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| **Joint Video Experts Team (JVET)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29**  30th Meeting, Antalya, TR, 21–28 April 2023 | Document: JVET-AD\_Notes\_d5d6 |

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| *Title:* | **Meeting Report of the 30th Meeting of the Joint Video Experts Team (JVET), by teleconference, 21–28 April 2023** | | |
| *Status:* | Report document from the chair of JVET | | |
| *Purpose:* | Report | | |
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| *Source:* | Chair 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 held its thirtieth meeting during 21–28 April 2023 in Antalya, Turkey, at Mirage Park Resort Hotel (Göynük Mahallesi, Ahu Ünal Aysal Caddesi No:29, 07994 Kemer/Antalya, Türkiye, Tel: +90 (0) 242 815 22 44, web <https://www.mirageparkresort.com.tr/en>). The meeting was held as a face-to-face meeting, but remote participation was provided on best-effort basis for experts who were unable to travel.

For ISO/IEC purposes, JVET is alternatively designated ISO/IEC JTC 1/‌SC 29/‌WG 5, and this was the eleventh meeting as WG 5. The JVET meeting was held under the chairmanship of 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 2.14 of this document. It is further noted that work items which had originally been conducted by the Joint Collaborative Team on Video Coding (JCT-VC) were continued in JVET as a single joint team, and explorations towards possible future need of standardization in the area of video coding are also conducted by JVET, as negotiated by the parent bodies.

The JVET meeting began at approximately 0900 TRT (UTC+3) on Friday 21 April 2023. Meeting sessions were held on all days, including the weekend days of Saturday and Sunday 22 and 23 April 2023, until the meeting was closed at approximately XXXX hours TRT on Friday 28 April 2023. Approximately XXX people attended the JVET meeting (XXX in person and XXX remotely), and approximately XXX input documents (not counting crosschecks, reports, and summary documents), 14 AHG reports, 2 EE summary reports, X BoG reports, and X incoming liaison document were discussed. The meeting took place in coordination with a meeting of various SC29 Working Groups and Advisory Groups – where WG 5 is representing the Joint Video Coding Team(s) and their activities from the perspective of the SC 29 parent body, under whose auspices this JVET meeting was held. The subject matter of the JVET meeting activities consisted of work on further development and maintenance of the twin-text video coding technology standards *Advanced Video Coding* (AVC), *High Efficiency Video Coding* (HEVC), *Versatile Video Coding* (VVC)*, Coding-independent Code Points (Video)* (CICP), and *Versatile Supplemental Enhancement Information Messages for Coded Video Bitstreams* (VSEI), as well as related technical reports, reference software and conformance testing packages. Further important goals were reviewing the results of the Exploration Experiment (EE) on Neural Network-based Video Coding, of the EE on Enhanced Compression beyond VVC capability, of other technical input on novel aspects of video coding technology, and to plan next steps for investigation of candidate technology towards further standard development.

As a primary goal, the JVET meeting reviewed the work that had been performed in the interim period since the twenty-ninth JVET meeting in producing the following documents:

* [JVET-AC1001](https://jvet-experts.org/doc_end_user/current_document.php?id=12566) Guidelines for HM-based software development
* [JVET-AC1004](https://jvet-experts.org/doc_end_user/current_document.php?id=12567) Errata report items for VVC, VSEI, HEVC, AVC, and Video CICP
* [JVET-AC1008](https://jvet-experts.org/doc_end_user/current_document.php?id=12568) Additional colour type identifiers for AVC, HEVC and Video CICP (Draft 3), also issued as WG 5 preliminary WD
* [JVET-AC1009](https://jvet-experts.org/doc_end_user/current_document.php?id=12569) Common test conditions for SHVC
* [JVET-AC1013](https://jvet-experts.org/doc_end_user/current_document.php?id=12570) Common test conditions of 3DV experiments
* [JVET-AC1015](https://jvet-experts.org/doc_end_user/current_document.php?id=12571) Common test conditions for SCM-based screen content coding
* [JVET-AC2002](https://jvet-experts.org/doc_end_user/current_document.php?id=12572) Algorithm description for Versatile Video Coding and Test Model 19 (VTM 19)
* [JVET-AC2003](https://jvet-experts.org/doc_end_user/current_document.php?id=12573) Guidelines for VTM-based software development
* [JVET-AC2005](https://jvet-experts.org/doc_end_user/current_document.php?id=12574) New level and systems-related supplemental enhancement information for VVC (Draft 4)
* [JVET-AC2011](https://jvet-experts.org/doc_end_user/current_document.php?id=12575) VTM and HM common test conditions and evaluation procedures for HDR/WCG video
* [JVET-AC2016](https://jvet-experts.org/doc_end_user/current_document.php?id=12576) Common test conditions and evaluation procedures for neural network-based video coding technology
* [JVET-AC2019](https://jvet-experts.org/doc_end_user/current_document.php?id=12563) Description of algorithms and software in neural network-based video coding (NNVC) version 2
* [JVET-AC2020](https://jvet-experts.org/doc_end_user/current_document.php?id=12577) Film grain synthesis technology for video applications (Draft 4), also issued as WG 5 CDTR
* [JVET-AC2021](https://jvet-experts.org/doc_end_user/current_document.php?id=12578) Draft verification test plan for VVC multilayer coding
* [JVET-AC2022](https://jvet-experts.org/doc_end_user/current_document.php?id=12579) Draft plan for subjective quality testing of FGC SEI message
* [JVET-AC2023](https://jvet-experts.org/doc_end_user/current_document.php?id=12560) Exploration experiment on neural network-based video coding (EE1)
* [JVET-AC2024](https://jvet-experts.org/doc_end_user/current_document.php?id=12562) Exploration experiment on enhanced compression beyond VVC capability (EE2)
* [JVET-AC2025](https://jvet-experts.org/doc_end_user/current_document.php?id=12580) Algorithm description of Enhanced Compression Model 8 (ECM 8)
* [JVET-AC2026](https://jvet-experts.org/doc_end_user/current_document.php?id=12581) Conformance testing for VVC operation range extensions (Draft 4)
* [JVET-AC2027](https://jvet-experts.org/doc_end_user/current_document.php?id=12582) SEI processing order SEI message in VVC (draft 3), also issued as WG 5 preliminary WD
* [JVET-AC2028](https://jvet-experts.org/doc_end_user/current_document.php?id=12583) Additional conformance bitstreams for VVC multilayer configurations
* [JVET-AC2030](https://jvet-experts.org/doc_end_user/current_document.php?id=12564) Optimization of encoders and receiving systems for machine analysis of coded video content (draft 1), also issued as WG 5 preliminary WD
* [JVET-AC2031](https://jvet-experts.org/doc_end_user/current_document.php?id=12584) Common test conditions for optimization of encoders and receiving systems for machine analysis of coded video content
* [JVET-AC2032](https://jvet-experts.org/doc_end_user/current_document.php?id=12585) Improvements under consideration for neural network post filter SEI messages

As main results, the JVET produced XX output documents from the current meeting (update):

* [JVET-AC1001](https://jvet-experts.org/doc_end_user/current_document.php?id=12566) Guidelines for HM-based software development
* [JVET-AC1004](https://jvet-experts.org/doc_end_user/current_document.php?id=12567) Errata report items for VVC, VSEI, HEVC, AVC, and Video CICP
* [JVET-AC1008](https://jvet-experts.org/doc_end_user/current_document.php?id=12568) Additional colour type identifiers for AVC, HEVC and Video CICP (Draft 3), also issued as WG 5 preliminary WD
* [JVET-AC1009](https://jvet-experts.org/doc_end_user/current_document.php?id=12569) Common test conditions for SHVC
* [JVET-AC1013](https://jvet-experts.org/doc_end_user/current_document.php?id=12570) Common test conditions of 3DV experiments
* [JVET-AC1015](https://jvet-experts.org/doc_end_user/current_document.php?id=12571) Common test conditions for SCM-based screen content coding
* [JVET-AC2002](https://jvet-experts.org/doc_end_user/current_document.php?id=12572) Algorithm description for Versatile Video Coding and Test Model 19 (VTM 19)
* [JVET-AC2003](https://jvet-experts.org/doc_end_user/current_document.php?id=12573) Guidelines for VTM-based software development
* [JVET-AC2005](https://jvet-experts.org/doc_end_user/current_document.php?id=12574) New level and systems-related supplemental enhancement information for VVC (Draft 4)
* [JVET-AC2011](https://jvet-experts.org/doc_end_user/current_document.php?id=12575) VTM and HM common test conditions and evaluation procedures for HDR/WCG video
* [JVET-AC2016](https://jvet-experts.org/doc_end_user/current_document.php?id=12576) Common test conditions and evaluation procedures for neural network-based video coding technology
* [JVET-AC2019](https://jvet-experts.org/doc_end_user/current_document.php?id=12563) Description of algorithms and software in neural network-based video coding (NNVC) version 2
* [JVET-AC2020](https://jvet-experts.org/doc_end_user/current_document.php?id=12577) Film grain synthesis technology for video applications (Draft 4), also issued as WG 5 CDTR
* [JVET-AC2021](https://jvet-experts.org/doc_end_user/current_document.php?id=12578) Draft verification test plan for VVC multilayer coding
* [JVET-AC2022](https://jvet-experts.org/doc_end_user/current_document.php?id=12579) Draft plan for subjective quality testing of FGC SEI message
* [JVET-AC2023](https://jvet-experts.org/doc_end_user/current_document.php?id=12560) Exploration experiment on neural network-based video coding (EE1)
* [JVET-AC2024](https://jvet-experts.org/doc_end_user/current_document.php?id=12562) Exploration experiment on enhanced compression beyond VVC capability (EE2)
* [JVET-AC2025](https://jvet-experts.org/doc_end_user/current_document.php?id=12580) Algorithm description of Enhanced Compression Model 8 (ECM 8)
* [JVET-AC2026](https://jvet-experts.org/doc_end_user/current_document.php?id=12581) Conformance testing for VVC operation range extensions (Draft 4)
* [JVET-AC2027](https://jvet-experts.org/doc_end_user/current_document.php?id=12582) SEI processing order SEI message in VVC (Draft 3), also issued as WG 5 preliminary WD
* [JVET-AC2028](https://jvet-experts.org/doc_end_user/current_document.php?id=12583) Additional conformance bitstreams for VVC multilayer configurations
* [JVET-AC2030](https://jvet-experts.org/doc_end_user/current_document.php?id=12564) Optimization of encoders and receiving systems for machine analysis of coded video content (draft 1), also issued as WG 5 preliminary WD
* [JVET-AC2031](https://jvet-experts.org/doc_end_user/current_document.php?id=12584) Common test conditions for optimization of encoders and receiving systems for machine analysis of coded video content
* [JVET-AC2032](https://jvet-experts.org/doc_end_user/current_document.php?id=12585) Improvements under consideration for neural network post filter SEI messages

The following documents were produced as WG 5 documents only:

* [MDS22362](https://dms.mpeg.expert/doc_end_user/current_document.php?id=86362&id_meeting=193) Disposition of comments received on ISO/IEC DIS 23008-2:202x (5th edition)
* [MDS22363](https://dms.mpeg.expert/doc_end_user/current_document.php?id=86363&id_meeting=193) Text of ISO/IEC FDIS 23008-2:202x High efficiency video coding (5th edition)
* [MDS22364](https://dms.mpeg.expert/doc_end_user/current_document.php?id=86364&id_meeting=193) Draft disposition of comments received on ISO/IEC 23090-3:2022 DAM 1
* [MDS22365](https://dms.mpeg.expert/doc_end_user/current_document.php?id=86365&id_meeting=193) Preliminary text of ISO/IEC FDIS 23090-3:202x Versatile video coding (3rd edition)
* [MDS22368](https://dms.mpeg.expert/doc_end_user/current_document.php?id=86368&id_meeting=193) Disposition of comments received on ISO/IEC 23090-15 DAM 1
* [MDS22369](https://dms.mpeg.expert/doc_end_user/current_document.php?id=86369&id_meeting=193) Text of ISO/IEC FDIS 23090-15:202x Conformance testing for versatile video coding (2nd edition)

For the organization and planning of its future work, the JVET established XX “ad hoc groups” (AHGs) to progress the work on particular subject areas. At this meeting, X Exploration Experiments (EE) were defined. The next ten JVET meetings were planned for 11 – 19 July 2023 under ITU-T SG16 auspices in Geneva, CH; during 13 – 20 October 2023 under ISO/IEC JTC 1/‌SC 29 auspices in Hannover, DE; during 17 – 26 January 2024 under ISO/IEC JTC 1/‌SC 29 auspices, to be conducted as teleconference meeting; during April 2024 under ITU-T SG16 auspices, date and location t.b.d.; during 12 – 19 July 2024 under ISO/IEC JTC 1/‌SC 29 auspices in Sapporo, JP; during October 2024 under ISO/IEC JTC 1/‌SC 29 auspices, date and location t.b.d.; during January 2025 under ITU-T SG16 auspices, date and location t.b.d.; during April 2025 under ITU-T SG16 auspices, date and location t.b.d.; during 11 – 18 July 2025 under ISO/IEC JTC 1/‌SC 29 auspices in Daejeon, KR; and during October 2025 under ITU-T SG16 auspices, date and location t.b.d..

The document distribution site <https://jvet-experts.org/> was used for distribution of all documents. It was noted that the previous sites <http://phenix.int-evry.fr/jvet/>, <http://phenix.int-evry.fr/jct/>, and <http://phenix.int-evry.fr/jct3v/> are still accessible, but were converted to read-only.

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 ISO/IEC JTC 1/‌SC 29/‌WG 5. The parent bodies of the JVET are ITU-T WP3/16 and ISO/IEC JTC 1/‌SC 29.

The Joint Video Experts Team (JVET) of ITU-T WP3/16 and ISO/IEC JTC 1/‌SC 29 held its thirtieth meeting during 21–28 April 2023 in Antalya, Turkey, at Mirage Park Resort Hotel (Göynük Mahallesi, Ahu Ünal Aysal Caddesi No:29, 07994 Kemer/Antalya, Türkiye, Tel: +90 (0) 242 815 22 44, web <https://www.mirageparkresort.com.tr/en>). The meeting was held as a face-to-face meeting, but remote participation was provided on best-effort basis for experts who were unable to travel. For ISO/IEC purposes, JVET is alternatively designated ISO/IEC JTC 1/‌SC 29/‌WG 5, and this was the eleventh meeting as WG 5. The JVET meeting was held under the chairmanship of 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 the *Versatile Video Coding* (VVC) and *Versatile Supplemental Enhancement Information Messages for Coded Video Bitstreams* (VSEI) standards, as well as associated conformance test sets, reference software, verification testing, and non-normative guidance information. Furthermore, starting from the twentieth meeting, work items which had originally been conducted by the Joint Collaborative Team on Video Coding (JCT-VC) were continued to be conducted in JVET as a single joint team, as negotiated by the parent bodies. This particularly consists of work on:

* *High Efficiency Video Coding* (HEVC) and its extensions, the development of associated conformance test sets, reference software, verification testing, and non-normative guidance information,
* Specification of *Coding-independent Code Points (Video)* (CICP), and associated technical report(s),
* Maintenance and enhancement work on the *Advanced Video Coding* (AVC) standard, associated conformance test sets and reference software.

Furthermore, explorations towards possible future need of standardization in the area of video coding are also conducted by JVET. Currently, the following topics are under investigation:

* Exploration on Neural Network-based Video Coding
* Exploration on Enhanced Compression beyond VVC capability

This report contains three important annexes, as follows:

* Annex A contains a list of the documents of the JVET meeting
* Annex B contains a list of the meeting participants, as recorded by the teleconferencing tool used for the meeting
* Annex C contains the meeting recommendations of ISO/IEC JTC 1/‌SC 29/‌WG 5 for purposes of results reporting to ISO/IEC.

## 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/2023_04_AD_Antalya/>.

## Primary goals

As a primary goal, the JVET meeting reviewed the work that was performed in the interim period since the twenty-eighth JVET meeting in producing the following documents:

* [JVET-AC1001](https://jvet-experts.org/doc_end_user/current_document.php?id=12566) Guidelines for HM-based software development
* [JVET-AC1004](https://jvet-experts.org/doc_end_user/current_document.php?id=12567) Errata report items for VVC, VSEI, HEVC, AVC, and Video CICP
* [JVET-AC1008](https://jvet-experts.org/doc_end_user/current_document.php?id=12568) Additional colour type identifiers for AVC, HEVC and Video CICP (Draft 3), also issued as WG 5 preliminary WD
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* [JVET-AC1015](https://jvet-experts.org/doc_end_user/current_document.php?id=12571) Common test conditions for SCM-based screen content coding
* [JVET-AC2002](https://jvet-experts.org/doc_end_user/current_document.php?id=12572) Algorithm description for Versatile Video Coding and Test Model 19 (VTM 19)
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* [JVET-AC2019](https://jvet-experts.org/doc_end_user/current_document.php?id=12563) Description of algorithms and software in neural network-based video coding (NNVC) version 2
* [JVET-AC2020](https://jvet-experts.org/doc_end_user/current_document.php?id=12577) Film grain synthesis technology for video applications (Draft 4), also issued as WG 5 CDTR
* [JVET-AC2021](https://jvet-experts.org/doc_end_user/current_document.php?id=12578) Draft verification test plan for VVC multilayer coding
* [JVET-AC2022](https://jvet-experts.org/doc_end_user/current_document.php?id=12579) Draft plan for subjective quality testing of FGC SEI message
* [JVET-AC2023](https://jvet-experts.org/doc_end_user/current_document.php?id=12560) Exploration experiment on neural network-based video coding (EE1)
* [JVET-AC2024](https://jvet-experts.org/doc_end_user/current_document.php?id=12562) Exploration experiment on enhanced compression beyond VVC capability (EE2)
* [JVET-AC2025](https://jvet-experts.org/doc_end_user/current_document.php?id=12580) Algorithm description of Enhanced Compression Model 8 (ECM 8)
* [JVET-AC2026](https://jvet-experts.org/doc_end_user/current_document.php?id=12581) Conformance testing for VVC operation range extensions (Draft 4)
* [JVET-AC2027](https://jvet-experts.org/doc_end_user/current_document.php?id=12582) SEI processing order SEI message in VVC (Draft 3), also issued as WG 5 preliminary WD
* [JVET-AC2028](https://jvet-experts.org/doc_end_user/current_document.php?id=12583) Additional conformance bitstreams for VVC multilayer configurations
* [JVET-AC2030](https://jvet-experts.org/doc_end_user/current_document.php?id=12564) Optimization of encoders and receiving systems for machine analysis of coded video content (Draft 1), also issued as WG 5 preliminary WD
* [JVET-AC2031](https://jvet-experts.org/doc_end_user/current_document.php?id=12584) Common test conditions for optimization of encoders and receiving systems for machine analysis of coded video content
* [JVET-AC2032](https://jvet-experts.org/doc_end_user/current_document.php?id=12585) Improvements under consideration for neural network post filter SEI messages

Further important goals were reviewing the results of the EE on Neural Network-based Video Coding, of the EE on Enhanced Compression beyond VVC capability, of other technical input on novel aspects of video coding technology, and planning next steps for investigation of candidate technology towards further standard development.

## Documents and document handling considerations

### General

The document distribution site <https://jvet-experts.org/> was used for distribution of all documents. It was noted that the previous site <http://phenix.int-evry.fr/jvet/> was still accessible, but had been converted to read-only.

Document 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 follow the TRT timezone (local time in Antalya), except as otherwise noted.

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 one of the various software packages but have no normative effect on text are marked by the string “Decision (SW):”.
* Decisions that fix a “bug” in one of the test model descriptions such as VTM, HM, etc. (an error, oversight, or messiness) or in the associated software package are marked by the string “Decision (BF):”.
* Decisions that are merely editorial without effect on the technical content of a draft standard are marked by the string "Decision (Ed.):". Such editorial decisions are merely suggestions to the editor, who has the discretion to determine the final action taken if their judgment differs.
* Some decisions are recorded with the word “agreed” rather than “Decision:”, especially for non-normative, editorial and planning matters.

This meeting report is based primarily on notes taken by the JVET chair. 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. Expressions such as “X.XX%” indicate that the desired results were not available at the time the information was recorded.

### Late and incomplete document considerations

The formal deadline for registering and uploading non-administrative contributions had been announced as Friday, 14 April 2023. Any documents uploaded after 1159 hours Paris/Geneva time on Saturday 15 April 2023 were considered “officially late”, with a grace period of 12 hours (to accommodate those living in different time zones of the world). The deadline does not apply to AHG reports and other such reports which can only be produced after the availability of other input documents.

All contribution documents with registration numbers higher than JVET-AD0243 were registered after the “officially late” deadline (and therefore were also uploaded late). However, some documents in the “late” range might include break-out activity reports that were generated during the meetings, or documents which were requested to be produced for the purpose of improving specification text, and are therefore better considered as report documents rather than as late contributions.

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 has been 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 has been agreed to be a helpful approach to be followed at the meeting.

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

* JVET-AD0XXX (a proposal on …), uploaded 04-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.

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

* JVET-AD0XXXX (a document discussing …), uploaded 04-XX,
* … .

Most cross-verification reports at this meeting were registered late, and/or uploaded late (except for JVET-AD0139). In the interest of brevity, the late ones are not specifically identified here. Initial upload times for each document are recorded in Annex A of this report.

The following contribution registrations were noted that were later cancelled, withdrawn, never provided, were cross-checks of a withdrawn contribution, or were registered in error: JVET-AD0046, JVET-AD0049, JVET-AD0098, JVET-AD0132, JVET-AD0224, JVET-AD0245, JVET-AD0301, JVET-0319, JVET-0390, JVET-0391, JVET-0392, JVET-0393, JVET-0394, … .

The following cross-verification report was still missing three weeks after the end of the meeting: JVET-AD0XXX. This was thus marked as withdrawn by the JVET chair.

“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 be counted as a late contribution if the update was after the document deadline). At the current meeting, this situation did apply with documents JVET-AD0212 and JVET-AD0218, which were categorized as late in the list above, based on the time of the first reasonable document upload.

Contributions that had significant problems with uploaded versions were not observed.

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 and HLS topic 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 may have been 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.). Any such 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 may have also 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-AC1000, the Errata report items for VVC, VSEI, HEVC, AVC, and Video CICP JVET-AC1004, the Additional colour type identifiers for AVC, HEVC and Video CICP (Draft 3) JVET-AC1008, the Common test conditions for SHVC [JVET-AC1009](https://jvet-experts.org/doc_end_user/current_document.php?id=12569), the Common test conditions of 3DV experiments [JVET-AC1013](https://jvet-experts.org/doc_end_user/current_document.php?id=12570), the Common test conditions for SCM-based screen content coding [JVET-AC1015](https://jvet-experts.org/doc_end_user/current_document.php?id=12571), the Algorithm description for Versatile Video Coding and Test Model 19 (VTM 19) JVET-AC2002, the Guidelines for VTM-based software development [JVET-AC2003](https://jvet-experts.org/doc_end_user/current_document.php?id=12573), the New level and systems-related supplemental enhancement information for VVC (Draft 4) JVET-AC2005, the VTM and HM common test conditions and evaluation procedures for HDR/WCG video JVET-AC2011, the Common test conditions and evaluation procedures for neural network-based video coding technology JVET-AC2016, the Description of algorithms and software in neural network-based video coding (NNVC) version 2 JVET-AC2019, the Film grain synthesis technology for video applications (Draft 4) JVET-AC2020, the Draft verification test plan for VVC multilayer coding JVET-AC2021, the Draft plan for subjective quality testing of FGC SEI message JVET-AC2022, the Description of the EE on Neural Network-based Video Coding JVET-AC2023, the Description of the EE on Enhanced Compression beyond VVC capability JVET-AC2024, the Algorithm description of Enhanced Compression Model 8 (ECM 8) JVET-AC2025, the Conformance testing for VVC operation range extensions (Draft 4) [JVET-AC2026](https://jvet-experts.org/doc_end_user/current_document.php?id=12581), the SEI processing order SEI message in VVC (Draft 2) JVET-AC2027, the Additional conformance bitstreams for VVC multilayer configurations JVET-AC2028, the Optimization of encoders and receiving systems for machine analysis of coded video content (Draft 1) [JVET-AC2030](https://jvet-experts.org/doc_end_user/current_document.php?id=12564), the Common test conditions for optimization of encoders and receiving systems for machine analysis of coded video content [JVET-AC2031](https://jvet-experts.org/doc_end_user/current_document.php?id=12584), and the Improvements under consideration for neural network post filter SEI messages JVET-AC2032, had been completed and were approved. The software implementations of HM (version 18.0), VTM (version 20.0), ECM (version 8.0), and NNVC (version 4.0) were also approved.

