT boundaries are deblocked on an 8x8 grid.

Decision(BF): Adopt JVET-N0473. Also include the deblocking of SBT boundaries in that bug fix (which is one of the aspects in the software and specification text of JVET-N0098, whereas the other aspects of that are not adopted). The SBT and ISP deblocking shall only be done on an 8x8 grid.

It is reported that a text for the long deblocking filters which already includes the bug fix on also deblocking ISP and SBT boundaries has been sent to the editor and is waiting for integration in draft 5. That text which reflect the decision above should be made available in an updated version of JVET-N0473.

[JVET-N0848](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6603) Cross-check of JVET-N0473 (Non-CE11: On ISP transform boundary deblocking) [S. De-Luxán-Hernández (HHI)] [late]

## CE12 related – Tile set boundary motion compensation handling (3)

No CE was planned for the contributions in this area; see the notes for CE12 in section 5.12.

[JVET-N0355](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6076) CE12-related: Normative temporally independent tile group coding [R. Skupin, Y. Sanchez, V. George, K. Sühring, T. Schierl (HHI)]

This was discussed Thursday 21 March at 1115 in track B (GJS).

This document proposes normative changes to allow temporally independent coding of tile groups in a coded video. The proposed changes include that when MVs point to disallowed sample positions near or beyond the boundaries of temporally independent tile groups, the following is carried out:

* MV clipping
* MV sub-pel component rounding
* Sub-block division
* MV predictor clipping and/or rounding for AMVP
* Disabling BDOF and DMVR next to boundaries of temporally independent tile groups
* TMVP and ATMVP handle boundaries of temporally independent tile groups similar to picture boundaries.

The document also reports coding results of the proposed scheme following the test conditions used in CE12.

Revision 1 of the document includes corrected results for the proposal and a correct the CE12 anchor (i.e. with BDOF enabled).

Revision 2 of the document includes updates for the test results.

Coding efficiency penalty relative to the CE12 anchor.

6x4 Tiles, RA

|  |  |  |  |
| --- | --- | --- | --- |
| **Test sequence** | **Y-PSNR** | **U-PSNR** | **V-PSNR** |
| Chairlift | 5.67% | 6.91% | 6.37% |
| GasLamp | 2.62% | 1.95% | 2.48% |
| Harbor | 1.52% | 1.70% | 0.79% |
| KiteFlite | 1.01% | 1.63% | 1.57% |
| SkateboardInLot | 8.68% | 10.95% | 12.13% |
| Trolley | 0.85% | 1.00% | 1.42% |
| **Average** | 3.39% | 4.03% | 4.13% |

12x8 Tiles, RA

|  |  |  |  |
| --- | --- | --- | --- |
| **Test sequence** | **Y-PSNR** | **U-PSNR** | **V-PSNR** |
| Chairlift | 19.26% | 23.17% | 21.44% |
| GasLamp | 11.11% | 10.98% | 11.41% |
| Harbor | 8.33% | 9.13% | 8.72% |
| KiteFlite | 3.83% | 5.11% | 5.07% |
| SkateboardInLot | 20.68% | 26.13% | 29.48% |
| Trolley | 4.40% | 5.12% | 5.93% |
| **Average** | 11.27% | 13.27% | 13.68% |

This proposal does not use boundary padding.

This approach is an alternative to method 1 of CE12 in the sense that it introduces normative decoder modifications but does not use padding. The coding efficiency of this approach is not as good as the padding approach of method 1 of CE12.

It was commented that it would be desirable from an implementation perspective for the edges of the picture to be handled the same way as the boundaries of tiles. However, this would degrade the RD performance of non-tiled picture coding.

If method 1 of CE12 is adopted, this approach would not need to be considered.

[JVET-N0402](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6124) CE12-related: MCTS improvement by modifying motion compensation filter coefficients [A. Aminlou, A. Zare, M. M. Hannuksela (Nokia)]

This was discussed Thursday 21 March at 1140 in track B (GJS).

This was discussed together with JVET-N0403.

Motion constrained tile set technique, as an encoder side method, restricts selection of motion vectors and merge modes in a way that no sample is used outside the current tile in motion compensation process of each block. According to JVET-M0445, this imposes 10.49% Y BD-Rate loss for 49 frames using the 360° CTC sequences with CMP projection format and a 6x4 uniform tile grid, i.e. 2x2 tiles per cube face. Instead of encoder side motion vector constraints of MCTS, this document proposes modifying motion compensation filter coefficients according to the position of the current tile, block, and length of motion vector to improve RD performance of the MCTS-coded video. For each block, based on the number of samples needed from other tiles, some of the coefficients of the motion compensation filter are changed to zero, and their original values are added to the first coefficient next to those coefficients. This removes the effect of those samples in the other tiles in derivation of the samples of the prediction block.

This technique is for when only some samples of the interpolation filter go outside the tile.

Only 17-frame estimated results were provided. The penalty relative to the CE12 anchor was estimated as 3% for 24 tiles and 6% for 96 tiles RA.

The proponent said that a combination with JVET-N0403 (based on how far outside the tile is reached by the MV) would also be interesting to study.

This approach and that of JVET-N0403 (or their combination) are alternatives to method 1 of CE12 in the sense that they introduce normative decoder modifications but do not use reference padding at tile boundaries. In terms of RD performance, these approaches seem unlikely to work as well as boundary padding (i.e., method 1 of CE12). For hardware it was commented that these would involve more substantial implementation work than the CE method 1 approach. For software, it would also probably also not be especially difficult to implement the CE method 1 approach, and this method would appear to at least touch more places in the implementation.

[JVET-N0403](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6125) CE12-related: MCTS improvement by modifying prediction block [A. Aminlou, A. Zare, M. M. Hannuksela (Nokia)]

This was discussed together with JVET-N0402.

Motion constrained tile set technique, as an encoder side method, restricts selection of motion vectors and merge modes in a way that no sample is used outside the current tile in motion compensation process of each block. According to JVET-M0445, this imposes 10.49% YBD-Rate loss for 49 frames using the 360° CTC sequences with CMP projection format and a 6x4 uniform tile grid, i.e. 2x2 tiles per cube face. Instead of encoder side motion vector constraints of MCTS, this document proposes modifying prediction block according to the position of the current tile, block, and length of motion vector to improve RD performance of the MCTS coded video. For each block, the samples of the prediction block which are affected by samples from the other tiles are replaced with other samples of that prediction block. This removes the effect of samples in the other tiles in derivation of the samples of the prediction block.

This technique involves changing the prediction block rather than the reference block and was suggested to be simpler to implement than tile boundary padding (but probably not as good in RD terms).

Only 17-frame estimated results were provided. The penalty relative to the CE12 anchor was estimated as 3% for 24 tiles and 6% for 96 tiles RA.

See also the notes for JVET-N0402.

## CE13 related – Neural-network based loop filtering (2)

Contributions in this category were discussed XXday XX March XXXX–XXXX (chaired by XXXqq).

[JVET-N0133](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5853) CE13-related: In-loop filter with only CNN-based filter [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-N0712](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6466) CE13-related: Adaptive CNN based in-loop filtering with boundary weights [K. Kawamura, Y. Kidani, S. Naito (KDDI)] [late]

## Quantization (3)

Contributions in this category were discussed Thursday 21 March 1945–2030 and … (Track A chaired by JRO).

[JVET-N0221](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5941) Chroma Quantization Parameter Qpc Table for HDR Signal [T. Lu, F. Pu, P. Yin, S. McCarthy, W. Husak, T. Chen (Dolby)]

This contribution proposes that a chroma quantization parameter QpC table for HDR content be added to VVC to complement the existing chroma quantization parameter QpC table for SDR content. The values in the proposed HDR Qpc table are derived from subjective comparison to HDR CTC Anchor.

It is asked if something similar could be done in a non-normative way, e.g. using chroma QP offset. There is however the case where QP varies over a picture and this cannot be handled by a constant offset.

It is however not clear if the table suggested here is optimum, in particular as this requires subjective judgement, and there has been no HDR equipment for several meeting cycles.

It is suggested to consider if it might be possible to signal such a table at some higher level. We are not even sure if the SDR table is optimum for today’s SDR.

To be further studied along with the existing SDR table in the AHGs on quantization (18) and HDR (7).

[JVET-N0793](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6548) Crosscheck of JVET-N0221 (Chroma Quantization Parameter Qpc Table for HDR Signal) [F. Hiron, C. Chevance (Technicolor)] [late]

[JVET-N0246](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5966) Modified dequantization scaling [K. Sharman, S. Keating (Sony)]

In VVC WD4, when the size of a transform block is not a power of 4, the transform coefficients are modified by a √2 factor, to compensate for an implicit scaling by the transform process.

It is proposed that the scaling be applied by a modification to the QP or QP levelScale table rather than by multiplication by 181/256 (or 181/128).

The proposal reportedly produces negligible BD-rate changes. It is a continuation of JVET-M0119, and is independent, but related to JVET-L0095.

Initial presentation Thu 21 evening, discussion continued Fri 22 11:30

Intent is simplification relative to the current method

6 different methods are proposed.

In the discussion, a certain preference is expressed to use either one of the solutions with 2 tables (methods 3/4, or (which is almost equivalent) to implement those as /2 or x2 (methods 5/6).

All differences in terms of performance are irrelevant. It is agreed to adopt method 6.

Decision: Adopt JVET-N0246, method 6.

## Entropy coding (9)

Contributions in this category were discussed Friday 22 March 1150-1350 (Track A chaired by JRO).

[JVET-N0112](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5832) Simplification of context modeling for coding CU split decisions [S.-T. Hsiang, S.-M. Lei (MediaTek)]

This contribution proposes the simplified context modeling schemes for entropy coding the syntax elements split\_cu\_flag, mtt\_split\_cu\_vertical\_flag and mtt\_split\_cu\_binary\_flag. The proposed method reportedly simplifies the process for deriving the selected context index while reducing the number of the context variables by 5. The luma BD bitrate results under the JVET CTCs are summarized below.

split\_cu\_flag: -0.01%, -0.01%, and -0.04% for the AI, RA, and LB settings, respectively  
mtt\_split\_cu\_vertical\_flag: 0.02%, 0.02%, and 0.02% for the AI, RA, and LB settings, respectively, and  
mtt\_split\_cu\_binary\_flag: 0.01%, 0.01%, and 0.01% for the AI, RA, and LB settings, respectively.

Targets reduction of context models by 5 in total

JVET-N0696 is related to the first aspect, which saves 2.

From the discussion: There are two aspects in reducing number of context models. One is the saving of memory (which may not be too important), the other is the potential complexity of the derivation. In the latter context, it is also important to consider if the same checks for determining are anyway necessary for other elements, such that they can be reduced.

Benefit not too obvious. It is also commented that many small losses in such aspects might sum uo to higher losses. No need for action

[JVET-N0523](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6249) Crosscheck of JVET-N0112 [P. Bordes, Y. Chen (Technicolor)] [late]

[JVET-N0689](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6440) Cross-check of JVET-N0112 (test 2 and 3) [J. Li, C.-W. Kuo, C. S.Lim (Panasonic)] [late]

[JVET-N0207](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5927) AHG14: CABAC skip mode [K. Abe, T. Toma (Panasonic)]

This contribution is a follow-up contribution to JVET-M0089 presented during the January 2019 meeting in Marrakech. Because CABAC throughput depends on the number of binarized bins and it is 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 be more significant for the use case of high bitrate with low performance hardware. This contribution proposes to introduce CABAC skip mode which directly outputs binarized bins as a bitstream without CABAC processing. This mode decreases the coding efficiency, but it can avoid CABAC throughput issue with very simple scheme. Simulation results reportedly show that the proposed mode can guarantee the fixed processing delay with the cost of 25%, 27%, and 31% bits increasing for AI, RA, and LDB on VTM-4.0.

The motivation of this contribution is to enable high throughput applications, where CABAC would be disabled for an entire stream. Part of the intent is doing it for the benefit of decoders in potential closed domains, where however the decoders could not claim to be conformant with VVC (unless VVC would define such a profile).

Technically simple, would require a high-level flag to disable the arithmetic coding engine.

Not intended for benefit of encoder.

Question was raised: Would we build mechanisms into VVC which are intended to implement non-conformant decoders?

(see further discussion in plenary Sunday)

[JVET-N0666](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6417) Crosscheck of JVET-N0207 (AHG14: CABAC skip mode) [C. Rosewarne (Canon)] [late]

[JVET-N0301](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6022) Simplification of the initialization process for context variables [H. Kirchhoffer, J. Stegemann, D. Marpe, H. Schwarz, T. Wiegand (HHI)]

This proposal introduces a simplification to the initialization process for context variables so that a 128x14 bit lookup table in the current VVC draft 4 can be removed. Furthermore, the number of bits per context model initialization value is reduced from 8 to 6. Experimental results show a BD rate of -0.01% for AI, 0.0% for RA, and -0.03% for LB for the proposed method.

In the previous meeting, a new CABAC engine with linear model for probability estimation was introduced, However, for initialization, the previous method of interpreting the initailization values was kept by introducing a LUT which translates the previous logarithmic meaning into the linear meaning. It is suggested to remove the LUT and make a more straightforward direct initialization, which also allows to use only 6 instead of 8 bit initialization values.

JVET-N0381 and JVET-N0425 have the same intent, but somewhat different solutions.

[JVET-N0697](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6449) Crosscheck of JVET-N0301 (Simplification of the initialization process for context variables) [J. Dong (Qualcomm)] [late]

[JVET-N0746](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6501) Crosscheck of JVET-N0301 and JVET-N0425 (CABAC initialization) [F. Bossen (Sharp)] [late]

[JVET-N0311](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6032) Context Modeling Simplification and Reduction in VVC [Y. Chen, F. Le Léannec, T. Poirier (Technicolor)]

This contribution proposes to simplify the context modelling and reduces the number of contexts for CABAC in VVC. In this contribution, the CABAC context modelling for the regular coded bins *sig\_coeff\_flag*, *par\_level\_flag*, *abs\_level\_gt1\_flag*, *abs\_level\_gt3\_flag*, *last\_sig\_coeff\_x\_prefix* and *last\_sig\_coeff\_y\_prefix* are investigated. With 24, 54, 66 and maximum 76 contexts reduction, the BD-Rate increase is reported as -0.01%, 0.01%, 0.03% and 0.06% for RA, respectively.

It is commented that except for method 1, the other methods are reducing the number of contexts, but may have more complicated context derivation. This may not be beneficial (see notes under JVET-N0112). Method 1 gives gain in luma, but some loss 0.15% in chroma (as it is touching the chroma contexts).

Benefit/tradeoff is not obvious. No need for action.

It is also mentioned that encoder runtime increases, but that may be due to measurement errors.

[JVET-N0772](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6527) Cross-check of JVET-N0311 and JVET-N0600: Context Modeling Simplification and Reduction in VVC [M. Coban (Qualcomm)] [late]

[JVET-N0381](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6103) Native CABAC initialization [F. Bossen (Sharp)]

A new arithmetic coding engine was adopted at the 13th JVET meeting. To derive the initial state for each context, a state variable is first computed according to the same rules used for the AVC and HEVC engines. This state variable is then mapped to reflect the state representation of the new engine. It is proposed to have a “native” initialization process that doesn’t require such mapping.

Here, the meaning of initialization values is more close to the old logarithmic approach, but the LUT mapping is replaced by arithmetic operations.

It is noted that the three proposals cannot be judged by results, as the training algorithms are soemwhat different.

[JVET-N0698](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6450) Crosscheck of JVET-N0381 (Native CABAC initialization) [J. Dong (Qualcomm)] [late]

[JVET-N0714](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6468) Crosscheck of JVET-N0381 (Native CABAC initialization) [H. Kirchhoffer (HHI)] [late]

[JVET-N0425](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6147) Simplification of CABAC initialization process [J. Dong, A. Said, V. Seregin, M. Karczewicz (Qualcomm)]

This contribution proposes a simplified CABAC initialization process, where the initial probability states represent the probability in the linear domain and can be used for the arithmetic coding engine directly. The proposed simplification saves a logarithmic to linear domain mapping process using a 256-byte look-up table, while achieves BD-rate reduction -0.01% AI, -0.02% RA, -0.01% LDB, and 0.01% LDP.

Investigate JVET-N0301, JVET-N0381, and JVET-N0425 in a CE. This should also include extended QP ranges beyond CTC, and use a common training algorithm. If the CE does not find problems with any of the methods in terms of results, the decision may be finally based on simplicity. Run time of training should also be reported. The common algorithm should be cross-checked and be made available after the CE.

[JVET-N0715](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6469) Crosscheck of JVET-N0425 (Simplification of CABAC initialization process) [H. Kirchhoffer (HHI)] [late]

[JVET-N0600](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6340) Context reduction for inter and split syntax elements [Y. Chen, F. Le Léannec, T. Poirier (Technicolor)] [late]

This contribution proposes to simplify the context modelling and reduces the number of contexts for CABAC in VVC. In this contribution, the CABAC context modelling for the regular coded bins *affine\_flag*, *amvr\_flag,* *triangle\_flag* and *qt\_split\_cu\_flag* are investigated. With 3, 4, 7 and maximum 83 contexts reduction, the BD-Rate increase is reported as XX%, XX%, XX% and 0.08% for RA, respectively.

Initial version placeholder?

Presentation deck not available in most recent version. The presentation shown has more results than the word document

If at all, method 2 may have some advantage, but results were not complete yet when first presented. Crosscheck in JVET-N0772. Was reviewed again after results are complete.

From the results, it is obvious that the two flags do not need context coding depending on neighbors.

Decision(cleanup): Adopt JVET-N0600 method 2

[JVET-N0696](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6448) Availability based context modelling for mtt\_split\_cu\_vertical\_flag [A. Wieckowski, T. Nguyen, H. Schwarz, D. Marpe, T. Wiegand (HHI)] [late]

The contribution JVET-N0112 proposes a simplification of the context modelling for the mtt\_split\_cu\_vertical\_flag syntax element. The proposed approach reduces the number of context models from five to three. This contribution proposes an alternative context model reduction approach. The authors assert that the proposed method presented in this document is simpler, while showing similar performance.

Targets reduction of context models by 2

The method is based on checking availability rather than using width and height of neighboring blocks in the context, where however the availability check still needs to check width and height of the current block.

See further notes under related proposal JVET-N0112. No need for action.

## Luma mapping with chroma scaling (9)

Contributions in this category were discussed Saturday 23 March 0900–1230 (Track A chaired by JRO).

[JVET-N0113](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5833) AHG16: Subblock-based chroma residual scaling [Z.-Y. Lin, T.-D. Chuang, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)] [late]

In VTM4.0, reconstruction of a chroma transform block (TB) has to be delayed until luma prediction of the corresponding luma TB is totally done when enabling chroma residual scaling. This contribution presents two methods to reduce the delay. In Method 1, subblock-based chroma residual scaling is applied. Each chroma TB is first converted into one or multiple M×N chroma subblocks, where M<=8 and N<=8 (M<8 when chroma TB width < 8; N<8 when chroma TB height < 8). The chroma residual inverse scale value of each chroma subblock is derived from the corresponding luma subblock. The delay of chroma reconstruction is reduced to the processing time of generating prediction samples for one luma subblock instead of one luma TB. In Method 2, the proposed subblock-based chroma residual scaling in Method 1 is further simplified. Instead of calculating the chroma residual inverse scale value for each M×N chroma subblock, one luma region of up to 256 luma samples corresponding to the chroma TB is used to derive one chroma residual inverse scale value, which is shared by the entire chroma TB. It is reported that Method 1 achieves 0.00%/0.03%/0.04% and 0.01%/0.25%/0.11% Y/Cb/Cr BD-rates with negligible encoding and decoding time changes for VTM4.0-RA and VTM4.0-LB, respectively. In Method 2, 0.01%/-0.02%/-0.01% and -0.01%/0.08%/-0.19% Y/Cb/Cr BD-rates are achieved with negligible encoding and decoding time changes for VTM4.0-RA and VTM4.0-LB, respectively.

The current design of LMCS requires to compute the scaling factor from the average of the prediction corresponding to the area of the whole luma TB before the chroma scaling can be performed. This can cause a pipeline delay of 64x64 samples. It is suggested to compute scaling factors from averages at 16x16 subblock levels instead, regardless of transform block size.

Method 2 uses only average from top left 16x16 block for whole 64x64 block.

JVET-N0220 and N0477 target similar issue.

Study as a possible solution to the latency problem in CE.

[JVET-N0755](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6510) Crosscheck of JVET-N0113 (AHG16: Subblock-based chroma residual scaling) [J. Lee, S.-C. Lim, H. Lee, J. Kang (ETRI)] [late]

[JVET-N0220](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5940) Simplification of Reshaper Implementation [T. Lu, F. Pu, P. Yin, S. McCarthy, W. Husak, T. Chen (Dolby)]

This contribution presents four normative changes to simplify VTM4 LMCS implementation:

* reduction of the pipeline delay for computing average luma for chroma residue scaling;
* reduction of the size of the local buffer needed to store chroma residue samples;
* unification of the fixed-point precision used in luma mapping and chroma residue scaling;
* unification of the method of calculating chroma residue scale with the method of calculating the luma inverse scale, and removal of the pre-computed LUT.

The combined simplification test results for SDR CTC over the VTM4.0 anchor are {BDRate for Y, U, V}:

* AI: 0.00%, 0.00%, 0.00%;
* RA: 0.01%, -0.05%, -0.01%;
* LDB: 0.01%, -0.09%, -0.42%;
* LDP: -0.01%, -0.19%, -0.07%.

The encoding and decoding times are found to be similar to VTM4.0.

This contribution also presents some non-CTC results for three non-normative topics:

* results for a VTM non-normative modification to enable support of InternalBitDepth other than 10;
* results for a test for interactions between LMCS and local QP adjustment. The test results indicate that LMCS and local QP adjustment are independent and the respective coding gains are additive. Test results for RA Class B/C/D/F are {average BDRate for Y,U,V}:
  + local QP only: -0.48%, -0.91%, -0.96%;
  + LMCS only: -1.48%, 2.85%, 2.85%;
  + both: -1.94%, 1.76%, 1.85%;
  + diff (c – (a + b)): 0.02%, -0.18%, -0.04%;
* test results for SCC TGM test sequences, (average BDRate for Y,U,V)
  + AI: -1.36%, 0.00%, 0.23%;
  + RA: -1.44%, -0.15%, 0.09%;
  + LDB: -1.67%, -0.10%, -0.19%;
  + LDP: -2.12%, -0.40%, -041%.

Aspect 1 is targeting the same issue as JVET-N0113, but is even simpler because it does not use an average but just the to left luma sample. Some experts say that this may be a questionable for certain type of content.

Study this aspect as a possible solution to the latency problem in CE.

Aspect 2 reduces the local buffer by 2.5 Kbyte by clipping right after inverse transform, i.e. the clipped values are used for scaling. This does not have any impact on performance. By the time when CS was adopted it was not clear that the local buffer size would increase. This is an obvious that should be adopted as cleanup.

Aspect 3 reduces the fixed-point precision of luma scaling from 14 to 11 bit (in total 3+11 bit, as scaling is a floating point representation), same as chroma now. Looks as a reasonable cleanup which could be adopted.

Aspect 4 proposes to replace the current expression of chroma scaling by a LUT through a computation formula doing piecewise linear mapping. This has a small deviation in results. However, if it is confrmed that the algorithm reproduces more or less the same values as the current LUT, this should be adopted as a reasonable cleanup (D. Rusanovskyy later confirmed in Tuesday morning Track A session that this is the case)

Another part of the contribution shows that LMCS would also work with other bit depth, and with local QP adjustment. There is some loss in chroma for RA, which is asserted to the fact that chroma scaling currently is disabled in case of dual tree.

LMCS and the current luma dQP of HDR CTC should not be used together, as they are not aligned with each other. Currently, LMCS shall be disabled in HDR CTC, unless there would be a proof that it povides better visual quality standalone than the luma dQP optimization.

Decision(cleanup): Adopt JVET-N0220 aspects 2,3, and 4

After some discussion in the Sunday plenary discussion, the method of clipping was further discussed in Track A Tuesday morning. New results in v3 of the document with the “special clipping” disabled indicated that a loss of 0.25% was observed in class D and 0.15% in class B. Loss is 0.07% on average in RA.

The “special clipping” is a processing that performs clipping into a range of 16 to 235 (scaled by bitdepth) whenever the first and last segment of the piecewise linear mapping don’t have any codewords, which could indicate that the original sequence was clipped to that range (effectively, only one end would be clipped)

It is also noted that JEM had an element where it was expicitly signalled which was the lowest and highest value of a dgiven picture, and then performed clipping to that range at the output. The BD rate benefit of that method was higher, but it was not transferred to VVC, as that was asserted to be dangerous as it might have interference with other tools).

It is generally agreed that it would be cleaner to not execute that specific clipping.

Decision(cleanup): Remove the special case in the clipping stage from LMCS (see powerpoint deck in v3, page 27)

[JVET-N0526](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6253) Crosscheck of JVET-N0220 (Simplification of Reshaper Implementation) [C. Chevance (Technicolor)] [late]

[JVET-N0274](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5995) Non-CE: Cleanups on in-loop reshaping [K. Zhang (Bytedance)]

In this contribution, three cleanups are proposed to address the syntax design of in-loop reshaping. First, the reshaping mapping is initialized to be an identity mapping when no reshaping information is presented for an I tile group. Second, the reshaping information is inherited from a reference picture which is signaled when no reshaping information is presented for a P/B tile group. Third, two constrains on syntax elements related to in-loop reshaping is proposed for conforming bit-stream. Simulation results reportedly show 0.00%, 0.01%, 0.03% BD-rate changing under AI, RA and LB configurations, respectively, with almost no impact on encoding and decoding time.

The first problem would be resolved if it is specified that at least one APS shall be present if LMCS is enabled. It is up to an encoder to fill reasonable values.

The second problem is resolved by the fact that the same APS can be used by differet tile groups.

The third problem is resolved by the las version of the draft.

It is suggested during the discussion that it might be beneficial in the decoder software if the mapping table would be initialized by an identity mapping rather than zero. This would however not have any impact in case of conformant bitstreams.

[JVET-N0612](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6353) Crosscheck of JVET-N0274 (Non-CE: Cleanups on in-loop reshaping) [T. Lu (Dolby)] [late]

[JVET-N0299](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6020) On Luma Dependent Chroma Residual Scaling of In-loop Reshaper [J. Zhao, S. Kim (LGE)]

In the reshaping tool of VTM4, Chroma residual scale factor is calculated from the average of luma block in reshaped domain. Specifically, the scale factor is found by the following three steps.

1. Calculate average luma value of a block in reshaped domain. If inter block, the block is mapped to reshaped domain first.
2. Find index (idxS) where the average luma value belongs to in inverse PWL mapping. This requires an iterative operation (a for loop).
3. Find scale factor from the index

In method 1 of this contribution, it is proposed to switch the order of mapping and averaging in step 1. In this way, it only needs to perform mapping on one average value instead of a block. This reduces the number of mapping operations.

In method 2 of this contribution, it is proposed to calculate the residual scaling factor using luma value in original domain. This eliminates the iterative operation to find the piece index (idxS) in step 2. idxS can now be found by simply shifting the average luma value. There is at most one extra mapping operation which can be done by a LUT, while it eliminates the iterative for loop during piece index identification.

It is asserted that proposed methods simplify the process to obtain Chroma residual scaling factor. Results show that there is no loss of performance. Method 1 and method 2 have near identical results. Their results are both are: 0.00%, -0.04%, 0.00% for Y, U, V in RA case, and -0.02%, 0.14%, 0.01% for Y, U,V respectively in LD case.

In this revision, supplemental results of combineing proposed method 2 and simplification 1 of JVET-N0220 is provided. In this test, it uses the top left luma value in original domain to derive the chroma residual scaling factor. It has benefit of both approaches. Result is 0.00%, -0.04%, -0.06% for Y, U, V in RA case, and -0.03%, 0.14%, -0.06% for Y, U,V respectively in LD case. The results are very close to JVET-N0220 simplification 1 result.

Method 1: Computing the average in the reshaped domain would not help with the latency problem. Furthermore, if the averaging would be reduced as per the planned CE, in particular with only one sample, there is no difference any more.

Method 2: This was the original method of JVET-N0427, but the current was designed by request of hardware implementers.

No action necessary.

[JVET-N0649](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6399) Crosscheck of JVET-N0299 (On Luma Dependent Chroma Residual Scaling of In-loop Reshaper) [G. Li (Tencent)] [late]

[JVET-N0300](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6021) On High Bit Depth Signaling of In-loop Reshaper [J. Zhao, S. Kim (LGE)]

In luma mapping with chroma scaling (so-called reshaper), the absolute reshaper delta code word values are signaled for every piece-wise linear (PWL) piece. Considering that the absolute reshaper delta code word values depend on internal coding bit-depth, a generalized reshaping code word signalling method depending on coding bit-depth is proposed. The proposed method can reduce number of bits for signalling reshaper at high internal bit-depth where the absolute reshaper delta code word values are just scaled by 2^(internal\_bit\_depth - 10).

This change has no impact on CTC test condition. For coding with 12-bit internal bit depth, it has no change on PSNR while can save bits to signal reshaper. In terms of BD rate, there are a small gain of -0.01% in AI case, 0.0% and 0.0% for RA and LD cases.

The current LMCS is already supporting higher bit depth, but the parameters for that case would require more rate. The proposal suggests that rather the scaling values should be bit-shifted according to the internal bit depth. As however the test was performed with native 10-bit content, the results may not be conclusive, as native 12-bit content would likely have other characteristics, where higher precision of scaling parameters might be useful.

It is suggested to perform further study on the benefit by using other content, e.g. original HDR data whih are available with higher bit depth. For high bit depth video, preserving is more important than saving some overhead of bit rate for parameter.

[JVET-N0613](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6354) Crosscheck of JVET-N0300 (On High Bit Depth Signaling of In-loop Reshaper) [T. Lu (Dolby)] [late]

[JVET-N0389](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6111) Chroma residual scaling with separate luma/chroma tree [E. François, C. Chevance (Technicolor)]

This contribution relates to chroma residual scaling used in the in-loop reshaping design. The contribution proposes to activate chroma residual scaling in tile groups supporting separate luma/chroma tree, while in the current VTM, both features cannot co-exist. Chroma residual scaling involves a dependency of chroma residual processing on luma samples, which results in a potential latency for processing the chroma samples. In this proposal, three options to control this latency are considered.

In Option 1, chroma residual scaling is only activated when the chroma block is inside a 16x16 non-overlapping area, and its co-located luma coding blocks are also inside the 32x32 co-located area. In the worst case, the maximum latency to process chroma samples is reportedly of 32x32 luma samples reconstruction delay.

In Option 2, chroma residual scaling uses the top or left luma sample neighboring the luma block co-located with the top-left sample of the chroma block. In addition, only the neighboring luma samples inside the current VDPU are used. The latency is in this case reportedly further reduced.

Option 3 is based on the same approach as Option 2 but uses the average value of the neighboring samples (instead of the top or left sample) of the co-located luma block to derive the chroma residual scaling factor.

For SDR content, reported psnr-Y, -U and -V BD-rate variations, in RA configuration, are as follows: for Option 1, 0.0%, -0.8%, -0.8%, for Option 2, 0.0%, -0.8%, -0.7%, for Option 3, 0.0%, -0.8%, -0.8%, and for Option 3 on top of JVET-N0220, 0.0%, -0.7%, -0.7%. For HDR content, reported wPsnr-Y, -U and -V BD-rate variations, in RA configuration, are as follows: for Option 1, 0.2%, -4.6%, -3.6%, for Option 2, 0.3%, -4.4%, -2.2%, for Option 3, 0.3%, -4.4%, -3.0%, and for Option 3 on top of JVET-N0220 0.3%, -5.8%, -5.2%.

Option 1 is unacceptable due to the strong dependency.

Generally, the results show that the gains are more balanced between luma and chroma when dual tree is enabled, both in SDR and HDR cases.

Study as another aspect of the latency problem in CE, as solutions suggested here are similar. However, it should be considered that CCLM is the other tool that introduces a similar chroma-from-luma dependency between the two trees, and if possible combined solutions should be sought

[JVET-N0614](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6355) Crosscheck of JVET-N0389 (Chroma residual scaling with separate luma/chroma tree) [T. Lu (Dolby)] [late]

[JVET-N0417](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6139) Simplified luma dependant chroma residual scaling of in-loop reshaper [N. Hu, V. Seregin, M. Karczewicz (Qualcomm)]

In this proposal, a subsampling based method is proposed to simplify the in-loop reshaping. The method was tested in VTM-4.0. Test results reportedly show 0.00%, 0.00% and 0.00% luma gain with similar encoding and decoding time in AI, RA and LDB configuration respectively over VTM-4.0 anchor with every second luma samples. Test results reportedly show 0.00% and 0.00% luma gain with similar encoding and decoding time in RA and LDB configuration respectively over VTM-4.0 anchor with every fourth luma samples.

Similar to N0477, but is always using subsampling equally over all block sizes. Does not solve the 64x64 latency problem. There are suggested solutions to the latency problem that even more radically would reduce the number of computations.

[JVET-N0664](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6415) Cross-check of JVET-N0417 (Simplified luma dependant chroma residual scaling of in-loop reshaper) [S.-C. Lim, H. Lee, J. Lee, J. Kang (ETRI)] [late]

[JVET-N0477](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6199) On luma mapping with chroma scaling [Y. Ye, J. Chen, R. Liao (Alibaba)]

At the 13th JVET meeting, luma mapping with chroma scaling (LMCS) (previously referred to as adaptive in-loop reshaper in JVET-M0427) was adopted into the VVC draft 4. In this contribution, three modifications to the chroma scaling process are proposed. In the current LMCS method, the chroma scaling process is performed at the block level, and the scaling factor is determined based on the average value of the corresponding luma prediction block. In the first proposed modification, the scaling factor computation is modified to use only up to 4x4 samples of the corresponding luma block. It is reported that the performance impact is minimal. Under the CTC, the overall impact for {Y, U, V} is {0.00%, -0.02%, -0.01%} for RA and {-0.04%, 0.20%, -0.03%} for LDB. In the second modification, it is proposed to bypass the chroma scaling process if the cbf’s of Cb and Cr are both zero. The second modification produces bit-exact coding results, but is asserted to simplify the decoder.

In the v2 revision, a third modification is proposed. In the third modification, for intra coded blocks, the top-left reference sample is used to derive the chroma scaling factor. This modification is only applied to the conventional intra coding mode. For all other modes, the proposed simplified luma averaging is used. Under the CTC, the overall impact for {Y, U, V} is {0.00%, -0.06%, -0.03%} for RA and {-0.03%, 0.24%, -0.16%} for LDB.

In the v3 revision, simulation results are updated.

First aspect: Simplified luma averaging

- Method 1: Use less samples (up to 4x4), which does not solve the latency problem.

- Method 2: Use top-left reference sample in case of intra coded blocks (it is pointed out in the discussion that this could also be applied in inter to solve the latency problem overall)

Study method 2 as a possible solution to the latency problem in CE.

Second aspect: Scaling not necessary if chroma CBF is zero.

Decision(cleanup text): Editors should check if it is reasonable to integrate the second aspect (not performing the scaling in case of CBF=0 in spec.

[JVET-N0615](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6356) Crosscheck of JVET-N0477 (On luma mapping with chroma scaling) [[T. Lu](mailto:tlu@dolby.com) (Dolby)] [late]

[JVET-N0805](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6560) AHG17: Design for signalling reshaper model [B. Heng, M. Zhou, W. Wan, P. Yin, Hendry, S. Paluri, J. Zhao, J. Lim, S. Kim, W. Choi, K. Choi, K. Choi (multi-company ??)] [late]

This contribution proposes a design for signalling luma mapping with chroma scaling (LMCS), a.k.a. reshaper model. The proposed design is based on the suggested design by the HLS BoG after review of all related contributions addressing the problem.

After review of contributions addressing signalling LMCS model, the following design was suggested by the HLS BoG:

* Optionally send LMCS parameters in the SPS.
* Define APS types for ALF and LMCS parameters. Each APS has only one type.
* Send LMCS parameters in APS
* If LMCS tool enabled, have a flag in the TGH to indicate that LMCS aps\_id is present or not. If not signaled, the SPS parameters are used.
  + Need to add semantic constraint to always have something valid that is referred to when tool enabled.

From the discussion in track A, it was suggested that it would be better to avoid sending LMCS parameters in SPS. This can easily be resolved by specifying that at least one corrsponding APS has to be available when LMCS is enabled.

Proponents are asked to update the proposal accordingly.

Revisit (relates to APS discussion with HLS experts)

[JVET-N0806](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6561) Suggested luma mapping with chroma scaling modifications in N0220/N0389/N0477 [E. François (Technicolor), Y. Ye (Alibaba), P. Yin (Dolby)] [late]

This contribution uses JVET-N0220 as the base package and combines the following chroma residual scaling related aspects from JVET-N0389 and JVET-N0477:

* From JVET-N0389: when dual tree partitioning is on, the scaling factor is derived using the top-left reconstruction sample neighboring the luma block containing the luma sample collocated with the top-left sample of the chroma block;
* From JVET-0477: 1) when single tree partitioning is on, and when the block is intra coded, the scaling factor is derived using the top-left reference sample used in intra prediction; 2) chroma scaling factor derivation is conditioned upon chroma cbf’s.

Further, it is proposed to disable chroma residual scaling if the chroma block contains less than or equal to 8 samples.

For SDR content, reported {Y, U, V} BD-rate variations are {0.03%, -0.61%, -0.56%} in RA. For HDR content, reported BD-rate variations are {0.40%, -6.81%, -6.71%} in RA, in terms of wPSNR.

Combination of the three docs – aspects should be studied separately.

## Other coding tools (2)

Contributions in this category were discussed Saturday 23 March 1500–1530 (Track A chaired by JRO).

[JVET-N0368](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6089) An implementation of adaptive color transform in VVC [X. Zhao, X. Xu, X. Li, S. Liu (Tencent)]

This contribution provides an implementation of adaptive color-space transform on top of VTM-4.0. With the proposed method, the processing of prediction and residual coding can be done in a different color space. The proposed method can be switched on and off for each CU using a flag explicitly signaled at CU-level. Experimental results show that, comparing to VTM-4.0 with support of chroma 4:4:4 format as proposed in JVET-N0367, the proposed method achieves up to 14.1% coding gain for RGB video content under All Intra (AI) configuration when IBC, Dualtree and LMCS is turned off.

Color transform is applied before prediction, prediction performed in transformed domain

ACT is different from HEVC, offset is applied

Question is asked if it was compared to the case performing YCoCg transform before – how useful is direct coding in RGB domain?

Gain with YUV is around 0.5% - how would it relate to the gain of joint chroma component coding?

How would it perform with ACT after prediction as in HEVC SCC? Answer is that this is difficult due to CCLM.

It is also remarked that the encoding time is rather high (80% increase)

Further study recommended. First need clarification of the role of 4:4:4

[JVET-N0421](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6143) Non-CE: Unsymmetrical quadtree partitioning [K. Zhang, L. Zhang, H. Liu, J. Xu, Y. Wang (Bytedance)]

In this contribution, four types of Unsymmetrical Quad-Tree (UQT) partitioning are proposed. In UQT, one block may be split either horizontally or vertically to four partitions. For each direction, the height or the width of a block can be split into either (1/8, 1/4, 1/2, 1/8) or (1/8, 1/2, 1/4, 1/8). Simulation results reportedly show -0.47%, -0.80% BD-rate changing under AI and RA configurations, respectively.

Encoder runtime is 250%.

Question is raised if the gain is due to the more options in partitioning, or due to more encoder tests? The new partitions have some option such as splitting a 32 block into 4-16-8-4 and reverse of that. From the results it is not clear if the new options are needed – like in the previous partitioning CE, comparison should be made under comparable encoder conditions.

It is also pointed out that class D has similar gain as other classes.

No need for action.

## High-level syntax (78)

Contributions in this category were discussed XXday XX March XXXX–XXXX (chaired by XXXqq).

### Interfacing with MPEG Systems (1)

[JVET-N0041](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5761) Summary of the status of systems-related issues for VVC [Y. Lim (Samsung), E. Thomas (TNO)]

### General high-level syntax (31)

#### NAL unit header and general apsects of parameter sets (7)

[JVET-N0050](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5770) AHG17: On Forbidden-Zero Bit in NAL Unit Header [S. Wenger, B. Choi, S. Liu (Tencent)]

[JVET-N0051](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5771) AHG17: On NAL Unit header design for VVC [S. Wenger, B. Choi, S. Liu (Tencent)]

[JVET-N0067](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5787) AHG17: On the first byte of the NAL unit header [M. M. Hannuksela, K. Kammachi-Sreedhar (Nokia)] [late]

[JVET-N0278](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5999) AHG17: On VVC HLS relevant to MPEG requirements on immersive media delivery and access (N18134) [J. Boyce (Intel)] [late]

[JVET-N0511](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6237) AHG17: Signalling leading picture information in the NAL unit header structure [L. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)] [late]

[JVET-N0349](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6070) AHG17: On Parameter Set Design for VVC [K. Sühring, R. Skupin, Y. Sanchez, T. Schierl (HHI)]

[JVET-N0823](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6578) AHG17: First octet of NAL unit header without forbidden\_zero\_bit [S. Wenger, B. Choi (Tencent), M. M. Hannuksela, K. Kammachi-Sreedhar (Nokia)] [late]

#### Reference picture management (4)

[JVET-N0058](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5778) AHG17: On decoded picture buffer management [B. Choi, S. Wenger, S. Liu (Tencent)] [late]

[JVET-N0100](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5820) AHG17: On Reference Picture List Signalling [S. Deshpande (Sharp)]

[JVET-N0135](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5855) AHG17: On reference picture list [Y. Fujimoto, T. Suzuki (Sony)] [late]

[JVET-N0136](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5856) AHG17: On non-referenced picture [[Y. Fujimoto](mailto:Yuji.Fujimoto@sony.com), T. Suzuki (Sony)] [late]

#### APS and tile group header (8)

[JVET-N0065](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5785) AHG17 & AHG9: Comments on carriage of coding tool parameters in Adaptation Parameter Set [M. Li, P. Wu (ZTE)]

[JVET-N0069](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5789) AHG16/AHG17: Proposed Cleanup for Reshaper High Level Syntax [B. Heng, M. Zhou, W. Wan (Broadcom)]

[JVET-N0117](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5837) AHG17: Signalling of reshaper parameters in APS [Y.-K. Wang, Hendry, J. Chen (Huawei), P. Yin, T. Lu, F. Pu, S. McCarthy (Dolby)]

[JVET-N0138](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5858) AHG17: Carriage of reshaper model parameters [W. Choi, K. Choi, K. Choi (Samsung)]

[JVET-N0284](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6005) AHG17: On ALF and Reshaper Signaling [S.Paluri, J. Zhao, J. Lim, S. Kim (LGE)]

[JVET-N0290](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6011) AHG17: Conditional Signaling of ALF and In-Loop Reshaper Model [S.Paluri, J. Zhao, J. Lim, S. Kim (LGE)]

[JVET-N0293](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6014) AHG17: Reshaper Reset Signaling [S. Paluri, J. Zhao, J. Lim, S. Kim (LGE)]

[JVET-N0297](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6018) AHG17: Reshaper Model Signaling for Intra Coded Tile Group [S. Paluri, J. Zhao, J. Lim, S. Kim (LGE)]

#### Interoperability and capability points definition and signalling (1)

[JVET-N0276](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5997) AHG15: On interoperability point signalling [J. Boyce (Intel)]

#### High efficiency random access (3)

Contributions in this category were discussed XXday XX March XXXX–XXXX (chaired by XXXqq).