Only minor editorial issues were found in the meeting report JVET-AC1000; no need to produce an update was identified (see section 2.12 for details).

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 5 (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.

It was further announced that it is necessary to register for the meeting through the ISO Meetings website for ISO/IEC experts or through the Q6/16 rapporteur for ITU-T experts. The password for meeting access had been sent to registered participants via these channels. Links to the Zoom sessions (without the necessary password) were available in the posted meeting logistics information and the calendar of meeting sessions in the JVET web site.

The following rules were established for those participating remotely via Zoom teleconference meeting:

* Use the “hand-raising” function to enter yourself in the queue to speak (unless otherwise instructed by the session chair). If you are dialed in by phone, request your queue position verbally. The online queue will be interleaved with the room queue, though it may not always be guaranteed that the sequence perfectly follows the sequence by which hand raising occurred.
* Stay muted unless you have something to say. People are muted by default when they join and need to unmute themselves to speak. The chair may mute anyone who is disrupting the proceedings (e.g. by forgetting they have a live microphone while chatting with their family or by causing bad noise or echo).
* Identify who you are and your affiliation when you begin speaking. The same applies for speakers in the room to let online participants know who is speaking.
* Use your full name and company/organization and country affiliation in your joining information, since the participation list of Zoom would also be used to compile the online part of attendance records.
* Turn on the chat window and watch for chair communication and side commentary there as well as by audio.
* Generally do not use video for the teleconferencing calls in order to avoid overloading people’s internet connections; enable only voice and screen sharing.
* Extensive use of screen sharing is encouraged, to enable participants to view the presented material and the meeting notes. At times, multiple sources of screen sharing may be enabled, so it may be necessary for participants to understand that this is happening and to understand how to select which one they want to watch.

## Agenda

The agenda for the meeting, for the further development and maintenance of the twin-text video coding technology standards *Advanced Video Coding* (AVC), *High Efficiency Video Coding* (HEVC), *Versatile Video Coding* (VVC)*, Coding-independent Code Points (Video)* (CICP), and *Versatile Supplemental Enhancement Information Messages for Coded Video Bitstreams* (VSEI), as well as related technical reports, software and conformance packages, was as follows:

* Opening remarks and review of meeting logistics and communication practices
* Roll call of participants
* Adoption of the agenda
* Code of conduct policy reminder
* IPR policy reminder and declarations
* Contribution document allocation
* Review of results of the previous meeting
* Review of target dates
* Reports of ad hoc group (AHG) activities
* Report of exploration experiments on neural-network-based video coding
* Report of exploration experiments on enhanced compression beyond VVC capability
* Consideration of contributions on high-level syntax
* Consideration of contributions and communications on project guidance
* Consideration of video coding technology contributions
* Consideration of contributions on conformance and reference software development
* Consideration of contributions on coding-independent code points for video signal type identification
* Consideration of contributions on film grain synthesis technology
* Consideration of contributions on optimization of encoders and receiving systems for machine analysis of coded video content
* Consideration of contributions on errata relating to standards in the domain of JVET
* Consideration of contributions on technical reports relating to standards and exploration study activities in the domain of JVET
* Consideration of contributions providing non-normative guidance relating to standards and exploration study activities in the domain of JVET
* Consideration of information contributions
* Consideration of future work items
* Coordination of visual quality testing
* Liaisons, coordination activities with other organizations
* Review of project editor and liaison assignments
* Approval of output documents and associated editing periods
* Future planning: Determination of next steps, discussion of working methods, communication practices, establishment of coordinated experiments (if any), establishment of AHGs, future meeting planning, other planning issues
* Other business as appropriate for consideration
* Closing

The agenda was approved as suggested.

The times of meeting sessions will follow the needs of the face-to-face meeting, with highest priority given to the aim of achieving the goals of the meeting. Typical meeting hours will be 0900-1900 TRT with coffee breaks and lunch breaks as appropriate, however some early morning or late-night sessions may be necessary. Sessions will be announced in the JVET calendar in advance as far as possible, but it might happen that some activities (such as breakout sessions) will be held at short notice.

## ISO and IEC Code of Conduct reminders

Participants were reminded of the ISO and IEC Codes of Conduct, found at

<https://www.iso.org/publication/PUB100397.html>.

<https://www.iecapc.jp/F/IEC_Code_of_Conduct.pdf>

These include points relating to (needs update):

* Respecting others
* Behaving ethically
* Escalating and resolving disputes
* Working for the net benefit of the international community
* Upholding consensus and governance
* Agreeing to a clear purpose and scope
* Participating actively and managing effective representation

## 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)

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 and ECM software implementation packages use 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 header is also used in the process of designing the VTM and ECM software, and for evaluating proposals for technology to be potentially included in these designs. This software or parts thereof might be published by ITU-T and ISO/IEC as an example implementation of a future video coding standard and for use as the basis of products to promote adoption of such technology.

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

These considerations apply to the 360Lib video conversion software and HDRTools as well. The SADL and NNVC packages for neural network-based video coding use the same licensing terms.

Software packages that had been developed in prior work of the JVT, the JCT-VC and the JCT-3V have similar considerations and are maintained according to the past practice in that work.

## Communication practices

The documents for the meeting can be found at <https://jvet-experts.org/>. It was noted that the previous site <http://phenix.int-evry.fr/jvet/> is still accessible, but was converted to read-only. 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 on the JVET email list was 1199 (as of 19 April 2023). All discussions (including those on AVC, HEVC, VVC, CICP, etc.) shall be conducted on the JVET reflector rather than any of the old reflectors (including JVT, JCT-VC, and JCT-3V) which are retained for archiving purposes.

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).

It is further emphasized that the document JVET-AB1012 gives valuable hints about communication practices as well as other IT resources used in JVET, such as software, conformance, and test materials.

## Terminology

* **ACT**: Adaptive colour transform
* **AFF**: Adaptive frame-field
* **AI**: All-intra
* **AIF**: Adaptive interpolation filtering
* **ALF**: Adaptive loop filter
* **AMP**: Asymmetric motion partitioning – a motion prediction partitioning for which the sub-regions of a region are not equal in size (in HEVC, being N/2x2N and 3N/2x2N or 2NxN/2 and 2Nx3N/2 with 2N equal to 16 or 32 for the luma component)
* **AMVP**: Adaptive motion vector prediction
* **AMT or MTS**: Adaptive multi-core transform, or multiple transform selection
* **AMVR**: (Locally) adaptive motion vector resolution
* **APS**: Adaptation parameter set
* **ARC**: Adaptive resolution conversion (synonymous with DRC, and a form of RPR)
* **ARMC**: Adaptive re-ordering of merge candidates
* **ARSS**: Adaptive reference sample smoothing
* **ATM**: AVC-based multiview and 3D test model
* **ATMVP** or “subblock-based temporal merging candidates”: Alternative temporal motion vector prediction
* **AU**: Access unit
* **AUD**: Access unit delimiter
* **AVC**: Advanced video coding – the video coding standard formally published as ITU-T Recommendation H.264 and ISO/IEC 14496-10
* **BA**: Block adaptive
* **BC**: See CPR or IBC
* **BCW**: Biprediction with CU based weighting
* **BD**: Bjøntegaard-delta – a method for measuring percentage bit rate savings at equal PSNR or decibels of PSNR benefit at equal bit rate (e.g., as described in document VCEG-M33 of April 2001)
* **BDOF**: Bi-directional optical flow (formerly known as **BIO**)
* **BDPCM**: Block-wise DPCM
* **BL**: Base layer
* **BMS**: Benchmark set (no longer used), a former preliminary compilation of coding tools on top of VTM, which provide somewhat better compression performance, but are not deemed mature for standardzation
* **BoG**: Break-out group
* **BR**: Bit rate
* **BT**: Binary tree
* **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
* **CCALF**: Cross-component ALF
* **CCLM**: Cross-component linear model
* **CCCM**: Cross-component convolutional model
* **CCP**: Cross-component prediction
* **CCSAO**:Cross-component SAO
* **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
* **CIPF**: CABAC initialization from the previous frame
* **CL-RAS**: Cross-layer random-access skip
* **CPB**: Coded picture buffer
* **CPMV**: Control-point motion vector
* **CPMVP**: Control-point motion vector prediction (used in affine motion model)
* **CPR**: Current-picture referencing, also known as IBC – a technique by which sample values are predicted from other samples in the same picture by means of a displacement vector called a block vector, in a manner conceptually similar to motion-compensated prediction
* **CST**: Chroma separate tree
* **CTC**: Common test conditions
* **CVS**: Coded video sequence
* **DCI**: Decoder capability information
* **DCT**: Discrete cosine transform (sometimes used loosely to refer to other transforms with conceptually similar characteristics)
* **DCTIF**: DCT-derived interpolation filter
* **DF**: Deblocking filter
* **DIMD**: Decoder intra mode derivation
* **DMVR**: Decoder motion vector refinement
* **DoCR**: Disposition of comments report
* **DPB**: Decoded picture buffer
* **DPCM**: Differential pulse-code modulation
* **DPS**: Decoding parameter sets
* **DRC**: Dynamic resolution conversion (synonymous with ARC, and a form of RPR)
* **DT**: Decoding time
* **DQ**: Dependent quantization
* **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)
* **ECM**: Enhanced compression model – a software codebase for future video coding exploration
* **ECV**: Extended Colour Volume (up to WCG)
* **EL**: Enhancement layer
* **EOS**: End of (coded video) sequence
* **ET**: Encoding time
* **FRUC**: Frame rate up conversion (pattern matched motion vector derivation)
* **GCI**: General constraints information
* **GDR**: Gradual decoding refresh
* **GLM**: Gradient linear model
* **GOP**: Group of pictures (somewhat ambiguous)
* **GPM**: Geometry partitioning mode
* **GRA**: Gradual random access
* **HBD**: High bit depth
* **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 conforms to the HEVC standard design (possibly with under-development extensions) – now also used especially in reference to the (non-normative) encoder algorithms (see WD and TM)
* **HMVP**: History based motion vector prediction
* **HRD**: Hypothetical reference decoder
* **HTM**: HEVC-based multiview and 3D test model (developed by JCT-3V)
* **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)
* **ILRP**: Inter-layer reference picture
* **IPCM**: Intra pulse-code modulation (similar in spirit to IPCM in AVC and HEVC)
* **IRAP**: Intra random access picture
* **ISP**: Intra subblock partitioning
* **JCCR**: Joint coding of chroma residuals
* **JCT-3V**: Joint collaborative team on 3D video (for AVC and HEVC)
* **JCT-VC**: Joint collaborative team on video coding (for HEVC)
* **JEM**: Joint exploration model – a software codebase previously used for 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
* **JVET**: Joint video experts team (initially for VVC, later expanded)
* **JVT**: Joint video team (for AVC)
* **KLT**: Karhunen-Loève transform
* **LB** or **LDB**: Low-delay B – the variant of the LD conditions that uses B pictures
* **LD**: Low delay – one of two sets of coding conditions designed to enable interactive real-time communication, with less emphasis on ease of random access (contrast with RA). Typically refers to LB, although also applies to LP
* **LFNST**: Low-frequency non-separable transform
* **LIC**: Local illumination compensation
* **LM**: Linear model
* **LMCS**: Luma mapping with chroma scaling (formerly sometimes called “in-loop reshaping”)
* **LP** or **LDP**: Low-delay P – the variant of the LD conditions that uses P frames
* **LUT**: Look-up table
* **LTRP**: Long-term reference picture
* **MANE**: Media-aware network element
* **MC**: Motion compensation
* **MCP**: Motion compensated prediction
* **MCTF**: Motion compensated temporal pre-filtering
* **MDNSST**: Mode dependent non-separable secondary transform
* **MIP**: Matrix-based intra prediction
* **MMLM**: Multi-model (cross component) linear mode
* **MMVD**: Merge with MVD
* **MPEG**: Moving picture experts group (an alliance of working groups and advisory groups in ISO/IEC JTC 1/‌SC 29, one of the two parent bodies of the JVET)
* **MPM**: Most probable mode (in intra prediction)
* **MRL**: Multiple reference line intra prediction
* **MV**: Motion vector
* **MVD**: Motion vector difference
* **NAL**: Network abstraction layer
* **NNVC**: Neural network-based video coding (experimental software package)
* **NSQT**: Non-square quadtree
* **NSST**: Non-separable secondary transform
* **NUH**: NAL unit header
* **NUT**: NAL unit type (as in AVC and HEVC)
* **OBMC**: Overlapped block motion compensation (e.g., as in H.263 Annex F)
* **OETF**: Opto-electronic transfer function – a function that converts to input light (e.g., light input to a camera) to a representation value
* **OLS**: Output layer set.
* **OOTF**: Optical-to-optical transfer function – a function that converts input light (e.g. l,ight input to a camera) to output light (e.g., light emitted by a display).
* **operation point**: A temporal subset of an OLS.
* **PDPC**: Position-dependent (intra) prediction combination.
* **PERP**: Padded equirectangular projection (a 360° projection format).
* **PH**: Picture header.
* **PHEC**: Padded hybrid equiangular cubemap (a 360° projection format).
* **PMMVD**: Pattern-matched motion vector derivation.
* **POC**: Picture order count.
* **PoR**: Plan of record.
* **PROF**: Prediction refinement with optical flow
* **PPS**: Picture parameter set (as in AVC and HEVC).
* **PTL**: Profile/tier/level combination.
* **QM**: Quantization matrix (as in AVC and HEVC).
* **QP**: Quantization parameter (as in AVC and HEVC, sometimes confused with quantization step size).
* **QT**: Quadtree.
* **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 (type of picture).
* **RASL**: Random-access skipped leading (type of picture).
* **R-D**: Rate-distortion.
* **RDO**: Rate-distortion optimization.
* **RDOQ**: Rate-distortion optimized quantization.
* **RDPCM**: Residual DPCM
* **ROT**: Rotation operation for low-frequency transform coefficients.
* **RPL**: Reference picture list.
* **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.
* **SADL**: Small adhoc deep learning library
* **SAO**: Sample-adaptive offset.
* **SBT**: Subblock transform.
* **SbTMVP**: Subblock based temporal motion vector prediction.
* **SCIPU**: Smallest chroma intra prediction unit.
* **SD**: Slice data; alternatively, standard-definition.
* **SDH**: Sign data hiding.
* **SDT**: Signal-dependent transform.
* **SE**: Syntax element.
* **SEI**: Supplemental enhancement information (as in AVC and HEVC).
* **SH**: Slice header.
* **SHM**: Scalable HM.
* **SHVC**: Scalable high efficiency video coding.
* **SIF**: Switchable (motion) interpolation filter.
* **SIMD**: Single instruction, multiple data.
* **SMVD**: Symmetric MVD.
* **SPS**: Sequence parameter set (as in AVC and HEVC).
* **STMVP**: Spatial-temporal motion vector prediction.
* **STRP**: Short-term reference picture.
* **STSA**: Step-wise temporal sublayer access.
* **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.
* **TIMD**: Template-based intra mode derivation
* **TM**: Template matching.
* **TMVP**: Temporal motion vector prediction.
* **TS**: Transform skip.
* **TSRC**: Transform skip residual coding.
* **TT**: Ternary tree.
* **UCBDS**: Unrestricted center-biased diamond search.
* **UGC**: User-generated content.
* **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).
* **VCM**: Video coding for machines.
* **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.
* **VQA**: Visual quality assessment.
* **VT**: Verification testing.
* **VTM**: VVC Test Model.
* **VUI**: Video usability information.
* **VVC**: Versatile Video Coding, the standardization project developed by JVET.
* **WAIP**: Wide-angle intra prediction
* **WCG**: Wide colour gamut.
* **WG**: Working group, a group of technical experts (usually used to refer to WG 11, a.k.a. MPEG).
* **WPP**: Wavefront parallel processing (usually synonymous with ECS).
* Block and unit names in HEVC:
  + **CTB**: Coding tree block (luma or chroma) – unless the format is monochrome, there are three CTBs per CTU.
  + **CTU**: Coding tree unit (containing both luma and chroma, synonymous with LCU), with a size of 16x16, 32x32, or 64x64 for the luma component.
  + **CB**: Coding block (luma or chroma), a luma or chroma block in a CU.
  + **CU**: Coding unit (containing both luma and chroma), the level at which the prediction mode, such as intra versus inter, is determined in HEVC, with a size of 2Nx2N for 2N equal to 8, 16, 32, or 64 for luma.
  + **PB**: Prediction block (luma or chroma), a luma or chroma block of a PU, the level at which the prediction information is conveyed or the level at which the prediction process is performed in HEVC.
  + **PU**: Prediction unit (containing both luma and chroma), the level of the prediction control syntax within a CU, with eight shape possibilities in HEVC:
    - **2Nx2N**: Having the full width and height of the CU.
    - **2NxN (or Nx2N)**: Having two areas that each have the full width and half the height of the CU (or having two areas that each have half the width and the full height of the CU).
    - **NxN**: Having four areas that each have half the width and half the height of the CU, with N equal to 4, 8, 16, or 32 for intra-predicted luma and N equal to 8, 16, or 32 for inter-predicted luma – a case only used when 2N×2N is the minimum CU size.
    - **N/2x2N** paired with **3N/2x2N** or **2NxN/2** paired with **2Nx3N/2**: Having two areas that are different in size – cases referred to as AMP, with 2N equal to 16 or 32 for the luma component.
  + **TB**: Transform block (luma or chroma), a luma or chroma block of a TU, with a size of 4x4, 8x8, 16x16, or 32x32.
  + **TU**: Transform unit (containing both luma and chroma), the level of the residual transform (or transform skip or palette coding) segmentation within a CU (which, when using inter prediction in HEVC, may sometimes span across multiple PU regions).
* Block and unit names in VVC:
  + **CTB**: Coding tree block (luma or chroma) – there are three CTBs per CTU in a P or B slice or in an I slice that uses a single tree, and one CTB per luma CTU and two CTBs per chroma CTU in an I slice that uses separate trees.
  + **CTU**: Coding tree unit (synonymous with LCU, containing both luma and chroma in a P or B slice or in an I slice that uses a single tree, containing only luma or only chroma in an I slice that uses separate trees), with a size of 16x16, 32x32, 64x64, or 128x128 for the luma component.
  + **CB**: Coding block, a luma or chroma block in a CU.
  + **CU**: Coding unit (containing both luma and chroma in P/B slice, containing only luma or chroma in I slice), a leaf node of a QTBT. It’s the level at which the prediction process and residual transform are performed in JEM. A CU can be square or rectangle shape.
  + **PB**: Prediction block, a luma or chroma block of a PU.
  + **PU**: Prediction unit, has the same size as a CU in the VVC context.
  + **TB**: Transform block, a luma or chroma block of a TU.
  + **TU**: Transform unit, has the same size as a CU in the VVC context.