[JVET-N0119](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5839) AHG17: EDR - external decoding refresh [Y.-K. Wang (Huawei)] [late]

[JVET-N0494](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6216) AHG17: Dependent random access point pictures in VVC [M. Pettersson, R. Sjöberg, M. Damghanian (Ericsson)]

[JVET-N0072](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5792) AHG17: New NAL unit types for VVC [L. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

The DRAP part of this document belongs to this agenda item.

[JVET-N0861](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6616) AHG17: Comparison between EDR and DRAP [H. Yu, L. Yu (Zhejiang Univ.)] [late]

TBP

[JVET-N0865](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6620) Gradual Random Access [S. Deshpande (Sharp), Y.-K. Wang, Hendry (Huawei), R. Sjöberg, M. Pettersson (Ericsson), L. Chen (MediaTek)] [late]

TBP

#### Miscellaneous general HLS topics (8)

[JVET-N0061](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5781) AHG19: Signalling temporal IDs and levels for HFR backwards compatible bitstreams [V. Drugeon (Panasonic)]

[JVET-N0063](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5783) AHG17: Separate essential display information from non-essential display information in the Video Usability Information [V. Drugeon (Panasonic)]

[JVET-N0120](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5840) AHG17: Misc. HLS clean-ups [Y.-K. Wang (Huawei)] [late]

[JVET-N0227](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5947) Maximum transform size signaling in HLS [L. Li, M. Koo, J. Nam, J. Heo, J. Lim (LGE)] [late]

[JVET-N0234](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5954) [AHG12/AHG17] Signaling of virtual boundaries [A. DSouza, C. Pujara, R. Gadde, W. Choi, K. Choi, K.P. Choi (Samsung)] [late]

[JVET-N0438](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6160) AHG12: Loop filter disabled across virtual boundaries [S.-Y. Lin, L. Liu, J.-L. Lin, Y.-C. Chang, C.-C. Ju (MediaTek), P. Hanhart, Y. He (InterDigital)]

[JVET-N0744](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6499) Crosscheck of JVET-N0438 (AHG12: Loop filter disabled across virtual boundaries) [A. Konda, C. Pujara (Samsung)] [late]

[JVET-N0288](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6009) AHG17: Comments on High-Level Syntax of VVC [S. Deshpande (Sharp)]

[JVET-N0352](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6073) AHG17: Conformance Window [K. Sühring, R. Skupin, Y. Sanchez, T. Schierl (HHI)]

[JVET-N0869](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6624) Decoding Parameter Set with default ID equal to zero [S. Wenger (Tencent), W. Wan (Broadcom)] [late]

### Coded picture regions (30)

#### Tiles and tile groups (11)

[JVET-N0056](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5776) AHG12: On tile design [B. Choi, S. Wenger, S. Liu (Tencent)]

TBP.

[JVET-N0057](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5777) AHG12: On tile group design [B. Choi, S. Wenger, S. Liu (Tencent)]

TBP.

[JVET-N0064](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5784) AHG17: Signalling of only one tile group per picture [V. Drugeon (Panasonic)]

TBP.

[JVET-N0066](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5786) AHG12: On top-to-bottom tile partitioning [Y. He, A. Hamza (InterDigital)]

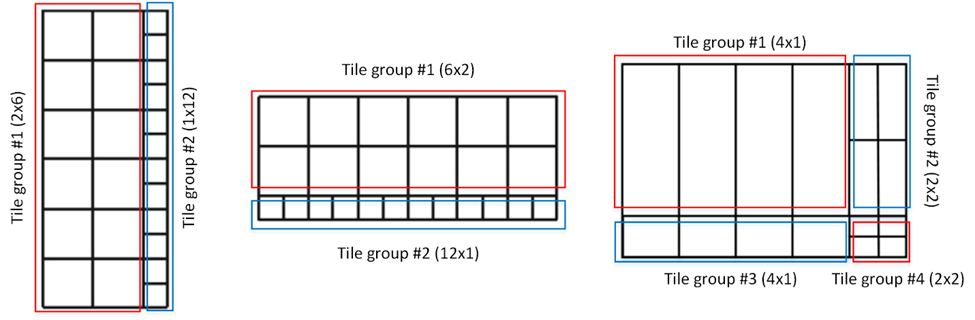
This was discussed in Track B on Saturday 23 March (GJS).

Current VVC tile partitioning design divides a picture into tile rows and columns first, then groups multiple tiles into either a raster scan tile group or rectangular tile group. The tile group configuration depends on the tile row and column configuration. This contribution proposes a top-to-bottom tile partitioning design as summarized below:

* The design first divides a picture into rectangular tile groups, and each tile group may be further partitioned into multiple tiles.
* Proposes to signal tile group partitioning at PPS.
* Proposed three options to signal local tile partitioning (1) PPS after tile group signaling; (2) tile group header; (3) sub-picture parameter set (proposed in JVET-N0099). Both (2) and (3) are asserted to simplify the sub-picture extraction and reposition process.
* Proposed tile group data syntax struct update based on new tile partitioning

Some partitionings of pictures into rectangles that are supported in HEVC are not supported in the current draft of VVC. In HEVC these involve partitioning tiles into (rectangular) slices.

This proposes to first divide pictures into rectangular tile groups and then each tile group could be partitioned into tiles without requiring tile boundary lines to cut all the way through the picture. Examples are illustrated in the figure below.



An example use case was said to be viewport-dependent streaming.

It was noted that in our current spec, each tile group is a single NAL unit, and this contribution does not seem oriented for that.

These examples have 2:1 size relationships, which would not always be desirable in general.

It was remarked that some decoder implementations have a two-stage process by which the bitstream is parsed first and then a second process operates in raster order.

It was remarked that this would be difficult to implement.

N0111 and N0348 are similar in spirit to this.

In the figure above, the tile group boundaries cut all the way through the picture, but the proposal is not restricted to that; it proposes a first partitioning of the picture into sub-picture rectangles and a second partitioning of each of those sub-pictures into tiles. In N0111 and N0348, that restriction does apply.

To some extent, the issue can be solved by just cutting the large areas into smaller ones to fulfil the “the-the-way-through” cutting method in the current design, but this would have a coding efficiency impact.

Ultimately, this comes down to a matter of how difficult it is to implement. We probably would not want to define a separate profile just to provide this functionality. It is asserted to be difficult to implement.

It was suggested that the “dependent tiles” concept of N0497 may mitigate the coding efficiency impact.

[JVET-N0111](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5831) AHG12: Flexible tiling [Y.-K. Wang, Hendry, M. Sychev (Huawei)]

See notes for N0066.

[JVET-N0348](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6069) AHG12: Hierarchical tiling for VVC [R. Skupin, Y. Sanchez, K. Sühring, T. Schierl (HHI)]

See notes for N0066.

[JVET-N0071](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5791) AHG12: Unified signalling of tile grouping information [L. Chen, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

TBP.

[JVET-N0124](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5844) AHG12: On Tile Group Signalling [S. Deshpande (Sharp)]

TBP.

[JVET-N0496](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6218) AHG12: Rectangular tile group address signaling [[R. Sjöberg](mailto:rickard.sjoberg@ericsson.com), [M. Damghanian](mailto:mitra.damghanian@ericsson.com), [M. Pettersson (Ericsson)](mailto:martin.m.pettersson@ericsson.com)]

TBP.

[JVET-N0497](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6219) AHG12: Dependent tiles [R. Sjöberg, M. Pettersson, M. Damghanian (Ericsson)]

This was first discussed in the BoG reported in N0754, then discussed in Track B Saturday 23 March 1800 (GJS). Notes from the BoG are below, followed by discussion notes from Track B.

The current tiles in VVC is seen as independent by the authors since there is no prediction between tiles and CABAC is initialized for each tile such that all tiles can be decoded in parallel. Dependent tiles, according to this proposal, would enable prediction across tiles within a tile group and only initialize CABAC for the first tile in the tile group. It is proposed that CABAC is byte-aligned for each dependent tile but that CABAC states are continuously updated within a tile group.

The contribution proposes that a flag is added for each tile group that specifies whether the tiles within a tile group are dependent or independent. For rectangular tile groups, where currently the tile group structure is signaled in the PPS, it is proposed that the flags are added to the PPS. For raster scan tile groups, it is proposed to add a single flag in the tile group header. The tile groups are always independent according to the proposal, it is only the internal tile boundaries within a tile group that are affected. The scan order of CTUs in a picture would according to the proposal stay the same regardless if tiles are made dependent or not.

It is claimed that the proposal would effectively add support for tiles of different sizes, something that is claimed to be useful for e.g. multi-resolution 360 video streaming. The authors claim that the required VVC text changes are small.

It was commented and agreed that a content preparation stage is needed to enable this.

It was agreed by the proponent that the main motivation for the proposal is flexible tiling. And assertedly this is a lightweight approach for enabling this.

It was agreed that this not needed if sub-pictures are supported. However if we go with MCTS this is asserted to be a good solution for the flexibility provided.

But also intention is that this ability should be supported by main profile.

It was commented that this seems simple approach compared to other flexible tiling proposals.

It was asked that for one of the use cases in the document, whether the proposal will really enable the required use case where the flags are set and it is unclear to the encoder what combination of flags is imagined by the encoder.

It was commented by the proponent that the scheme will work on extraction and repositioning on tile group level not on tile level. So for example the Fig. 1 is enabled, but Fig. 2 with tile based operation will not actually be enabled.

A previous experiment shows overhead of 1-2% for OMAF 360 use case for HEVC based simulations.

A comment was made that software should be available for understanding decoder implementation impact for such proposals.

Notes from the track B discussion:

An example usage is shown in the figure below.

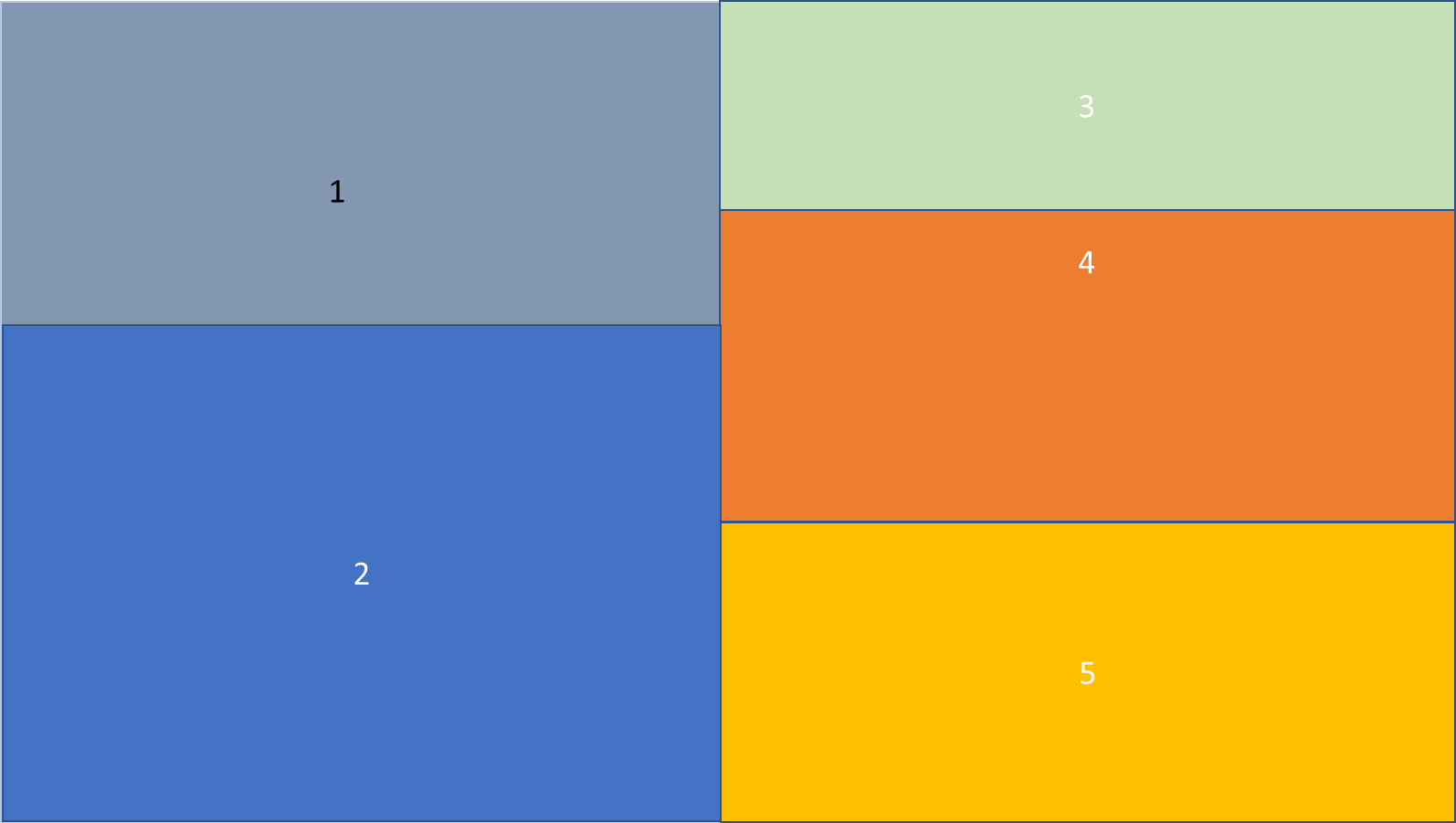


What is carried over across dependent tile boundaries is neighbour availability and CABAC state.

This was said to be easier to implement than the more general partitioning structures.

It was noted that the current VVC design has less partitioning flexibility than HEVC, since HEVC allows chopping tiles into slices. Even with this proposal, that would still be the case to some extent, since HEVC slice boundary lines are not required to cut all the way through the picture, where that constraint applies in this proposal.

It was noted that allowing any individual tile to be partitioned vertically at CTU row boundaries (whether independent or dependent) should not be any more difficult than supporting HEVC, since that is just a subset of what can be done with slices. Having a partitioning as shown below should not be any more difficult than HEVC’s tiles/slices scheme.



The order of the data in the bitstream would be required to be 1, 2, 3, 4, 5, as shown (completing all small rectangles within a large rectangle before moving to the next large rectangle). To pick an initial terminology, the large rectangles could be called tiles and the smaller ones called bricks.

The syntax of the partitioning of tiles into bricks could hypothetically use a stop flag after each CTU row in a tile or could be at the tile level, tile group level, picture level, or even a higher level.

For mapping these to NAL units, each NAL unit would contain a rectangular region. It was suggested that each NAL unit would contain a tile group or a part of a tile group.

We current have a raster scan mode of tile groups. In that mode, perhaps the restriction we imposed in HEVC should be similarly imposed – a NAL unit would need to be within a tile or contain multiple tiles. Another suggestion was to not allow tiles to be divided into multiple bricks in this mode – this was agreed as a starting point.

We want to enable rewriting without modifying data within the VCL NAL units. In the rectangular mode, the PPS would contain the entire map of tiles and bricks (not using a stop bit within the NAL unit). As in the current syntax, we start the NAL unit with an ID that would be mapped by the PPS (or higher) information to identify the specific brick that starts the NAL unit.

It was not clear that having dependent bricks would be needed, so no action was taken on that aspect.

Decision in principle: As described above.

This is basically a constrained form of N0111 and N0348 (without vertical cuts and preserving the current raster mode).

Revisit after proposed text to be provided in a new contribution.

[JVET-N0498](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6220) AHG12: On Uniform Tile Partitioning [R. Sjöberg, M. Pettersson, M. Damghanian (Ericsson)]

This contribution was discussed in Track B Saturday 23 March 1750 (GJS).

This contribution is a follow-up contribution of JVET-M0375 and proposes modifications to the case where uniform tile partitioning is enabled (uniform\_tile\_split\_flag = 1). It is proposed to signal the desired tile column width and tile row height directly, in contrast to the current draft VVC that signals the number of tile columns and the number of tile rows for a uniform tile partitioning. The outcome is a partition with tile columns having the specified width and tile rows having the specified height with a possible remainder tile column at the right and a possible tile row remainder at the bottom of the picture.

The proponents claim the proposed modifications to the uniform tile partitioning have the following advantages over the draft VVC:

* The proposal removes the pseudo-random location of tile boundaries, as it exists in the HEVC and the current draft VVC.
* The proposal keeps tile boundary locations static in case tile rows and/or tile columns are removed from the picture.
* The exact width and height of the tiles are known for extraction purposes regardless of the positioning of the tile in the picture and regardless of uniform\_tile\_split\_flag being equal to 0 or 1.

This proposal would enable extraction of any row(s) or column(s) of tiles while still allowing the default layout to be indicated rather than requiring use of the explicit layout syntax.

The proposal differs from that of the previous meeting. It follows the previously suggested alternative of using equal tile sizes except at the right and bottom edges.

At the previous meeting, there had been some concern about potential load balancing impact. This did not appear to be a significant concern, at least for the current proposal.

Decision: Adopt (text is in proposal, may need harmonization if other actions taken).

[JVET-N0852](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6607) AHG12: Tile group order restriction [R. Sjöberg (Ericsson), Hendry (Huawei)] [late]

[JVET-N0857](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6612) AHG12: Signalling for tile and brick partitioning [Y.-K. Wang, Hendry, M. Sychev (Huawei), R. Skupin, Y. Sanchez, K. Sühring, T. Schierl (HHI)] [late]

TBP

#### Independently coded picture regions (16)

[JVET-N0042](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5762) AHG12: Comments on MPEG draft requirements on immersive media access and delivery [M. M. Hannuksela, E. B. Aksu, A. Hourunranta (Nokia)]

[JVET-N0043](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5763) AHG12: VVC design goals related to MPEG requirements on immersive media access and delivery [M. M. Hannuksela, E. B. Aksu (Nokia)]

[JVET-N0044](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5764) AHG12: Comparison of approaches for independently coded picture regions [M. M. Hannuksela, A. Aminlou, K. Kammachi-Sreedhar (Nokia)]

[JVET-N0045](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5765) AHG12: Sub-picture layers for realizing independently coded picture regions [M. M. Hannuksela, K. Kammachi-Sreedhar, A. Aminlou (Nokia)]

[JVET-N0046](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5766) AHG12: Sub-picture-based picture partitioning and decoding [M. M. Hannuksela, A. Aminlou (Nokia)]

[JVET-N0055](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5775) AHG12: On sub-picture design [B. Choi, S. Wenger, S. Liu (Tencent)]

[JVET-N0073](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5793) AHG17: [SYS-VVC] Signalling subpicture coded video sequence [L. Chen, C.-Y. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-N0099](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5819) AHG12/AHG17 On sub-picture parameter set [Y. He, A. Hazma (InterDigital)]

[JVET-N0107](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5827) Sub-picture based video coding [Y.-K. Wang, Hendry, J. Chen (Huawei)]

[JVET-N0191](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5911) [AHG17/AHG12] On APS id for bitstream merging for VVC [N. Ouedraogo, E. Nassor, J. Taquet, G. Kergourlay, F. Maze (Canon)]

[JVET-N0192](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5912) [AHG17/AHG12] Bitstream extraction and merging with variable initial Qp [N. Ouedraogo, E. Nassor, G. Kergourlay, F. Maze (Canon)]

[JVET-N0354](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6075) AHG12: Conformance of temporally independent tile groups [R. Skupin, Y. Sanchez, K. Sühring, T. Schierl (HHI)]

[JVET-N0411](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6133) AHG12: Layout signalling of independent coded regions [E. Thomas (TNO)]

[JVET-N0528](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6255) AHG12/AHG19/SYS-VVC: Sub-picture decoding design: a comparison of proposed solutions [E. Thomas (TNO)] [late]

[JVET-N0047](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5767) AHG12/AHG17: Merging IRAP and non-IRAP VCL NAL units into the same coded picture [M. M. Hannuksela (Nokia)]

[JVET-N0108](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5828) AHG12/AHG17: Allowing mixed IRAP and non-IRAP NAL unit types within a picture [Y.-K. Wang, Hendry (Huawei)]

[JVET-N0753](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6508) AHG12: Design decision questions on independently coded picture regions [M. M. Hannuksela (Nokia), S. Deshpande (Sharp)] [late]

[JVET-N0826](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6581) AHG12: Harmonized proposal for sub-picture-based coding for VVC [Y.-K. Wang, Hendry, J. Chen, R. Skupin, Y. Sanchez, K. Sühring, M.M. Hannuksela (multi-company??)] [late]

TBP

[JVET-N0859](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6614) Sub-picture design principles [J. Boyce (Intel)] [late]

TBP

#### Wavefront parallel processing (3)

TBP

[JVET-N0060](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5780) AHG12: Improved parallel processing capability with WPP [Y. Fujimoto, M. Ikeda, T. Suzuki (Sony)]

[JVET-N0559](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6290) Crosscheck of JVET-N0060 (AHG12: Improved parallel processing capability with WPP) [T. Ikai (Sharp)] [late]

[JVET-N0149](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5869) AHG12: Signalling on wavefront parallel processing [T. Ikai, S. Deshpande, T. Chujoh, E. Sasaki, T. Aono (Sharp)] [late]

[JVET-N0150](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5870) AHG12: One CTU delay wavefront parallel processing [T. Ikai (Sharp)]

[JVET-N0646](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6396) Crosscheck of JVET-N0150 (AHG12: One CTU delay wavefront parallel processing) [M. Ikeda (Sony)] [late]

### Low latency random access (11)

[JVET-N0114](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5834) AHG14: A delay analysis for IRAP and GDR [Hendry, Y.-K. Wang, M. Sychev (Huawei)]

Track B 1815 Saturday (GJS)

This is an information contribution, not a proposal.

This contribution provides analysis on encoder-decoder delays for access unit (AU) based and decoding unit (DU) based encoder-decoder operations for bitstream coded with intra random access point (IRAP) pictures at regular interval and for bitstream coded with gradual decoding refresh (GDR) picture at regular interval. The objective of this analysis is to understand whether GDR feature can help reduce encoder-decoder end-to-end delay for both AU and DU based operations when compared to using IRAP pictures.

The finding from the analysis is that a GDR feature can help reduce encoder-decoder end-to-end delay for both AU and DU based operations.

Details of the analysis are provided in the attachment.

It was suggested that with the IRAP method, for low delay, the QP might be increased for the I frames, relative to that usually used in common test conditions, to reduce the delay. This had not been considered in the study. As tested, the fidelity of the I pictures was exceptionally high.

The ChinaSpeed sequence was used in the test (a game streaming sequence).

Summary results are tabulated below:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Delay A | Delay B | Delay C | Delay D | (A + B + C + D) | Initial join delay |
| IRAP with AU based | 39.66 | 107.62 | 74.67 | 31.25 | 253.20 | 253.20 |
| IRAP with AU based, multiple VCL NAL units | 1.24 | 107.62 | 0.00 | 31.25 | 140.11 | 140.11 |
| GDR with AU based | 31.25 | 28.58 | 0.00 | 31.25 | 91.08 | 1091.08 |
| GDR with AU based, multiple VCL NAL units | 1.24 | 28.58 | 0.00 | 31.25 | 61.07 | 1061.07 |
| IRAP with DU based | 1.24 | 3.36 | 73.97 | 31.25 | 109.83 | 109.83 |
| GDR with DU based | 1.24 | 3.36 | 0.00 | 31.25 | 35.86 | 1035.86 |

[JVET-N0080](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5800) AHG14: Revised software for ultra low-latency encoding [K. Kazui (Fujitsu)]

Track B 1915 Saturday (GJS)

This contribution proposes revised software for ultra low-latency encoding. Previous software was proposed in JVET-M0197.

The proposed software is based on VTM-4.0 and incorporates the progressive intra refresh scheme and multiple decoding units to simulate the reduction of the CPB size. The proposed software does not include any normative changes to the current VVC design.

This contribution also proposes testing conditions, including parallel processing for reducing the turnaround time of simulation.

Discussed schemes:

* Vertical striped (implemented L to R)
* Horizontal striped
* Isolated
* Having a tile grid and having one tile per picture coded as intra.
* Having a wider refresh region that does not span the entire picture vertically (similar to the above)

It was suggested to consider turning off the deblocking if turning it on would cause a need to code more of a picture as intra.

It was asked whether to focus on high fidelity or lower fidelity. At higher fidelity, deblocking is less necessary.

Substantial coding efficiency penalty was reported for a vertical stripe approach relative to an anchor with IRAP refresh (average ~33%, up to ~80%), without normative change to the decoding process – using only encoding restrictions to accomplish the refresh.

[JVET-N0115](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5835) AHG14/AHG17: GDR - gradual decoding refresh [Hendry, Y.-K. Wang, J. Chen, S. Hong (Huawei)]

Track B 2000 Saturday (GJS)

This contribution proposes a design for supporting gradual decoding refresh (GDR) for VVC. It is asserted that techniques for supporting GDR that are being studied in AHG14 are unnecessarily complex. It is also asserted that the use of constrained intra prediction (CIP) and encoder constraints on motion vector search causes sub-optimal coding performance.

The proposed GDR design is summarized as follows:

* A new VCL NAL unit with type, GDR\_NUT, is defined. A picture with VLC NAL units of type GDR\_NUT is a GDR picture and is the first picture in a GDR period.
* The access unit containing a GDR picture may start a CVS and consequently may start a bitstream.
* A flag called gdr\_enabled\_flag is signalled in the SPS to indicate whether GDR pictures may be present in CVSs referring to the SPS.
* When decoding starts from a GDR picture, the GDR picture is treated similarly to CRA picture treatment.
* Progressive intra refresh for GDR is performed based on intra coding of entire tile groups.
* Neither CIP nor constraining of MVs is proposed to be used. Instead, the TMVP derivation process and the interpolation processes are modified such that a boundary of the refreshed region in a reference picture is treated as if it were a picture boundary in decoding of a current block referring to that reference picture for inter prediction.
* A flag called loop\_filter\_across\_refreshed\_region\_enabled\_flag is defined to specify the in-loop filter operations at the boundary between the refreshed region and the un-refreshed region.

Text changes are provided in the attachment of this contribution.

Problems asserted to occur in some of the prior investigated techniques.

* Forcing intra prediction mode for CU on column basis may cause coding sub-optimality as it interferes with coding block splitting algorithm. Furthermore, it seems to cause complicated implementation since one needs to trace the refresh direction at CU granularity.
* The refreshed region that is coded only with intra-prediction is not CTU size, instead it can go smaller than CTU size, down to minimum CU size. This makes the implementation unnecessary complicated as it may need indication at block level.
* The use of CIP is harmful to intra blocks in the un-refreshed region. Although it is necessary to code refreshed region that is coded with intra-prediction with some constraints to prevent any samples from un-refreshed region to be used for spatial reference, when CIP is used, it is picture based, meaning that all intra blocks in the picture must also be coded as CIP intra blocks. This consequently causes performance degradation. The proposed normative change such that CIP is used adaptively depending on the position and direction of the intra refresh area requires additional complexity as it is necessary to trace the intra refresh direction.
* The use of encoder constraint to limit motion search prevents encoder to choose the best motion vector if samples of the reference block associated with the motion vector are not completely within the refreshed region in the reference picture. Figure 1 illustrates the reason for non-optimality in motion search when using encoder restriction for supporting GDR. During motion search process, the encoder is constrained to not select any motion vector which resulted in some of samples of the reference block located outside the refreshed region, even if that reference block is the best reference block in rate-distortion cost criteria.

A three-tile-group approach was suggested, where the the picture is divided vertically into a “clean tile group”, a “refresh tile group”, and a “not-yet-refreshed tile group” (dirty) area.

Each reference picture is proposed to have its clean+refresh area treated as its picture boundary, so each reference picture has a different virtual picture boundary.

The refresh area can use inter prediction using the clean area of each reference picture.

It was commented that the “clean area” could be in the same tile as the “refresh area”, to allow intra prediction of the refresh area from the clean area.

A flag is proposed to enable/disable the loop filter between the refreshed area and the “not-yet-refreshed” area.

As proposed, the decoder could only join the stream at the position where a refresh cycle starts, not on any picture. So if joining randomly, there would be an average of one and a half periods before full recovery.

The scheme had not been tested.

It was commented that if the decoder knows what area is not yet refreshed, it could skip decoding of that area. Also if the decoder has faster than real time access to the data (e.g., for a bitstream that has been stored after its initial reception), it could recover more rapidly if it does that skipping.

JVET-N0310 is said to be similar in spirit in terms of basic operation, but using the “sub-picture” concept rather than tile groups.

[JVET-N0310](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6031) AHG14: On gradual decoding refresh [M. M. Hannuksela, K. Kammachi-Sreedhar, A. Aminlou (Nokia)] [late]

See the notes for N0115.

[JVET-N0116](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5836) AHG14/AHG17: DDR - distributed decoding refresh [Y.-K. Wang, M. Sychev, Hendry (Huawei)]

Track B 2040 Saturday (GJS)

This contribution proposes a method for reducing bit rate fluctuations for achieving low end-to-end delay with random access capabilities. The method is referred to as distributed decoding refresh (DDR). The key idea is to distribute IDR pictures over multiple inter-coded pictures, and such an IDR picture cannot be used by these inter-coded pictures, except for the last one, for inter prediction reference. Such an IDR picture is referred to as a distributed IDR (DIDR) picture. A DIDR picture is not for output. Rather, the inter-coded associated DDR picture, which is a different representation of the same source picture, is for output.

It is asserted that the DDR-based approach can achieve rate smoothness while higher coding efficiency than GDR-based approaches, because no motion restrictions as in GDR are needed. Compared to usual IRAP picture based coding, the DDR-based approach needs to encode one additional inter-coded picture for each random access period, and the last of the multiple inter-coded pictures over which the VCL NAL units of the DIDR picture are distributed is less efficient than usual due to that it cannot use the DIDR picture for reference, while the DIDR would often be a number of pictures away in POC distance.

The proposed detailed spec text changes are provided in an attachment.

The whole distributed picture is conceptually held in the CPB until it has been completely delivered, then decoded. It was commented that alternatively, there could be partial picture decoding as each chunk arrives. This could be done non-normatively with existing standards by having hidden pictures that reference other hidden pictures to gradually fill a whole frame, although the level limits on speed of decoding might require using a higher level.

It was commented that if there is camera motion, the efficiency of referencing this distributed picture may not be very good.

[JVET-N0391](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6113) AHG14: Software updates for intra refresh [J.-M. Thiesse, D. Gommelet, D. Nicholson (VITEC)] [late]

Track B 2100 Saturday (GJS)

This contribution reports an update of the software modifications for the study of progressive intra refresh (AHG 14). This code has been updated in the AHG Gitlab repository. Both encoder-only modifications and a normative solution have been updated to VTM 4.0.1 with handling of new tools adopted at Marrakech meeting. In particular, the stronger deblocking filter significantly deteriorates the performance of encoder-only implementation. Affine prediction also implies new constraints at refresh borders within clean region. This contribution introduces the implementation of discussed testing conditions. In particular the adaptation of refresh region to handle whatever refresh cycle and the computation of bitrate and metrics after the first refreshing cycle. The corresponding performance draws similar conclusion as the results presented at Marrakech meeting with a loss of 17.97% in average for the encoder-only modifications against a low-delay B reference with a comparable intra period of 1second. This significant loss demonstrates that a better handling of progressive intra refresh in VVC is relevant. The normative proposal brings an improvement of 7% against the encoder-only modification solution by adding a signalling to derive the position of the intra refresh area and then exploit this position for decoding process.

The authors suggest to integrate the encoder-only modifications for intra-refresh support on VTM 5 and to consider the proposed normative solution for integration in the standard.

This uses a vertical refresh strip that is a multiple of 8 in width. All CUs that cover or partly cover this strip are required to be intra coded.

Constrained intra prediction is enabled for the whole picture in the “encoder-only” approach. That is supported in the VTM but not in the draft text and design. That approach has a loss averaging 18% in the experiments relative to LB with the same intra period.

Normative approach aspects:

* Enable CIP only for intra refresh CUs.
* Disabling the loop filter on boundary of intra refresh CUs.
* Skip a couple of flags for IR CUs (minor).
* Intra refresh direction (right to left or top to bottom, top to bottom or bottom to top)
* Delta QP for intra refresh CUs (also proposed in some form in N0275)

It was discussed whether the adopted virtual boundaries filter disabling is adequate for the loop filter switch, and it seemed adequate (or at least potentially adequate).

Constrained intra prediction is the primary remaining low-level proposed extra capability proposed here that is not currently planned.

It was agreed to plan to test CIP, both for whole pictures and with switching within a picture.

The treating of different boundaries as picture boundaries, which is likely to be adopted in some form, could also helpful for GDR, but is not part of this proposal, and might be designed somewhat differently from using tile boundaries if intended for this purpose.

Offline activity was encouraged to propose a description of what could be tested in a CE and how.

Revisit for that.

[JVET-N0830](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6585) AHG14 related: low-level design directions for progressive intra prediction [K. Kawamura, S. Naito (KDDI)] [late]

Track B 2200 Saturday (GJS)

This is an information contribution. Three directions of design directions are described to consider / develop the progressive intra refresh (PIR aka GDR) mechanism. This contribution focuses on the low-level, which is video coding layer.

* Restriction flags (or other feature support) in the video coding layer are used that are in common with other applications. This would mean that no special syntax or decoding process is specified only PIR.
* Tile functionality may be decomposed into smaller parts, where bitstream extraction is not necessarily needed for PIR, but other aspects of the current tile design are helpful.
* Intra coded regions are specified that are aligned with CTU boundaries. This would mean that CTU granularity is guaranteed by the specification but CU granularity is done by encoder design.

No particular action was requested – this was just presented as information for study toward developing approaches.

[JVET-N0072](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5792) AHG17: New NAL unit types for VVC [L. Chen, C.-W. Hsu, Y.-W. Huang, S.-M. Lei (MediaTek)]

The GDR part of this document belongs to this agenda item.

TBP.

[JVET-N0101](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5821) AHG14/ AHG17: On Gradual and Clean Random Access [S. Deshpande (Sharp)]

TBP HLS-only.

[JVET-N0495](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6217) AHG14: Recovery point indication NAL unit [R. Sjöberg, M. Pettersson, M. Damghanian (Ericsson)]

TBP HLS-only.

[JVET-N0275](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5996) AHG14/AHG8/AHG17: Sections for intra refresh and inloop filter disabling [J. Boyce, R. Lei, L. Xu (Intel)]

This was reviewed in the HLS BoG.

### HRD (7)

[JVET-N0062](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5782) AHG19: Signalling HRD models for HFR backwards compatible bitstreams [V. Drugeon (Panasonic)]

[JVET-N0077](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5797) Hypothetical Reference Decoder in VVC [K. Kazui (Fujitsu)]

[JVET-N0350](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6071) AHG17: HRD starting point [R. Skupin, Y. Sanchez, K. Sühring, T. Schierl (HHI)]

[JVET-N0351](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6072) AHG17: HRD parameters for temporal scalability [R. Skupin, Y. Sanchez, K. Sühring, T. Schierl (HHI)]

[JVET-N0353](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6074) AHG17: Parsing of HRD related SEI messages [K. Sühring, R. Skupin, Y. Sanchez, T. Schierl (HHI)]

[JVET-N0423](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6145) AHG17: Hypothetical Reference Decoder [S. Deshpande (Sharp)]

[JVET-N0706](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6459) AHG17: Decoded Picture Hash SEI [K. Sühring, R. Skupin, Y. Sanchez (HHI)] [late]

[JVET-N0867](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6622) Harmonized proposal on HRD parameters for temporal scalability [V. Drugeon (Panasonic), R. Skupin, Y. Sanchez (HHI)] [late]

TBP

# Complexity analysis and reduction (2)

Contributions in this category were discussed XXday XX March XXXX–XXXX (chaired by XXXqq).

[JVET-N0238](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5958) AHG13: ISP Tool-off Tests in VTM-4.0.1 [S. De-Luxán-Hernández, B. Bross, H. Schwarz, D. Marpe, T. Wiegand (HHI)]

Was discussed with AHG report.

[JVET-N0049](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5769) AHG16: A study of bin to bit ratio in VTM4.0 and HM16.19 [M. Zhou (Broadcom)]

(include abstract)

Was presented Tue 03-26 1720 (chaired by JRO)

The contribution points out that a relatively higher percentage of bins seems to be context coded rather than bypass coded. A calculation is made that weights context coded bins by a factor of 4, and bypass coded bins by a factor of 1, to reflect the higher complexity of contex coded bins. The resulting “BD rate” based on the distortion-complexity criterion indicates that VVC is worse than HEVC.

Further study is necessary. It is however well known that the ratio between complexity and additional compression is not linear. It wouldin particular be interesting how many context coded bins are consumed by which part of the bitstream, such as transform coefficients, mode/motion etc.

[JVET-N0397](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6119) AHG16: Memory bandwidth reduction for small CUs [X. Li, G. Li, X. Xu, S. Liu (Tencent)]

To reduce worst-case memory bandwidth for small CUs, it is proposed to use size dependent interpolation filter in motion compensation. A shorter filter (4-tap chroma interpolation filter or 2-tap bilinear filter) is used in luma motion compensation for the direction in which the length of a block is 4 luma pixel. Compared to VTM-4.0, 0.05% RA loss and 0.08% LDB loss are reported when 4-tap filter is used; while 0.13% RA loss and 0.24% LDB loss are reported when 2-tap filter is used.

This was considered in track B on Monday 25 March 2019 1720-2225, chaired by Y. Ye.

The proponent said there was no need to present the contribution.

[JVET-N0564](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6296) Crosscheck of JVET-N0397 (AHG16: Memory bandwidth reduction for small CUs) [Y. He (InterDigital)] [late]

# Encoder optimization (3)

Contributions in this category were discussed XXday XX March XXXX–XXXX (chaired by XXXqq).

[JVET-N0247](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5967) Non-CE: An improvement to hash-based motion estimation [J. Li, J. Xu, L. Zhang, K. Zhang, H. Liu, Y. Wang (Bytedance)]

Was reviewed in CE8 BoG and adopted for CTC in class F

[JVET-N0779](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6534) Crosscheck of JVET-N0247: Non-CE: An improvement to hash-based motion estimation [X. Xu (Tencent)] [late]

[JVET-N0741](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6496) AHG10: Enable Rate Control with In-Loop Reshaping [Z. Liu, Z. Chen, Y. Li (Wuhan Univ.), X. Li, S. Liu (Tencent)] [late]

In current VVC common test conditions, the newly adopted tool In-Loop Reshaping will cause a huge coding efficiency decrease when rate control is applied due to its RD cost calculation in RDO. In this contribution, some changes for the parameters used in RDO are proposed to maintain the coding performance of rate control when In-Loop Reshaping is enabled.

Obvious bug which should be corrected. Adopted in spirit. To be further handled via bug tracker.

# Metrics and evaluation criteria (X)

Contributions in this category were discussed XXday XX March XXXX–XXXX (chaired by XXXqq).

# Withdrawn (6)

JVET-N0156 Withdrawn

JVET-N0231 Withdrawn

JVET-N0244 Withdrawn

JVET-N0245 Withdrawn

JVET-N0315 Withdrawn

JVET-N0422 Withdrawn

JVET-N0431 Withdrawn

JVET-N0501 Withdrawn

JVET-N0530 Withdrawn

JVET-N0561 Withdrawn

JVET-N0633 Withdrawn

JVET-N0733 Withdrawn

JVET-N0773 Withdrawn

JVET-N0784 Withdrawn

JVET-N0858 Withdrawn

JVET-N0863 Withdrawn

JVET-N0871 Withdrawn

# Plenary meetings, joint meetings, BoG reports, and summary of actions taken

## Plenary meeting Friday 22 March 1600-1800

Reports of the tracks were presented as follows:

The general status of track A was presented and discussed.

The general status of track B was then presented and discussed, which particularly included the following aspects:

* CE2 subblock motion compensation
  + Complexity reduction: CE2 related JVET-N0266 test 2, to remove 4x4 unipred, and 4x8/8x4 bipred regular inter modes (as in HEVC) (pending text check)
  + Cleanup: Remove the use of for shared merge candidates in the regular merge list. (The text impact is a simplification and will be provided in a revision of JVET-N0266.)
  + Complexity reduction: 2-4.8b computing a bounding box and preventing affine motion from referencing outside the box by replacing the affine model with a single MV for the whole CU if the bounding box constraint is violated (with a max difference of 2 integer positions)
  + Further discussion planned: Review of test results for using shorter filters for small subblocks for regular and affine inter prediction
  + Further discussion planned: Storage reduction for subblock modes after offline study
* CE4 inter prediction and motion vector coding
  + Cleanup: Modified signalling order to assign the shortest codeword to regular merge mode among all the 5 modes of merge candidates
  + Cleanup: Remove temporal MVP merge candidate for the block size of 4xN / Nx4 and 8x8
  + Complexity reduction/cleanup: CE4-related JVET-N0340 improved triangle merge list construction
  + Further discussion planned: Simplifying MV list construction for triangle mode
* CE9 decoder MV derivation
  + Complexity reduction: CE-9-1.1a Disable 8x8/4xN CUs for DMVR
  + Complexity reduction/cleanup: Adopt CE9-2.4 Implicitly split BDOF application region along 16x16 boundaries (for VPDU principle)
* CE10 combined intra/inter prediction
  + Complexity reduction: CE10-1.1 simplification with implicit weight assignment. This includes reducing the number of CIIP modes from 4 to 1 (planar). This removes sub-block boundary filtering, since it was only used in the modes that were removed. Deblocking filtering of the CU boundary strength should be further studied. It was remarked that perhaps we should just establish the idea that all subblock boundaries and transform boundaries on the 8x8 grid should be filtered. (It was commented that there may not be a need to filter affine subblock boundaries since there should be similar motion across the boundary.)
* CE12 tile set boundary motion compensation handling
  + Further discussion: Functionality improvement: Ability to treat tile group boundaries as picture boundaries (needs text work as well as software and experiments)

## Closing Plenary meeting Wednesday 27 March

It was suggested to add SPS flags for disabling ISP, MRL, Matrix weighted intra prediction

Decision: Agreed.

## High-level syntax / systems relation meeting Saturday 23 March 0900-1230

This session, held on 23 March at 0900, was co-chaired by GJS and Youngkown Lim.

Y. Lim indicated that no real issues seemed to have arisen in the work so far. It was suggested to first review HLS BoG JVET-N0724 and then a study on an immersive media decoding interface for VVC JVET-N0831.

N0724 BoG report

The BoG met on 19 March 2019 from 17:30 to 20:00. The BoG met again on 20 March 2019 from 09:00 to 13:00. The BoG met again on 22 March 2019 from 18:15 to 21:00. The BoG planned to meet more, later in the meeting.

The BoG recommended the following:

* Adopt a Decoder Parameter Set (DPS), from JVET-N0349 and previously proposed in JVET-M0101. This is something that applies to the entire bitstream and cannot change. It expresses a worst-case capability.
  + It was mentioned that this could be used to control the number of temporal sub-layer ID bits in the NAL unit headers. Another participant said it would be best for this to signal properties only, without affecting interpretation of other data.
  + Another participant commented that, similar to the VPS in HEVC, the VPS was considered by some to be unnecessary, and suggested that it be optional. It was suggested to use the value 0 as a DPS ID to indicate that no constraints are imposed by the DPS. It was commented that parameter sets were never required to be carried in the bitstream – they could be conveyed by other means – e.g., they could be conveyed by a system or even in a document. Decision: Adopt the DPS, with this special definition of the value 0 (text to be provided).
* Adopt signalling information about long-term reference picture POC LSB in reference picture list syntax structure or collocated with corresponding long-term reference picture’s delta POC MSB related syntax elements in the tile group header, from JVET-N0100. Decision: Adopted (text in JVET-N0100).
* Adopt loop filtering disabling aross virtual boundaries, from JVET-N0438 (not necessarily aligned with tile boundaries), signalled at the SPS level, with a limit of three horizontal, three vertical, with a granularity of 8 luma samples, cutting all the way through the picture, with the minimum horizontal or vertical distance between cuts of the same type being the CTU width/height. It was asked whether this should be at the PPS level rather than the SPS level, to allow it to be used for other purposes such as gradual decoder refresh. Decision: Adopted with syntax at the PPS level (text to be provided in a revision of JVET-N0438).
* Adopt 5 new constraint flags, from JVET-N0276. [copy these in here] Decision: Adopted.
* Adopt adding a syntax element in the profile\_tier\_level( ) syntax structure for sub-profile indication, as specified by ITU-T T.35 (using exactly 3 bytes), from JVET-N0276. Decision: Adopted.