## Standards, TRs, supplements and technical papers approval and publication status

* AVC
  + ITU-T H.264 V14 Consented at 22nd meeting on 2021-04-30 (with annotated regions, shutter interval, and miscellaneous corrections), approved 2021-08-22, published 2021-10-13
  + ISO/IEC 14496-10:2020 (Ed. 9) FDIS ballot closed 2020-11-27, published 2020-12-15
  + ISO/IEC 14496-10:2022 (Ed. 10), had been forwarded from DIS directly for publication 2022-01-21 (with annotated regions, shutter interval, and miscellaneous corrections) with an editing period, submitted to ITTF in 2022-05 after consultation with ISO staff on format of graphics files, upgraded to “DIS approved for registration” in ISO Project system 2022-07-04, published 2022-11-07
  + Preliminary draft text for YCgCo-Re and YCgCo-Ro issued at 26th meeting, second draft including SMPTE ST 2128 issued at 28th meeting (not yet formally requested as a project)
  + Conformance testing
    - ITU-T H.264.1 V6 Approved 2016-02-13, published 2016-06-17
    - Various amendments of ISO/IEC 14496-4:2004, including:
      * ISO/IEC 14496-4:2004/AMD 6:2005 Advanced Video Coding conformance
      * ISO/IEC 14496-4:2004/AMD 9:2006 AVC fidelity range extensions conformance
      * ISO/IEC 14496-4:2004/AMD 30:2009 Conformance testing for new profiles for professional applications
      * ISO/IEC 14496-4:2004/AMD 31:2009 Conformance testing for SVC profiles
      * ISO/IEC 14496-4:2004/AMD 38:2010 Conformance testing for Multiview Video Coding
      * ISO/IEC 14496-4:2004/AMD 41:2014 Conformance testing of MVC plus depth extension of AVC
      * ISO/IEC 14496-4:2004/AMD 42:2014 Conformance testing of Multi-Resolution Frame Compatible Stereo Coding extension of AVC
      * ISO/IEC 14496-4:2004/AMD 43:2015 3D-AVC conformance testing
      * ISO/IEC 14496-4:2004/AMD 45:2016 Conformance Testing for the Multi-resolution Frame Compatible Stereo Coding with Depth Maps Extension of AVC
  + Reference software
    - ITU-T H.264.2 V7 Approved 2016-02-13, published 2016-05-30
    - Various amendments of ISO/IEC 14496-5:2001, including:
      * ISO/IEC 14496-5:2001/AMD 6:2005 Advanced Video Coding (AVC) and High Efficiency Advanced Audio Coding (HE AAC) reference software
      * ISO/IEC 14496-5:2001/AMD 8:2006 AVC fidelity range extensions reference software
      * ISO/IEC 14496-5:2001/AMD 15:2010 Reference software for Multiview Video Coding
      * ISO/IEC 14496-5:2001/AMD 18:2008 Reference software for new profiles for professional applications
      * ISO/IEC 14496-5:2001/AMD 19:2009 Reference software for Scalable Video Coding
      * ISO/IEC 14496-5:2001/AMD 33:2015 Reference software for MVC plus depth extension of AVC
      * ISO/IEC 14496-5:2001/AMD 34:2014 Reference software of the multi-resolution frame compatible stereo coding of AVC
      * ISO/IEC 14496-5:2001/AMD 35:2015 3D-AVC Reference software
      * ISO/IEC 14496-5:2001/AMD 39:2016 Reference software for the Multi-resolution Frame Compatible Stereo Coding with Depth Maps of AVC
      * ISO/IEC 14496-5:2001/AMD 42:2017 Reference software for the alternative depth information SEI message extension of AVC
* HEVC
  + ITU-T H.265 V7 approved 2019-11-29, published 2020-01-10
  + ISO/IEC 23008-2:2020 (Ed. 4) FDIS ballot closed 2020-07-16, published 2020-08-27
  + ITU-T H.265 V8 Consented at the 22nd meeting (shutter interval information SEI message and miscellaneous corrections), published 2020-10-13
  + ISO/IEC 23008-2:2020/AMD 1:2021 (shutter interval information SEI message) published 2021-07-12
  + ISO/IEC 23008-2:202x (Ed. 5) began as CDAM 2 High-range levels output of 25th meeting of January 2022, CDAM ballot closed 2022-04-15, conversion to 5th edition with miscellaneous corrections planned at 26th meeting of April 2022, text submitted for DIS ballot 2022-07-10, DIS ballot closed 2023-01-10
  + Preliminary draft text for YCgCo-Re and YCgCo-Ro issued at 26th meeting, second draft including SMPTE ST 2128 issued at 28th meeting (not yet formally requested as a project)
  + Conformance testing
    - ITU-T H.265.1 V3 approved 2018-10-14, published 2019-01-15
    - ISO/IEC 23008-8:2018 (Ed. 2) Conformance specification for HEVC, published 2018-08-06
    - ISO/IEC 23008-8:2018/AMD 1:2019 Conformance testing for HEVC screen content coding (SCC) extensions and non-intra high throughput profiles, published 2019-10-15
  + Reference software
    - ITU-T H.265.2 V4 approved 2016-12-22, published 2017-04-10
    - ISO/IEC 23008-5:2017 (Ed. 2) Reference software for high efficiency video coding, published 2017-03-01
    - ISO/IEC 23008-5:2017/AMD 1:2017 Reference software for screen content coding extensions, published 2017-11-09
* VVC
  + ITU-T H.266 V1 approved 2020-08-29, published 2020-11-10
  + ISO/IEC 23090-3:2021 (Ed. 1) published 2021-02-16
  + ITU-T H.266 V2 with operation range extensions, Consented 2022-01-28, Last Call began 2022-04-01, Approved 2022-04-29, pre-published 2022-06-06, published 2022-07-12
  + ISO/IEC 23090-3:2022 (Ed. 2) with operation range extensions, approval at WG level to proceed to FDIS 2022-01-21, published 2022-09-25
  + ISO/IEC 23090-3:202x (Ed. 2) / Amd.1 New level and systems-related supplemental enhancement information, CDAM 1 issued from 26th meeting, ballot closed 2022-07-14, DAM 1 issued from 27th meeting, ballot closed 2023-01-03 (ready for action at this meeting)
  + Conformance testing
    - ITU-T H.266.1 V1 Consented 2022-01-28, Last Call began 2022-04-01, Approved 2022-04-29, pre-published 2022-05-17, published 2022-07-12
    - ISO/IEC 23090-15:2022 V1 approval at WG level to proceed to FDIS 2022-10-15, upgraded to “DIS approved for registration” in ISO Projects system 2021-10-24, upgraded to “FDIS registered for formal approval” 2022-07-11, FDIS ballot closed 2022-11-04, published 2022-11-24
    - ISO/IEC 23090-15:202x Amd.1 Operation range extensions – DAM 1 issued from 25th meeting 2022-01-21, upgraded to “CD approved for registration as DIS” status in ISO Projects system 2022-05-31, upgraded to “DIS registered” 2022-06-22, DAM ballot closed 2022-11-15 (ready for action at this meeting)
  + Reference software
    - ITU-T H.266.2 V1 Consented 2022-01-28, Last Call began 2022-04-01, Approved 2022-04-29, pre-published 2022-05-17, published 2022-07-12
    - ISO/IEC 23090-16:2022 V1 approval at WG level to proceed to FDIS 2022-01-21, upgraded to “DIS approved for registration” status in ISO Projects system 2022-04-21, upgraded to “FDIS registered for formal approval” 2022-04-22, FDIS ballot initiated 2022-07-24, FDIS ballot closed 2022-09-19, published 2022-10-23
* VSEI
  + ITU-T H.274 V1 approved 2020-08-29, published 2020-11-10
  + ISO/IEC 23002-7:2021 (Ed. 1) published 2021-01-28
  + ITU-T H.274 V2 Consented 2022-01-28, Last Call began 2022-04-01, Approved 2022-05-22 (after 1 Last Call comment and Additional Review), pre-published 2022-06-17, published 2022-07-25
  + ISO/IEC 23002-7:2022 (Ed. 2) approval at WG level to proceed to FDIS 2022-01-21, upgraded to “DIS approved for registration” status in ISO Projects system 2022-05-05 and “FDIS registered for formal approval” 2022-05-08, FDIS ballot closed 2022-09-27, published 2022-10-30
  + ISO/IEC 23002-7:202x (2nd Ed.) Amd.1 Request for new edition and CD for additional SEI messages issued at 27th meeting, ballot closed 2022-10-10, DAM registered 2022-11-13, DAM ballot closed 2022-04-06: comments in [m62571](https://dms.mpeg.expert/doc_end_user/current_document.php?id=86620&id_meeting=194) from Finland, Japan, US, ISO CS (minor)
* CICP
  + ISO/IEC 23091-2:2021 (Ed. 2) had been forwarded from DIS directly for publication in 2021-04 and published 2021-10-18
  + ITU-T H.273 V2 (with 4:2:0 sampling alignment and corrections for range of values for sample aspect ratio, ICTCP equations for HLG, and transfer characteristics function for sYCC of IEC 61966-2-1) Consented on 2021-04-30, Last Call closed during the 23rd meeting with approval on 2021-07-14, published 2021-09-24
  + ISO/IEC 23091-2:202x (Ed. 3) Request for new edition and CD for new edition (including YCgCo-Re and YCoCg-Ro) issued at 27th meeting, ballot closed 2022-10-10, DIS registered 2022-11-13, pending DIS ballot (no action at this meeting)
  + Preliminary draft text for including SMPTE ST 2128 issued at 28th meeting (not yet formally requested as a project)
* Conversion and coding practices for HDR/WCG Y′CbCr 4:2:0 video with PQ transfer characteristics
  + H.Sup15 V1, approved 2017-01-27, published 2017-04-12
  + ISO/IEC TR 23008-14:2018 published 2018-08
* Signalling, backward compatibility and display adaptation for HDR/WCG video coding
  + H.Sup18 V1, approved 2017-10-27, published 2018-01-18
  + ISO/IEC TR 23008-15:2018 published 2018-08
* Usage of video signal type code points
  + H.Sup19 V3 approved 2021-04-30, published 2021-06-04
  + ISO/IEC TR 23091-4 (Ed. 3) published 2021-05-23
* Working practices using objective metrics for evaluation of video coding efficiency experiments
  + HSTP-VID-WPOM V1: approved 2020-07-03, published 2020-11
  + ISO/IEC TR 23002-8 (Ed. 1) published 2021-05-20
* Film grain synthesis technologies for video applications
  + ISO/IEC TR 23002-9 Request for subdivision and WD 1 issued at 25th meeting 2022-01-21, WD 2 issued at 27th meeting, WD 3 issued at 28th meeting
* The following freely available standards are published here in ISO/IEC:  
  <https://standards.iso.org/ittf/PubliclyAvailableStandards/index.html>
  + Various amendments of ISO/IEC 14496-4:2004
  + Various amendments of ISO/IEC 14496-5:2001
  + ISO/IEC 23008-2:2020 (Ed. 4) HEVC
* The following standards that have been intended by JVET to be publicly available were not available at <https://standards.iso.org/ittf/PubliclyAvailableStandards/index.html> as of 2023-01-08. (Please see below for record of previously issued requests.)
  + ISO/IEC 23091-2:2021 (Ed. 2) Video CICP (was requested in April 2021, and the 2019 previous edition was also not available there)
  + ISO/IEC 23008-2:2020 (Ed. 4) Amd.1:2021: Shutter interval information SEI message, published 2021-07-12 (has not been requested)
  + ISO/IEC 23008-5:2017 (Ed. 2) Reference software for high efficiency video coding, published 2017-03-01
  + ISO/IEC 23008-5:2017/AMD 1:2017 Reference software for screen content coding extensions, published 2017-11-09
  + ISO/IEC 23008-8:2018 (Ed. 2) Conformance specification for HEVC, published 2018-08, published 2018-08-06
  + ISO/IEC 23008-8:2018/AMD 1:2019 Conformance testing for HEVC screen content coding (SCC) extensions and non-intra high throughput profiles, published 2019-10-15
  + ISO/IEC 14496-10:2022 (Ed. 10) – AVC – final text issued and public availability requested at the 25th meeting (January 2022)
  + ISO/IEC 23002-7:2022 (Ed. 2) – VSEI – FDIS issued and public availability requested at the 25th meeting (January 2022)
  + ISO/IEC 23090-3:2022 (Ed. 2) – VVC – FDIS issued and public availability requested at the 25th meeting (January 2022)
  + ISO/IEC 23090-15:2022 (Ed. 1) – VVC conformance – FDIS issued and public availability requested at the 24th meeting (October 2021)
  + ISO/IEC 23090-16:2022 (Ed. 1) – VVC reference software – FDIS issued and public availability requested at the 25th meeting (January 2022)
* It appears necessary to check if all older software and conformance packages are publicly available – it might be that it was never requested, e.g. for those that were produced by JCT-3V. This topic was left TBD until the next meeting – perhaps it would be best to compile a list of all relevant software and conformance parts of AVC, HEVC, MPEG-2 aka H.262, CICP, and request these in bulk.

## Draft standards progression status

* AVC and HEVC colour type indicators for YCgCo-Re, YCgCo-Ro, and SMPTE ST 2128 (IPT-PQ-C2) are drafted and pending formal action
* HEVC new levels (from JVET-Z1005) – ISO/IEC 23008-2 DIS of new edition of HEVC was issued from the April 2022 26th meeting, incorporating Amd.1 and corrigenda items (ballot closed 2023-01-10, ballot comments in the Summary of Voting document [m61834](https://dms.mpeg.expert/doc_end_user/current_document.php?id=85619&id_meeting=193)); note that Amd.1 = shutter interval SEI is already included in latest ITU-T edition of H.265. It is noted that there are potential additional items (corrigenda+tickets, YCgCo-Re and YCgCo-Ro draft, SMPTE ST 2128, multiview profiles draft) where only corrigenda items were included in the FDIS text based on ballot comments, ballot has not been started yet. ITU-T consent for a new edition is planned for July. It was noted that the referencing of VSEI is also somewhat different in the ITU-T and ISO/IEC versions of HEVC and AVC, which might be aligned at the next convenient time (basically editorial – e.g., the ITU version of AVC specifies the annotated regions SEI message without referencing VSEI, whereas the ISO/IEC version references VSEI for the syntax and semantics of that SEI message). Proceeding to FDIS should be considered at the current meeting.
* VVC new level and systems-related supplemental enhancement information (from JVET-AA2005) – VVC DAM was issued from 27th meeting, ballot closed 2023-01-03, ballot comments in the Summary of Voting document [m61833](https://dms.mpeg.expert/doc_end_user/current_document.php?id=85618&id_meeting=193). This was converted into a preliminary FDIS of VVC 3rd edition ([WG 5 N 183](https://dms.mpeg.expert/doc_end_user/current_document.php?id=86365&id_meeting=193)) at the 29th meeting, anticipating that some alignment will be necessary with the ongoing VSEI amendment. ITU-T consent is planned for July 2023 when a new edition of VSEI is also planned to be consented, to keep VVC and VSEI aligned.
* VVC Conformance testing for operation range extensions – (from JVET-Y2026) – the DAM ballot closed 2022-11-15 (ballot comments in the Summary of Voting document [m61832](https://dms.mpeg.expert/doc_end_user/current_document.php?id=85617&id_meeting=193)), and this was issued as FDIS at the 29th meeting, but ballot has not been started yet. ITU-T consent is planned for July 2023.
* VSEI additional SEI messages (from JVET-AB2006) – VSEI DAM (JVET draft 3) was issued from the 28th meeting and a DAM ballot was issued, Summary of Voting document is available as [m62571](https://dms.mpeg.expert/doc_end_user/current_document.php?id=86620&id_meeting=194). It was planned to be converted into FDIS of new edition in April (if possible) or July, ITU-T consent in July 2023. There are numerous input contributions in particular on NNPF.
* Film grain synthesis technology for video applications – JVET draft 4 was issued at the 29th meeting (JVET-AC2020), and the ISO/IEC 23002-9 CDTR was issued (a request to start work on the TR had been made at the 25th meeting), but ballot has not been started yet. The publication limit date is 2023-08-09, so an extension request may be needed, but perhaps not at the current meeting.
* Video CICP new edition with for YCgCo-Re and YCgCo-Ro (from JVET-Z1003), an ISO/IEC 23091-2 DIS was issued from the 28th meeting and the Summary of Voting document is available as [m62572](https://dms.mpeg.expert/doc_end_user/current_document.php?id=86621&id_meeting=194). ITU-T consent is planned for July 2023.
* Video CICP colour type indicator for SMPTE ST 2128 is drafted and pending formal action. It was reported that it is expected to become finalized in the SMPTE meeting in March. It was further reported that some clarification on conversion equations is necessary.
* A request for free availability in ISO/IEC has to be made for each edition, amendment and corrigendum, and the request needs to be approved in the WG 5 Recommendations. A request form also needs to be filled out (but the form does not need to be issued as a WG 5 document). A freely available URL for the ITU publication should be provided for the following parts:
  + For the ongoing work items, when they become finalized
  + ISO/IEC 23008-2:2020/Amd.1:2021 – HEVC FDAM issued 20th meeting (October 2020), public availability not yet requested but may not be necessary as it becomes included in next edition

## Opening remarks

Remarks during the opening session of the meeting Friday 21 April at 0900 TRT were as follows.

* Timing and organization of the meeting and online access, calendar posting of session plans
  + The initial number of documents was was again higher than for the previous meeting (160->200) – parallel sessions appear to be necessary
  + Scheduling of NNVC discussions – JPEG meeting and JPEG-AI sessions in parallel (virtual, typically in afternoon time TRT, not over the weekend)
* Plans for subsequent F2F meetings in July (Geneva) and October (Hannover)
* The meeting logistics, agenda, working practices, policies, and document allocation considerations were reviewed.
  + Remote access to the meeting was provided using Zoom. This requires discipline in the meeting room (no microphone to be switched on, podium and room microphones to be under central control).
  + Having text and software available is crucial (and not just arriving at the end of the meeting).
  + There were no objections voiced in the opening plenary to the consideration of late contributions.
* The results of the previous meeting and the meeting report JVET-AC1000 were reviewed. The following small issues in the meeting report were noted and were not considered sufficient to warrant issuing a revision. These are obviously left over from a previous report, and the correct information can be found in other places of the report:
  + In section 2.10, it is mentioned that JVET-AB1012 would become updated, but this did not happen.
  + In section 2.10, the number of email list subscribers relates to the status of January 2023 rather than 2022.
  + In section 7.2, the times for the first two information sharing sessions should have been Monday 16 Jan. 0500-0730 UTC, and Wednesday 18 Jan. 0500-0600 UTC
  + In Annex B2, the twenty-ninth meeting should be referred rather than the twenty-eighth.
  + …
* There was somewhat less of a problem of late non-cross-check documents.
* There were again a few documents registered where authors’ given names were not abbreviated, and/or company affiliation was missing in the authors’ list. Participants were reminded to stick to JVET’s conventions.
* Experts are asked to inform the chair when the title of a document is changed, or if authors are added. Otherwise, that might not be correct in the meeting notes.
* The primary goals of the meeting were
  + VVC and VSEI third editions FDIS (and plans for next ITU editions in July)
    - VVC DAM draft DoCR (from last meeting) in [MDS22364](https://dms.mpeg.expert/doc_end_user/current_document.php?id=86364&id_meeting=193)
    - VSEI DAM ballot response in [m62571](https://dms.mpeg.expert/doc_end_user/current_document.php?id=86620&id_meeting=194): Relatively large number of comments, and numerous input contributions in particular on NNPF; relation with proposed processing order SEI message (JVET-AC2027) ?
    - Stay with preliminary FDIS as output from this meeting?
  + New edition video CICP FDIS (DIS ballot response in [m62572](https://dms.mpeg.expert/doc_end_user/current_document.php?id=86621&id_meeting=194)) (and plans for next ITU edition in July) – ballot comment on including ST 2128 descriptor may need consideration of the status, would be good to include but this may impose delay
  + Optimization of encoders and receiving systems for machine analysis of coded video content – WD of TR to be issued
  + Preparation of verification tests film grain and multilayer
  + Any action items on reference software JM/HM/VTM? Status of MV-HEVC software and test conditions?
  + Additional colour type identifiers for AVC and HEVC (Draft 2 in JVET-AC1008 was issued at the last meeting)
    - there is a ballot comment for including identifier for SMPTE ST 2128 in new edition of CICP
    - might also be included in new edition of H.265 in July (there was no ISO/IEC 23008-2 DIS ballot comment on this, so it is not in the newest edition of 23008-2)
    - no action yet to be taken for AVC at this moment. It was suggested to consider new editions of ITU-T H.264 and ISO/IEC 14496-10 in the near future.
  + Exploration Experiments
    - Neural network-based video coding
    - Enhanced compression beyond VVC
* Liaison communication:
  + One from JPEG
* Joint meetings: with AG 5 on subjective testing, with WG 4 on VCM, any other?
* Principles of standards development were discussed.

## Scheduling of discussions

The times of meeting sessions followed the needs of the face-to-face meeting, with highest priority given to the aim of achieving the goals of the meeting. Typical meeting hours were in the range of 0900-1900 TRT with coffee breaks and lunch breaks as appropriate, however some early morning or late-night sessions may be necessary. Sessions were announced in the JVET calendar in advance as far as possible, but it might happen that some activities (such as breakout sessions) will be held at short notice.

Particular scheduling notes are shown below, although not necessarily 100% accurate or complete. Times are recorded in the local timzone of the meeting venue, except as otherwise noted:

* Fri. 21 April, 1st day
  + Morning session:
    - 0900–45 Opening remarks, review of practices, agenda, IPR policy reminder
    - 0945–1245 Reports of AHGs
  + Afternoon session:
    - 1400–2000 EE2 summary report
    - 1400–1900 BoG on NNPF (Y.-K. Wang, M. Hannuksela, S. Deshpande)
* Sat. 22 April, 2nd day
  + Morning session:
    - 0900–1250 Review of EE1 summary and 5.1.4
    - 0900–1300 BoG on NNPF (Y.-K. Wang, M. Hannuksela, S. Deshpande)
  + Afternoon session:
    - 1400–2000 Review of 5.2.3, 5.2.4 (and 4.5 for 45 minutes)
    - 1400–2000 BoG on NNPF (Y.-K. Wang, M. Hannuksela, S. Deshpande)
* Sun. 23 April, 3rd day
  + Morning session:
    - 0900––1300 Review of 5.2.4
    - 0900-1300 BoG on NNPF (Y.-K. Wang, M. Hannuksela, S. Deshpande)
    - 0900-1400 BoG on NNVC loop filters (E. Alshina, F. Galpin)
  + Afternoon session:
    - 1400–1915 Review of 5.2.4, 5.2.5 (chaired by Y. Ye from 1600)
    - 1400–2000 BoG on NNPF (Y.-K. Wang, M. Hannuksela, S. Deshpande)
* Mon. 24 April, 4th day
  + 0900–1130 MPEG information sharing session
  + Morning session:
    - 1130–1330 BoG on NNVC loop filters (E. Alshina, F. Galpin)
  + Afternoon session:
    - 1430–1545 Plenary for coordination and BoG reports
    - 1600–2010 Review 4.10 AHG8: Optimization of encoders and receiving systems for machine analysis of coded video content
    - 1600–2000 BoG on NNPF (Y.-K. Wang, M. Hannuksela, S. Deshpande)
* Tue. 25 April, 5th day
  + Morning session:
    - 0900–1000 Joint Meeting with VCEG/AG 5 on visual testing topics
    - 1000–1110 BoG report NNPF
    - 1125-1255 review 6.2 non-NNPF SEI
  + Afternoon session:
    - 1400–1445 Report of BoG on NNVC loop filter
    - 1445–1545 Review 4.9 AHG7: ECM tool assessment
    - 1600–1840 review 6.2 non-NNPF SEI
    - 1840–2015 Review 4.11 AHG10: Encoding algorithm optimization
* Wed. 26 April, 6th day
  + 0900–1030 MPEG information sharing session
  + Morning session:
    - 1030–1300 Further planning, review of remaining docs 4.x (except film grain synthesis), and other  
      (session starts as soon as the room is ready)
    - 1100–1300 BoG on NNVC loop filter
  + Afternoon session:
    - 1400–1500 Joint with VCEG/AG 5: 4.6; 4.5 on multi-layer verification tests
    - 1500–1730 4.12 Film grain synthesis, remaining 4.x and other, revisits
* Thu. 27 April, 7th day
  + Morning session:
    - 0900–1030 Joint Meeting with WG 4 and VCEG on VCM
    - 1030–1100 Joint Meeting with WG 7 and VCEG on NNPF for V-PCC
    - 1100–1300 Remaining doc review, revisits, further planning, a.o.b.
  + Afternoon session:
    - 1400–1500 Joint with VCEG/AG 5: 4.6; 4.5 on verification test planning
    - 1500–1800 Review draft DoCRs, planning of output docs and AHGs, draft recommendations, revisits, remaining doc review (if any), a.o.b.
* Fri. 28 April, 8th day
  + Plenary:
    - 0900–XXXX Review and approval of output docs, AHGs
    - XXXX–XXXX Recommendations, future planning, a.o.b.
  + 1400–XXXX MPEG information sharing session
  + XXXX–XXXX WG 5 Closing plenary: Approval of meeting recommendations

## 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 summary reports, and may not be completely accurate; documents which are allocated to multiple sections are only counted in one of them):

* AHG reports (14) (section 3)
* Project development (section 4)
  + AHG1: Deployment and advertisement of standards (2)
  + AHG2: Text development and errata reporting (1)
  + AHG3: Test conditions (0)
  + AHG3: Software development (1)
  + AHG4: Subjective quality testing and verification testing (5)
  + AHG4: Test Material (4)
  + AHG4: Subjective quality assessment methodology (0)
  + AHG5: Conformance test development (1)
  + AHG7: ECM tool assessment (4)
  + AHG8: Optimization of encoders and receiving systems for machine analysis of coded video content (12)
  + AHG10: Encoding algorithm optimization (4)
  + AHG13: Film grain synthesis (2)
  + Implementation studies (2)
  + Profile/tier/level specification (1)
  + General aspects of standards development and applications of standards (0)
* Low-level tool technology proposals (section 5) with subtopics (number counts excluding BoG and summary reports)
  + AHG11/AHG14 and EE1: Neural network-based video coding (28) (section 5.1)
  + AHG6/AHG12 and EE2: Enhanced compression beyond VVC capability (103) (section 5.2)
* AHG9: High-level syntax (HLS) proposals (section 6) with subtopics
  + SEI messages on neural-network post filter (36) (section 6.1)
  + SEI messages on topics other than NNPF (9) (section 6.2)
  + Non-SEI HLS aspects (0) (section 6.3)
* Joint meetings, plenary discussions, BoG reports (2), liaison (1), summary of actions (section 7)
* Project planning (section 8)
* Establishment of AHGs (section 9)
* Output documents (section 10)
* Future meeting plans and concluding remarks (section 11)

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

# AHG reports (14)

These reports were discussed during 0945–1245 on Friday 21 April 2023 (chaired by JRO).

[JVET-AD0001](https://jvet-experts.org/doc_end_user/current_document.php?id=12732) JVET AHG report: Project Management (AHG1) [J.-R. Ohm (chair), G. J. Sullivan (vice-chair)]

1. **Goals and activity**

The work of the JVET overall had proceeded well in the interim period with approximately 20% higher number of input documents (as compared to the previous meeting) submitted to the current meeting. Intense discussion had been carried out on the group email reflector, and most output documents from the preceding meeting had been produced as planned.

Output documents from the preceding meeting had been made initially available at the JVET web site (<https://jvet-experts.org/>) or the ITU-based JVET site (<http://wftp3.itu.int/av-arch/jvet-site/2023_01_AC_Virtual/>). It is noted that the previous document sites <http://phenix.int-evry.fr/jvet/>, <http://phenix.int-evry.fr/jct/>, and <http://phenix.int-evry.fr/jct3v/> are still accessible, but were converted to read-only.

The list of documents produced included the following, particularly:

* The meeting report (JVET-AC1000) [Posted 2023-02-17, also submitted as WG 5 N 173]
* Guidelines for HM-based software development (JVET-AC1001) [Posted 2023-01-24]
* Errata report items for VVC, HEVC, AVC, and Video CICP (JVET-AC1004) [Posted 2023-03-21]
* Additional colour type identifiers for AVC, HEVC and Video CICP (Draft 3) (JVET-AC1008) [Posted 2023-02-24, last update 2023-03-08, also submitted as WG 5 preliminary WD N 186]
* Common test conditions for SHVC (JVET-AC1009) [Posted 2023-04-04]
* Common test conditions of 3DV experiments (JVET-AC1013) [not posted yet, situation about unavailable sequences needs to be clarified]
* Common test conditions for SCM screen content coding (JVET-AC1015) [Posted 2023-04-04]
* Algorithm description for Versatile Video Coding and Test Model 19 (VTM 19) (JVET-AC2002) [Posted 2023-04-07, also submitted as WG 5 WD N 161]
* Guidelines for VTM-based software development (JVET-AC2003) [Posted 2023-01-25]
* New level and systems-related supplemental enhancement information for VVC (Draft 4) (JVET-AC2005) [Posted 2023-01-31]
* VTM and HM common test conditions and evaluation procedures for HDR/WCG video (JVET-AC2011) [Posted 2023-02-25]
* Common Test Conditions and evaluation procedures for neural network-based video coding technology (JVET-AC2016) [Posted 2023-02-15]
* Description of algorithms and software in neural network-based video coding (NNVC) version 2 (JVET-AC2019) [Posted 2023-03-09, also submitted as WG 5 N 165]
* Film grain synthesis technology for video applications (Draft 4) (JVET-AC2020) [Posted 2023-03-27, last update 2023-03-31, to be submitted as WG 5 CDTR N 188]
* Draft verification test plan for VVC multilayer coding (JVET-AC2021) [Posted 2023-03-07]
* Draft plan for subjective quality testing of FGC SEI message (JVET-AC2022) [Posted 2023-03-07]
* Exploration experiment on Neural Network-based Video Coding (EE1) (JVET-AC2023) [Posted 2023-01-20, last update 2023-02-06, also submitted as WG 5 N 187]
* Exploration experiment on Enhanced Compression beyond VVC capability (EE2) (JVET-AC2024) [Posted 2023-01-20, last update 2023-02-20, also submitted as WG 5 N 189]
* Algorithm description of Enhanced Compression Model 8 (ECM 8) (JVET-AC2025) [Posted 2023-04-06, also submitted as WG 5 N 190]
* Conformance testing for VVC operation range extensions (Draft 4) (JVET-AC2026) [Posted 2023-04-XX]
* SEI processing order SEI message in VVC (Draft 1) (JVET-AC2027) [Posted 2023-03-23, also submitted as WG 5 preliminary WD N 182]
* Additional conformance bitstreams for VVC multilayer configurations (JVET-AC2028) [Posted 2023-04-XX]
* Optimization of encoders and receiving systems for machine analysis of coded video content (draft 1) (JVET-AC2030) [Posted 2023-03-20, also submitted as WG 5 preliminary WD N 177]
* Common test conditions for optimization of encoders and receiving systems for machine analysis of coded video content (JVET-AC2031) [Posted 2023-02-02, last update 2023-03-30]
* Improvements under consideration for neural network post filter SEI messages (JVET-AC2032) [Posted 2023-01-27, last update 2023-02-01, also submitted as WG 5 N 175]

Furthermore, the following documents were submitted to the ISO/IEC JTC1/SC29 parent body on behalf of its WG 5:

* Recommendations of the 10th WG 5 meeting (WG 5 N 173)
* Disposition of comments received on ISO/IEC DIS 23008-2:202x (5th edition) (WG 5 N 178)
* Text of ISO/IEC FDIS 23008-2:202x High efficiency video coding (5th edition) (WG 5 N 179)
* Draft disposition of comments received on ISO/IEC 23090-3:2022 DAM 1 (WG 5 N 180)
* Preliminary text of ISO/IEC FDIS 23090-3:202x Versatile video coding (3rd edition) (WG 5 N 181)
* Disposition of comments received on ISO/IEC 23090-15 DAM 1 (WG 5 N 184)
* Text of ISO/IEC FDIS 23090-15:202x Conformance testing for versatile video coding (2nd edition) (WG 5 N 185) – submission under preparation
* Liaison statement to SC 29/WG 1 (JPEG) on JPEG AI and neural network-based video coding (WG 5 N 191)
* List of AHGs established at the 10th WG 5 meeting (WG 5 N 192)

The fourteen *ad hoc* groups had made progress, and reports from those activities had been submitted. Furthermore, two exploration experiments (EE) on neural network-based video coding and on enhanced compression beyond VVC capability were conducted.

The arrangements for the 30th meeting had been announced in the JVET reflector, in the JVET logistics document (<https://www.itu.int/wftp3/av-arch/jvet-site/2023_04_AD_Antalya/JVET-AD_Logistics.docx>), and in the WG 5 calling notice (N 193) and agenda (N 194) for the 11th WG 5 meeting.

Software integration 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 200 input contributions (not counting the AHG reports, summary reports and crosschecks) had been registered for consideration at the current meeting.

It is further noted that, starting from the twentieth JVET meeting, work items which had originally been conducted by the Joint Collaborative Team on Video Coding (JCT-VC) were continued to be conducted in JVET as a single joint team, as negotiated by the parent bodies. This particularly consists of work on

* *High Efficiency Video Coding* (HEVC) and its extensions, the development of associated conformance test sets, reference software, verification testing, and non-normative guidance information,
* Specification of *Coding-independent Code Points (Video)* (CICP), and associated technical report(s),
* Maintenance and minor enhancement work on the *Advanced Video Coding* (AVC) standard, associated conformance test sets and reference software.

To retain a consistent numbering scheme, the number range of output documents starting from 1001 was reserved for the previous JCT-VC topic items listed above, whereas the number range starting from 2001 was retained for VVC, VSEI and exploration activities.

A preliminary basis for the document subject allocation and meeting notes for the 30th meeting had been made publicly available on the ITU-hosted ftp site as <http://wftp3.itu.int/av-arch/jvet-site/2023_04_AD_Antalya/JVET-AD_notes_d0.docx>.

1. **Recommendations**

The AHG recommends its continuation.

[JVET-AD0002](https://jvet-experts.org/doc_end_user/current_document.php?id=12733) JVET AHG report: Draft text and test model algorithm description editing (AHG2) [B. Bross, C. Rosewarne (co-chairs), F. Bossen, A. Browne, S. Kim, S. Liu, J.-R. Ohm, G. J. Sullivan, A. Tourapis, Y.-K. Wang, Y. Ye (vice-chairs)]

2.1 Output documents produced

2.1.1 JVET-AC1004 - Draft Errata report items for VVC, VSEI, HEVC, AVC, and Video CICP

Incorporated items at the JVET-AC meeting:

• For VVC, all errata items have been incorporated in JVET-AC2005: New level and systems-related supplemental enhancement information for VVC (Draft 4).

• For HEVC, incorporated the following items:

o Confirmed redudnant call to clause 8.6.1 (reported by Cliff Reader – thanks!).

o Confirmed JVET-AB0120: Addition of interpolation for "initial CPB removal delay offset".

o JVET-AC0311: On number of conformance tests (option 1.)

o Updated issues 1 to 4 in Subsection 4.4 per inputs from Miska M. Hannuksela (thanks!).

o Change the font size from 8 pt to 10 pt for "Table 9-4" in a paragraph in clause 9.3.2.2 (reported by Cliff Reader – thanks!).

• For AVC, incorporated the following items:

o Confirmed JVET-AB0120: Addition of interpolation for "initial CPB removal delay offset".

o An issue of talking about VUI in subclause 0.6.1 in ISO/IEC 14496-10:2022 (Edition 10) while the sentence should only talk about SEI messages.

2.1.2 JVET-AC1008 - Additional colour type identifiers for AVC, HEVC and Video CICP (Draft 3)

This document contains the draft text for the specification of additional colour type identifiers for AVC (Rec. ITU-T H.264 | ISO/IEC 14496-10), HEVC (Rec. ITU-T H.265 | ISO/IEC 23008-2), and CICP (Rec. ITU-T H.273 | ISO/IEC 23091-2). Text modifications are provided for specification of code point identifiers for YCgCo-R colour representation with equal luma and chroma bit depths and for Draft SMPTE ST 2128. The new code points for for YCgCo-R are referred to as YCgCo-Re and YCgCo-Ro, where the number of bits added to a source RGB bit depth is 2 (i.e., even) and 1 (odd), respectively. Draft SMPTE ST 2128 specifies a colour representation referred to as IPT-PQ-C2. The affected sections are provided relative to corresponding basis texts (based on the 2021-08 edition of Rec. ITU-T H.264 (the most recent edition), the 2020 edition of ISO/IEC 23008-2 (not the 5th edition currently under preparation), and ISO/IEC DIS 23091-2:202x (3rd Ed.), respectively). Equation numbers and their cross-references have been updated without revision marking. Change marks are included to show the changes since the October output (JVET-AB1008), which reflect the LMS equations for SMPTE ST 2128 as provided in JVET-AC0352 and some minor refinements and corrections since the previous draft.

2.1.3 JVET-AC2002 - Algorithm description for Versatile Video Coding and Test Model 19 (VTM 19)

The JVET established the VVC Test Model 20 (VTM20) software at its 29th meeting (11-20 January 2023, teleconference). This document serves as a source of general tutorial information on the VVC design and also provides an algorithm description and encoding method description of VTM20 software. It is noted that, as no update of the algorithm description document had been released at the 27th JVET meeting, the numbering of the VTM software version is one higher than that of this description document. In the main body of the text, numbering refers to the software version. The VVC has been developed by a joint collaborative team of ITU-T and ISO/IEC experts known as the Joint Video Experts Team (JVET), which is a partnership of ITU-T Study Group 16 Question 6 (known as VCEG) and ISO/IEC JTC 1/SC 29/WG 11 (known as MPEG). This draft new standard has been designed with two primary goals. The first of these is to specify a video coding technology with a compression capability that is substantially beyond that of the prior generations of such standards, and the second is for this technology to be highly versatile for effective use in a broadened range of applications. Some key application areas for the use of this standard particularly include ultra-high-definition video (e.g., with 3840×2160 or 7620×4320 picture resolution and bit depth of 10 or 12 bits as specified in Rec. ITU-R BT.2100), video with a high dynamic range and wide colour gamut (e.g., with the perceptual quantization or hybrid log-gamma transfer characteristics specified in Rec. ITU-R BT.2100), and video for immersive media applications such as 360° omnidirectional video projected using a common projection format such as the equirectangular or cubemap projection format, in addition to the applications that have commonly been addressed by prior video coding standards.

Ed. Notes:

VVC Test Model 19 (VTM20) algorithm description and encoding method v1

• General improvements to neural network-based post filtering SEI messages (section 4.4) to bring the section up to date with the current filtering purposes of the NNPFC and NNPFA messages

• Incorporated JVET-AC0096: AHG10/12: Suggestion for new CTC for RPR in VTM and ECM

2.1.4 JVET-AC2005 - New level and systems-related supplemental enhancement information for VVC (Draft 4)

This document contains a draft amendment for changes to the Versatile Video Coding (VVC) standard (ITU T H.266 | ISO/IEC 23090-3). This amendment includes the following: 1) the support of an unlimited level for video profiles; 2) some technical corrections and editorial improvements to the 2nd edition text of VVC; and 3) the VVC-specific supports for some supplemental enhancement information (SEI) messages that may be included in VVC bitstreams but are not to be specified in the VVC specification. These SEI messages include two systems-related SEI messages, one for signalling of "green metadata" as to be specified in ISO/IEC 23001-11 and the other for signalling of an alternative video decoding interface for immersive media as to be specified in ISO/IEC 23090-13, and five other SEI messages, namely the shutter interval information SEI message, the neural network post-filter characteristics SEI message SEI message, the neural-network post-processing filter activation SEI message, the phase indication SEI message, and the post filter hint SEI message, that are to be specified in a new edition of the Versatile Supplemental Enhancement Information messages for coded video bitstreams (VSEI) standard (ITU T H.274 | ISO/IEC 23002-7).

Draft 4 incorporated items:

• All errata items for VVC in Subsection 2.3 of JVET-AB1004-v1/JVET-AC0346.

• JVET-AC0311 option 1: Remove equations and related text from both VVC and HEVC (but leave the statements about testing the buffer behaviour in HRD similar as in AVC).

• Errata item 3 in Subsection 4.3 of JVET-AB1004-v1.

• Added the payload type of the post filter hint SEI message.

• Modified the subclause specifying the use of the neural-network post-filter characteristics SEI message as noted in the BoG report on neural-network based post-filtering contributions (JVET-AC0324-v4):

o Action on Item 14 (cleanup): Adopt Option A approach in JVET-AC0074-v2 with editorial rephrasing as noted in discussion.

o Action on Item 16 (BF/cleanup): Adopt to specify that when picture rate upsampling is applied together with the frame packing arrangement SEI message with fp\_arrangement\_type equal to 5 (temporal interleaving), the pictures are the pictures from the same view, based on text in JVET-AC0074-v2 as expressed under Item 14.

o Action on Item 17 (sensibility constraint): Specify that frame rate upsampling can only be used when all input pictures have the same cropped dimensions, after applying the super resolution post-filter applicable to the input picture, if any, based on text in JVET-AC0074-v2 as expressed under Item 14.

• DAM ballot comment US-008/FI-06: add a subclause specifying the use of the phase indication SEI message.

• DAM ballot comments FI-07 and FI-08: add a subclause specifying the use of the post-filter hint SEI message and specify constraints for its syntax element filter\_hint\_chroma\_coeff\_present\_flag.

2.1.5 JVET-AC2027 - SEI processing order SEI message in VVC (draft 3)

This document contains the draft text for changes to the Versatile Video Coding (VVC) standard (Rec. ITU-T H.266 | ISO/IEC 23090-3), to specify the SEI processing order SEI message.

2.1.6 JVET-AC2032 - Improvements under consideration for neural network post filter SEI messages

This document contains the draft text for changes to the versatile supplemental enhancement information messages for coded video bitstreams (VSEI) standard (Rec. ITU-T H.274 | ISO/IEC 23002-7), to specify additional SEI messages, including the shutter interval information SEI message, neural-network post-filter characteristics SEI message, neural-network post-filter activation SEI message, phase indication SEI message, and post-filter hint SEI message.

3 Related input contributions

The following input contribution was noted as relevant to the work of this ad hoc group:

• JVET-AD0077 - AHG2: On num\_l0\_weights and num\_l1\_weights for VVC specification

4 Remaining bug tickets

• #1593 Figure 5 in the VVC specification shows the incorrect number of slices

• #1594 Mismatch between VVC spec and VTM for sample generation in CCLM process

5 Recommendations

The AHG recommends to:

• Approve JVET-AC1004, JVET-AC1008, JVET-AC2002, JVET-AC2005, JVET-AC2027, and JVET-AC2032 documents as JVET outputs,

• 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 text and the algorithm and encoder description,

• Continue to improve the editorial consistency of VVC text specification and Test Model documents,

• Ensure that, when considering changes to VVC, properly drafted text for addition to the VVC Test Model and/or the VVC specification text is made available in a timely manner,

• Review bug tickets, and other AHG2 related inputs and act on them if found to be necessary.

[JVET-AD0003](https://jvet-experts.org/doc_end_user/current_document.php?id=12735) JVET AHG report: Test model software development (AHG3) [F. Bossen, X. Li, K. Sühring (co-chairs), E. François, Y. He, K. Sharman, V. Seregin, A. Tourapis (vice-chairs)]

The software model versions prior to the start of the meeting were:

• VTM 20.0 (Apr. 2023)

• HM-17.0 (Jan. 2023)

• HM-16.21+SCM-8.8 (Mar. 2020)

• SHM 12.4 (Jan. 2018)

• HTM 16.3 (Jul. 2018)

• JM 19.1 (Apr. 2023)

• JSVM 9.19.15

• JMVC 8.5

• 3DV ATM 15.0 (no version history)

• HDRTools 0.23 (October 2021)

Software for MFC and MFCD is only available as published by ITU-T and ISO/IEC. It is planned to create repositories with the latest versions available in ITU-T H.264.2 (02/2016). All development history is lost.

2 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 are documented at:

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

Although the development process is described in the context of the VTM software, it can be applied to all other software projects hosted on the GitLab server as well.

3 VTM related activities

The VTM software can be found at

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

The software development continued on the GitLab server. VTM versions 19.1 and 19.2 were tagged on Jan. 18, and VTM version 20.0 was tagged on Apr. 4. VTM 20.1 is expected during the 30th JVET meeting.

VTM 19.1 was tagged on Jan. 18, 2023. Changes include:

• Remove unused functions

• Use constant for subblock size in deblocking filter

• Fix variable names

• Define constant for VDPU size and fix function name

• Clean up intra and CIIP code

• Fix variable names

• Fixes in SubpicMergeApp for NumSubPics and SubPicId setters

• Use strong-typed enum for MtsType

• Clean deblocking filter code

• SubPicMergeApp: remove duplicate ceilLog2 function

• Clean up DMVR code

• Fix compilation when disabling REUSE\_CU\_RESULTS

• Use named constants

• Use named variable for unset cost

• Clean up reading/parsing of number of active refs

• JVET-T0056: SEI manifest and SEI prefix indication

• Define named reference index for IBC

• Clean up ISP and use strong typed enum

• Use strong typed enum for SEI payload type

• Rename dynamic\_cache to Pool

• JVET-AB0069 change the length of the po\_sei\_processing\_order[i] syntax element

• JVET-AB0135 and BC#017 Add nnpfc\_total\_kilobyte\_size and replace nnpfc\_complexity\_idc with a flag

• Rename LFCUParam data structure

• M60678: ballot comments of FI\_03

• Clean up MMVD related code

• Define RefSetArray template to define arrays indexed by listIdx and refIdx

• Move new macros into section where they are indicated to be removed in next cycle

• Fix compilation when JVET\_R0351\_HIGH\_BIT\_DEPTH\_ENABLED is enabled

• Use python3 as interpreter for cmake/CMakeBuild/bin/cmake.py

• Use single variable to control ENABLE\_TRACING

• JVET-AB0058: signal frame upsampling in neural network post-filter characteristics

• Fix a gcc12 compiling warning/error

• Add option to enable RExt\_\_HIGH\_BIT\_DEPTH\_SUPPORT from command line

• Fix variable names

• Clean up hash related functions

• Remove Ubuntu 18.04 from auto-build pipeline

• Use ptrdiff\_t for strides

• Use strong enum type for AffineModel

• Clean buffer usage in merge RD checking functions

• Clean up BCW and AMVR related code

• Clean up merge context data structure

• Use strong typed enum for MESearchMethod

• Remove unused field

• Use strong typed ChannelType

• Use strong typed enum for MergeType

• Fix gcc 12 compiling errors

• Replace m\_subPuMC by a local variable

• Clean up MV precision handling functions and use strong-typed enum

• Define MergeIdxPair type to hold pair of merge indices

• Clean up inter merge related functions

• Clean up width/height in InterPrediction::xPredInterBlk

• Remove m\_iRefListIdx field from InterPrediction class

• Use strong typed enum for APS type

• Remove unused variable

• Use proper data type for RPR scaling

• Fix variable names and use named constants

• Use strong-type enum for DFunc

• Change copyright year to 2023

• Remove unused field

• Fix parameter type in function definition: use ptrdiff\_t instead of uint32\_t

• JVET-AB0051: Modification of SEI processing order SEI message

• Clean up MVD encoding

• Group partition contexts for faster copy

• Define enum for MIP size and use Pel elements for buffers

• Improve adherence to coding guidelines in EncGOP.cpp

• JVET-AB0049: Modifications of NNPFC and NNPFA

• Improve adherence to coding guidelines

• JVET-AB0050: Add two flags for NNPFA

• Remove mvRefine field from InterPredictionData

• Fix macOS build with trace file enabled

• Use Size type instead of array of two values

• Remove g\_tbMax and use floorLog2 instead

• Move sei\_processing\_order.cfg into sei\_vui subdirectory

• Remove duplicate function and fix data types

• Add Ubuntu 22.04 auto-build

• JVET-AB0070: post-filter hint SEI

• Remove macros for HLS syntax element read/write

• Fix #1586 and #1584: invalid syntax and cfg params for NNPFC SEI message

• Clean up definition and use of g\_GeoParams

• Fix xParsePrefixSEIsForUnknownVCLNal

• Clean up handling of PTLs in VPS

• Fix xCheckScalableNestingConstraints()

• Fix getInterLayerRefIdc with wrong parameter

• Fix #1587: Set NumPTLsInVPS to 2 to avoid encoder crash

• Fix compilation when green SEI metadata is enabled

• Fix compilation: remove unused variable

• Fix use of a not initialized value when decoding

VTM 19.2 was tagged on Jan. 18, 2023. Changes include:

• Remove macros from previous cycle

VTM 20.0 was tagged Apr. 4, 2023. Changes include:

• JVET-AC0166: Set C++ version to C++17

• JVET-AC0139: Unified merge function and updated cfg settings

• JVET-AC0096: RPR functionality testing

• JVET-AC0154: NNPF SEI IuC item 13, 31, and 34

• JVET-AC0127: NNPF SEI IuC item 11, 20, 28, 30, 32

• JVET-AC0058 indicates the SEI processing order of T35 SEI messages with

• JVET-AC0061: Define new syntax elements to specify input and output integer...

• JVET-AC0062: Update constraint checks for nnpfc\_num\_input\_pics\_minus1 and...

• JVET-AC0344: Signal 2 new syntax elements,...

• JVET-AC0074: adopted constraints for NNPF frame rate upsampling

• JVET-AC0353: Implementation of nnpfc\_base\_Flag

• Move GDR status out of PicHeader structure into Picture

• Adapt code to new SW guidelines

• Fix and enable SIMD SSE functions

• Use strong-typed enum for deblocking's EdgeDir

• Minor cleanup for Slice.h

• Use standardized memory alignment features

• Minor style improvements in AnnexBread

• Avoid use of std::iterator which is deprecated in C++17

• Clean up RPL-related code

• Clean up adaptive QP code

• Fix of the RelCU speed-up of ISP

• Remove use of 'using namespace std'

• Split ConstraintInfo class out of Slice.h/cpp

• Update .clang-format file

• Adjust size of be a multiple of alignment when using std::aligned\_alloc

• StreamMergeApp: fix VPS allocation issue

• Rename m\_tmpStorageLCU to m\_tmpStorageCtu

• Define AlfMode element that captures enable flag and filter index

• Fix compilation when JVET\_O0756\_CALCULATE\_HDRMETRICS is enabled

• Add GCC 12 to build configuration

• Include additional build with high bit depth enabled

• Move parameter sets out of Slice.h/cpp

• Ignore CLion files

• Rename "LevelTier" to "TierLevel"

• Move MergeCtx and related classes from ContextModelling to InterPrediction

• add options --SourceScalingRatio to rescale source video

• Fix parsing of unknown SEI message type.

• Clean up GDR condition checks

• Fix assert() statement

• Minor cleanup for affine block checking

• add option --PrintRefLayerMetrics to compute and display PSNR between current layer and reference layer

• Fix compiling issues with clang-14

• Fix memory leak in MergeItemList

• Store latest EDRAP POC in DecLib and set it to Slice

• Fix: Use size of reference picture instead of using picture size from PPS...

• Fix rpl\_idx parsing when numRplsInSps == 1 && rplSpsFlag == 1

• Use strong-typed enum for chroma format

• Fix rpl use in checkSubpicTypeConstraints function

• Fix for sequential coding of PPS for RPR

• Clean up BCW target block computation for bipred

• Align variable name to JVET-AC2032 text

• Fix issue with m\_olsHrdParams

• Fix PicHeader::m\_maxNumAffineMergeCand value when Affine is OFF and RDO for merge if no affine and no sbTMVP for picture

• Fix: Related to HashME and sequential coding

• Fix to conformance window usage for RPR

• Fix multilayer with fields

• Update software documentation for several SEINNPostFilterCharacteristics parameters.