Further meetings of the BoG were expected to occur.

N0831

The contribution contained a set of presentation slides discussing an immersive media decoding interface concept for VVC.

It was described that a legacy system model is that a series of AUs of an elementary stream that conforms to a particular profile/tier/level are fed to a decoder to produce a series of presentation units.

Some systems would use multiple bitstreams – e.g., for “360° tiled video streaming” (using tiles at the system level rather than tiles within a single video stream as in HEVC) or for point cloud objects. In such a scenario, there might be more data conveyed than what is actually decoded and presented.

It was suggested to develop a generalized system decoder model, and that this might affect the NAL unit header design and independent coded picture region support.

It was noted that our constraints on the ordering of tiles in a tile group and the ordering of sending tile groups in a picture may be affected by this goal.

It remains to be determined whether the VVC spec is written in the traditional way of assuming there is a complete bitstream that covers all areas of the entire picture and the decoder consumes this entire bitstream (or at least the identified layers of that bitstream). A “bitstream extractor/merger” functionality has been assumed to be outside the scope of the video coding standard (although the video syntax may be designed with consideration of that functionality).

The HEVC has considered extraction and conformance of extracted subsets, but not multistream handling, and this will likely also be the same in VVC.

It was discussed whether it may be necessary to have special profiles for some features relating to this.

N0754 Coded picture regions BoG report

The BoG met on 20 Mar 2019 from 14:30 to 20:45.

The BoG met on 21 Mar 2019 from 9:00 to 10:00 and 4:20 PM to 9:10 PM.

The BoG met on 22 Mar 2019 from 9:00 to 13:30 and 14:45 to 16:00.

Approaches for *independently* coded picture regions can be categorized as follows:

1. Motion-constrained tile sets (MCTSs)
   * Encoding-constrained, such that encoding is constrained in a manner that a rectangular set of tile groups can be extracted and repositioned without affecting their decoding or decoding of other tile groups.
   * Independent rectangular tile groups (IRTGs): Encoding and decoding are modified to treat IRTG boundaries like picture boundaries. Implications on IRTG boundaries are handled in low-level decoding process.

Encoding-constrained and IRTG are similar except how they treat boundaries. The term MCTS is used below for this category

1. Sub-pictures (non-layer approach): Sub-pictures are treated like pictures in the low-level decoding process. Sub-pictures of the same timestamp are spatially arranged onto an output picture.
2. Independent sub-picture layers (in the sense of the way HEVC uses the term “layer”, what HEVC calls independent non-base layers): Decoded pictures of the same timestamp and of different layers (each potentially having different SPS, potentially different CTU sizes and tool enabling/disabling) could be either
   * Composed into the same output picture or
   * Output separately for use by the system for different purposes (e.g., view scalability, texture versus depth, etc.)

Decision (bug fixes): The BoG recommended, and Track B agreed, to the following:

* Adopt an inference rule for single\_tile\_per\_tile\_group\_flag syntax element when not present, from JVET-N0124 Proposal 1 (also reported in JVET-N0071).
* Adopt an inference rule for num\_tiles\_in\_tile\_group\_minus1 syntax element in tile group header from N0288 Proposal 1.

In the discussion, it was noted that there are some differences between our tile groups and HEVC MCTSs – e.g., we have a one-to-one mapping of tile groups to NAL units, whereas an HEVC MCTS has no particular relationship to NAL units.

For “sub-pictures”, it was asked whether there would be anything fundamentally different about these from the decoder perspective, versus just a grouping of tile groups (possibly as IRTGs). It was said that there is no intent to have a significant difference.

Further meetings of the BoG were expected to occur.

## Plenary meeting Sunday 24 March 0900-XXX

Track B activity since the previous plenary was summarized, with actions discussed:

* The systems discussion session described in the above section was overviewed and the actions taken in that session were noted.
* Further segmentation of subpictures/tiles: Use cases incl. 360° viewport-dependent streaming, multi-party low-delay videoconferencing, region-of-interest extraction. This should be further discussed in Track B or plenary.
* Relating to the shortcut signalling for pseudo-equal width/height of tiles (JVET-N0498), it was noted that if there is a minimum tile width/height constraint (which is something we have in HEVC), this proposal would increase the likelihood that the constraint would be violated. The prior syntax would not violate such a constraint. At the previous meeting there was a proposal that would not have that issue. This should be further discussed in Track B or plenary.

Track A discussed topics included:

* CABAC skip mode of JVET-N0207: It was reported that a mechanism to indicate that everything in the bitstream would be coded in bypass mode had been proposed. There was a substantial R-D penalty ~25% in CTC, but it was suggested that it could be useful as something equivalent to a high-throughput profile. Testing had not been done for the low QP range. It was asked whether this would be required to be supported in all decoders. It was commented 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. It was agreed to not take action in this and request it to be studied in an AHG (e.g., an expanded scope for what was the intra refresh AHG).
* In LMCS, it was commented that there is a special clipping to “standard range” in the LMCS scheme that cannot be switched off. This had not been generally known, and it was later decided in Track A to remove that special clipping case.
* The concept of having APS subtypes was discussed, so that ALF parameters and LMCS data are in not in the same syntax structure. This was said to be under discussion in the high level syntax BoG. Revisit.
* Affine linear weighted prediction – current proposal with memory requirement reduced to below 8k (about 12k if done in software, since using 10 bit data). It is not applied to chroma. For testing different variants, retraining is generally needed. (The test set was not used in the training.) The proponent offered to share the code used for training. AI benefit: 0.8% @ 138% encode time or 0.5% @ 110% encode time. RA benefit: 0.42% @ 104% encode time. No impact on decoder runtime. It was discussed whether this would interfere with NSST. Two suggestions for further work that seemed feasible included 1) reducing the bit depth of the coefficients, 2) harmonizing with the latest MPM design, 3) additional study of behaviour on HDR material, 4) considering the binarization.
* It was commented that it may be desirable to add more test sequences to AH13 studies.

Contributions on 4:4:4 and 4:2:2 coding were then discussed at 1220; see notes in section 4.4.3.

The results of the CE2 related BoG were then discussed at 1500; see the notes for JVET-N0776.

The results of the CE8 related BoG were then discussed at 1600; see the notes for JVET-N0780.

Contributions on adaptive resolution conversion were then discussed at 1715; see the notes in section 4.4.1.

## Joint meeting XXday XX March XXXX-

JVET with … .

## Closing plenary sessions

## BoGs (X)

[JVET-N0724](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6479) BoG report on general high level syntax [J. Boyce]

[Harmonize/merge with notes elsewhere – e.g., in Saturday session notes below]

[Discussed Tuesday in Room K (GJS)]

* Previously discussed:
  + Adopt a Decoder Parameter Set (DPS), from JVET-N0349 and previously proposed in JVET-M0101
  + Adopt signalling information about long-term reference picture POC LSB in reference picture list syntax structure or collocated with corresponding long-term reference picture’s delta POC MSB related syntax elements in the tile group header, from JVET-N0100
  + Adopt loop filtering disabling aross virtual boundaries, from JVET-N0438
  + Adopt 5 new constraint flags, from JVET-N0276
  + Adopt adding a syntax element in the profile\_tier\_level( ) syntax structure for sub-profile indication, as specified by ITU-T T.35.
* Adopt a NUH design which assigns a wider range of NUT values while still avoiding MPEG-2 PES start code emulation while eliminating the forbidden\_zero\_bit and recapturing the bits allocated to temporal id for NUTs which require temporal id equal to 0, from JVET-N0823. Further discussed below.
* Adopt a VUI design that contains parameters for aspect ratio, colours description, field seq flag, chroma location, overscan info, and video format and full range flag, as reflected section 4 of in a –v4 version of the document, from JVET-N0063. Decision: Adopt without the “video format” field.
* Editorial improvements to sections 8.1.1, 8.1.2, and 8.1.3 to clarify the difference between a CVS and a bitstream, from JVET-N0120. Decision: Adopt.
* Adopt syntax for conformance window, following HEVC, from JVET-N0352. Decision: Adopt.
* Adopt a CRA decoding processs with support for reference picture lists, from JVET-N0101. Decision: Adopt.
* Adopt conditional signalling of num\_ref\_idx\_active\_override\_flag, with an inference rule, Proposal 2 from N0100. Decision: Adopt.
* Adopt APS types, and define APS types for ALF parameters and LMCS (reshaper) parameters, and signal the LMCS APS\_ID in the tile group header when LMCS is enabled, from option 2 of JVET-N0805. Decision: Adopt (with a loop in the tile group header when multiple ALF APSs are used in the same tile, with the number of loop entries determined by a number minus 1 coded as ue(v))
* Adopt a GRA approach as described in JVET-N0865 v3, with the following characteristics:
  + One flag gra\_enabled\_flag in the SPS that specifies whether GRA pictures may be present or not
  + One new VCL NAL unit type, GRA\_NUT, that indicates a GRA picture
  + One syntax element, recovery\_poc\_cnt, in the tile group header that is a copy of the recovery\_poc\_cnt syntax element from the recovery point SEI of HEVC.
  + A process to start a CVS with a GRA picture similar to how a CVS is started with a CRA picture

There would be a generation of non-existing reference pictures and filling in these pictures with mid-level grey. It was commented that this would effectively prescribe a particular decoding process for the intermediate pictures prior to the recovery point. The decoder would be required to output conforming pictures that are subsequent to the recovery point. It was asked what this accomplishes that is not provided by the recovery point SEI message. This would allow the bitstream to start with a non-intra picture.

It was suggested to impose a conformance constraint that the output following the recovery point is required to be the same regardless of what the decoder uses to fill in for the motion and sample data of non-existing reference pictures. Then the decoder would not be required to use a particular method filling in the non-existing pictures. Decision: Adopted as described.

* Adopt copying the HEVC dependent random access point indication SEI message (with modifications as appropriate to adapt to VVC), from JVET-N0494. Decision: Adopt.
* Adopt restructuring of buffering period and picture timing SEI messages as proposed, except removal of bp\_seq\_parameter\_set\_id in buffering period SEI, from JVET-N0353. Decision: Adopt.
  + It was suggested to put the basic type/size for SEI in “part a” and HRD parameter SEI messages in an annex of “part a”, and other SEI messages in a separate annex or a separate document. For now we put those in a separate annex that would be likely to become a separate document later. Decision (editorial action item): Agreed.
* Adopt a starting point for HRD design as captured above, from an editorial combination of JVET-N0423 and JVET-N0350, using the most recent version of HEVC as the basis.
  + CPB and DPB
  + AU but not DU based operation
  + Filler data NUT and SEI
  + picture timing SEI and buffering period SEI
  + Sub-layer DPB parameters in SPS
  + VUI HRD parameters (exact location TBD) (revisit once N0353 is reviewed)
  + TGH pic output flag
  + TGH no\_output\_of prior\_pics\_flag for all IRAP
  + Sub-layer HRD CPB
  + Not include alternative timing at this stage (further study encouraged, especially for potential new NUTs)
  + Updated definitions in Section 3
  + Decision: Agreed – HRD to be specified in an annex of “part a”. (And early distribution of text for review was requested.)
* Adopt decoded picture hash SEI message copied from HEVC, from JVET-N0706. Decision: Agreed.
* Adopt a NUH design which assigns a wider range of NUT values while still avoiding MPEG-2 PES start code emulation while eliminating the forbidden\_zero\_bit and recapturing the bits allocated to temporal id for NUTs which require temporal id equal to 0, from either JVET-N0823 of JVET-N0067.
  + JVET-N0067 syntax is as follows (~13 reserved NUTs):

|  |  |
| --- | --- |
| nal\_unit\_header( ) { | **Descriptor** |
| **zero\_tid\_required\_flag** | u(1) |
| **nuh\_temporal\_id\_plus1** | u(3) |
| **nal\_unit\_type\_lsb** | u(4) |
| … // remaining part of the NAL unit header |  |
| } |  |

* + JVET-N0823 syntax is as follows (~40 reserved NUTs):

|  |  |
| --- | --- |
| nal\_unit\_header( ) { | **Descriptor** |
| **nuh\_first\_octet** | u(8) |
| … // remaining part of the NAL unit header |  |
| } |  |

* + where **nuh\_first\_octet** specifies the type of RBSP data structure contained in the NAL unit and a temporal identifier for the NAL unit as specified in tables.

Either approach seemed OK. It was suggested N0067 seemed more straightforward, avoiding the level of indirection for interpretation. Decision (compacting NUT fields into one byte): Adopt N0067.

* Add an editor’s note to the HRD to note the need to study to consider if there is a bug for the concatenation flag in equation C-10. Decision (editorial action item): Agreed.
* Adopt HRD parameters for temporal scalability for each AU in single picture timing SEI message, without the need for scalable nesting SEI messages, from JVET-N0867. Decision: Agreed.
* Adopt an interpretation of what dps\_id equal to 0 means, from JVET-N0869. Decision: Agreed.

[JVET-N0754](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6509) BoG Report on Coded Picture Regions [S. Deshpande (Sharp)]

[Harmonize with systems meeting notes which included a review of an earlier version of this bog report]

Discussed Tues 1500 (GJS). Some aspects had been previously discussed, as noted elsewhere.

The BoG met on 20 Mar 2019 from 14:30 to 20:45.

The BoG met on 21 Mar 2019 from 9:00 to 10:00 and 16:20 to 21:10.

The BoG met on 22 Mar 2019 from 9:00 to 13:30 and 14:45 to 16:00.

The BoG met on 24 Mar 2019 from 10:40 to 12:30.

The BoG met on 25 March 2019 from 18:00 to 22:15.

The BoG met on 26 March 2019 from 19:30 to 22:15.

Approaches for independently coded picture regions are categorized as follows:

* Motion-constrained tile sets (MCTSs): Encoding is constrained in a manner that a rectangular set of tile groups can be extracted and repositioned without affecting their decoding or decoding of other tile groups.

Independent rectangular tile groups (IRTGs): Encoding and decoding are modified to treat IRTG boundaries like picture boundaries. Implications on IRTG boundaries are handled in low-level decoding process.

MCTS and IRTG are similar except how they treat boundaries. The term MCTS is used below for this category

* Sub-pictures (non-layer approach): Sub pictures are treated like pictures in the low-level decoding process. Sub-pictures of the same timestamp are spatially arranged onto an output picture.
* Independent sub-picture layers: It can be controlled if decoded pictures of the same timestamp and of different layers are composed onto the same output picture or output separately.

The BoG recommends the following:

* Adopt an inference rule for single\_tile\_per\_tile\_group\_flag syntax element when not present, from JVET-N0124 Proposal 1.

Previously reported; see notes elsewhere.

* Adopt an inference rule for num\_tiles\_in\_tile\_group\_minus1 syntax element in tile group header from N0288 Proposal 1.

Previously reported; see notes elsewhere.

* The BoG recommended Track/Plenary discussion on whether WPP in a form affecting the decoding process is included in the VVC design.
  + It was asked how the experience had been with WPP in HEVC. It was commented that it had been designed well in terms of avoiding significant difficulty of implementation. It was commented that WPP had been used substantially in the market, especially for software encoders and decoders, while others said it had not been necessary and that there were other ways to achieve parallelism. It was asked whether its use in the bitstream should have been mandatory. It was said that it was appropriate that it was not mandatory to be enabled. Decision (parallelism): Include WPP. Whether to prohibit some combination with tiles or not is for further study.
  + If the WPP feature is included in VVC, the BoG recommends adoption of JVET-N0150 (option 1). HEVC has a 2-CTU lag, and this proposal shows 0.2% penalty relative to a 2-CTU lag and 1% penalty relative to not using WPP. If the CTU size is smaller, the penalty relative to a 2-CTU lag was reported to be about 0.6%. It would be possible to have both the 1-CTU lag and 2-CTU lag schemes in the design, but others suggested just having the 1-CTU lag schme. With the larger CTU size of VVC relative to HEVC, it seems important to minimize the lag in units of CTUs. Decision: Adopt (option 1).
  + If the WPP feature is included in VVC, the BoG recommends adoption of JVET-N0149. Text is provided in v3. It is proposed to allow WPP to be switched on and off on a per-tile-group basis for rectangular tile groups, motivated by the desire for extraction and merging of content from different encoders. For raster scan tile groups, the flag would not be sent. It was commented that this issue is not unique to WPP – every coding option that can be enabled or disabled at level higher than the tile group level in a way that affects the decoding process. Further study is needed to determine how we will approach this issue in general. It was commented that it is not uncommon for there to need to be some high degree of control over what an encoder will do when operating in a mix/extract system environment. For WPP, the proponent suggested that an encoder might want to enable WPP on large tiles and disable it on smaller ones.
* BoG recommends to adopt from N0852 the change in constraints as described as a more accurate representation of the Marrakech meeting notes. This had become obsolete based on other decisions of this meeting.
* The BoG recommends adoption of a layer concept without inter-layer referencing in N0278-v3 with following changes: Constraint flags are: optional in VPS and retain it as mandatory in SPS as in current VVC WD
* Decision (functionality): Adopt. Software (not necessarily merged into the main branch) is to be made available by J. Boyce within one month).
* VPS presence optional; the target layer is the first layer in the bitstream if the VPS is not present.
* Aspects agreed for further study:
* Parameter set sharing across layers.
* HRD parameters signalling and HRD model
* BoG recommended adoption of N0857 as an implementation of a “design in principle” which was agreed in Track B as noted in the main meeting notes.
  + It was noted that software for this had not been implemented, although the software actually supports slices, which are a superset of the functionality.
  + Regarding uniform spacing, it should work the same way for tiles widths and heights and for brick heights. The issue raised in the plenary was further discussed and agreed not to be so relevant, and typically a system would want widths and heights to be exactly equal as much as possible. It was confirmed that the approach of N0498 would be applied. Each tile will have a flag for whether it is decomposed into bricks and if so, there would then be a flag for uniformity, and if so, one height (minus 1) would be sent. If not , the number of bricks (minus 2) and then N-1 heights (minus 1) would be sent. Decision (more typical as default): Adopted as described.
  + Decision (functionality): Adopt. Software (not necessarily merged into the main branch) is to be made available by K. Suehring within one month).

Further BoG meeting was held Tuesday evening in K.

Discussed in plenary Wed ~1000 (GJS & JRO).

BoG recommends to adopt proposal 2 of N0124, to modify to signal the bottom right tile index as a delta from top left tile index. Decision: Adopted.

BoG recommends adoption of option 1 of N0047 with modifications which allow signalling reference picture lists for IDR pictures controlled by a SPS level flag. It was said that this is the same as BLA, just using the IDR NUT value. Decision: Adopted.

[JVET-N0776](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6531) BoG Report on CE2-related Subblock Motion Compensation Contributions [C.-C. Chen, Y. He]

This was reviewed in plenary Sunday 24 March 1500 (GJS & JRO)

The sessions were held 1915~2345 on March 20 and 1430~1600 on March 21 for discussing 15 technical contributions in 4 categories:

* Shared merging candidate list region for sub-block merge modes (1)
* Memory bandwidth and complexity reduction (3)
* Affine motion compensation (10)
* Storage reduction for sub-block modes (1)

The BoG recommended, and JVET agreed, to adopt the following.

JVET-N0481 (Method 3): BCW index inheritance for constructed affine merge candidate

Divide BCW index into groups of {0}, {1, 2, 3} and {4}. If all the BCW indices are from the same group, method 1 will be used; otherwise, the default BCW index will be set. (Method 1: if at least 2 out of the 3 CPMVs (top-left, top-right and bottom-left) are sharing the same BCW index, this BCW index will be set to all three CPMVs; otherwise, default BCW index will be set).

The motivation is consistency between inherited affine merge and constructed affine merge. This has basically no effect on coding performance or runtime.

Decision (cleanup): Adopted.

The BoG recommended CE investigation of the following:

* JVET-N0236: Prediction refinement with optical flow for affine mode test 1 (~0.48% with 103% encoding time) and test 2 (8x8 affine for biprediction subblock)
  + It was clarified in the plenary that test 2 was the intended variant, not test 5
* JVET-N0273: Affine motion compensation using 2x2 subblocks for uniprediction, while keeping within a bounding box (~0.34%)
* JVET-N0399: Simplifications of interweaved affine mode (said to make the scheme operation more similar to ordinary biprediction)
* JVET-N0504: Simplification of 2x2 sub-block based affine motion compensation (a simplification relative to N0236)
  + It was clarified in the plenary that this refers only to the 2x2 part of the proposal, not padding.
* JVET-N0510: Phase-variant affine subblock motion compensation (~0.33% estimated benefit with 101% encoding time.

In the plenary review, it was agreed not to test the 2x2 method of JVET-N0273, due to complexity concerns.

Additional items in the BoG report and CE category were reviewed in track B on Monday 25 March 2019 1720-2225, chaired by Y. Ye.

The BoG requested the following revisits.

* JVET-N0737: Combination of affine MV clip (CE2-4.4 in JVET-N0398) and prediction refinement with optical flow (JVET-N0236)
  + Combination of Affine MV clipping (CE2-4.4 in JVET-N0398) and optical-flow based refinement (JVET-N0236). (-0.35% for RA with Tx=Ty=0)
  + Revisit to determine whether this proposal can be considered for further study in a CE.