• Fix formatting of Neural network post-filter characteristics SEI parameter table

• Add CI build for PDF manual

• Update version number in SW manual

VTM 20.1 is expected to be tagged during the 30th JVET meeting. Changes include so far:

• Add command line option to print per-frame encoding time in float format

• Fix parsing of multiple SEI payloads in one NAL unit

• Fix parsing of MAI SEI message

• Fix parsing of SDI SEI message

• Fix m\_maxChromaFormatConstraintIdc derivation

• Fix subpictures compliance check on monochrome streams after !2541

• Fix build when GDR\_ENABLED is 0

• Undefine macro from HDRTools

3.1 CTC Performance

The following tables shows **VTM 20.0** performance over **HM 17.0**.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra Main10** |  |  |
|  |  |  | **Over HM-17.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -29.50% | -32.81% | -33.83% | 1273% | 166% |
| Class A2 | -29.73% | -24.39% | -21.58% | 2142% | 174% |
| Class B | -22.32% | -27.21% | -30.98% | 2397% | 175% |
| Class C | -22.89% | -19.53% | -23.19% | 3348% | 179% |
| Class E | -26.04% | -25.90% | -24.15% | 1869% | 158% |
| **Overall** | -25.50% | -25.75% | -27.02% | 2187% | 171% |
| Class D | -18.80% | -13.85% | -13.68% | 4270% | 189% |
| Class F | -39.49% | -40.23% | -42.90% | 4220% | 171% |
|  |  |  |  |  |  |
|  |  |  | **Random access Main10** |  |  |
|  |  |  | **Over HM-17.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -40.60% | -40.71% | -47.16% | 586% | 158% |
| Class A2 | -44.02% | -41.73% | -40.78% | 679% | 170% |
| Class B | -37.41% | -50.12% | -48.51% | 672% | 161% |
| Class C | -33.86% | -36.28% | -38.21% | 923% | 164% |
| Class E |  |  |  |  |  |
| **Overall** | -38.42% | -42.87% | -43.95% | 713% | 163% |
| Class D | -31.72% | -32.60% | -31.95% | 970% | 161% |
| Class F | -46.07% | -49.76% | -50.65% | 490% | 145% |
|  |  |  |  |  |  |
|  |  |  | **Low delay B Main10** |  |  |
|  |  |  | **Over HM-17.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -30.40% | -37.43% | -35.12% | 629% | 152% |
| Class C | -28.18% | -21.23% | -21.06% | 817% | 167% |
| Class E | -31.16% | -35.72% | -28.79% | 309% | 140% |
| **Overall** | -29.85% | -31.60% | -28.85% | 575% | 154% |
| Class D | -26.75% | -16.50% | -14.88% | 881% | 179% |
| Class F | -42.17% | -44.02% | -44.14% | 435% | 137% |
|  |  |  |  |  |  |
|  |  |  | **Low delay P Main10** |  |  |
|  |  |  | **Over HM-17.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -34.52% | -38.34% | -36.12% | 526% | 160% |
| Class C | -28.07% | -17.73% | -18.09% | 670% | 176% |
| Class E | -33.06% | -37.89% | -31.10% | 280% | 146% |
| **Overall** | -32.01% | -31.36% | -28.85% | 487% | 161% |
| Class D | -26.68% | -12.73% | -11.47% | 762% | 175% |
| Class F | -40.13% | -41.24% | -41.72% | 437% | 145% |

According to common test conditions in random access configuration HM is using a GOP size of 16 pictures compared to VTM using a GOP of 32 pictures. Random access points are inserted approximately every second aligned with a GOP boundary of GOP 32 in both VTM and HM. VTM uses two more reference pictures in random access than HM (due to more memory being availably in typical level settings).

The following tables show **VTM 20.0** performance compared to **VTM 19.0** using SDR CTC:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra Main10** |  |  |
|  |  |  | **Over VTM-19.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.00% | 0.06% | -0.03% | 99% | 101% |
| Class A2 | 0.00% | 0.03% | 0.00% | 99% | 101% |
| Class B | 0.00% | 0.01% | 0.02% | 99% | 99% |
| Class C | 0.00% | 0.02% | 0.04% | 100% | 97% |
| Class E | 0.00% | -0.01% | 0.23% | 99% | 99% |
| **Overall** | 0.00% | 0.02% | 0.05% | 99% | 99% |
| Class D | -0.01% | -0.05% | 0.20% | 100% | 98% |
| Class F | -0.02% | -0.09% | -0.02% | 101% | 99% |
|  |  |  |  |  |  |
|  |  |  | **Random access Main10** |  |  |
|  |  |  | **Over VTM-19.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -0.01% | 0.06% | -0.07% | 96% | 100% |
| Class A2 | -0.03% | -0.03% | 0.01% | 95% | 100% |
| Class B | 0.05% | 0.05% | 0.01% | 96% | 98% |
| Class C | 0.05% | 0.02% | 0.11% | 95% | 96% |
| Class E |  |  |  |  |  |
| **Overall** | 0.02% | 0.03% | 0.02% | 96% | 98% |
| Class D | 0.01% | 0.14% | 0.09% | 96% | 94% |
| Class F | 0.01% | 0.09% | 0.10% | 96% | 97% |
|  |  |  |  |  |  |
|  |  |  | **Low delay B Main10** |  |  |
|  |  |  | **Over VTM-19.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | 0.05% | -0.05% | -0.45% | 98% | 97% |
| Class C | 0.03% | 0.04% | 0.00% | 98% | 93% |
| Class E | -0.08% | -0.27% | 0.81% | 99% | 96% |
| **Overall** | 0.01% | -0.07% | 0.01% | 98% | 95% |
| Class D | 0.07% | -0.40% | 0.87% | 99% | 93% |
| Class F | 0.13% | 0.05% | 0.03% | 98% | 94% |
|  |  |  |  |  |  |
|  |  |  | **Low delay P Main10** |  |  |
|  |  |  | **Over VTM-19.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | 0.03% | -0.06% | 0.01% | 91% | 97% |
| Class C | 0.12% | -0.10% | 0.20% | 91% | 97% |
| Class E | -0.09% | 0.45% | 0.24% | 92% | 95% |
| **Overall** | 0.03% | 0.06% | 0.13% | 91% | 96% |
| Class D | 0.02% | 0.06% | 0.24% | 93% | 91% |
| Class F | 0.09% | 0.45% | 0.02% | 93% | 94% |

The following tables show **VTM 20.0** performance over **HM 17.0** using HDR CTC:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | | | | | | |
|  | **Over HM17.0** | | | | | | | | | |
|  |  |  | **wPSNR** |  |  | **PSNR** |  |  |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | -39.54% | -37.56% | -36.67% | -54.98% | -48.45% | -33.68% | -49.48% | -40.84% | 286% | 97% |
| Class H2 |  |  |  |  |  | -31.97% | -57.69% | -63.36% | 271% | 97% |
| **Overall** | -39.54% | -37.56% | -36.67% | -54.98% | -48.45% | -33.06% | -52.47% | -49.03% | 280% | 97% |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **All Intra** | | | | | | | | | |
|  | **Over HM17.0** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | -41.45% | -27.31% | -26.79% | -57.74% | -52.79% | -24.00% | -52.93% | -45.13% | 1538% | 113% |
| Class H2 |  |  |  |  |  | -21.76% | -47.21% | -50.57% | 1320% | 109% |
| **Overall** | -41.45% | -27.31% | -26.79% | -57.74% | -52.79% | -23.18% | -50.85% | -47.11% | 1455% | 112% |

The following tables show **VTM 20.0** performance compared to **VTM 19.0** using HDR CTC:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | | | | | | |
|  | **Over VTM19.0** | | | | | | | | | |
|  |  |  | **wPSNR** |  |  | **PSNR** |  |  |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | 0.00% | 0.04% | 0.00% | -0.05% | 0.00% | -0.01% | -0.05% | 0.00% | 95% | 95% |
| Class H2 |  |  |  |  |  | 0.07% | 0.08% | -0.06% | 95% | 97% |
| **Overall** | 0.00% | 0.04% | 0.00% | -0.05% | 0.00% | 0.02% | -0.01% | -0.02% | 95% | 96% |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **All Intra** | | | | | | | | | |
|  | **Over VTM19.0** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | -0.04% | 0.00% | 0.01% | 0.00% | 0.00% | 0.00% | 0.04% | -0.04% | 98% | 96% |
| Class H2 |  |  |  |  |  | 0.00% | -0.01% | -0.01% | 98% | 99% |
| **Overall** | -0.04% | 0.00% | 0.01% | 0.00% | 0.00% | 0.00% | 0.02% | -0.03% | 98% | 97% |

The following tables show VTM 20.0 performance compared to VTM 19.0 using high bit depth CTCs at ‘low’ QP ranges. The simulations for VTM20.0 included two additional merge requests (2566 and 2567) to fix chroma format errors and a compilation error regarding HDR tools integration.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **HDR PQ** |  |  | **AI** |  |  |  |  |  |
|  |  |  | **Over VTM19.0** |  |  |  |  |  |
|  | wPsnrY | wPsnrU | wPsnrV | psnrY | psnrU | psnrV | EncT | DecT |
| PQ444 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 98% |
| PQ422 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 98% | 98% |
| **Overall** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 98% |
|  |  |  | **LDB** |  |  |  |  |  |
|  |  |  | **Over VTM19.0** |  |  |  |  |  |
|  | wPsnrY | wPsnrU | wPsnrV | psnrY | psnrU | psnrV | EncT | DecT |
| PQ444 | 0.07% | 0.13% | 0.06% | 0.07% | 0.13% | 0.06% | 97% | 100% |
| PQ422 | 0.03% | 0.01% | 0.06% | 0.03% | 0.01% | 0.05% | 96% | 101% |
| **Overall** | 0.05% | 0.07% | 0.06% | 0.05% | 0.07% | 0.06% | 96% | 100% |
|  |  |  | **RA** |  |  |  |  |  |
|  |  |  | **Over VTM19.0** |  |  |  |  |  |
|  | wPsnrY | wPsnrU | wPsnrV | psnrY | psnrU | psnrV | EncT | DecT |
| PQ444 | 0.03% | 0.03% | 0.02% | 0.03% | 0.03% | 0.02% | 97% | 100% |
| PQ422 | 0.00% | -0.02% | 0.02% | 0.00% | -0.01% | 0.01% | 96% | 99% |
| **Overall** | 0.01% | 0.01% | 0.02% | 0.01% | 0.01% | 0.02% | 96% | 100% |
| **Overall PQ** | 0.02% | 0.03% | 0.03% | 0.02% | 0.03% | 0.02% | 97% | 99% |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **HDR HLG** |  |  | **AI** |  |  |
|  |  |  | **Over VTM19.0** |  |  |
|  | psnrY | psnrU | psnrV | EncT | DecT |
| HLG444 | 0.00% | 0.00% | 0.00% | 99% | 99% |
| HLG422 | 0.00% | 0.00% | 0.00% | 98% | 98% |
| **Overall** | 0.00% | 0.00% | 0.00% | 99% | 98% |
|  |  |  | **LDB** |  |  |
|  |  |  | **Over VTM19.0** |  |  |
|  | psnrY | psnrU | psnrV | EncT | DecT |
| HLG444 | -0.01% | 0.00% | 0.00% | 98% | 101% |
| HLG422 | 0.00% | 0.00% | 0.00% | 98% | 99% |
| **Overall** | -0.01% | 0.00% | 0.00% | 98% | 100% |
|  |  |  | **RA** |  |  |
|  |  |  | **Over VTM19.0** |  |  |
|  | psnrY | psnrU | psnrV | EncT | DecT |
| HLG444 | 0.00% | -0.01% | 0.00% | 98% | 97% |
| HLG422 | 0.00% | 0.01% | -0.01% | 99% | 98% |
| **Overall** | 0.00% | 0.00% | 0.00% | 98% | 98% |
| **Overall HLG** | 0.00% | 0.00% | 0.00% | 98% | 99% |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **SVT RGB** |  |  | **AI** |  |  |
|  |  |  | **Over VTM19.0** |  |  |
|  | psnrG | psnrB | psnrR | EncT | DecT |
| SVT16 | 0.00% | 0.00% | 0.00% | 100% | 101% |
| SVT12 | 0.00% | 0.00% | 0.00% | 100% | 100% |
| **Overall** | 0.00% | 0.00% | 0.00% | 100% | 100% |
|  |  |  | **LDB** |  |  |
|  |  |  | **Over VTM19.0** |  |  |
|  | psnrG | psnrB | psnrR | EncT | DecT |
| SVT16 | 0.00% | 0.00% | 0.00% | 100% | 102% |
| SVT12 | 0.00% | 0.00% | 0.00% | 99% | 100% |
| **Overall** | 0.00% | 0.00% | 0.00% | 99% | 101% |
|  |  |  | **RA** |  |  |
|  |  |  | **Over VTM19.0** |  |  |
|  | psnrG | psnrB | psnrR | EncT | DecT |
| SVT16 | 0.00% | 0.00% | 0.00% | 100% | 102% |
| SVT12 | 0.00% | 0.00% | 0.00% | 99% | 101% |
| **Overall** | 0.00% | 0.00% | 0.00% | 100% | 102% |
| **Overall RGB** | 0.00% | 0.00% | 0.00% | 100% | 101% |

The following tables show VTM 20.0 performance compared to VTM 19.0 using high bit depth CTCs at ‘standard’ QP ranges. The simulations for VTM20.0 included the two aforementioned merge requests (2566, 2567).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | |
|  | **Over VTM19.0** | | | | |
|  | **PSNR** | | |  |  |
|  | Y | U | V | EncT | DecT |
| Class H1 | 0.00% | 0.04% | -0.17% | 96% | 100% |
| Class H2 | -0.02% | -0.12% | -0.16% | 97% | 101% |
| **Overall** | -0.01% | -0.04% | -0.16% | 97% | 100% |
|  | **All Intra** | | | | |
|  | **Over VTM19.0** | | | | |
|  | **PSNR** | | |  |  |
|  | Y | U | V | EncT | DecT |
| Class H1 | 0.01% | -0.09% | -0.02% | 100% | 100% |
| Class H2 | 0.01% | -0.03% | 0.01% | 101% | 101% |
| **Overall** | 0.01% | -0.06% | -0.01% | 100% | 101% |

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

3.2 Issues in VTM affecting conformance

The following issues in VTM master branch may affect conformance:

• Missing HLS features (see sections below)

3.3 Status of implementation of proposals of previous JVET meetings

The following list contains all adoptions of the Q and R meetings that were not marked as merged (or submitted) or specification only change in the software coordinator tracking sheet:

• JVET-Q0112

• JVET-Q0154: Disallow mixing of GDR and IRAP (Disallow mixing of GDR with any non-GDR).

• JVET-Q0164

• JVET-Q0402

• JVET-R0178: Require that when no\_aps\_constraint\_flag is equal to 1, sps\_lmcs\_enabled\_flag and sps\_scaling\_list\_enabled\_flag shall be equal to 0

• JVET-R0221

• JVET-R0046: Change the description of the bitstream extraction process per the value of max\_tid\_il\_ref\_pics\_plus1[ ][ ] (aspect 1.2 per JVET-R0046-v4).

• JVET-R0065: Specify that GDR AUs shall be complete – i.e., all of the layers in the CVS shall have a picture in the AU (as with IRAP AUs).

• JVET-R0191: Update the range value for num\_ols\_hrd\_params\_minus1.

• JVET-R0222 aspect 1: Infer vps\_max\_sublayers\_minus1 to be equal to 6 when sps\_video\_parameter\_set\_id is equal to 0 (i.e. VPS is not present). The exact editorial expression is at the discretion of the editor.

• JVET-S0196 (JVET-S0144 item 17)

• JVET-S0227 (JVET-S0144 item 22)

• JVET-S0077 (JVET-S0139 item 5)

• JVET-S0174 aspect 2 (JVET-S0139 item 18.b)

• JVET-S0156 aspect 3 (JVET-S0139 item 21)

• JVET-S0139 item 26 (no source listed, text only?)

• JVET-S0188 aspect 1 (JVET-S0139 item 28)

• JVET-S0139 item 40 (item does not exist)

• JVET-S0042 (JVET-S0142 item 1.b)

• JVET-S0174 aspect 1 (JVET S0143 item 19)

• JVET-S0096 aspect 3 (JVET-S0140 item 10)

• JVET-S0096 aspect 4 (JVET-S0140 item 13)

• JVET-S0159 aspect 3 (JVET-S0140 item 16)

• JVET-S0171 (JVET-S0256)

• JVET-S0118 (JVET-S0141 item 7)

• JVET-S0102 (JVET-S0141 item 9.a)

• JVET-S0157 item 2 (JVET-S0141 item 13)

• JVET-S0157 item 4 (JVET-S0141 item 14)

• JVET-S0175 aspect 3 (JVET-S0141 item 16)

• JVET-S0175 aspect 1, 2 (JVET-S0141 item 17)

• JVET-S0175 aspects 4 and 5 (JVET-S0141 item 18)

• JVET-S0175 aspect 6 (JVET-S0141 item 19)

• JVET-S0198/ JVET-S0223 (JVET-S0141 item 24)

• JVET-S0173 aspect 2 (JVET-S0141 item 40.b)

• JVET-S0173 item 1 (JVET-S0141 item 51)

• JVET-S0173 item 3 (JVET-S0141 item 52)

• JVET-S0173 item 5 (JVET-S0141 item 53)

• JVET-S0173 item 6 (JVET-S0141 item 54)

• JVET-S0173 item 4 (JVET-S0141 item 56)

• JVET-S0176 item 4 (JVET-S0141 item 60)

• JVET-S0154 aspect 5 (JVET-S0141 item 68)

• JVET-S0154 aspect 6 (JVET-S0141 item 69)

• JVET-S0154 aspect 8 (JVET-S0141 item 71)

• JVET-S0095 aspect 5 (JVET-S0145 item 5)

• JVET-S0095 aspect 6 (JVET-S0145 item 6)

• JVET-S0100 aspect 1, depends on JVET-R0193 (JVET-S0147 item 2)

• FINB ballot comments

• Make high tier support up to 960.

4 HM related activities

HM 18.0 was tagged on Apr. 20, 2023. Changes include:

• Update to Ubuntu 22.04 build server

• Update the HDR configuration files to align with the HDR CTC document (JVET-AC2011)

• Update to FilmGrainCharacteristics SEI support, including applying film grain noise onto the decoded output.

The performance of HM 18.0 is identical to HM 17.0 under SDR CTCs. Initial results also indicate that the performance is identical to HM 17.0 under HDR, RExt non-4:2:0 and RExt high bit depth CTCs.

The following MRs are pending [with status indicated]:

• Port the Y4M support [one issue remains]

• Mark the current picture as short-term ref (for SCM) [need SCC expert reviewer]

The HM SCC (SCM) branch (HM-16.21+SCM-8.8) has not been updated for the recent HM versions. Updating SCM to, for example, HM-18.0+SCM-8.8 should be considered. It may though be helpful to move SCC related functionality into separate source files. Volunteer work towards merging the branches would be appreciated.

As reported in the previous reports, further information on lambda optimisation in HM would be appreciated, including comparison of allocation of bits within the GOP structures between HM and VTM.

The HEVC bug tracker lists:

• 43 tickets for “HM”, most of which are more than 5 years,

• 1 ticket for “HM RExt”,

• 9 tickets for “HM SCC”, most of which are at least 3 years old,

Help to address these tickets would be appreciated.

One merge request (MR#40) is available related to HM SCC for ticket #1511 on SCC reference picture marking. We would appreciate help to confirm that the proposed change matches the SCC text.

5 360Lib related activities

The latest 360Lib software can be found at https://vcgit.hhi.fraunhofer.de/jvet/360lib

The following table is for the projection formats comparison using VTM-20.0 according to 360-degree video CTC (JVET-U2012) compared to that using VTM-19.0 (VTM-19.0 as anchor).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **PERP: VTM-20.0 over VTM-19.0** | | | | | |
|  | **End-to-end**  **WS-PSNR** | | | **End-to-end**  **S-PSNR-NN** | | |
|  | Y | U | V | Y | U | V |
| Class S1 | -0.01% | -0.02% | 0.02% | 0.00% | -0.02% | 0.02% |
| Class S2 | -0.02% | 0.07% | 0.06% | -0.02% | 0.07% | 0.06% |
| **Overall** | -0.01% | 0.02% | 0.04% | -0.01% | 0.02% | 0.04% |

The following table compares generalized cubemap (GCMP) coding and padded equi-rectangular projection (PERP) coding using VTM-20.0 (PERP as anchor).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **GCMP Over PERP** | | | | | |
|  | **End-to-end WS-PSNR** | | | **End-to-end S-PSNR-NN** | | |
|  | Y | U | V | Y | U | V |
| Class S1 | -11.50% | -5.44% | -6.08% | -11.49% | -5.37% | -6.02% |
| Class S2 | -3.69% | 0.81% | 1.28% | -3.67% | 0.90% | 1.37% |
| **Overall** | -8.38% | -2.94% | -3.13% | -8.36% | -2.86% | -3.07% |

The following tables are for PERP and GCMP coding comparison between VTM-20.0 and HM-16.22 (HM as anchor), respectively.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **VTM-20.0 PERP Over HM-16.22 PERP (anchor)** | | | | | |
|  | **End-to-end WS-PSNR** | | | **End-to-end S-PSNR-NN** | | |
|  | Y | U | V | Y | U | V |
| Class S1 | -30.91% | -38.82% | -41.28% | -30.91% | -38.88% | -41.28% |
| Class S2 | -36.89% | -37.33% | -39.65% | -36.88% | -37.36% | -39.71% |
| **Overall** | -33.30% | -38.23% | -40.63% | -33.29% | -38.27% | -40.65% |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **VTM-20.0 GCMP Over HM-16.22 PCMP (anchor)** | | | | | |
|  | **End-to-end WS-PSNR** | | | **End-to-end S-PSNR-NN** | | |
|  | Y | U | V | Y | U | V |
| Class S1 | -35.60% | -40.82% | -42.80% | -35.56% | -40.75% | -42.75% |
| Class S2 | -39.84% | -39.52% | -41.44% | -39.85% | -39.52% | -41.48% |
| **Overall** | -37.29% | -40.30% | -42.25% | -37.27% | -40.26% | -42.24% |

6 SCM related activities

There had not been any further developments to SCC’s SCM during this meeting cycle.

7 SHM related activities

There had not been any further developments to SHVC’s SHM during this meeting cycle.

8 HTM related activities

There had not been any releases of HTM of MV-HEVC and 3D-HEVC.

The next release will include the following changes:

• JVET-Z0209: Early termination during calculating RDcost of depth

9 HDRTools related activities

There had not been any updates of HDRTools.

New development is being added under the branch named 0.24-dev.

10 JM, JSVM, JMVM related activities

A new version of JM was tagged on April 20, 2023. Changes include:

• Change build system to cmake

• fix build of rtpdump and rtploss on linux

• add config file for automatic building

• remove VS2015 from build spec

• Compile fixes for newer compilers

Basic testing was performed to confirm that the code still works, but performance testing is pending. Performance changes are unlikely but may occur due to bug fixes.

There had not been any updates to the JSVM and JMVM software.

11 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

Bug tracking for HDRTools is located at:

https://gitlab.com/standards/HDRTools/-/issues

Please file all issues related to the VVC reference software and HDRTools into the appropriate 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.

12 Software repositories

Git repositories that were previously assigned to the JCT-VC group on the GitLab server were re-assigned to the JVET group. The old URLs are still working and will forward the user to the new location, with the display of a warning suggesting to update bookmarks to the new location. The SVN repository for 360Lib was converted to git and development was moved to the GitLab server. Historical branches can still be accessed in the SVN repository.

13 CTC alignment and merging

There are currently 8 JVET CTC documents:

JVET-Y2010 VTM/HM 4:2:0 test conditions

JVET-Z2011 VTM/HM HDR test conditions

JVET-AA2018 VTM/HM high bit depth test conditions (without spreadsheet)

JVET-T2013 VTM non-4:2:0 test conditions

JVET-AA1100 HM non-4:2:0 test conditions

JVET-U2012 VTM 360 video test conditions

JVET-AC1009 SHVC test conditions

JVET-AC1015 SCM test conditions

Older CTC documents are:

JCT3V-G1100 3DV test conditions

JVET-AC1013 was a planned output document for updating JCT3V-G1100, which was not produced. JVET-AD0201 was submitted with a description of the problems that were found during editing.

Further merging of HM RExt CTC into the appropriate VVC CTC was investigated (non 4:2:0 chroma formats), but proper comparable HM configuration files were not yet available by the beginning of this meeting.

The HM HDR test conditions require additional post-processing stages, due to WPSNR, deltaE100 and PSNRL100 values not being generated directly by the HM encoder. Merging of respective functions from VTM is recommended to streamline the process.

14 Guidelines for reference software development

Guidelines for VVC and HEVC reference software development have been released as output document JVET-AC2003 and JVET-AC1001.

15 Recommendations

The AHG recommends to:

- Continue to develop reference software.

- Improve documentation, especially the software manual.

- Encourage people to test VTM and other reference 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 and other reference software.

- Encourage people to submit non-normative changes that either reduce encoder run time without significantly sacrificing compression performance or improve compression performance without significantly increasing encoder run time.

- Design and add configuration files to the VTM software for testing of HLS features.

- Review VTM-related contributions and determine whether features should be added (or removed) from the software.

- Continue to investigate the merging of branches.

- Continue to investigate merging of CTC documents.

- Verify correctness of CTC documents and issue updates as appropriate

- Keep common test conditions aligned for the different standards.

- Consider documents (including late documents) related to AHG3 activities.

[JVET-AD0004](https://jvet-experts.org/doc_end_user/current_document.php?id=12736) JVET AHG report: Test material and visual assessment (AHG4) [V. Baroncini, T. Suzuki, M. Wien (co-chairs), S. Liu, S. Puri, A. Segall, P. Topiwala, S. Wenger, J. Xu, Y. Ye (vice-chairs)]

**Ad hoc group activity**

**Output documents produced**

**JVET-AC1004 - Draft Errata report items for VVC, VSEI, HEVC, AVC, and Video CICP**

Incorporated items at the JVET-AC meeting:

* For VVC, all errata items have been incorporated in JVET-AC2005: New level and systems-related supplemental enhancement information for VVC (Draft 4).
* For HEVC, incorporated the following items:
  + Confirmed redudnant call to clause 8.6.1 (reported by [Cliff Reader](mailto:cliff@reader.com) – thanks!).
  + Confirmed JVET-AB0120: Addition of interpolation for "initial CPB removal delay offset".
  + JVET-AC0311: On number of conformance tests (option 1.)
  + Updated issues 1 to 4 in Subsection 4.4 per inputs from Miska M. Hannuksela (thanks!).
  + Change the font size from 8 pt to 10 pt for "Table 9-4" in a paragraph in clause 9.3.2.2 (reported by [Cliff Reader](mailto:cliff@reader.com) – thanks!).
* For AVC, incorporated the following items:
  + Confirmed JVET-AB0120: Addition of interpolation for "initial CPB removal delay offset".
  + An issue of talking about VUI in subclause 0.6.1 in ISO/IEC 14496-10:2022 (Edition 10) while the sentence should only talk about SEI messages.

**JVET-AC1008 - Additional colour type identifiers for AVC, HEVC and Video CICP (Draft 3)**

This document contains the draft text for the specification of additional colour type identifiers for AVC (Rec. ITU-T H.264 | ISO/IEC 14496-10), HEVC (Rec. ITU-T H.265 | ISO/IEC 23008-2), and CICP (Rec. ITU-T H.273 | ISO/IEC 23091-2). Text modifications are provided for specification of code point identifiers for YCgCo-R colour representation with equal luma and chroma bit depths and for Draft SMPTE ST 2128. The new code points for for YCgCo-R are referred to as YCgCo-Re and YCgCo-Ro, where the number of bits added to a source RGB bit depth is 2 (i.e., even) and 1 (odd), respectively. Draft SMPTE ST 2128 specifies a colour representation referred to as IPT-PQ-C2. The affected sections are provided relative to corresponding basis texts (based on the 2021-08 edition of Rec. ITU-T H.264 (the most recent edition), the 2020 edition of ISO/IEC 23008-2 (not the 5th edition currently under preparation), and ISO/IEC DIS 23091-2:202x (3rd Ed.), respectively). Equation numbers and their cross-references have been updated without revision marking. Change marks are included to show the changes since the October output (JVET-AB1008), which reflect the LMS equations for SMPTE ST 2128 as provided in JVET-AC0352 and some minor refinements and corrections since the previous draft.

**JVET-AC2002 - Algorithm description for Versatile Video Coding and Test Model 19 (VTM 19)**

The JVET established the VVC Test Model 20 (VTM20) software at its 29th meeting (11-20 January 2023, teleconference). This document serves as a source of general tutorial information on the VVC design and also provides an algorithm description and encoding method description of VTM20 software. It is noted that, as no update of the algorithm description document had been released at the 27th JVET meeting, the numbering of the VTM software version is one higher than that of this description document. In the main body of the text, numbering refers to the software version. The VVC has been developed by a joint collaborative team of ITU-T and ISO/IEC experts known as the Joint Video Experts Team (JVET), which is a partnership of ITU-T Study Group 16 Question 6 (known as VCEG) and ISO/IEC JTC 1/SC 29/WG 11 (known as MPEG). This draft new standard has been designed with two primary goals. The first of these is to specify a video coding technology with a compression capability that is substantially beyond that of the prior generations of such standards, and the second is for this technology to be highly versatile for effective use in a broadened range of applications. Some key application areas for the use of this standard particularly include ultra-high-definition video (e.g., with 3840×2160 or 7620×4320 picture resolution and bit depth of 10 or 12 bits as specified in Rec. ITU-R BT.2100), video with a high dynamic range and wide colour gamut (e.g., with the perceptual quantization or hybrid log-gamma transfer characteristics specified in Rec. ITU-R BT.2100), and video for immersive media applications such as 360° omnidirectional video projected using a common projection format such as the equirectangular or cubemap projection format, in addition to the applications that have commonly been addressed by prior video coding standards.

Ed. Notes:

VVC Test Model 19 (VTM20) algorithm description and encoding method v1

* General improvements to neural network-based post filtering SEI messages (section 4.4) to bring the section up to date with the current filtering purposes of the NNPFC and NNPFA messages
* Incorporated JVET-AC0096: AHG10/12: Suggestion for new CTC for RPR in VTM and ECM

**JVET-AC2005 - New level and systems-related supplemental enhancement information for VVC (Draft 4)**

This document contains a draft amendment for changes to the Versatile Video Coding (VVC) standard (ITU‑T H.266 | ISO/IEC 23090-3). This amendment includes the following: 1) the support of an unlimited level for video profiles; 2) some technical corrections and editorial improvements to the 2nd edition text of VVC; and 3) the VVC-specific supports for some supplemental enhancement information (SEI) messages that may be included in VVC bitstreams but are not to be specified in the VVC specification. These SEI messages include two systems-related SEI messages, one for signalling of "green metadata" as to be specified in ISO/IEC 23001-11 and the other for signalling of an alternative video decoding interface for immersive media as to be specified in ISO/IEC 23090-13, and five other SEI messages, namely the shutter interval information SEI message, the neural network post-filter characteristics SEI message SEI message, the neural-network post-processing filter activation SEI message, the phase indication SEI message, and the post filter hint SEI message, that are to be specified in a new edition of the Versatile Supplemental Enhancement Information messages for coded video bitstreams (VSEI) standard (ITU‑T H.274 | ISO/IEC 23002-7).

Draft 4 incorporated items:

* All errata items for VVC in Subsection 2.3 of JVET-AB1004-v1/JVET-AC0346.
* JVET-AC0311 option 1: Remove equations and related text from both VVC and HEVC (but leave the statements about testing the buffer behaviour in HRD similar as in AVC).
* Errata item 3 in Subsection 4.3 of JVET-AB1004-v1.
* Added the payload type of the post filter hint SEI message.
* Modified the subclause specifying the use of the neural-network post-filter characteristics SEI message as noted in the BoG report on neural-network based post-filtering contributions (JVET-AC0324-v4):
  + Action on Item 14 (cleanup): Adopt Option A approach in JVET-AC0074-v2 with editorial rephrasing as noted in discussion.
  + Action on Item 16 (BF/cleanup): Adopt to specify that when picture rate upsampling is applied together with the frame packing arrangement SEI message with fp\_arrangement\_type equal to 5 (temporal interleaving), the pictures are the pictures from the same view, based on text in JVET-AC0074-v2 as expressed under Item 14.
  + Action on Item 17 (sensibility constraint): Specify that frame rate upsampling can only be used when all input pictures have the same cropped dimensions, after applying the super resolution post-filter applicable to the input picture, if any, based on text in JVET-AC0074-v2 as expressed under Item 14.
* DAM ballot comment US-008/FI-06: add a subclause specifying the use of the phase indication SEI message.
* DAM ballot comments FI-07 and FI-08: add a subclause specifying the use of the post-filter hint SEI message and specify constraints for its syntax element filter\_hint\_chroma\_coeff\_present\_flag.

**JVET-AC2027 - SEI processing order SEI message in VVC (draft 3)**

This document contains the draft text for changes to the Versatile Video Coding (VVC) standard (Rec. ITU-T H.266 | ISO/IEC 23090-3), to specify the SEI processing order SEI message.

**JVET-AC2032 - Improvements under consideration for neural network post filter SEI messages**

This document contains the draft text for changes to the versatile supplemental enhancement information messages for coded video bitstreams (VSEI) standard (Rec. ITU-T H.274 | ISO/IEC 23002-7), to specify additional SEI messages, including the shutter interval information SEI message, neural-network post-filter characteristics SEI message, neural-network post-filter activation SEI message, phase indication SEI message, and post-filter hint SEI message.

**Related input contributions**

The following input contribution was noted as relevant to the work of this ad hoc group:

* [JVET-AD0077](https://jvet-experts.org/doc_end_user/current_document.php?id=12625) - AHG2: On num\_l0\_weights and num\_l1\_weights for VVC specification

**Remaining bug tickets**

* [#1593](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/1593) Figure 5 in the VVC specification shows the incorrect number of slices
* [#1594](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/1594) Mismatch between VVC spec and VTM for sample generation in CCLM process

**Recommendations**

The AHG recommends to:

* Approve JVET-AC1004, JVET-AC1008, JVET-AC2002, JVET-AC2005, JVET-AC2027, and JVET-AC2032 documents as JVET outputs,
* 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 text and the algorithm and encoder description,
* Continue to improve the editorial consistency of VVC text specification and Test Model documents,
* Ensure that, when considering changes to VVC, properly drafted text for addition to the VVC Test Model and/or the VVC specification text is made available in a timely manner,
* Review bug tickets, and other AHG2 related inputs and act on them if found to be necessary.

The report has an annex with an extensive list of available test materials. This annex should be put into a new version of AD1012.

[JVET-AD0005](https://jvet-experts.org/doc_end_user/current_document.php?id=12738) JVET AHG report: Conformance testing (AHG5) [D. Rusanovskyy, I. Moccagatta (co-chairs), F. Bossen, K. Kawamura, T. Ikai, H.-J. Jhu, K. Sühring, Y. Yu (vice-chairs)]

**Activities**

The AHG communication is conducted through the main JVET reflector, jvet@lists.rwth-aachen.de, with [AHG5] in message headers. However, no correspondence marked as AHG5 was sent between the 29th and 30th meetings.

**Timeline**

The progress on the Conformance testing specification is proceeding per the timeline below:

* **VVCv1 conformance:**
  + ISO/IEC FDIS 23090-15 issued from 2021-10 meeting, FDIS registered for formal approval 2022-07-11, FDIS ballot closed 2022-11-04, standard published 2022-11-24
  + H.266.1 V1 Consent 2022-01-28, Last Call began 2022-04-01, Approved 2022-04-29, pre-published 2022-05-17, standard published 2022-07-12.
* **VVCv2 conformance:**
  + ISO/IEC 23090-15/Amd.1 CDAM: 2021-10
  + ISO/IEC 23090-15/Amd.1 DAM: 2022-01
  + DAM ballot closed 2022-11-15, ready to proceed to FDAM at current meeting 2023-01
  + H.266.1 V2 Consent planned for 2023-07

**Status on bitstream submission**

There were no changes to the submitted bitstreams. The status at the time of preparation of this report is as follows:

* conformance bitstreams for VVC:
  + 104 bitstream categories have been identified
  + At least one bitstream has been submitted in each identified category
  + 283 total bitstreams have been provided, checked, and made available
  + As reported in JVET-AB0005, HRD\_A\_Fujitsu (HRD\_A\_Fujitsu\_4) has been regenerated to avoid CPB underflow
  + 7 of the 10 bitstreams reported in Ticket #1581 have been re-generated
* conformance bitstreams for VVC operation range extensions:
  + 57 bitstream categories have been identified
  + 1 bitstream of 1 identified category has been re-generated
  + 128 bitstreams of 57 identified categories have been cross-checked and uploaded.
  + No changes between 29th and 30th meeting.

**Activities and Discussion**

The AHG activities are on schedule with the preliminary timeline shown in section 2.

VVC activities:

Seven of the 10 bitstreams reported in Ticket #1581 have been re-generated:

* ILRPL\_A\_Huawei (ILRPL\_A\_Huawei\_3)
* OPI\_B\_Nokia (OPI\_B\_Nokia\_4)
* SPATSCAL444\_A\_Qualcomm (SPATSCAL444\_A\_Qualcomm\_3)
* SPATSCAL\_A\_Qualcomm (SPATSCAL\_A\_Qualcomm\_4)
* VPS\_A\_INTEL (VPS\_A\_INTEL\_4)
* VPS\_B\_ERICSSON (VPS\_B\_ERICSSON\_2)
* VPS\_C\_ERICSSON (VPS\_C\_ERICSSON\_3)

and are available in the dropbox.

The remaining 3 bitstreams

* OLS\_A\_Tencent\_5
* OLS\_B\_Tencent\_5
* OLS\_C\_Tencent\_5

have been re-generated with unmodified VTM-20.0 encoder, but VTM-20.0 decoder cannot decode them correctly. Ticket #1595 has been filed to report this problem. The problem may be related to #1581.

The 7 re-generated bitstreams, HRD\_A\_Fujitsu\_4, and the remaining conformance streams are decoded correctly using VTM-20.0 w/o range extension support.

VVC operation range extensions activities:

All bitstreams are decoded correctly using VTM-20.0.

The regular JVET e-mail reflector was used for discussions ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de)).

The AHG5 chairs and JVET chairs can be reached at [jvet-conformance@lists.rwth-aachen.de](mailto:jvet-conformance@lists.rwth-aachen.de). Participants should not subscribe to this list but may send emails to it.

**Contributions**

JVET-AD0101 - Additional conformance tests of scaling window functionality for multilayer coding [Shunsuke Iwamura, Shimpei Nemoto, Atsuro Ichigaya].

JVET-AD0232 - HEVC Multiview Profiles: Implementation Status [Seethal Paluri, Dimitri Podborski, Alexis Tourapis].

**Ftp site information**

The procedure to exchange the bitstream (ftp cite, bitstream files, etc.) is specified in Sec 2 “Procedure” of [JVET-R2008](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=8861). The ftp and http sites for downloading bitstreams are

* VVC:

<ftp://ftp3.itu.int/jvet-site/bitstream_exchange/VVC>

<https://www.itu.int/wftp3/av-arch/jvet-site/bitstream_exchange/VVC/>

* VVC operation range extensions:

[ftp://ftp3.itu.int/jvet-site/bitstream\_exchange/VVCv2](ftp://ftp3.itu.int/jvet-site/bitstream_exchange/VVCv2/draft_conformance/draft)

<https://www.itu.int/wftp3/av-arch/jvet-site/bitstream_exchange/VVCv2>

The ftp site for uploading bitstream file is as follows.

<ftp://ftp3.itu.int/jvet-site/dropbox/>

(user id: avguest, passwd: Avguest201007)

If using FileZilla, the following configuration is suggested:

Graphical user interface, text, application, email

Description automatically generated

In the Filezilla Edit 🡪 Settings 🡪 Connection menu, it may also be necessary to set the minimum TLS level to 1.0.

**Recommendations**

The AHG recommends the following:

* Proceed with the generation, cross-checking, and documentation of the additional conformance bitstreams for VVC, in particular conformance bitstreams for VVC multilayer configurations (JVET-AC2028).
* Maintain and update the conformance bitstream database and contribute to report problems in JVET document 1004.
* Start the generation, cross-checking, and documentation of the conformance streams for the HEVC multiview profiles supporting extended bit depth (JVET-AA1011).

[JVET-AD0006](https://jvet-experts.org/doc_end_user/current_document.php?id=12588) JVET AHG report: ECM software development (AHG6) [V. Seregin (chair), J. Chen, F. Le Léannec, K. Zhang (vice-chairs)]

**Software** development

ECM software repository is located at [https://vcgit.hhi.fraunhofer.de/ecm/ECM.](https://vcgit.hhi.fraunhofer.de/ecm/ECM.E)

ECM software is based on VTM-10.0 with enabled MCTF including the update from JVET-V0056, and GOP32, which is very close to VTM-11.0.

VTM-11.0ecm anchor <https://vcgit.hhi.fraunhofer.de/ecm/ECM/-/tree/VTM11_ANC>is used for ECM performance evaluation.

The following adopted aspects were integrated into ECM-7.0:

JVET-AB0171: Asymmetric deblocking (MR 303)

JVET-AC0105: Directional planar (MR 306)

JVET-AC0095: fix padding at picture boundary (MR 312)

JVET-AC0189: SGPM without blending (MR 313)

JVET-AC0144: affine DMVR regression (MR 310)

JVET-AC0147: Subsampling is not applied to CCCM (MR 314)

JVET-AC0112: IBC-CIIP, IBC-GPM, IBC-LIC (MR 315)

JVET-AC0053: Gaussian solver for filter coefficients (MR 318)

JVET-AC0071: Direct block vector mode for chroma prediction (MR 325) (part of AC0113 3.5a)

JVET-AC0130: NSPT replacing DCT-II + LFNST for certain block shapes (MR 319)

JVET-AC0123: MTT correction for class B QP22 (MR 322)

JVET-AC0158: Pixel based affine motion compensation (MR 327)

JVET-AC0094: Optimizing the use of reference samples (MR 311)

JVET-AC0185: Enhanced temporal motion information derivation (MR 317)

JVET-AC0162: ALF using residual samples as additional inputs (MR 323)

JVET-AC0335: Content adaptive OBMC enabling (MR 324)

JVET-AC0119: On Chroma Fusion improvement (MR 331)

JVET-AC0098: Location-dependent DIMD (MR 329)

JVET-AC0054: Gradient and location-based CCCM (MR 332)

JVET-AC0115: Intra mode derivation for IntraTMP transform (Test 4.1a) (MR 320)

JVET-AC0104: Block vector difference prediction for IBC blocks (part of AC0113 Test 3.5a) (MR 333)

JVET-AC0060: IBC BVP candidates clustering and BVD sign derivation for reconstruction-reordered IBC mode (test EE2-3.4, as part of test EE2-3.5a) (MR 335)

JVET-AC0096: RPR functionality testing (MR 338)

Bug fixes:

Fix VB handling when SAO is EDGE 135 (MR 304)

Fix the wrong stride for TIMD (MR 305)

The following adopted aspects were integrated into VTM-11ecm anchor:

JVET-AB0081: Upscaling filter for display 12-tap luma and 6-tap chroma (MR 341)

The integrated changes do not change VTM-11 anchor performance under CTC.

JVET-AC0123: MTT correction for class B QP22 (MR 328)

JVET-AC0096: RPR functionality testing (MR 339)

ECM-8.0 and VTM-11ecm8.0 were tagged on February 24, 2023.

The following bug fixes were integrated into ECM-8.0:

Fix to prevent it from crashing by calling getIpmInfo() with cs NULL (MR 374)

Fix OBMC SPS settings based on hash for low-delay config (MR 380)

Upgrade to C++17 (MR 381)

Enable BVD prediction and BVP clustering when  --EnableTMTools=0, issue #38 (MR 386)

Fix issue #35 (MR 385)

Fix IBC-GPM when --EnableTMTools=0 (MR 383)

Fix propagation of intra modes for IBC blocks, issue #40 (MR 387)

Pass the correct buffer when CTU is divided by VB (MR 382)

Use MAX\_NUM\_REF in regression motion info vector (MR 391)

Fix GCC 12.2 compiler errors in GCC 12.2, issue #39 (MR 393)

The following fixes were integrated into VTM-11ecm anchor:

Address GCC12 compiling errors (MR 388)

ECM-8.1 and VTM-11ecm8.1 were tagged on April 18, 2023. The performance of VTM-11ecm8.1 is the same as VTM-11ecm8 under CTC.

***CTC Performance***

In this section, ECM test results following ECM CTC configuration descried in JVET-Y2017 are summarized.

Next tables show ECM-8.0 performance over ECM-7.0 anchor.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **All Intra Main 10** | | | | |
|  | **Over ECM-7.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 | -0.40% | -1.62% | -1.41% | 113% | 108% |
| Class A2 | -0.75% | -1.83% | -1.71% | 119% | 110% |
| Class B | -0.74% | -1.59% | -1.62% | 117% | 113% |
| Class C | -1.22% | -1.79% | -1.72% | 119% | 111% |
| Class E | -0.86% | -1.15% | -1.01% | 115% | 109% |
| **Overall** | -0.81% | -1.61% | -1.52% | 117% | 111% |
| Class D | -0.88% | -1.65% | -1.70% | 118% | 108% |
| Class F | -4.77% | -5.65% | -5.71% | 122% | 113% |
| Class TGM | -6.14% | -7.04% | -7.77% | 118% | 109% |
|  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | |
|  | **Over ECM-7.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 | -0.53% | -1.23% | -1.18% | 109% | 112% |
| Class A2 | -1.18% | -1.93% | -2.42% | 109% | 111% |
| Class B | -0.72% | -1.49% | -1.53% | 100% | 108% |
| Class C | -0.86% | -1.40% | -1.44% | 108% | 108% |
| Class E |  |  |  |  |  |
| **Overall** | -0.81% | -1.50% | -1.61% | 106% | 109% |
| Class D | -0.63% | -1.55% | -1.42% | 109% | 108% |
| Class F | -3.87% | -5.14% | -5.27% | 111% | 106% |
| Class TGM | -4.71% | -4.90% | -5.03% | 112% | 114% |
|  |  |  |  |  |  |
|  | **Low delay B Main 10** | | | | |
|  | **Over ECM-7.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -0.23% | -0.62% | -0.81% | 104% | 112% |
| Class C | -0.32% | -0.78% | -0.71% | 104% | 110% |
| Class E | -0.11% | -2.86% | -0.72% | 103% | 108% |
| **Overall** | -0.23% | -1.23% | -0.75% | 104% | 110% |
| Class D | -0.22% | -0.70% | -1.28% | 106% | 109% |
| Class F | -2.03% | -3.11% | -3.96% | 110% | 110% |
| Class TGM | -2.15% | -2.53% | -2.65% | 107% | 115% |
|  |  |  |  |  |  |
|  | **Low delay P Main 10** | | | | |
|  | **Over ECM-7.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -0.12% | -0.66% | -0.90% | 109% | 113% |
| Class C | -0.30% | -0.91% | -0.72% | 109% | 111% |
| Class E | 0.13% | -1.06% | -0.26% | 107% | 110% |
| **Overall** | -0.12% | -0.84% | -0.68% | 109% | 112% |
| Class D | -0.19% | -1.24% | -2.08% | 109% | 108% |
| Class F | -2.23% | -3.42% | -3.41% | 111% | 111% |
| Class TGM | -2.37% | -2.74% | -3.06% | 111% | 109% |

The below tables show ECM-8.0 performance comparing to VTM-11.0ecm8.0 anchor.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **All Intra Main 10** | | | | |
|  | **Over VTM-11.0ecm8** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 | -9.03% | -18.78% | -25.18% | 703% | 380% |
| Class A2 | -13.53% | -22.78% | -25.89% | 695% | 382% |
| Class B | -8.30% | -21.80% | -20.07% | 692% | 421% |
| Class C | -9.22% | -14.00% | -14.34% | 677% | 419% |
| Class E | -10.49% | -18.86% | -17.70% | 648% | 423% |
| **Overall** | -9.86% | -19.24% | -20.22% | 684% | 407% |
| Class D | -7.50% | -11.48% | -11.53% | 672% | 418% |
| Class F | -22.22% | -30.58% | -30.24% | 460% | 365% |
| Class TGM | -35.58% | -42.92% | -42.31% | 387% | 329% |
|  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | |
|  | **Over VTM-11.0ecm8** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 | -19.88% | -22.82% | -29.84% | 687% | 742% |
| Class A2 | -22.38% | -29.61% | -32.91% | 632% | 887% |
| Class B | -18.26% | -29.12% | -27.08% | 558% | 758% |
| Class C | -19.95% | -23.64% | -23.52% | 574% | 757% |
| Class E |  |  |  |  |  |
| **Overall** | -19.86% | -26.50% | -27.85% | 601% | 779% |
| Class D | -20.75% | -25.02% | -25.17% | 594% | 876% |
| Class F | -24.95% | -32.44% | -32.74% | 438% | 465% |
| Class TGM | -33.27% | -38.66% | -38.88% | 489% | 417% |
|  |  |  |  |  |  |
|  | **Low delay B Main 10** | | | | |
|  | **Over VTM-11.0ecm8** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -16.36% | -30.93% | -29.37% | 543% | 665% |
| Class C | -17.70% | -26.18% | -26.20% | 559% | 671% |
| Class E | -14.69% | -24.67% | -23.73% | 545% | 419% |
| **Overall** | -16.39% | -27.78% | -26.90% | 549% | 594% |
| Class D | -19.81% | -26.86% | -27.28% | 545% | 768% |
| Class F | -22.06% | -31.32% | -30.64% | 448% | 474% |
| Class TGM | -30.41% | -36.98% | -36.69% | 458% | 388% |
|  |  |  |  |  |  |
|  | **Low delay P Main 10** | | | | |
|  | **Over VTM-11.0ecm8** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -15.52% | -30.67% | -28.56% | 501% | 648% |
| Class C | -17.16% | -25.51% | -24.94% | 481% | 736% |
| Class E | -14.20% | -22.86% | -23.10% | 514% | 481% |
| **Overall** | -15.74% | -26.99% | -25.99% | 497% | 627% |
| Class D | -19.95% | -26.98% | -27.49% | 462% | 750% |
| Class F | -21.24% | -31.27% | -29.98% | 436% | 436% |
| Class TGM | -27.60% | -35.05% | -34.98% | 490% | 361% |