The proponent mentioned that the main benefit of this proposal was to facilitate SIMD for 8x4 blocks in software implementation. From further discussion in track B, the first 4x4 samples in the 8x4 blocks and the second 4x4 samples in the 8x4 blocks can share the same samples fetched from the same integer positions, which can be loaded together, but the phase filters used for these two 4x4 blocks are not necessarily the same.

Further study encouraged.

* JVET-N0752: Supplementary results for CE2-5.5.c
  + Test 1: At most 2 merge candidates can be inherited from the history table or neighbouring blocks. (-0.04% for RA)
  + Test 2: 5 affine constructed merge candidates are removed. (-0.01% for RA)

Introduces 3 new potential candidates with removing 5 constructed candidates, so the total potential candidate is reduced from 8 to 6.

Revisit for reviewing the supplemental results with CE2-5.5c (i.e. Parameter-based HMVP affine candidates + Replace spatial affine inheritance by affine HMVP + Affine inheritance from line buffer).

In further discussion in track B:

CE2-5.5c uses 3 more affine merge candidates than the anchor, and because of the additional candidates CE2-5.5c performs 5+6 additional checks. In N0752, further tests were performed without using more affine merge candidates than the anchor.

Test 1 in N0752 uses the same number of candidates as anchor and performs 2+6 checks.

Test 2 uses one candidate less than the anchor, and performs 5+1 checks.

The original motivation of CE2-5.5c and N0752 is to reduce storage for CPMVs used in affine inheritance. In track B discussion, it was agreed that the storage reduction does not seem to be critical for hardware implementation.

The proponent suggested to consider N0752 test 1 in the context of CE revisit discussion. See notes in the section on CE2-5.

* JVET-N0268: Remove above-left affine inherited motion vector predictor and inter merge mode
  + (Test 1) 0.01% for RA and -0.03% for LB; (Test 2) 0.03% for RA and -0.01% for LDB
  + Revisit: how much the memory storage saving in the proposed method in Track B.

In track B discussion, there are two tests in N0268:

* Test 1 proposes to remove above-left affine inherited motion vector predictor from affine inheritance.
* Test 2 additionally proposes to remove above-left motion vector predictor in regular inter merge mode.

This is said to reduce the storage of some MVs. It was agreed that the benefit of such reduction is not sufficient to take action.

No action was taken on this.

[JVET-N0780](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6535) BoG report on CE8-related contributions and updates for screen content CTC [X. Xu, Y.-C. Sun]

Initially reviewed in plenary Sunday 24 March 1600 (GJS & JRO), further review Monday 25 1640-2030 in Track A (chaired by JRO)

The mandates of this BoG are 1) to make an initial review of CE related contributions and identify the aspects to be investigated in the upcoming CE. 2) discuss possible updates on screen content CTC.

There are 82 technical contributions in the CE-8 related category (some of them are cross-check reports). These contributions are classified into the following 5 categories:

* IBC (47)
* Palette (9)
* BDPCM (3)
* Transform skip (14)
* Others (7)
* Screen content test materials (2).

BoG sessions were held:

* 20:30 – 22:30 on 03/21 in Room H1;
* 13:00 –16:00 on 03/22 in Room A;
* 9:00–12:30 on 03/23 in Room H2;
* 15:00–17:00 on 03/23 in Room H2.

Section 1 of this document summarizes the BoG’s recommendations. Section 2 of this document contains detailed notes of BoG discussion. Section 3 of this document contains BoG discussion of input test materials and class F updates.

The BoG recommended the following adoptions:

* JVET-N0175 M1/JVET-N0251/JVET- N0384 M2, increase IBC range for small CTUs (Bug fix, 13.4% gain TGM AI in non-CTC with 64x64 CTU): Decision (coding efficiency): Adopt as recommended.
* JVET-N0316: default IBC compensation using value of 1<<(bitdepth - 1) when 0 vector is detected (Design consideration). Was further discussed in Track A Mon. afternoon. The bitstream restriction of not sending a merge index or whatever points to the current block should be easy described. The 0,0 vector case does not seem to be the most complicated one among other possibilities where an encoder would generate a bitstream withinvalid vectors. Therefore, the problem should be further investigated in a CE which is planned. There are other solutions to the case of invalid vectors, such as clipping, etc.
* JVET-N0317: put (0,0) vector as default vector in merge list to make spec complete (Bug fix). Decision (BF): Adopt JVET-N0317. The corresponding bitstream restriction is already in the spec.
* JVET-N0383/JVET-N0251: IBC search range constraint to avoid reading/writing memory conflict (Bug fix). This bug fix was previously adopted in the opening plenary. Decision: Adopt JVET-N0383 (which is identical with one of the aspects of JVET-N0251).
* JVET-N0413: BDPCM applied in quantized residual domain (2.1% TGM AI gain over CE8-4.4a). .This is better harmonized with the conventional intra prediction than the BDPCM from CE8-3/5. First, the whole block residual is computed (only horizontal/vertical), and then the residuals are predicted line by line or column by column. At the decoder, the reconstruction of the block residual could be seen as a replacement of the transform step which is operated between entropy decoding and intra reconstruction (only additions). Furthermore, the block does not need to be subdivided into two parts as in the CE8-3 proposal, such that the performance is slightly better. In terms of additional specification text, it is simple and straightforward. Decision: Adopt JVET-N0413. It is noted that the second part of the document “Transform skip residual coding modification for BDPCM” is not adopted, and also not incuded in the WD text v3. The text may need some more checking e.g. for removing remainders from the previous BDPCM design such as “bdpcm\_cbf\_flag”.
* JVET-N0260: Disable fractional search refinement part in DMVR from tile group header (complexity reduction). It was commented that DMVR could just be disabled if the goal is to reduce its complexity. This was further discussed in Track A, but it was found to be not well motivated. Screen content motion is probably often full-pel, but the saving of rate by disabling fractional pel in such cases is due to the lower rate for MVs. DMVR does not cause any rate overhead, and the proposal also does not show any BD rate difference.

Recommended adoptions to VTM, endorsed by plenary. Decision (SW-NN):

* JVET-N0247: Hash based ME improvement (0.65%/1.4% gain RA/LB for TGM).
* JVET-N0251: encoder only improvement for IBC, increase search range (0.2%/0.8% gain in AI/RA for TGM)
* JVET-N0318: encoder only improvement for IBC, increase block sizes (0.8% TGM AI gain)
* JVET-N0329: encoder only improvement for IBC, by more predictors, SAD/SATD evaluation and bug fixes (1.3% TGM AI gain).

Common test conditions:

* JVET-N0386: AOV (a gaming sequence more similar to camera video in its coding characteristics) in 4:4:4 format (for 4:4:4 support);
* Section 3 discussion: replace class F with 4:2:0 versions of AOV and 4 TGM sequences (for CTC updates) Decision (CTC): Agreed. [Replaced by closing discussion for N1010]

Decision: Test sequences for 4:4:4 should be as per SCM CTC 4:4:4 plus AOV 4:4:4 (in the animation category). YUV only as CTC (for now; RGB results encouraged but not mandatory as CTC). [Harmonize with closing discussion for N1010]

We should continue to look for more variety of material and high-res screen content.

Options available might be Blender sequences (Sintel, CosmoLaundromat, better not BBB), or also some sequences from the 3D testsets (Undo Dancer, GT Fly, Sharks), Netflix – not clear if 4:4:4 versions of all those are available.

Further discuss the recommendations for CE and items requested in the BoG report for further discussion.

The following contributions were suggested for CE:

* JVET-N0095/JVET-N0289: on MVD/BVD unified coding (1.4% TGM AI gain)
* JVET-N0201/JVET-N0316: default IBC compensation mode in case of invalid vector (Design consideration)
* JVET-N0459: BVD binarization changes (1.1% TGM AI gain)
* JVET-N0316/JVET-N0466: subblock BV vs. CU based BV (Complexity reduction)
* JVET-N0472: IBC reference memory size reduction (Complexity reduction) -> should also be investigated in low QP range
* JVET-N0258: PLT mode flag signaling changes, this is a bug fix to be included into basic PLT software of CE (0.4% TGM AI gain) PLT is still signalled when IBC is used.
* JVET-N0259: PLT and IBC combination (1.0% TGM AI gain)
* JVET-N0550: CG (per 16 samples) based PLT mode (Complexity reduction)
* JVET-N0366: Syntax arrangement and context change for TS coding (0.4% TGM AI gain)
* JVET-N0094: Context modelling of transform skip mode (2.1% TGM AI gain, over VTM-4.0)
* JVET-N0357: Context Modelling of Sign for TS Residual Coding (0.2%~0.3% TGM AI gain) – it is noted that this gain may not be too exciting for adding complexity
* JVET-N0401/JVET-N0475: TS enabling for ISP mode (0.5% TGM AI gain, over VTM-4.0)
* JVET-N0455: simplification of TS mode (0.5% TGM AI gain)
* JVET-N0337: Disabling intra sample interpolation for SCC at tile group level (0.4% TGM AI gain) – it is noted that this would require a very low level change in the intra prediction stage which should be sufficiently justified, and 0.4% in TGM does not sound exciting. As a general comment, disabling tools at tile group level might already be useless for mixed content

It was further mentioned during the track A discussion whether proposals that would change the shape of the available reference area should be evaluated. In the last meeting, the current arrangement was adopted because it was asserted being a good compromise between compression performance and necessary checking for availability. We would rather seek for more simple solutions, in particular with regard to the bitstream conformance checking at encoder, or corresponding availability checking at the decoder.

It is suggested to move the aspects related to TS coding aspects to CE7. TS with ISP stays in CE8.

Open issues from BoG and further clarification in plenary

* JVET-N0346: PLT in 4:4:4 -> put this into the HEVC-style base PLT mode for 4:4:4 test.
* JVET-N0853 is an extension of the CE8-2.2c method to 4:4:4 that should also be investigated in the CE
* JVET-N0405: on PLT implementation simplification – probably interesting (no loss in compression), but seems rather to be at the level of fine-tuning which could be done once a decision about a basic design on palette was made.
* JVET-N0318/JVET-N0467: explicitly use syntax constraint for disabling 128x128 IBC mode, on top of the current bitstream constraint. Decision: Adopt this aspect, make presence of IBC flag dependent on CU size < 128x128
* JVET-N0123: Chroma TS mode in the context of 4:4:4 -> test in CE8
* JVET-N0093/JVET-N0174: Disallowing coexistence of regular merge and IBC merge in SMR – the problem does not exist any more since inter 4x4 blocks and merge list sharing in inter does not exist.
* JVET-N0843: combination of JVET-N0176/JVET-N0317/JVET-N0382, on simplification of block vector prediction. Consider adoption pending the combined results. It is agreed in Track A that this is a desirable simplification, the loss in compression is comparably low (0.15% in TGM AI), and the spec text is significantly shortened. Decision: Adopt JVET-N0843 Test1 option 1 (B. Bross had later confirmed that option 1 is the simpler solution.)

[JVET-N0809](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6564) BoG report on CE4 inter prediction and motion vector coding related contributions [H. Yang]

Discussed in Track B Monday 25 March 1045 (GJS)

Two sessions of BoG meeting were held, first one from 1615 to 2230 on Mar. 21, and second one from 0915 to 1515 on Mar. 22. 44 contributions have been reviewed.

JVET-N0334, JVET-N0335, JVET-N0336 and JVET-N0235 were identified as appropriate to be discussed in CE4 BoG by proponents, though not marked clearly in the title.

JVET-N0086 was identified to be more closely related CE9 during the discussion, and was recommended to be reviewed in CE9 BoG.

Normative changes:

* N0085/N0335: unified MV rounding by setting the rounding offset to (1 << (shift – 1)) − 1 for rounding applied to an absolute value, to round toward zero.
  + Notes of Track B review:
    - At the Macao meeting, based on JVET-L0377 we made the software match the text by rounding toward zero rather than toward minus infinity (at least for AMVR).
    - Then at the Marrakech meeting, based on JVET-M0265, we tried to consistently apply rounding away from zero.
      * Offset = 1 << (F-1);
      * M= S >= 0 ? (S + Offset) >> F: -((-S + Offset) >> F).
    - It was said that for deriving chroma vectors from luma vectors, it is necessary to round toward negative infinity for IBC to avoid a range problem. This is an exception.
    - For temporal scaling in HEVC, it was said that we rounded toward zero. Some (tiny) gain was shown for doing that.
    - Decision (consistency): Round MVs toward zero for MV rounding (incl. temporal scaling and spatial neighbour MV scaling and other cases if applicable). Use the software variation from M0335.
* N0127: MMVD enabling signalling in SPS.
  + Decision (bug fix of basic intent): Adopted
* N0265: simplification of HMVP candidate derivation in AMVP list construction, POC checking in HMVP table is replaced by reference index checking. This removes some compares, since it replaces a series of checks with one check. It was commented that there would be a coding performance loss for this and would be inconsistent with how other AMVP candidates are checked and is not in the critical path. In the low delay case with lower QP this was said to have a loss relating to the same picture being in both lists (about 0.1% for camera content and more for some screen content). No action was taken on this.
* N0267/N0385/N0486: single HMVP table for all CUs inside the shared merge list region for IBC. No update of the table within the share merge list region. This saves some repeated updating that seems to provide no benefit. Currently, we update the history always for non-subblock modes. At this meeting, as a consequence of removal of 4x4 inter CUs, we removed shared merge lists for inter, so we now have it only for IBC. It was suggested that removing shared merge lists or doing what is proposed here could be studied in a next round of CE8.
* N0286: by-pass coding of bins except for the first bin in BCW index coding. No loss was observed. Decision (cleanup): Adopted.
* N0332: disable MVD scaling for MMVD in case LTRP is used. Decision (bug fix): Adopt.
* N0334: MV clipping for MMVD, DMVR and CPMV of constructed affine merge candidadates. Decision (bug fix): Adopt.
* N0448/N0380: implicitly infer the number of MMVD base merge candidate to be 1 as MaxNumMergeCand being equal to 1. mmvd\_merge\_flag is not signalled in this case. Decision (bug fix): Adopt.
* N0483: disable sub-block transform when triangle mode is used. This was based on the assertion that this combination is basically never used and could create visual artefact if it is used. Decision (cleanup): Adopt.

SW change

* N0449: adopt the encoder speed up for MMVD, by reducing the number of offsets from 8 to 6. Add an encoder parameter to control. This saves about 2% encoder runtime for LB. This was neutral to beneficial in coding performance. Decision (SW-NN): Adopt (and use in CTC).
* N0462: Decision (SW bug fix): change the software to match the text for the context modeling of inter\_pred\_idc (different from what was recommended).

Decision (non-normative bug fixes):

* N0168: bugfix of cost calculation in AMVR mode.
* N0334: align with the text on MV wrap around for regular inter mode and affine inter mode.

A CE4 test was agreed to be planned from following contributions

* N0309: Adding half pel mode to AMVR (the current design does not have a half-pel case with AMVR mode) and select a switched half-pel interpolation filter (one or two alternative filters). As tested thus far, this provided 0.3% gain for 10% runtime increase, but this was not with an optimized encoder search technique. It was noted that there is a trick for applying the interpolation filter in HEVC to keep the dynamic range within 16 bits for processing data with a bit depth up to 12 bits. Filters that would need a different implementation technique than this would be less desirable. It was asked whether this would cause visual blurriness.

Topics requested for further discussion:

* For resolving a previous discussion in the CE, it was said that 4-1.5b and 4-1.5c have some interaction with work to simplify the MV list construction for triangle mode, since some of these are based on trying to use a similar process as in regular merge list construction with spatial and TMVP candidates.
  + N0213 was discussed in the BoG, proposing to remove TMVP candidates in the list construction of both merge and AMVP. This was suggested to be considered with CE4.1.5, when additional simulation results were available.
  + 4-1.5b and 4-15c were tested in combination with N0340. A small coding loss of about 0.09% was observed with the combination in LB configuration. There was no impact on the RA case. 4-1.5a has no interaction with N0340. It was suggested to apply 4-1.5a. It was also suggested to consider N0213, which includes CE4-1.5a and also removes TMVP from the AMVP list for 4x8 and 8x4. Decision (complexity reduction): Adopt N0213 test D (removing TMVP from merge and AMVP list for 4x8 and 8x4 CUs).
* N0240: conversion of bi-prediction motion to uni-prediction motion before MVD derivation in MMVD for small blocks. This was said to remove some redundant operations – saving one scaling and some adds/subtracts and shifts and clipping. It had been requested for text to be provided. The text impact was minor – just moving something from one place to another. The benefit for this was very small. There were mixed opinions, with some believing this was more logical and some saying it there was no need to change what was there. There was some (small) loss for luma in LB configuration – about 0.05%. No action was taken on this.
* N0235: discuss whether parsing CU level syntax depends on the constructed reference picture list is a real problem or not in track. This was not considered a real problem – although it might be nice to editorially move the necessary parts of RPL derivation to avoid having the parsing process depend on the semantics/parsing process. Another aspect of N0235 was to add an SPS-level flag to turn on and off symmetric MVD – a feature with about 0.25% coding gain and 3% encoder runtime increase. Decision: Add such a flag (and the lower level syntax presence should be gated by the flag).
* N0447/N400/N500/N0851: harmonized design of triangle merge candidate number and regular merge candidate number.
  + It was agreed that the other actions taken at this meeting would break the syntax design; a partial fix was proposed and agreed as in section 2 of N0851 (also in some others). Decision: Adopted this aspect.
  + There were opinions about refining other aspects, but the action taken seems adequate to fix the basic problem. Further refinements may be considered in further study (not in a CE, since an experiment probably wouldn’t show any meaningful difference in coding effects).

[JVET-N0815](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6570) BoG report on CE9 related contributions [S. Esenlik]

This was reviewed on Monday 25 March 2019 1720-2225, chaired by Y. Ye.

The BoG met in 3 sessions to discuss CE9 (decoder motion vector derivation) related contributions. The first session was held on 21 Mar 2019 from 20:00 to 22:45. The second session was held on 22 Mar 2019 from 18:15 to 22:30. The third session was held on 23 Mar 2019 from 10:45 to 12:00.

The CE9-related BoG recommend the following adoptions:

* JVET-N0146 Non-CE9: On conditions for DMVR and BDOF

This contribution proposes when any of BCW and weighted prediction are applied, DMVR and BDOF are both disabled.

On average no loss is observed, with 1% decoding time reduction.

On sequence basis, the maximum luma coding loss is 0.07% (daylightroad sequence). Slideshow sequence shows 0.34% luma coding gain.

For the BDOF part, the contribution proposes to align the specification draft text with the VTM software. It was confirmed during the track B discussion that the VTM 4.0 software is already disabling the BDOF when either BCW or weighted prediction is on. Decision (cleanup): change the spec to match that of the VTM software.

For the DMVR part, the motivation is alignment with BDOF. In the DMVR part both software and the spec text is recommended to be changed. In track B discussion, it was agreed that DMVR should be aligned with BDOF. Decision (cleanup): change the spec and the software as proposed.

The contributions proposing the same modification are: JVET-N0153, JVET-N0442, JVET-N0162, JVET-N0262, JVET-N0440 and JVET-N0086.

It was asked if all these contributions used the same software implementation. It was commented that all software implemention seem to produce very similar results, and that the suggested changes are simple.

Decision (SW): use the N0146 software implementation.

* JVET-N0325 CE9-related: Improvements on bi-directional optical flow (BDOF)

The contribution proposes to use fixed precision for BDOF calculations (gradient and flow), irrespective of internal bit-depth (8-12 bits). The fixed precision is the one used for 8-bit sequences.

In the 12-bit coding case 0.17% luma coding gain without increasing encoding and decoding times.

It is asserted that 32-bit precision condition is still kept.

For 10-bit coding (CTC): {Y, U, V} BD-rate of {-0.01%, -0.01%, -0.03%}, Enc: 102%, Dec: 101%;

For 8-bit: coding: {Y, U, V} BD-rate of { 0.00%, 0.00%, 0.00%}, Enc: 100%, Dec: 100%;

For 12-bit coding: {Y, U, V} BD-rate of {-0.17%, -0.10%, -0.09%}, Enc: 100%, Dec: 100%.

A crosschecker confirmed the software and the spec., and the crosscheck document had been uploaded as JVET-N0618.

In track B discussion, it was asked why this proposal has coding performance improvement. The proponent commented that the gain comes from redistributing the precision between gradient and sample values such that the sample values get more precision for higher bit-depth video.

The proposal changes some shift values in BDOF calculation from bit-depth dependent values to fixed values. It was asked whether this might produce an overflow situation for other bit-depth video, and it was commented that during BoG discussion, this aspect was checked and it was confirmed that for 8- to 12-bit video, there is no such overflow.

However, upon reviewing the proposed spec text change, it was commented that having the shift operations use fixed values instead of bit-depth-dependent values might “break” the text for bit-depths other than 8- to 12-bit.

The proponent was asked to upload revised specification text changes to only apply the proposed changes to 8- to 12-bit video.

This was discussed again just before the closing of the meeting, while the group was being requested to leave the room. The meeting had run past the pre-arranged hours of the meeting facility. The requested text had been provided and had been checked and confirmed to be correct by an interested leading non-proponent. However, an author of a different approach objected to proceeding with adoption, saying that something was wrong with this approach, although no clear indication of a problem was evident to others. The group considered extending the meeting further into the evening by having everyone move to another meeting room in a different building, but the overwhelming view of the group was that the meeting needed to be closed and any concerns about the adoption should be deferred for further study.

Decision (cleanup): Adopted the N0325 approach.

* JVET-N0444 Non-CE9: Mismatch beween test specification and reference software on BDOF and DMVR

This contribution is about text and software cleanup, to achieve alignment of BDOF conditions with contribution JVET-N0266 (disabling 4x8,8x4 bi-prediction), which is adopted recently.