Next tables show ECM-8.1 performance over ECM-8.0 anchor.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **All Intra Main 10** | | | | |
|  | **Over ECM-8.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.00% | 0.00% | 0.00% | 96% | 98% |
| Class A2 | 0.00% | 0.00% | 0.00% | 95% | 98% |
| Class B | 0.00% | 0.00% | 0.00% | 96% | 97% |
| Class C | 0.00% | 0.00% | 0.00% | 97% | 97% |
| Class E | 0.00% | 0.00% | 0.00% | 95% | 95% |
| **Overall** | 0.00% | 0.00% | 0.00% | 96% | 97% |
| Class D | 0.00% | 0.00% | 0.00% | 97% | 97% |
| Class F | 0.02% | -0.05% | -0.26% | 94% | 94% |
| Class TGM | -0.06% | -0.03% | 0.00% | 94% | 95% |
|  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | |
|  | **Over ECM-8.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.00% | 0.00% | 0.00% | 97% | 96% |
| Class A2 | 0.00% | 0.00% | 0.00% | 97% | 97% |
| Class B | 0.00% | 0.00% | 0.00% | 97% | 98% |
| Class C | 0.00% | 0.00% | 0.00% | 98% | 98% |
| Class E |  |  |  |  |  |
| **Overall** | 0.00% | 0.00% | 0.00% | 97% | 97% |
| Class D | 0.00% | 0.00% | 0.00% | 97% | 98% |
| Class F | 0.01% | -0.36% | 0.06% | 93% | 93% |
| Class TGM | -0.01% | 0.02% | 0.03% | 90% | 91% |
|  |  |  |  |  |  |
|  | **Low delay B Main 10** | | | | |
|  | **Over ECM-8.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | 0.00% | 0.00% | 0.00% | 97% | 95% |
| Class C | 0.00% | 0.00% | 0.00% | 99% | 99% |
| Class E | 0.00% | 0.00% | 0.00% | 96% | 99% |
| **Overall** | 0.00% | 0.00% | 0.00% | 97% | 97% |
| Class D | 0.00% | 0.00% | 0.00% | 98% | 98% |
| Class F | -0.01% | 0.44% | 1.38% | 92% | 92% |
| Class TGM | -2.57% | -2.10% | -2.08% | 92% | 93% |
|  |  |  |  |  |  |
|  | **Low delay P Main 10** | | | | |
|  | **Over ECM-8.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | 0.00% | 0.00% | 0.00% | 95% | 97% |
| Class C | 0.00% | 0.00% | 0.00% | 96% | 98% |
| Class E | 0.00% | 0.00% | 0.00% | 94% | 100% |
| **Overall** | 0.00% | 0.00% | 0.00% | 95% | 98% |
| Class D | 0.00% | 0.00% | 0.00% | 96% | 99% |
| Class F | -0.14% | -0.54% | 0.24% | 92% | 93% |
| Class TGM | -1.87% | -1.17% | -1.32% | 93% | 97% |

The Excel files with the complete test results are attached to this report.

**ECM** memory **consumption**

ECM memory consumption is provided in ECM encoder log files and is summarized in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
|  | RA | LD | AI |
| class A | 24 GB |  | 11 GB |
| class B | 13 GB | 12 GB | 9 GB |
| class C | 6 GB | 6 GB | 5 GB |
| class E |  | 7 GB | 6 GB |
| class D | 5 GB | 5 GB | 4 GB |
| class F | 13 GB | 11 GB | 11 GB |
| class TGM | 16 GB | 14 GB | 11 GB |

It is encouraged to care about memory allocation when developing and integrating tools into ECM. In particular, it is strongly recommended to re-use already allocated memory wherever possible, rather than systematically allocating new memory.

Recommendations

The AHG recommends to:

* Continue to develop ECM software.
* Improve the software documentation.
* Encourage people to report all (potential) bugs that they are finding using GitLab Issues functionality <https://vcgit.hhi.fraunhofer.de/ecm/ECM/-/issues>.
* Encourage people to submit merge requests fixing identified bugs.

[JVET-AD0007](https://jvet-experts.org/doc_end_user/current_document.php?id=12631) JVET AHG report: ECM tool assessment (AHG7) [X. Li (chair), L.-F. Chen, Z. Deng, J. Gan, E. François, H.-J. Jhu, R.-L. Liao, H. Wang (vice-chairs)]

AhG meeting summary

The AhG meeting was held on Feb. 17, 2023. The meeting report was uploaded as JVET-AD0041. The agreed items during the meeting are summarized as below.

* ECM tool grouping
  + Group 1: Inter template matching tools
  + Group 2: Coding tools that interleave the (merge/skip/AMVP/subblock/IBC/etc) list derivation with the intra prediction/reconstruction process
  + Group 3: Intra and IBC template matching (with search) related tools
  + Group 4: Tools that require more processing on the neighboring reconstructed samples than VVC
  + Group 5: Remaining tools
* Tool grouping list

|  |  |
| --- | --- |
| Group | Tools |
| 1 | TM, TM OBMC, ARMC-TM, TM GPM, TM-Merge, TM-AMVP, TM-MMBD, block level reference picture list reordering, TM based BCW index derivation, MVD sign prediction |
| 2 | LIC, CIIP with TIMD and TM merge, coefficient sign prediction |
| 3 | TM IBC, IBC BVD prediction, IBC BVP clustering, intra TMP, TIMD, TMRL, SGPM, Direct BV for chroma prediction |
| 4 | DIMD, CCCM |
| 5 | Remaining tools |

* The missing cfg options of tools in group 1-4 are as below. The cfg options of tools in group5 are to be further identified. Note that the missing control for TM IBC and TMRL affected testing for Group 3 off and Group 1-4 off. The controls of TM based BCW, CIIP with TM merge and IBC BVP clustering have been added to ECM 8.1 and included in the following tests.
  + TM based BCW index derivation, CIIP with TM merge, TM IBC, IBC BVP clustering, TMRL
* Testing configurations
  + ECM anchor: ECM-8.1
  + VTM anchor: VTM11-ecm8.1
  + Configurations: AI, RA, LDB (with TGM class), do not test LDB for group 3 and 4
  + Cfg options are used to disable tools
  + Test each group on their own, i.e., anchor vs anchor + disable tool group x (1-5)

**Issues during testing**

During the testing, several issues were identified.

ECM-8 decoding mismatch was observed for SCC sequences during tool off tests. In addition, a tool control issue and several compiling issues were reported. These issues which blocked the tool off tests were resolved in a short time. We thank the effort from the proponents and AHG6 to resolve these issues.

Minor issues on test setting and bitrate/PSNR calculating were observed and resolved during the crosschecking.

There are still open software issues related to tool off tests, such as issue #27, #36, #42, #43 (<https://vcgit.hhi.fraunhofer.de/groups/ecm/-/issues>). These issues didn’t block AHG7 tests. But it would be good to have them fixed.

**Results of group off tests**

***Test* anchor *and crosschecking***

As ECM-8.0 has software issues when some tools are disabled, ECM-8.1 is used as the first anchor for the group off tests. The second anchor is VTM-11ecm8.1. As the second anchor data is directly copied from AHG6 report, the runtime info is removed to avoid confusion.

The testers and crosscheckers are summarized in the table below. All the tests below have been crosschecked.

|  |  |  |
| --- | --- | --- |
| Tests | Tester | Crosschecker |
| Group 1 off | Jonathan Gan (v-jonathan.gan@oppo.com) | Charles Salmon-Legagneur (charles.salmon-legagneur@interdigital.com) |
| Group 2 off | Jonathan Gan (v-jonathan.gan@oppo.com) | Ru-Ling Liao (ruling.lrl@alibaba-inc.com) |
| Group 3 off | Xiang Li (xlxiangli@google.com) | Zhipin Deng (zhipin.deng@bytedance.com) |
| Group 4 off | Xiang Li (xlxiangli@google.com) | Hong-Jheng Jhu (jhuhong-jheng@kwai.com) |
| Group 1-4 off | Xiang Li (xlxiangli@google.com) | Lien-Fei Chen (lienfei.chen@global.tencent.com),  Hongtao Wang  (hongtaow@qti.qualcomm.com) |

**Group *1 off***

Group 1 includes inter template matching tools.

The command line setting of this test is: --EnableTMTools=0

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | | | |
|  | **Over ECM-8.1** | | | | | **Over VTM-11ecm8.1** | | | | |
|  | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| Class A1 | 0.00% | 0.00% | 0.00% | 100% | 100% | -9.04% | -18.79% | -25.18% | #DIV/0! | #DIV/0! |
| Class A2 | 0.00% | 0.00% | 0.00% | 100% | 100% | -13.53% | -22.78% | -25.89% | #DIV/0! | #DIV/0! |
| Class B | 0.00% | 0.00% | 0.00% | 100% | 100% | -8.31% | -21.80% | -20.07% | #DIV/0! | #DIV/0! |
| Class C | -0.01% | -0.01% | -0.01% | 100% | 100% | -9.23% | -14.01% | -14.35% | #DIV/0! | #DIV/0! |
| Class E | -0.01% | -0.01% | -0.01% | 100% | 100% | -10.50% | -18.87% | -17.71% | #DIV/0! | #DIV/0! |
| **Overall** | -0.01% | -0.01% | -0.01% | 100% | 100% | -9.87% | -19.24% | -20.23% | #DIV/0! | #DIV/0! |
| Class D | -0.03% | -0.02% | -0.02% | 100% | 100% | -7.53% | -11.50% | -11.55% | #DIV/0! | #DIV/0! |
| Class F | 0.32% | 0.24% | 0.74% | 100% | 97% | -21.97% | -30.46% | -29.87% | #DIV/0! | #DIV/0! |
| Class TGM | 1.48% | 1.45% | 1.48% | 100% | 88% | -34.68% | -42.11% | -41.45% | #DIV/0! | #DIV/0! |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | | | | | | |
|  | **Over ECM-8.1** | | | | | **Over VTM-11ecm8.1** | | | | |
|  | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| Class A1 | 3.63% | 4.06% | 4.42% | 89% | 84% | -16.99% | -19.85% | -26.72% | #DIV/0! | #DIV/0! |
| Class A2 | 3.93% | 4.25% | 4.61% | 86% | 78% | -19.33% | -26.63% | -29.84% | #DIV/0! | #DIV/0! |
| Class B | 3.40% | 3.66% | 3.62% | 86% | 78% | -15.47% | -26.52% | -24.41% | #DIV/0! | #DIV/0! |
| Class C | 3.94% | 4.12% | 4.39% | 81% | 70% | -16.77% | -20.48% | -20.12% | #DIV/0! | #DIV/0! |
| Class E |  |  |  |  |  |  |  |  |  |  |
| **Overall (Ref)** | 3.70% | 3.98% | 4.18% | 85% | 77% | -16.89% | -23.60% | -24.81% | #DIV/0! | #DIV/0! |
| Class D | 3.23% | 3.79% | 3.80% | 80% | 65% | -18.15% | -22.11% | -22.24% | #DIV/0! | #DIV/0! |
| Class F | 2.77% | 2.74% | 2.67% | 90% | 82% | -22.80% | -30.73% | -30.86% | #DIV/0! | #DIV/0! |
| Class TGM | 4.47% | 4.45% | 4.39% | 91% | 82% | -30.30% | -35.90% | -36.18% | #DIV/0! | #DIV/0! |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **Low delay B Main10** | | | | | | | | | |
|  | **Over ECM-8.1** | | | | | **Over VTM-11ecm8.1** | | | | |
|  | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |  |  |  |  |  |
| Class A2 |  |  |  |  |  |  |  |  |  |  |
| Class B | 4.18% | 4.84% | 5.12% | 77% | 69% | -12.85% | -27.67% | -25.87% | #DIV/0! | #DIV/0! |
| Class C | 4.43% | 4.86% | 5.46% | 75% | 60% | -14.03% | -22.60% | -22.14% | #DIV/0! | #DIV/0! |
| Class E | 4.28% | 5.75% | 5.37% | 78% | 78% | -11.04% | -20.42% | -19.67% | #DIV/0! | #DIV/0! |
| **Overall (Ref)** | 4.29% | 5.07% | 5.30% | 77% | 68% | -12.79% | -24.17% | -23.08% | #DIV/0! | #DIV/0! |
| Class D | 3.73% | 3.63% | 4.80% | 73% | 58% | -16.80% | -24.23% | -23.72% | #DIV/0! | #DIV/0! |
| Class F | 3.63% | 3.04% | 2.93% | 87% | 75% | -19.17% | -28.87% | -27.57% | #DIV/0! | #DIV/0! |
| Class TGM | 5.98% | 6.05% | 5.85% | 88% | 78% | -28.11% | -34.34% | -34.26% | #DIV/0! | #DIV/0! |

***Group 2 off***

Group 2 includes coding tools that interleave the (merge/skip/AMVP/subblock/IBC/etc) list derivation with the intra prediction/reconstruction process.

The command line setting of this test is: --LIC=0 --CIIPTM=0 --CIIPTIMD=0 --NumSignPred=0 --IBCLIC=0

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | | | |
|  | **Over ECM-8.1** | | | | | **Over VTM-11ecm8.1** | | | | |
|  | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| Class A1 | 0.45% | 0.71% | 0.73% | 87% | 91% | -8.62% | -18.26% | -24.61% | #DIV/0! | #DIV/0! |
| Class A2 | 0.50% | 0.59% | 0.70% | 84% | 91% | -13.09% | -22.32% | -25.37% | #DIV/0! | #DIV/0! |
| Class B | 0.45% | 0.58% | 0.63% | 83% | 89% | -7.89% | -21.35% | -19.56% | #DIV/0! | #DIV/0! |
| Class C | 0.37% | 0.44% | 0.50% | 80% | 87% | -8.89% | -13.62% | -13.92% | #DIV/0! | #DIV/0! |
| Class E | 0.66% | 0.82% | 0.91% | 83% | 90% | -9.90% | -18.24% | -16.96% | #DIV/0! | #DIV/0! |
| **Overall** | 0.47% | 0.61% | 0.68% | 83% | 89% | -9.44% | -18.76% | -19.68% | #DIV/0! | #DIV/0! |
| Class D | 0.30% | 0.33% | 0.48% | 78% | 85% | -7.23% | -11.19% | -11.11% | #DIV/0! | #DIV/0! |
| Class F | 2.47% | 2.44% | 2.86% | 88% | 92% | -20.39% | -29.10% | -28.55% | #DIV/0! | #DIV/0! |
| Class TGM | 0.49% | 0.56% | 0.56% | 88% | 98% | -35.30% | -42.63% | -41.99% | #DIV/0! | #DIV/0! |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | | | | | | |
|  | **Over ECM-8.1** | | | | | **Over VTM-11ecm8.1** | | | | |
|  | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| Class A1 | 2.14% | 1.29% | 1.77% | 89% | 98% | -18.18% | -21.79% | -28.57% | #DIV/0! | #DIV/0! |
| Class A2 | 1.60% | 1.06% | 1.56% | 89% | 97% | -21.14% | -28.86% | -31.85% | #DIV/0! | #DIV/0! |
| Class B | 1.50% | 1.05% | 1.23% | 88% | 96% | -17.03% | -28.35% | -26.17% | #DIV/0! | #DIV/0! |
| Class C | 1.14% | 0.70% | 0.92% | 86% | 95% | -19.05% | -23.14% | -22.82% | #DIV/0! | #DIV/0! |
| Class E |  |  |  |  |  |  |  |  |  |  |
| **Overall (Ref)** | 1.55% | 1.01% | 1.32% | 88% | 96% | -18.62% | -25.75% | -26.89% | #DIV/0! | #DIV/0! |
| Class D | 0.71% | 0.63% | 0.52% | 85% | 94% | -20.18% | -24.57% | -24.82% | #DIV/0! | #DIV/0! |
| Class F | 2.91% | 2.39% | 2.72% | 91% | 95% | -22.81% | -31.17% | -31.01% | #DIV/0! | #DIV/0! |
| Class TGM | 1.52% | 1.39% | 1.50% | 90% | 99% | -32.21% | -37.78% | -37.91% | #DIV/0! | #DIV/0! |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **Low delay B Main10** | | | | | | | | | |
|  | **Over ECM-8.1** | | | | | **Over VTM-11ecm8.1** | | | | |
|  | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |  |  |  |  |  |
| Class A2 |  |  |  |  |  |  |  |  |  |  |
| Class B | 1.57% | 0.68% | 1.11% | 86% | 95% | -15.04% | -30.43% | -28.52% | #DIV/0! | #DIV/0! |
| Class C | 1.08% | 1.16% | 1.27% | 85% | 95% | -16.82% | -25.36% | -25.26% | #DIV/0! | #DIV/0! |
| Class E | 1.10% | 2.15% | 0.47% | 87% | 95% | -13.73% | -23.05% | -23.41% | #DIV/0! | #DIV/0! |
| **Overall (Ref)** | 1.29% | 1.21% | 1.00% | 86% | 95% | -15.31% | -26.90% | -26.16% | #DIV/0! | #DIV/0! |
| Class D | 0.59% | 0.17% | 1.21% | 85% | 96% | -19.33% | -26.86% | -26.34% | #DIV/0! | #DIV/0! |
| Class F | 2.64% | 1.10% | 1.12% | 90% | 97% | -20.03% | -30.26% | -28.94% | #DIV/0! | #DIV/0! |
| Class TGM | 1.68% | 1.70% | 1.86% | 92% | 99% | -31.01% | -37.15% | -36.76% | #DIV/0! | #DIV/0! |

**Group *3 off***

Group 3 includes intra and IBC template matching (with search) related tools. Note that the control of TM IBC and TMRL are still missing. The tests were performed with these two tools on.

The command line setting of this test is: --BvdPred=0 --IntraDBV=0 --BvpCluster=0 --IntraTMP=0 --TIMD=0 --SGPM=0

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | | | |
|  | **Over ECM-8.1** | | | | | **Over VTM-11ecm8.1** | | | | |
|  | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| Class A1 | 0.45% | 0.29% | 0.35% | 83% | 93% | -8.62% | -18.55% | -24.91% | #DIV/0! | #DIV/0! |
| Class A2 | 1.03% | 1.10% | 1.19% | 84% | 88% | -12.59% | -21.88% | -24.97% | #DIV/0! | #DIV/0! |
| Class B | 1.15% | 1.04% | 1.23% | 83% | 86% | -7.24% | -20.96% | -19.06% | #DIV/0! | #DIV/0! |
| Class C | 0.95% | 0.78% | 0.80% | 84% | 83% | -8.36% | -13.33% | -13.64% | #DIV/0! | #DIV/0! |
| Class E | 1.89% | 1.88% | 1.88% | 84% | 84% | -8.80% | -17.33% | -16.14% | #DIV/0! | #DIV/0! |
| **Overall** | 1.09% | 1.01% | 1.09% | 84% | 86% | -8.87% | -18.41% | -19.33% | #DIV/0! | #DIV/0! |
| Class D | 0.72% | 0.38% | 0.53% | 85% | 82% | -6.84% | -11.13% | -11.06% | #DIV/0! | #DIV/0! |
| Class F | 1.79% | 1.69% | 2.05% | 92% | 92% | -20.84% | -29.45% | -28.95% | #DIV/0! | #DIV/0! |
| Class TGM | 4.10% | 4.52% | 4.91% | 93% | 98% | -33.05% | -40.44% | -39.56% | #DIV/0! | #DIV/0! |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | | | | | | |
|  | **Over ECM-8.1** | | | | | **Over VTM-11ecm8.1** | | | | |
|  | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| Class A1 | 0.26% | 0.13% | 0.39% | 96% | 99% | -19.67% | -22.70% | -29.57% | #DIV/0! | #DIV/0! |
| Class A2 | 0.54% | 0.22% | 0.71% | 96% | 99% | -21.96% | -29.46% | -32.43% | #DIV/0! | #DIV/0! |
| Class B | 0.61% | 0.40% | 0.55% | 95% | 99% | -17.76% | -28.83% | -26.67% | #DIV/0! | #DIV/0! |
| Class C | 0.40% | 0.30% | 0.63% | 96% | 98% | -19.63% | -23.42% | -23.01% | #DIV/0! | #DIV/0! |
| Class E |  |  |  |  |  |  |  |  |  |  |
| **Overall (Ref)** | 0.47% | 0.28% | 0.57% | 96% | 99% | -19.48% | -26.29% | -27.43% | #DIV/0! | #DIV/0! |
| Class D | 0.38% | 0.24% | 0.37% | 96% | 98% | -20.45% | -24.87% | -24.96% | #DIV/0! | #DIV/0! |
| Class F | 1.01% | 1.14% | 0.96% | 97% | 99% | -24.22% | -31.97% | -32.16% | #DIV/0! | #DIV/0! |
| Class TGM | 2.04% | 2.28% | 2.40% | 96% | 100% | -31.92% | -37.31% | -37.43% | #DIV/0! | #DIV/0! |

**Group *4 off***

Group 4 includes tools that require more processing on the neighboring reconstructed samples than VVC.

The command line setting of this test is: --DIMD=0 --CCCM=0

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | | | |
|  | **Over ECM-8.1** | | | | | **Over VTM-11ecm8.1** | | | | |
|  | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| Class A1 | 1.53% | 4.43% | 5.96% | 88% | 96% | -7.64% | -15.40% | -20.83% | #DIV/0! | #DIV/0! |
| Class A2 | 2.41% | 4.37% | 4.80% | 87% | 98% | -11.55% | -19.47% | -22.51% | #DIV/0! | #DIV/0! |
| Class B | 1.00% | 4.75% | 3.80% | 88% | 97% | -7.39% | -18.37% | -17.18% | #DIV/0! | #DIV/0! |
| Class C | 0.87% | 2.21% | 1.97% | 87% | 98% | -8.44% | -12.20% | -12.72% | #DIV/0! | #DIV/0! |
| Class E | 1.11% | 4.73% | 2.84% | 88% | 97% | -9.50% | -15.26% | -15.52% | #DIV/0! | #DIV/0! |
| **Overall** | 1.31% | 4.07% | 3.76% | 87% | 97% | -8.71% | -16.17% | -17.41% | #DIV/0! | #DIV/0! |
| Class D | 0.79% | 1.79% | 1.75% | 87% | 98% | -6.77% | -9.91% | -9.99% | #DIV/0! | #DIV/0! |
| Class F | 1.15% | 2.95% | 2.87% | 93% | 96% | -21.31% | -28.65% | -28.46% | #DIV/0! | #DIV/0! |
| Class TGM | 1.74% | 2.69% | 2.84% | 92% | 98% | -34.53% | -41.48% | -40.76% | #DIV/0! | #DIV/0! |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | | | | | | |
|  | **Over ECM-8.1** | | | | | **Over VTM-11ecm8.1** | | | | |
|  | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| Class A1 | 1.36% | 2.96% | 4.83% | 93% | 99% | -18.78% | -20.62% | -26.72% | #DIV/0! | #DIV/0! |
| Class A2 | 1.13% | 2.55% | 3.37% | 94% | 99% | -21.50% | -27.88% | -30.73% | #DIV/0! | #DIV/0! |
| Class B | 0.58% | 4.28% | 3.64% | 93% | 99% | -17.79% | -26.18% | -24.55% | #DIV/0! | #DIV/0! |
| Class C | 0.34% | 1.41% | 1.39% | 95% | 100% | -19.68% | -22.56% | -22.43% | #DIV/0! | #DIV/0! |
| Class E |  |  |  |  |  |  |  |  |  |  |
| **Overall (Ref)** | 0.78% | 2.91% | 3.22% | 94% | 99% | -19.23% | -24.45% | -25.65% | #DIV/0! | #DIV/0! |
| Class D | 0.35% | 2.04% | 1.32% | 96% | 100% | -20.47% | -23.43% | -24.25% | #DIV/0! | #DIV/0! |
| Class F | 0.61% | 1.96% | 1.60% | 97% | 100% | -24.50% | -31.39% | -31.66% | #DIV/0! | #DIV/0! |
| Class TGM | 0.53% | 1.09% | 1.02% | 94% | 100% | -32.93% | -37.99% | -38.25% | #DIV/0! | #DIV/0! |

***Group 5 off***

Group 5 includes all coding tools which are not in group 1-4. Unfortunately, many tools in this group cannot be switched off with cfg options. Considering these limitations, the tools off test of group 5 was not performed.

**Group *1-4 off***

This test was not discussed during the AHG interim meeting. As no progress was achieved for group 5 off test, this test was suggested.

The command line setting of this test is: --EnableTMTools=0 --LIC=0 --CIIPTM=0 --CIIPTIMD=0 --NumSignPred=0 --IBCLIC=0 --BvdPred=0 --IntraDBV=0 --BvpCluster=0 --IntraTMP=0 --TIMD=0 --SGPM=0 --DIMD=0 --CCCM=0

Note that the control of TM IBC and TMRL are still missing. The tests were performed with these two tools on.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | | | |
|  | **Over ECM-8.1** | | | | | **Over VTM-11ecm8.1** | | | | |
|  | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| Class A1 | 2.72% | 5.93% | 7.43% | 61% | 81% | -6.55% | -14.21% | -19.69% | #DIV/0! | #DIV/0! |
| Class A2 | 4.20% | 6.34% | 6.84% | 58% | 75% | -9.95% | -17.91% | -20.96% | #DIV/0! | #DIV/0! |
| Class B | 2.83% | 6.57% | 5.78% | 58% | 70% | -5.71% | -16.93% | -15.57% | #DIV/0! | #DIV/0! |
| Class C | 2.50% | 3.63% | 3.52% | 56% | 64% | -6.97% | -10.97% | -11.38% | #DIV/0! | #DIV/0! |
| Class E | 4.13% | 7.65% | 5.95% | 59% | 70% | -6.79% | -12.87% | -12.95% | #DIV/0! | #DIV/0! |
| **Overall** | 3.18% | 5.95% | 5.76% | 58% | 71% | -7.02% | -14.64% | -15.79% | #DIV/0! | #DIV/0! |
| Class D | 2.15% | 3.11% | 3.11% | 56% | 60% | -5.52% | -8.74% | -8.79% | #DIV/0! | #DIV/0! |
| Class F | 5.85% | 7.74% | 7.60% | 76% | 75% | -17.79% | -25.61% | -25.40% | #DIV/0! | #DIV/0! |
| Class TGM | 9.12% | 10.07% | 10.93% | 76% | 81% | -29.90% | -37.36% | -36.20% | #DIV/0! | #DIV/0! |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | | | | | | |
|  | **Over ECM-8.1** | | | | | **Over VTM-11ecm8.1** | | | | |
|  | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| Class A1 | 7.85% | 9.43% | 12.35% | 69% | 81% | -13.60% | -15.79% | -21.40% | #DIV/0! | #DIV/0! |
| Class A2 | 7.55% | 9.08% | 10.44% | 68% | 76% | -16.51% | -23.31% | -26.02% | #DIV/0! | #DIV/0! |
| Class B | 6.31% | 9.83% | 9.65% | 66% | 74% | -13.07% | -22.23% | -20.12% | #DIV/0! | #DIV/0! |
| Class C | 6.11% | 7.38% | 7.61% | 62% | 65% | -15.02% | -17.98% | -17.62% | #DIV/0! | #DIV/0! |
| Class E |  |  |  |  |  |  |  |  |  |  |
| **Overall (Ref)** | 6.81% | 8.95% | 9.80% | 66% | 73% | -14.39% | -20.03% | -20.89% | #DIV/0! | #DIV/0! |
| Class D | 4.89% | 6.34% | 6.41% | 62% | 61% | -16.80% | -20.21% | -20.31% | #DIV/0! | #DIV/0! |
| Class F | 7.67% | 8.82% | 8.71% | 76% | 78% | -19.25% | -26.86% | -26.97% | #DIV/0! | #DIV/0! |
| Class TGM | 9.51% | 10.19% | 10.44% | 77% | 82% | -26.93% | -32.44% | -32.52% | #DIV/0! | #DIV/0! |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **Low delay B Main10** | | | | | | | | | |
|  | **Over ECM-8.1** | | | | | **Over VTM-11ecm8.1** | | | | |
|  | Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |  |  |  |  |  |
| Class A2 |  |  |  |  |  |  |  |  |  |  |
| Class B | 6.25% | 7.49% | 8.35% | 60% | 63% | -11.10% | -25.86% | -23.62% | #DIV/0! | #DIV/0! |
| Class C | 6.11% | 6.82% | 7.45% | 58% | 53% | -12.65% | -21.18% | -20.70% | #DIV/0! | #DIV/0! |
| Class E | 5.76% | 10.68% | 8.79% | 63% | 73% | -9.76% | -16.83% | -17.10% | #DIV/0! | #DIV/0! |
| **Overall (Ref)** | 6.08% | 8.06% | 8.16% | 60% | 62% | -11.29% | -22.04% | -21.02% | #DIV/0! | #DIV/0! |
| Class D | 4.71% | 5.31% | 7.21% | 58% | 52% | -15.99% | -22.98% | -21.93% | #DIV/0! | #DIV/0! |
| Class F | 7.48% | 8.07% | 7.73% | 73% | 70% | -16.24% | -25.50% | -24.25% | #DIV/0! | #DIV/0! |
| Class TGM | 10.15% | 10.71% | 11.08% | 79% | 75% | -25.27% | -31.58% | -31.10% | #DIV/0! | #DIV/0! |

***Result* summary**

The average results compared to ECM-8.1are summarized in the table below. Note that SCC results are not included.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **AI** | PRSNY | PSNRU | PSNRV | EncT | DecT |
| Off1 | -0.01% | -0.01% | -0.01% | 100% | 100% |
| Off2 | 0.47% | 0.61% | 0.68% | 83% | 89% |
| Off3 | 1.09% | 1.01% | 1.09% | 84% | 86% |
| Off4 | 1.31% | 4.07% | 3.76% | 87% | 97% |
| Test1 (off1-4) | 3.18% | 5.95% | 5.76% | 58% | 71% |
|  |  |  |  |  |  |
| **RA** | PRSNY | PSNRU | PSNRV | EncT | DecT |
| Off1 | 3.70% | 3.98% | 4.18% | 85% | 77% |
| Off2 | 1.55% | 1.01% | 1.32% | 88% | 96% |
| Off3 | 0.47% | 0.28% | 0.57% | 96% | 99% |
| Off4 | 0.78% | 2.91% | 3.22% | 94% | 99% |
| Test1 (off1-4) | 6.81% | 8.95% | 9.80% | 66% | 73% |
|  |  |  |  |  |  |
| **LDB** | PRSNY | PSNRU | PSNRV | EncT | DecT |
| Off1 | 4.29% | 5.07% | 5.30% | 77% | 68% |
| Off2 | 1.29% | 1.21% | 1.00% | 86% | 95% |
| Test1 (off1-4) | 6.08% | 8.06% | 8.16% | 60% | 62% |

***Open* Questions**

The following questions were raised during AHG teleconference and testing.

* How to further improve the methodology of tool grouping and assessment?
* Should cfg controls for tools in group 5 be added? If not, how to assess tools in group 5?
* Should the visual quality of group off tests be evaluated?

**Input contributions**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| [JVET-AD0041](https://jvet-experts.org/doc_end_user/current_document.php?id=12587) | m62485 | 2023-02-27 18:21:13 | 2023-02-27 22:19:31 | 2023-02-27 22:19:31 | AHG7: Report on AHG meeting on ECM tool assessment | X. Li |
| [JVET-AD0082](https://jvet-experts.org/doc_end_user/current_document.php?id=12633) | m62708 | 2023-04-14 05:52:30 | 2023-04-14 19:59:34 | 2023-04-14 19:59:34 | [AHG7] A configuration option for TMRL mode | L. Xu, J. Gan, Y. Yu, H. Yu, D. Wang(OPPO) |
| [JVET-AD0131](https://jvet-experts.org/doc_end_user/current_document.php?id=12682) | m62775 | 2023-04-14 12:37:51 | 2023-04-14 21:48:52 | 2023-04-14 21:48:52 | AhG 7: Coding efficiency/runtime tradeoff metrics | P. Onno, G. Laroche (Canon) |
| [JVET-AD0229](https://jvet-experts.org/doc_end_user/current_document.php?id=12793) | m62914 | 2023-04-15 00:15:43 | 2023-04-15 00:19:30 | 2023-04-17 07:34:52 | AHG4/AHG12/AHG7: Mixed-Content Sequences for ECM CTC or Tool Assessment | X. Li (Google), Z. Deng, K. Zhang, L. Zhang (Bytedance) |
| [JVET-AD0246](https://jvet-experts.org/doc_end_user/current_document.php?id=12810) | m62973 | 2023-04-17 02:10:57 | 2023-04-17 03:19:18 | 2023-04-17 03:19:18 | [AHG7] ECM tool assessment with HDR dataset | Z. Fan, Y. Yausig, T. Chujoh, T. Ikai (Sharp) |

**Recommendations**

* Continue and improve tool assessment
* Given the existing and potential software issues related to tool assessment, it is recommended to add a new mandate “Coordinate with AHG6 on resolving tool assessment related ECM software issues”
* Discuss the open questions
* Review all the input contributions

[JVET-AD0008](https://jvet-experts.org/doc_end_user/current_document.php?id=12739) JVET AHG report: Optimization of encoders and receiving systems for machine analysis of coded video content (AHG8) [C. Hollmann, S. Liu, S. Wang, M. Zhou (AHG chairs)]

***Common Test Conditions***

Common test conditions (CTC) for optimization of encoders and receiving systems for machine analysis of coded video content, are summarized in output document JVET-AC2031. This document includes detailed descriptions of test datasets, anchor software and configurations, anchor generation processes, machine task networks used, test and training conditions, evaluation methodologies and metrics. A reporting template in Excel format is enclosed in the document package. The first version of this output document was uploaded on 2023-02-02, followed by a couple of revisions, the final verison includes crosschecked CTC results.

**Test datasets**

Two video datasets, referred as SFU-HW and TVD, are included in the CTC and results on both are expected to be reported. In addition, three image datasets, referred as TVD (image), OpenImageV6 and FLIR, are included in the CTC and can be tested using intra-only configuration. The results on the image datasets are optional.

It was decided in the last JVET meeting to remove four sequences from the originally proposed SFU-HW (SFU-HW-objects-v1) dataset, including one class B sequence (Kimono) and three class E sequences, and thus the SFU-HW dataset now consist of 13 test video sequences, as shown in Table 1. The sequences can be found on <ftp://hevc@mpeg.tnt.uni-hannover.de>. The annotations are available at <https://data.mendeley.com/datasets/hwm673bv4m/1>.

Table 1. Test sequences in SFU-HW dataset

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Class** | **Sequence name** | **Frame count** | **Frame rate** | **Bit depth** | **Frames skipped** | **Frames coded** | **Intra** | **RA** | **LD** |
| A | Traffic | 150 | 30 | 8 | 117 | 33 | M | M | M |
| B | ParkScene | 240 | 24 | 8 | 207 | 33 | M | M | M |
| B | Cactus | 500 | 50 | 8 | 403 | 97 | M | M | M |
| B | BasketballDrive | 500 | 50 | 8 | 403 | 97 | M | M | M |
| B | BQTerrace | 600 | 60 | 8 | 471 | 129 | M | M | M |
| C | RaceHorses | 300 | 30 | 8 | 235 | 65 | M | M | M |
| C | BQMall | 600 | 60 | 8 | 471 | 129 | M | M | M |
| C | PartyScene | 500 | 50 | 8 | 403 | 97 | M | M | M |
| C | BasketballDrill | 500 | 50 | 8 | 403 | 97 | M | M | M |
| D | RaceHorses | 300 | 30 | 8 | 235 | 65 | M | M | M |
| D | BQSquare | 600 | 60 | 8 | 471 | 129 | M | M | M |
| D | BlowingBubbles | 500 | 50 | 8 | 403 | 97 | M | M | M |
| D | BasketballPass | 500 | 50 | 8 | 403 | 97 | M | M | M |

*Note: M – mandatory; O – optional.*

It was decided in the last JVET meeting to split the originally proposed long sequences in Tencent Video Dataset (TVD) into multiple short clips. With some investigations, experiments and validations, seven clips are extracted from the originally proposed TVD sequences, as shown in Table 2. The dataset with corresponding annotations is available at <https://multimedia.tencent.com/resources/tvd>.

Table 2. Test sequences in TVD

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sequence name** | **Frame count** | **Frame rate** | **Bit depth** | **Frames skipped** | **Frames coded** | **Intra** | **Random access** | **Low delay** |
| TVD-01\_1 | 3000 | 50 | 8 | 1500 | 500 | M | M | M |
| TVD-01\_2 | 3000 | 50 | 8 | 2000 | 500 | M | M | M |
| TVD-01\_3 | 3000 | 50 | 8 | 2500 | 500 | M | M | M |
| TVD-02\_1 | 636 | 50 | 8 | 0 | 636 | M | M | M |
| TVD-03\_1 | 2334 | 50 | 8 | 0 | 500 | M | M | M |
| TVD-03\_2 | 2334 | 50 | 8 | 500 | 500 | M | M | M |
| TVD-03\_3 | 2334 | 50 | 8 | 1000 | 500 | M | M | M |

The original sequences are available in .mp4 format and shall be converted to YUV420 using FFmpeg:

ffmpeg -i {input.mp4} -f rawvideo -pix\_fmt yuv420p -dst\_range 1 {output.yuv}

The TVD (image) dataset is an image dataset of 166 images of 1920x1080 resolution that have annotations for object detection and instance segmentation. The dataset with corresponding annotations is available at <https://multimedia.tencent.com/resources/tvd>.

The OpenImages dataset consists of around 9 million images. A subset of the validation set of its version 6 containing 5000 images are selected for testing object detection in this activity. The dataset with corresponding annotations is available at <https://storage.googleapis.com/openimages/web/index.html>.

The FLIR dataset used in the WG 4 VCM activities is a dataset consisting of 300 infrared images. The images, annotations and the fine-tuned model for thermal images can be found on the MPEG content repository (<https://content.mpeg.expert/data/>).

More detailed information about these test datasets can be found in JVET-AC2031.

**Anchor software and configuration**

Version 12.0 of the VTM software is used for generating anchor results. The VTM software is available at <https://vcgit.hhi.fraunhofer.de/jvet/VVCSoftware_VTM/>.

In addition, version 4.2.2 of the FFmpeg is used for the format conversion. The FFmpeg software is available at <https://ffmpeg.org/releases>.

Three test conditions are used for experimenting encoder and receiving system optimizations on video coding for machine consumptions, i.e., random-access, low-delay and all-intra. The default configuration files provided with the VTM software are used for anchor generation.

* “Random access” (RA): encoder\_randomaccess\_vtm.cfg
* “Low delay” (LD): encoder\_lowdelay\_vtm.cfg
* “All Intra” (AI): encoder\_intra\_vtm.cfg

It was decided in the last JVET meeting that temporal subsampling is disabled for “All Intra” configuration for this activity, thus the following line

TemporalSubsampleRatio : 8

in “encoder\_intra\_vtm.cfg” needs to be modified to

TemporalSubsampleRatio : 1

A subset of these configurations might be used for a particular experiment. However, as these test conditions are for video coding experiments, results for at least one of the random access or low delay configurations are expected to be provided.

**Anchor generation**

The anchor generation process is illustrated in Figure 1. The task network Faster R-CNN X101-FPN which is part of Detectron2 (<https://github.com/facebookresearch/detectron2>) is used to evaluate object detection (SFU-HW dataset and image datasets), the model is available [here](https://dl.fbaipublicfiles.com/detectron2/COCO-Detection/faster_rcnn_X_101_32x8d_FPN_3x/139173657/model_final_68b088.pkl). The task network JDE-1088x608 which is part of the Towards Realtime MOT framework (<https://github.com/Zhongdao/Towards-Realtime-MOT>) is used to evaluate object tracking (TVD), the model is available [here](https://drive.google.com/open?id=1nlnuYfGNuHWZztQHXwVZSL_FvfE551pA). More details about anchor generation process and these machine task networks are referred to JVET-AC2031.

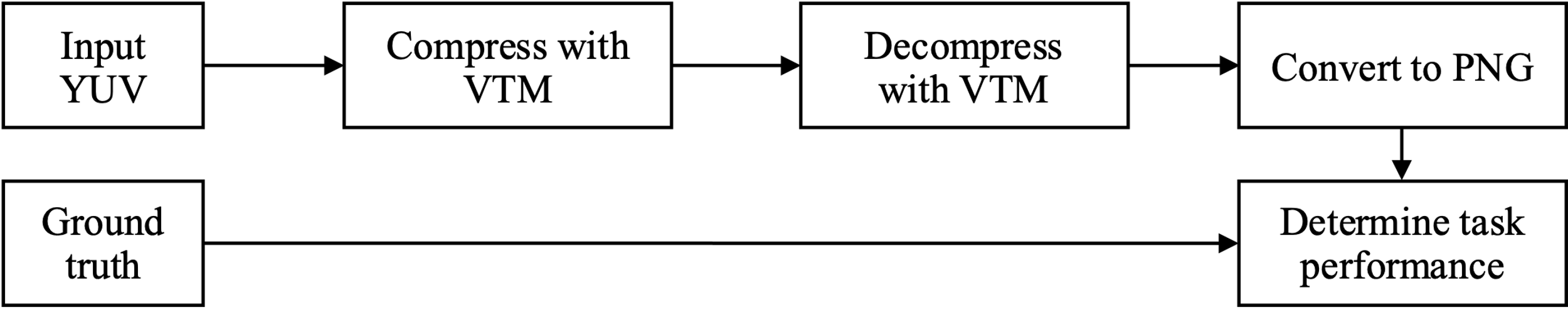


Figure 1. Anchor generation pipeline

Experiments were conducted after the last JVET meeting to carefully select the QP values for future tool development, testing and evalution. The updated QP values are listed in Table 3, Table 4 and Table 5.

Table 3. QPs for sequences in SFU-HW dataset

|  |  |  |  |
| --- | --- | --- | --- |
| **Class** | **Sequence name** | **Configuration** | **QP values** |
| A | Traffic | RA, LD, AI | {39, 45, 48, 51, 54, 58} |
| B | ParkScene | RA, LD, AI | {32, 36, 40, 44, 48, 52} |
| B | Cactus | RA, LD, AI | {43, 46, 49, 52, 55, 58} |
| B | BasketballDrive | RA, LD, AI | {40, 43, 46, 49, 52, 55} |
| B | BQTerrace | RA, LD, AI | {40, 43, 46, 49, 52, 55} |
| C | RaceHorses | RA, LD, AI | {27, 31, 35, 39, 43, 47} |
| C | BQMall | RA, LD, AI | {27, 32, 37, 42, 47, 52} |
| C | PartyScene | RA, LD, AI | {31, 35, 39, 43, 47, 51} |
| C | BasketballDrill | RA, LD, AI | {27, 31, 35, 39, 43, 47} |
| D | RaceHorses | RA, LD, AI | {22, 26, 30, 34, 38, 42} |
| D | BQSquare | RA, LD, AI | {24, 28, 31, 34, 38, 41} |
| D | BlowingBubbles | RA, LD, AI | {27, 31, 34, 37, 40, 43} |
| D | BasketballPass | RA, LD, AI | {22, 26, 30, 34, 38, 42} |

Table 4. QPs for sequences in TVD

|  |  |  |
| --- | --- | --- |
| **Sequence name** | **Configuration** | **QP values** |
| TVD-01\_1 | RA, LD, AI | {20, 23, 26, 29, 32, 35} |
| TVD-01\_2 | RA, LD, AI | {21, 24, 28, 31, 34, 37} |
| TVD-01\_3 | RA, LD, AI | {23, 26, 30, 34, 38, 42} |
| TVD-02\_1 | RA, LD, AI | {26, 32, 37, 42, 48, 53} |
| TVD-03\_1 | RA, LD, AI | {34, 39, 42, 46, 50, 54} |
| TVD-03\_2 | RA, LD, AI | {28, 32, 36, 40, 43, 49} |
| TVD-03\_3 | RA, LD, AI | {22, 27, 32, 37, 42, 47} |

Table 5. QPs for image datasets

|  |  |  |
| --- | --- | --- |
| **Dataset** | **Configuration** | **QP values** |
| OpenImageV6 | AI | {22, 27, 32, 37, 42, 47} |
| FLIR (IR) | AI | {22, 27, 32, 37, 42, 47} |
| TVD-I | AI | {22, 27, 32, 37, 42, 47} |

Anchor results were generated following the CTC described in JVET-AC2031 and crosschecked by Ericsson and Tencent.

**Evaluation and reporting**

Proposed technologies are evaluated based on their compression performance, measured by bitrate, PSNR, mAP and MOTA, as well as encoding and decoding runtime to reflect the complexity of the proposed technology, to some extent. Definitions and detailed descriptions of these metrics can be found in JVET-AC2031.

It is noted that the mean Average Precision (mAP) is used to measure object detection performance, and Multiple Object Tracking Accuracy (MOTA) is used to measure object tracking performance. For the purpose of reporting encoding and decoding running times, the anchor and proposal should be simulated on the same platform, e.g. similar CPU and GPU configuration, to have reliable time comparison. Parallel encoding and decoding as described in JVET-B0036 may be applied for RA configurations.

In addition, relevant inference and training information should be reported if the proposed technology consists of learning-based components, such as network structure, number of network parameters, precision of network parameters, number of multiply–accumulate operations (MAC) per pixel, patch size, batch size, epoch, training time, training datasets, lost function, number of iterations, optimizer, and any pre- and post-processings used. More details can be found in JVET-AC2031.

A reporting template in Excel file format has been prepared to illustrate results following CTC and evaluation methodology described in JVET-AC2031. It is enclosed in JVET-AC2031 package. Some cleanups of the reporting template are suggested in input contribution JVET-AD0043.



Figure 2. Reporting template summary

***Technical Report***

The draft 1 of the technical report (TR) has been prepared and uploaded as JVET-AC2030 based on discussions in the last JVET meeting on 2023-03-20. An input contribution JVET-AD0042 was submitted to suggest additional content to be discussed in this meeting. Another input contribution JVET-AD0135 was submitted to provide additional details on RoI-based adaptive QP for the TR.

***Git Management***

Following the decision in the last JVET meeting, a git repository was set up for software development, experiments, document management and other activities that are related to this AHG, at <https://vcgit.hhi.fraunhofer.de/jvet-ahg-ofm>. This repository contains two projects, one containing instrucitons and information such as scripts for conducting experiements and evaluation, together with anchor results, while the other one containing implementation examples.

Two software example packages have been uploaded to the git, which can be found in the two branches under project <https://vcgit.hhi.fraunhofer.de/jvet-ahg-ofm/vtm-ofm>:

* JVET-AB0275: a region of interest-based method that uses adaptive QP to reduce the quality in background areas
* JVET-AC0086: a method that uses a pre-analysis to perform content adaptive machine vision oriented preprocessing

***AHG Coordination***

Intensive and collabrative discussions were held between this AHG and the VCM AHG in WG4 to synchronize common test conditions including test datasets, anchor QP points, encoder configurations, etc. By now the common test conditions of this AHG and the VTM branch of WG4 VCM AHG are largely aligned.

1. **Input contributions**

There are 15 input contriubtions related to AHG 8 mandates. They are