Software: the block size condition for BDOF need to be modified. This change should be taken into consideration during integration of JVET-N0266.

Text: the modification in the text suggests to remove the “cbWidth x cbHeight>=64” condition, since this is not necessary anymore after adoption of JVET-N0266. This also needs to be taken into consideration during integration of JVET-N0266.

During track discussion, it was commented that the proposal produces bit-exact results as N0266. Due to N0266 adoption, all bi-predicted blocks must be at least 8x8. In VTM 4.0, after checking bi-prediction condition, block size is further checked using two conditions to determine if BDOF is applied: 1) block height is not equal to 4; 2) block size is not equal to 4x8. Due to the adoption of N0266, the second block size check (i.e. block size is not equal to 4x8) could be removed from the next VTM software version. The suggested software change will be delegated to the software coordinators.

It was confirmed the VVC draft 4 currently does not have block size condition checks when invoking BDOF, it is suggested to add the condition check of block height is not equal to 4 to the spec text to reflect the design intention and match the VTM software.

Decision (bug fix): add the suggested condition check into the draft text

The BoG recommends the following for further study in CE:

* JVET-N0097 CE9-related: Simplification of cascading DMVR and BDOF processes

2-stage early termination of BDOF is replaced by one-stage, where SAD is calculated 16x16 blocks. Same as DMVR.

Additionally the BDOF reuses the SAD cost calculated in DMVR.

No change (-0.01% luma gain) in BD-rate performance.

* JVET-N0148 CE9-related: Early termination for BDOF

Second test in contribution:

BDOF reuses SAD cost function of DMVR for early termination. Disable early termination of BDOF (completely). The SAD based early termination is disabled even if DMVR is not applied.

0.02% luma coding gain is reported with same encoding and decoding time.

Recommendation to study the second test in CE.

* JVET-N0158 CE9-related: Alternative method of SAD based early termination for BDOF

This contribution is similar to second test of JVET-N0148. The difference is only the threshold of early termination that is used.

It is reported to have: 0.01%luma coding loss with 2% reduction in decoding time.

* JVET-N0296 CE9-related: DMVR costs based early termination for BDOF in CE9-2.6

If DMVR and BDOF are applied together, SAD cost of DMVR is used for BDOF early termination.

A derived cost is calculated which is different from other proposals.

The results are shown on top of CE9-2.6.

2 stage early termination is removed.

* JVET-N0507 CE9-related: Early termination of BDOF with DMVR cost

Proposes to reuse the SAD cost calculated in DMVR for early termination of BDOF. There is a scaling (by a factor of 16) for threshold comparison.

Test 1: if DMVR is disabled original early termination of BDOF if used. If DMVR on, BDOF uses SAD cost of DMVR. 0.02% degradation in luma BD-rate.

Test2: in addition to test 1, if DMVR is disabled, no early termination for BDOF is applied. No BD-rate impact, 1% decoding time reduction.

Recommended to test both test 1 and test 2 in CE.

During discussion in track B about N0097, N0148, N0158, N0296, and N0507, it was noted that all these proposals are about using the SAD calculated in DMVR stage to early terminate BDOF.

It was commented that the early termination topic was discussed when CE9-2.4 (JVET-N0178) was discussed earlier in track B. It was questioned if such a CE was necessary. It was mentioned that N0148 might be a favorable choice for adoption because it uses the DMVR SAD for BDOF early termination if BDOF is applied on top of DMVR; otherwise, if BDOF is applied by itself, the early termination is simply removed.

It was commented that N0158 is the same as N0148 except that the threshold used to early terminate the BDOF process after DMVR is slightly different.

In terms of performance,

N0148: -0.02%, same encoding/decoding time

N0158: 0.01%, same encoding time, 2% reduction in decoding time

It was commented that other proposals are similar in spirit, and it might be the best to test all methods in a CE.

Further study in CE.

* JVET-N0145 Non-CE9: Harmonization of DMVR and MMVD

-0.10 % coding gain in RA under CTC. 6% increase in encoding time.

DMVR is applied on MMVD with selection threshold (set to 2).

In track B discussion, it was commented that the gain was somewhat small, and the increase in encoding time and potentially increase in decoding time (since DMVR may be applied on MMVD conditionally) may not be desirable.

It was reported that the class A1/A2 gains are -0.09% and -0.27% respectively, showing higher potential for UHD sequences.

Further study in CE.

The BoG requests to revisit in track B the following proposal:

* JVET-N0162 CE9-related: Modified enabling condition for DMVR

Second part of this proposal is related to POC based enabling condition of BDOF. It proposes to only invoke the BDOF if the two reference pictures are at equal distance to the current picture. The same condition (of equal POC distance) is applied to DMVR.

0.01% luma coding loss for RA configuration. Reported decoding time might not be reliable. 1% decoding times increase is reported.

Proponents are asked to report number of samples processed by BDOF before and after this modification (similar to AHG 13). The crosscheck results to be updated by that time to measure decoding time.

In track B discussion, the cross check document was confirmed to have been uploaded as N0692. The cross check reported 1% decoding time reduction.

The proponent reported that samples processed by BDOF is 3% lower than that of anchor. In AHG13 report, BDOF sample usage was reported to be 44%.

The performance difference does not seem to justify action.

No action was taken on this.

The track B discussed a specific division operation in the spec text (section 8.5.3.5. Parametric motion vector refinement process). In the spec text, there is a note describing that this division can be implemented as shifts and bit masks. The software is currently using shifts and bit masks. It was suggested to change the text to match the software. It was suggested that this change is mathematically equivalent.

It was requested by some experts to see the suggested spec change. S. Sethuraman uploaded a late contribution N0868 and attached the suggested text change.

Editor action item: Consider this for potential editorial improvement.

[JVET-N0838](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6593) BoG report on intra prediction and mode coding (CE3-related) [G. Van der Auwera] [late]

(perhaps move the docs that were presented in track A to the corresponding section)

Reviewed in Track A (chaired by JRO) Sat 03-23 1530-1945

The BoG reviewed proposals related to the intra prediction and mode coding topic (CE3-related). In this report, recommendations are included for the creation of CE3-subtests, a list of proposals to be further presented and reviewed in track A, including recommendations for adoption of proposals.

The BoG recommendation was to continue CE3-subtest on MPM list harmonization with following proposals:

* JVET-N0170: “Explicitly signal non angular modes”
* JVET-N0185 (presentation requested in track A): “Unified MPM list for intra mode coding”

On the harmonization issue, JVET-N0185 was presented in Track A Saturday 03-23 15:55. The proposal now includes planar and DC for ISP and MRL list construction. This is the best harmonized solution in terms of the MPM list construction (identical processes). It is based on the MPM list construction of the regular mode, but codes the first bin (which is planar) with context. Exactly the same MPM list is applied to ISP and MRL, which can now both use both DC and planar. This was already available in software, but disabled. The draft text currently does not specify usage of DC with ISP, and does not specify usage of DC and planar with MRL. This should however not be difficult to add, and would allow to completely remove two out of the three MPM list construction processes. Performance difference is negligible.

Different from the proposal, it is suggested to remove the planar mode from the MPM list and code it as a separate context-coded flag before the MPM list (with the 5 remaining entries, all bypass coded). This is purely editorial, no change in the bitstream. It is further suggested to run an experiment during the meeting to identify if it would be beneficial to make that planar flag dependent on the MRL mode, refindexline=0. Results on that were presented by F. Bossen Tue 26 13:00 which indicated that results are almost identical for cases where MRL is allowing or not allowing planar mode for lines 1 or 3. As requiring planar mode for MRL would mean that it introduces need for additional conformance checks, the method without planar mode for MRL seems preferable.Decision: Adopt JVET-N0185, with modification such that a planar mode flag (context coded as the first bin for MPM0 was suggested in N0185) is introduced hich goes ahead the 5 MPM signaling (all bypass coded as the MPM1-5 in N0185). Furthermore, the planar mode flag is not coded and inferred to be 0 in MRL mode, and shall have different context for regular and ISP.

JVET-N0303: “Simplified unified luma intra mode coding”

JVET-N0394: “Unified MPM list based on CE3-3.3 and CE3-3.5.1”

JVET-N0412: “Modification on the intra luma mode coding process”

JVET-N0433: “Unification of MPM derivation for luma intra modes”

JVET-N0450: “Unified MPM list construction”

JVET-N0451: “Harmonization of MPM lists”

There was discussion on test conditions, including defining a ‘fairer’ codebase to evaluate the MPM harmonization proposals in addition to the VTM anchor, as well as criteria for complexity assessment.

In the Track A discussion, it was concluded

* On block size restrictions and CE3-2 related topics, presentation of following proposals in track A for further discussion:

JVET-N0308 (recommended for adoption): “Restriction of the maximum CU size for ISP to 64x64”

Decision (from track A): Adopt JVET-N0308. Note that the same is proposed in JVET-N0362, and JVET-N0469, where each of these proposals has some other aspects which are not being adopted.

JVET-N0390: “Study of CCLM restrictions in case of separate luma/chroma tree”

Was presented in track A Sat. 03-23 afternoon. Additional restristions are imposed that would bring down the luma-to-chroma delay in separate tree from 64x64 to smaller block sizes, e.g. by disallowing certain block shape combinations, which then would inhibit CCLM for certain situations. The CCLM flag is made dependent on the position and shape of the colocated luma block. This has some impact on description of conditions, which would need to be added to the text.

Include in new CE on luma-chroma dependencies, including both LMCS (see under 6.16) and this proposal

JVET-N0082: “Constrained partitioning of chroma intra CBs”

Was presented in track A, Sat. 03-23 afternoon. It suggest a concept of “smallest intra processing unit” which is similar to the restriction in HEVC that the smallest chroma block has 4x4 samples, but here can be cases of 8x4/4x8 in case of ternary split. Samples in SIPU use only samples from outside for intra prediction. Loss in chroma around 0.6%.

JVET-N0396: “Enabling parallel reconstruction of small intra-coded blocks”

Was presented in track A, Sat. 03-23 afternoon. Conceptually similar to N0082 in terms of smallest allowed chroma block shapes, but uses sample substitution for generating reference samples. Loss in chroma around 0.4%. It is commented that in terms of keeping small blocks this has similar disadvantages as the previous CE3-2.1.3.

JVET-N0453: “On chroma 2xN and Nx2 intra prediction in single tree”

Was presented in track A, Sat. 03-23 afternoon. Test 2.1. was generally agreed to be the most preferable solution as a tradeoff between loss in compression and reduction of complexity

Study JVET-N0082, JVET-N0396 and JVET-N0453 in CE to further resolve the problem of small chroma blocks for the single tree case.

* Create CE3-subtest on ISP simplifications including tests from following proposals:

JVET-N0159: “Relaxation method of processing dependency in ISP for small blocks”

JVET-N0186: “Simplification on Intra sub-partition coding mode”

JVET-N0313: “Low latency intra sub-partitions”

JVET-N0330: “Intra sub-partition coding without thin partitions”

JVET-N0372: “ISP with independent sub-partitions for certain block sizes”

JVET-N0432: “On 1xN and 2xN subpartitions in intra subpartition coding”

Agreed in Track A Sat 03-23 afternoon that such a sub-CE should be established. However the aspect of disabling any subpartition that is not 1xN or 2xN should not be studied, as it had been confirmed by hardware experts that with common memory access structures horizontal thin partitions are not of concern.

* On other ISP topics, presentation in track A of following proposals for further discussion:

JVET-N0358: “Harmonization of CBF coding for intra sub-partition coding mode”

Was presented in track A, Sat. 03-23 afternoon. The inferral of CBF that is used in ISP is also present in other places of the spec. The suggested change is not having any significant enough impact on complexity to justify the small loss that occurs.

No need for action.

JVET-N0437: “On allowing non-MPM modes for ISP and non-zero reference line”

Was presented in track A, Sat. 03-23 afternoon. The MPM flag would be present also in MRL or ISP modes (separate context for those). This would mean that any remaining modes could be invoked in combination with MRL and ISP. Results show that the loss is very small (0.04%/0.02% in AI/RA) when modes other than those in MPM list are not checked at all. Initial results on modified encoders that check other modes in a similar fashion as for regular prediction has some gain but also not insignificant increase of encoder runtime (10% for 0.1% gain).

Generally, such a change might be interesting for further harmonization, however the current results do not indicate that the enabling of remaining modes is beneficial by itself, as similar or even higher gains are known to be possible by testing more modes in intra coding.

Further study recommended.

* On other intra topics:

JVET-N0129 (recommended for adoption): “PDPC simplification”

It was discussed in Track A (Sat. evening) that this is not worthwhile to consider, saving each one shift, and & add ops each.

JVET-N0222: “CIIP intra mode propagation to intra block”

From discussion in Track A (Sat. evening). The contribution points out a misalignment between text and software. The software does not use propagation of the intra mode from a neighbor block if that is CIIP, but the text describes a propagation as if the CIIP block would be an intra block.

As it was decided at the current meeting in Track B that CIIP can only use planar mode, and further decided through the adoption in the context of JVET-N0185 (see above) that planar mode signalling is a separate flag independent from the MPM list construction, the corresponding text needs various alignments, which will definitely include the suggested removal of the phrase. This is part of a larger editorial action necessary in the context of aligning different adoptions from this meeting

JVET-N0435 (recommended for adoption): “Harmonization between WAIP and intra smoothing filters”

From Track A (Sat. evening): Decision: Adopt JVET-N0435

Create CE test on CCLM model improvement:

JVET-N0524: “Modified beta derivation in CCLM”

(Agreed in Track A)

The CE3 BoG met during these times:

20 March 2019, from 15:30-18:15 and from 18:45-21:00

21 March 2019, from 11:00-13:00 and from 19:00-22:00

22 March 2019, from 9:00-11:30 and from 18:45-20:15

[JVET-N0840](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6595) BoG report on Neural Network based Filter for Video Coding [Y. Li] [late]

Was presented in Track A Mon 03-25 20:40-21:10.

This BoG met on 23 Mar 2019 from 09:00 to 12:00 to review the CE13-related contributions of the 14th JVET meeting. The subjective viewing session and the discussion of the next CE plan are included in this BoG.

-The following BoG recommendations were made:

* Adoptions:
  + X
* CE tests:
  + JVET-N0133, JVET-N0712
* Open issues:
  + X

-For the methods in this CE, several problems are suggested to be investigated and answered in the next CE:

1) In inference stage, investigating the performances change when the parameters are in the different bit-depths. Some typical values of the bit depth include 4/6/8/16. The method to get the integer parameters from floating point value depends on the proponents.

2) Investigating the difference of the performance and subjective quality when treating the NN filter as the in-loop filter and post filter. The behavior of post filter might be indicated in SEI message. Since the subjective viewing should be considered in this subtest, full test is preferred instead of only testing the first RAS.

3) Investigating the performance impact when using the following two different methods to get the integer parameters. When doing this investigation, bit-depth of the converted integer parameters should be the same:

Method 1: The parameters that obtained in the training stage is floating point value first. And then they are converted to integer value from the floating point value.

Method 2: Using quantization-aware training to get the integer parameters directly.

4) Investigating the performance change when the test QP is far more different from the training QP. The difference of test QP and training QP should be larger than 5.

-General comments on the test sequences.

In general, no much difference can recognized. Some comments made by viewers were as follows.

Comments on CE13-2.2: It is similar as the anchor, some details are different.

Comments on CE13-2.4: The proposed method has better quality in some part of the picture, while in some other part, the anchor is better. In the area including face (lips), the proposed method is better in some frames.

Comments on CE13-2.7: The comparison is between CE13-2.7a (CTU level adaptive on/off) and CE13-2.7b (always on). No difference can be seen.

[JVET-N0841](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6596) BoG report on CE5-1.2 and CE5-2.1 complexity analysis [V. Seregin] [late]

BoG conclusion: after analysing the proposals, BoG concludes that the additional weighted averaging step, as in CE5-1.2, is an additional processing comparing to the other proposal CE5-2.1, while other aspects of the proposals are similar or the same in the implementation. There is no significant difference either in the subjective tests nor in the performance results, so BoG suggests the simpler CE5-2.1 method for the line buffer reduction.

Was presented in Track A Mon 03-25 20:30-20:40.

Decision: Adopt JVET-N0180, configuration CE5-2.1. There were two implementations in SW and text, one with padding and one with changing filter coefficients. In the CE, these produced 100% identical results. However, upon adoption of 5-3.2, this would no longer be the case, only the padding version should be adopted in text description and software.

[JVET-N0855](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6610) BoG report on CE6-related and Non-CE6 contributions [H.E. Egilmez] [late]

Was presented in Track A, Mon 03-25 11:00-XXXX (chaired by JRO)

This BoG met on 22 Mar 2019 from 18:20 to 21:10 and 23 Mar 2019 from 09:00 to 19:05 to review the CE6-related and Non-CE6 contributions of the 14th JVET meeting. In total, 26 contributions have been reviewed, which are categorized as follows:

1. Implicit MTS and Transform Derivation for ISP and SBT (9 proposals)
2. MTS Designs – Modification of Signalling and Transform Kernels (9 proposals)
3. Secondary Transform (4 proposals)
4. Other Proposals (4 proposals)

Based on the review of CE6-related and non-CE6 proposals and discussions, the BoG recommends:

* To adopt
  + one of the five candidates proposing simplifications and/or unifications for implicit MTS and transform derivation for ISP (in Section 1.1), and
  + JVET-N0105 proposing to remove intra mode dependency in context selection of secondary transform modes.

From Track A review, Mon 03-25 morning:

For the first bullet point, see notes of discussion further below.

From the results available in JVET-N0105r2, the loss compared to CE6-3.1d is almost negligible. Decision: Adopt JVET-N0105 on top of CE6-3.1d.

It is noted that this does not remove the mode dependency of NSST entirely, but is a step in the right direction.

* To have CE tests based on:
  + JVET-N0424 and JVET-N0491 proposing new MTS designs and fast encoder methods. It has been shown that encoder time can be reduced about 10% with a coding gain loss less than 0.1%, and
  + JVET-N0555 proposing to normatively set all primary coefficients to zeros when a secondary transform is used.

It was agreed in Track A to investigate these in CE.

Revisits suggested by BoG:

* + JVET-N0388 proposing to replace implicit MTS by creating a new mode in MTS that uses the same transform derivation in the current MTS,
  + JVET-N0121 proposing an editorial change (as one of the aspects), such that DST-VII and DCT-VIII are not both expressed as matrices, but one of them is just described as flipped version of the other, plus sign changes.
  + JVET-N0364 proposing to reduce the worst-case in terms of number of multiplies per coefficient,
  + JVET-N0363 proposing to change the metric used to estimate RD in intra mode selection, and
  + JVET-N0808 proposing to add a high-level syntax for setting maximum transform size.

From Track A discussion:

- About JVET-N0388: See notes further below.

- About JVET-N0121: Up to the discretion of the editor if the suggested editorial change is useful.

- About JVET-N0364: From implementation perspective, there is no problem that this further zeroing-out is necessary. More cases of zeroing are undesirable if not urgently necessary. Furthermore, it is mentioned that 16x16 DST-VII would be an equivalent worst case not resolved here.

- About JVET-N0363: Decision (SW/CTC): Adopt. It is agreed that this is useful to give identical chances to transform skip in early decision stage. It is asked if SAD and SATD are properly scaled, but this seems to be the case as there is a scaling factor depending on block sizes in SATD.

- About JVET-N0808: In the accompanying powerpoint deck, results are provided, where the suggested method is compared against a configuration (a), where split to a maximum size is enforced by CU splits. This has large loss. This loss is becoming lower, when the method (b) performs implicit split into smaller transform blocks is performed for large CU sizes. However, with (a) the encoder runtime is much lower (18% for a versus 98% for b). From this, it cannot be concluded that the suggested method has benefit. The benefit for hardware encoders is also not fully clear. Further study (not CE) suggested to give more evidence about benefit, e.g. comparing encoders of similar complexity with and without the syntax change.

BoG recommended to adopt one of the following five candidates:

|  |  |  |
| --- | --- | --- |
| **Proposal(s)** | **Coding gains (AI / RA / LDB)** | **Comments** |
| (1) Change Implicit MTS to unify with current transform derivation in ISP  [JVET-N0089](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5809), [JVET-N0161](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5881), [JVET-N0338](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6059) | Implicit MTS:  -0.24% / -0.04% / -0.03%  CTC:  0.00% (No impact) | - replaces the shape-dependent derivation in implicit MTS with the mode-dependent one in ISP  - more complex than current design  - keeps the current ISP design |
| (2) Simplify both Implicit MTS and transform derivation in ISP  [JVET-N0172](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=5892), [JVET-N0375](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6097), [JVET-N0419](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6141), [JVET-N0420](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6142) | Implicit MTS:  -0.11% / -0.02% / 0.02%  CTC:  -0.01% / 0.00% / 0.01% | - removes the shape dependency in implicit MTS by using DST-7 whenever size is <= 16  - removes the mode-dependency in ISP by using DST-7 whenever size is <=16 and >=4  - simple HEVC-like design |
| (3) Same as above (2) except  2-pt DST-7 is added for ISP in JVET-N0420  [JVET-N0419](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6141), [JVET-N0420](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6142) | Implicit MTS:  -0.11% / -0.02% / 0.02%  CTC:  -0.04% / -0.02% / -0.02% | - removes the shape-dependency by using DST-7 whenever size is <=16  - removes the mode-dependency in ISP by using DST-7 whenever size is <=16  - simple HEVC-like design  - design consistency: allows ISP to use DST-7 in Nx2 and 2xN  - 4 bytes of additional memory  - does not change the overall worst-case |

The following proposal only provided test results on VTM 4.0.1

|  |  |  |
| --- | --- | --- |
| **Proposal(s)** | **Coding gains (AI / RA / LDB)** | **Comments** |
| (4) [JVET-N0375](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6097) | CTC:  -0.01% / 0.00% / 0.01% | - keeps the current implicit MTS  - removes mode-dependency in by using DST-7 whenever size is <=16 (same as (2) in the above table) |
| (5) [JVET-N0375](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6097) | CTC:  -0.01% / -0.01% / -0.04% | - keeps the current implicit MTS  - removes mode-dependency in by using DST-7 whenever size is <=8 |

From Track A discussion:

Implicit MTS as such has an average loss of around 0.6%-0.7% compared to explicit MTS. It however still gains compared to not using MTS at all, and does not require extensive encoder checks.

1 and 2 unify ISP and implicit MTS. However, 1 introduces an intra mode dependency of the transform which may be undesirable if the inverse transform and the prediction are performed in different pipelines. 3 also unifies, but introduces a length-2 DST-7, which would require some additional specification, and the additional gain in CTC is marginal.

4 and 5 keep the current MTS (which is also not mode dependent), and simplify ISP giving up the mode dependency, but not fully harmonizing with implicit MTS.

From the results above, 2 is asserted to be the best solution, as it provides a small compression benefit over the current implicit MTS, and gives up the mode dependency in ISP, and unifies all cases between ISP and implicit MTS transform selection where the block sizes are identical. As for block size 2 only 1 transform exists, it is obvious that there cannot be an implicit choice along that direction.

It is noted that it would be desirable to also remove the mode dependency of secondary transform.

It was decided to adopt solution (2) (the proponents of the 4 documents were requested to provide a joint document with the specification text) – see further notes under JVET-N0866.

In this context, the proposal JVET-N0388 (recommended for further discussion in Track A) was also discussed. It introduces implicit MTS (in the VTM4 style) as a replacement mode in explicit MTS. Furthermore, it is unifying ISP with the VTM4 MTS, giving up the undesirable intra mode dependency of ISP transform. As this comes with no loss, and the modification of ISP likely introduces some loss, it could be anticipated that the introduction of the implicit MTS as a mode in explicit MTS gives some additional coding gain. As a total package, it does not have advantage over the adopted solution. Proponents are suggested to investigate if it might also give gain together with the new version of MTS/ISP.

[JVET-N0870](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6625) BoG report on 360° video [J. Boyce]

This report was discussed Wednesday 27 March (GJS & JRO).

[add notes from BoG report]

Decision: Adopt semantic restrictions to reference wrap-around from N0070 (additional detail in BoG report)

The BoG identified SEI for further study and suggested to copy the HEVC ERP SEI message.

[JVET-N0835](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6590) Core Experiment Viewing Test Procedure and Results [M. Wien, P. Hanhart]

TBP.

## List of actions taken affecting Draft 3 of VVC, VTM 3, 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.

Note that various other aspects that were just marked as decisions after some discussion, without any particular proposal behind are not listed in the table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Category | Sub-Category | Adoption | Tool | Document |
| Inloop Filter | |  |  |  |
|  | ALF | coding efficiency | Non-linear ALF (clipping) | JVET-N0242 |
|  | ALF | coding efficiency | CTU adaptive ALF | JVET-N0415 |
|  | ALF | complexity reduction | ALF line buffer reduction | JVET-N0180 |
|  | Deblocking | bugfix | Deblocking of ISP/SBT TU boundaries | JVET-N0473 |
|  | LMCS | cleanup | No chroma scaling for cbf=0 | JVET-N0477 |
|  | LMCS | simplification | Simplification of Reshaper Implementation | JVET-N0220 |
|  |  |  |  |  |
| Intra |  |  |  |  |
|  | IBC | bugfix | IBC search range adjustment | JVET-N0383 |
|  | IBC | coding efficiency (SCC) | increase IBC range for small CTUs | JVET-N0175 M1 JVET-N0251 JVET-N0384 M2 |
|  | IBC | bugfix | put (0,0) vector as default in IBC merge list | JVET-N0317 |
|  | IBC | bugfix | IBC search range constraint | JVET-N0383 JVET-N0251 |
|  | IBC | bugfix | explicitly use syntax constraint for disabling 128x128 IBC | JVET-N0318 JVET-N0467 |
|  | IBC | complexity reduction | unification of IBC merge and MVP list | JVET-N0843 |
|  | RDPCM | coding efficiency (SCC) | Quantized residual DPCM | JVET-N0413 |
|  | Prediction | coding efficiency | Affine linear weighted intra prediction ("Matrix based intra prediction") | JVET-N0217 |
|  | CCLM | complexity reduction | CCLM derived from four neighbouring samples CE5-1.5 | JVET-N0271 |
|  | ISP | complexity reduction | Restriction of the maximum CU size for ISP to 64x64 | JVET-N0308 |
|  | WAIP | cleanup | Harmonization between WAIP and intra smoothing filters | JVET-N0435 |
|  |  | complexity reduction | Disable 2x2/4x2/2x4 in dual tree only | JVET-N0137 |
|  | MPM | cleanup | Unified MPM list for intra mode coding | JVET-N0185 |
|  |  |  |  |  |
|  |  |  |  |  |
| Trafo |  |  |  |  |
|  | NSST | coding efficiency | Secondary transform | JVET-N0193 |
|  | NSST | simplification | remove mode dep. In RST binarization | JVET-N0105 |
|  | MTS | simplification | Unification of Transform Selection for ISP and implicit MTS | JVET-N0866 |
|  |  |  |  |  |
| Quantization | |  |  |  |
|  |  | simplification | Modified dequantization scaling | JVET-N0246 |
|  |  | functionality | default and user-defined scaling matrices | JVET-N0847 |
|  |  |  |  |  |
|  |  |  |  |  |
| CABAC |  |  |  |  |
|  | Coeff. Coding | coding efficiency | Joint coding of chrominance residuals | JVET-N0054 |
|  | Coeff. Coding | simplification | Unified rice parameter derivation for coefficient level coding | JVET-N0188 |
|  | Coeff. Coding | coding efficiency (SCC) | Transform skip residual coding | JVET-N0280 |
|  | Coeff. Coding | bugfix | Context selection of last x/y based on non-reduced TU size | JVET-N0194 |
|  | Coeff. Coding | cleanup | CBF flags signalling | JVET-N0492 |
|  | Coeff. Coding | cleanup | Coefficient group size harmonisation | JVET-N0103 |
|  | Ctx | cleanup | Context reduction for inter and split syntax | JVET-N0600 |
|  |  |  |  |  |
| Inter |  |  |  |  |
|  | Regular Inter | complexity reduction | remove 4x4 unipred, and 4x8/8x4 bipred regular inter modes | JVET-N0266 |
|  | AFFINE | complexity reduction | 6-tap interpolation filters with affine, and 4x4 block for both uni and bi prediction | JVET-N0124 |
|  | AFFINE | complexity reduction | Disabling bi-prediction or inter prediction for small blocks | JVET-N0068 |
|  | Regular inter and  AFFINE | complexity reduction | combination JVET-N0068 and JVET-N0196 and JVET-N0266 | JVET-N0821 |
|  | AFFINE | cleanup | BCW index inheritance for constructed affine merge candidate | JVET-N0481 |
|  | AFFINE | bugfix | MV clipping for MMVD, DMVR and CPMV of constructed affine merge candidadates | JVET-N0334 |
|  | DMVR | complexity reduction | Disable 8x8/4xN CUs for DMVR | JVET-N0407 |
|  | DMVR | complexity reduction | Implicitly split BDOF application region along 16x16 boundaries | JVET-N0178 |
|  | DMVR | cleanup | align DMVR with BDOF | JVET-N0146  JVET-N0153 JVET-N0442 JVET-N0162 JVET-N0262 JVET-N0440 JVET-N0086 |
|  | BDOF | bugfix | condition check of block height is not equal to 4 | JVET-N0444 |
|  | BDOF | cleanup | disabling BDOF for BCW and WP | JVET-N0146 |
|  | BCW | cleanup | only first BCW idx bin ctx coded | JVET-N0286 |
|  | MMVD | bugfix | MMVD enabling signalling in SPS | JVET-N0127 |
|  | MMVD | bugfix | disable MVD scaling for MMVD for LTRP | JVET-N0332 |
|  | MMVD | bugfix | infer the number of MMVD base merge candidate to 1 | JVET-N0448 JVET-N0380 |
|  | CIIP | complexity reduction | CIIP with position-independent weights | JVET-N0302 |
|  | MERGE | cleanup | Signal a regular merge flag right after the merge flag and skip flag | JVET-N0324 |
|  | MERGE | bugfix | align triangle merge candidate number and regular merge candidate number | JVET-N0447 JVET-N0400 JVET-N0500 JVET-N0851 |
|  | Triangle | complexity reduction | regular merge candidate list is re-used for triangle | JVET-N0340 |
|  | Triangle | cleanup | disable sub-block transform when triangle mode is used | JVET-N0483 |
|  | MV | cleanup | Round MVs toward zero | JVET-N0335 |
|  | MVP | cleanup | add an SPS-level flag to turn on and off symmetric MVD | JVET-N0235 |
|  | TMVP | complexity reduction | removing TMVP from merge and AMVP list for 4x8 and 8x4 CUs | JVET-N0213 |
|  |  |  |  |  |
| Partitioning | |  |  |  |
|  | chroma formats | functionality | Support of 4:4:4 and 4:2:2 chroma formats | JVET-N0671 |
|  | chroma formats | functionality | separate color plane id | JVET-N0225 |
|  |  |  |  |  |
| HLS |  |  |  |  |
|  | Tiles |  | Uniform Tile Partitioning | JVET-N0498 |
|  | Parameter sets |  | Decoder Parameter Set (DPS) | JVET-N0349 |
|  | Reference Pictures | | signalling information about long-term reference picture POC LSB | JVET-N0100 |
|  | Parameter sets |  | loop filtering disabling aross virtual boundaries | JVET-N0438 |
|  | Parameter sets |  | 5 new constraint flags | JVET-N0276 |
|  | Profile/Level/Tier | | syntax element in the profile\_tier\_level( ) syntax structure for sub-profile indication | JVET-N0276 |
|  | Tiles | bugfix | inference rule for single\_tile\_per\_tile\_group\_flag + other aspects | JVET-N0124 |
|  | Tiles | bugfix | inference rule for num\_tiles\_in\_tile\_group\_minus1 | JVET-N0288 |
|  | Parameter sets |  | VUI design | JVET-N0063 |
|  | WPP |  | Wavefront Parallel Processing | JVET-N0150  JVET-N0060 |
|  | WPP |  | One CTU delay WPP | JVET-N0150 |
|  |  |  | layer concept without inter-layer referencing | JVET-N0278 |
|  | Tiles |  | Signalling for tile and brick partitioning | JVET-N0857 |
|  | Tiles |  | Signalling for tile and brick partitioning | JVET-N0857 |
|  |  |  | Ref pic list for IDR | JVET-N0047 |
|  |  |  | Conformance window | JVET-N0352 |
|  |  |  | Aspects of ref pic list management for CRA | JVET-N0101 |
|  |  |  | Ref pic wraparound | JVET-N0070 |
|  |  |  | Conditional signalling of num\_ref\_idx\_active\_overwrite\_flag | JVET-N0100 |
|  |  |  | APS types (with loop) | JVET-N0805 |
|  |  |  | Gradual RA recovery | JVET-N0865 |
|  |  |  | Dependent RAP indication SEI | JVET-N0494 |
|  |  |  | Buffering period & pic timing SEI | JVET-N0353 |
|  |  |  | HRD | JVET-N0423  JVET-N0350 |
|  |  |  | Dec. Picture hash | JVET-N0706 |
|  |  |  | NAL Unit pic type | JVET-N0067 |
|  |  |  | Temp scalability HRD params | JVET-N0867 |
|  |  |  | dps\_id=0 | JVET-N0869 |
|  |  |  |  |  |
| Software |  |  |  |  |
|  | IBC | coding efficiency (SCC) | Hash based ME improvement | JVET-N0247 |
|  | IBC | coding efficiency (SCC) | increase IBC search range | JVET-N0251 |
|  | IBC | coding efficiency (SCC) | IBC search increase block sizes | JVET-N0318 |
|  | IBC | coding efficiency (SCC) | IBC more predictors, SAD/SATD evaluation | JVET-N0329 |
|  | CTC |  | replace class F with 4:2:0 versions of AOV and 4 TGM sequences |  |
|  | MMVD | speedup | encoder speed up for MMVD | JVET-N0449 |
|  |  | bugfix | fix context modeling of inter\_pred\_idc | JVET-N0462 |
|  |  | bugfix | bugfix of cost calculation in AMVR mode | JVET-N0168 |
|  |  | bugfix | align with the text on MV wrap around for regular inter mode and affine inter mode | JVET-N0334 |
|  | Intra Search | cleanup | metric for RD in intra mode selection | JVET-N0363 |

# 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.

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.
* All substantial communications about a CE, other than logistics arrangements, exchange of data, minor refinement of the test plans, and preparation of documents shall be conducted on the main JVET reflector. In the case that large amounts of data are to be distributed is recommended to send an announcement to the JVET reflector without attaching the materials, and send the materials to those who have requested it directly, or provide a link to it, or upload the data as an input contribution to the next meeting.

General timeline for CEs

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 merked 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 18 January (GJS); CE plan documents were reviewed Friday 19 January (GJS & JRO).

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:

* VTM5.0 will be released by 2019-04-29 including all adoptions necessary for CTC (likely not yet including APS). VTM5.1 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.
* Timeline of 360lib9.1 (related to finalization of inclusions from last meeting): 2019-04-29.

# 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-N1001 VVC text specification draft 4. * Produce and finalize JVET-N1002 VVC Test Model 5 (VTM 5) 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. 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 5 behaviour relative to HEVC and VTM 4 using the VTM common test conditions and the multi-resolution streaming test conditions described in JVET-N0446. * 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, A. Norkin, 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, P. Hanhart, 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-chair), K. Choi, P. Hanhart, J.-L. Lin (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 15th JVET meeting if feasible. * Coordinate implementation of HDR anchor aspects in the test model software with AHG3. * Study additional aspects of coding HDR/WCG content. | A. Segall (chair), E. François, W. Husak, D. Rusanovskyy (vice-chairs) | N |
| **vacant (AHG8)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * do this. * do that. | n/a (chair), n/a (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, re-sampling 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 (chair), 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), C. Helmrich, S. Ikonin, A. Norkin, R. Sjöberg (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-N1005, 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), Y.-W. Chen, R. Chernyak, K. Choi, R. Hashimoto, Y.**-**W. Huang, H. Jang, R.-L. Liao, S. Liu, D. Luo (vice-chairs) | N |
| **Operation modes for low latency support (AHG14)**  **(find more generic name)**  ([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 as in JVET-N0865. * 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 |
| **vacant**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de)) | J. Boyce (chair), J. Chen, S. Deshpande, M. Karczewicz, A. Tourapis, Y.-K. Wang, S. Wenger (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 the proposed picture header designs and alternatives * 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 alternatives 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-chair), S. Deshpande, M. M. Hannuksela, R. Skupin, A. Tourapis, Y.-K. Wang, W. Wan, S. Wenger (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 impact of MTS transforms on quantization matrices and the need for default matrices * Study the interaction between LMCS and quantization step size control * 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 two adaptive quantization control techniques currently available in the VTM | R. Chernyak (chair), E. François, C. Helmrich, S. McCarthy, A. Segall (vice-chairs) | N |
| **Layered coding and resolution adaptivity (AHG19)**  **Move into 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 filters for resampling, reference picture management, and related scope and signalling * Study approaches for temporal scalability to avoid temporal judder when temporal scalability sub-bitstream extraction is used for achieving lower frame rate, and consider whether this should have a normative impact. * Identify related test conditions for an upcoming core experiment, test sequences, and evaluation techniques (including subjective assessment techniques), including a base configuration to test other ARC modalities against. * Develop a software framework which allows testing various modalities of ARC in the context of the VTM software * Study potential approaches for support of layered coding scalability including spatial, temporal, quality, and view scalability | S. Wenger and A. Segall (co-chairs), M. M. Hannuksela, Hendry, S. McCarthy, Y.-C. Sun, P. Topwala, M. Zhou (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-N1000 Meeting Report of the 14th JVET Meeting [G. J. Sullivan, J.-R. Ohm] (2019-07-02, near next meeting)

Initial versions of the meeting notes (d0 … d9) were made available on a daily basis during the meeting.

JVET-N1001 Versatile Video Coding (Draft 5) [B. Bross, J. Chen, S. Liu] [WG 11 N 18370] (2019-06-15)

(Initial version planned to be made available by 2019-04-18.)

See the list of elements under section 11.8, as agreed by the Wed. 27 March plenary.

JVET-N1002 Algorithm description for Versatile Video Coding and Test Model 5 (VTM 5) [J. Chen, Y. Ye, S. Kim] [WG 11 N 18371] (2019-06-15)

(Initial version planned to be made available by 2019-04-18.)

See the list of elements under section 11.8, as agreed by the Wed. 27 March plenary.

JVET-N1003 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-N1005](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=4837) Methodology and reporting template for coding tool testing [W.-J. Chien and J. Boyce] (2019-04-12)

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-N1010](http://phenix.int-evry.fr/jvet/doc_end_user/current_document.php?id=5759) JVET common test conditions and software reference configurations for SDR video [F. Bossen, J. Boyce, X. Li, V. Seregin, K. Sühring] (2019-04-12)

Decided in closing plenary: Keep class F unchanged in CTC. AHG shall further work on defining better test sets for SC. For the current CE, classes F and TGM to be used for 4:2:0 (unchanged), investigations on testing 4:2:0 vs. 4:4:4 to be done with a set TGM + AOV + TBD . A more reasonable set of sequences needs to be defined by next meeting, otherwise CE8 cannot be continued.JVET-N1011 JVET common test conditions and evaluation procedures for HDR/WCG video [A. Segall, E. François, W. Husak, S. Iwamura, D. Rusanovskyy] (2019-04-05)

See notes for N0828 regarding action items.

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-N1021 Description of Core Experiment 1 (CE 1): CABAC initialization [F. Bossen, J. Dong, H. Kirchhoffer]

New – previous CE1 was closed, and aspects on LIC subsumed under CE4

JVET-N1022 Description of Core Experiment 2 (CE2): Luma/chroma dependency reduction [J. Chen, E. François, P. Yin]

New – previous CE2 was subsumed under CE4

JVET-N1023 Description of Core Experiment 3 (CE3): Intra prediction and mode coding [G. Van der Auwera, L. Li, A. Filippov]

Continue

It is emphasized that CE3-1 shall concentrate on simplifying the implementation of 1xN and and 2xN blocks, and not making the design more complicated for the benefit of compression. If there are elements in a proposal that try to compensate a loss due to simplification by adding other elements, it shall be possible to judge the benefit or disadvantage separately. This remark would equivalently apply to other CEs that target simplification of design.

JVET-N1024 Description of Core Experiment 4 (CE4): Inter prediction [H. Yang, C.-C. Chen]

CE4-2.x should also conduct subjective tests, as it is claimed to have subjective benefit.

It is noted that for CE4-2.1, test case a would be preferable, as it is best aligned with the new affine mode design of using 4x4 block sizes for uni and bi pred, and same 6-tap filters.

A detailed complexity analysis of CE4-2 and CE4-3 is mandatory.

CE4-3 only two tests

JVET-N1025 Description of Core Experiment 5 (CE5): Loop filtering [C.-Y. Chen, A. Norkin]

Includes ALF, and deblocking

JVET-N1026 Description of Core Experiment 6 (CE6): Transforms and transform signalling [X. Zhao, H. E. Egilmez]

Joint chroma coding shall also test HDR

JVET-N1027 Description of Core Experiment 7 (CE 7): Quantization and coefficient coding [H. Schwarz, M. Coban, C. Auyeung]

includes the coding part of TS residual which was previously in CE8.

JVET-N1028 Description of Core Experiment 8 (CE8): Screen Content Coding Tools [X. Xu, Y.-H. Chao, Y.-C. Sun, J. Xu]

Coordination between CE7 and CE8 is desired for TS coefficient coding evaluation, in particular regarding the planned 4:4:4 tests.

JVET-N1029 Description of Core Experiment 9 (CE9): Decoder Motion Vector Derivation [S. Esenlik, X. Xiu]

JVET-N1030 Description of Core Experiment 10 (CE10): Neural-network based loop filtering [Y. Li, S. Liu, K. Kawamura]

Previous CE10 was closed, and previous CE13 re-numbered

JVET-N1031 Description of Core Experiment 11 (CE11): Gradual random access [K. Kazui, J.-M. Thiesse, Hendry, K. Kawamura]

New - previous CE11 was subsumed under CE5

Previous CE12 (Tile set boundary MC handling) is discontinued as per discussion in HLS topics.

It is emphasized that those CEs which plan subjective testing to study JVET-N0835 which points to some issues of selecting the test conditions for that.

# 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 (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 (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.

Some specific future meeting plans (to be confirmed) were established as follows:

* Wed. 3 – Fri. 12 July 2019, 15th meeting under WG 11 auspices in Gothenburg, SE.
* Tue. 1 – Wed. 9 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.

The agreed document deadline for the 15th JVET meeting was planned to be Tuesday 25 June 2019. Plans for scheduling of agenda items within that meeting remained TBA.

ITU was thanked for the excellent hosting of the 14th meeting of the JVET.

EBU, HHI, ITU-T and Sharp Labs of America were thanked for providing equipment used for subjective viewing during the 14th JVET meeting. Philippe Hanhart, Andrew Segall and Mathias Wien were thanked for preparing and conducting the subjective test efforts related to CE1, CE5 and CE11, and Vittorio Baroncini was thanked for his advice. Roger Miles was thanked for support in providing the displays from EBU; Kenneth Andersson, Johannes Sauer and Vadim Seregin were thanked for carefully transporting these. The experts who participated in the role as test subjects were also thanked.

The 14th JVET meeting was closed at approximately 1850 hours on Wednesday 27 March 2019.

# Annex A to JVET report: List of documents

# Annex B to JVET report: List of meeting participants

The participants of the fourteenth meeting of the JVET, according to a sign-in sheet circulated during the meeting sessions (approximately XXX people in total), were as follows: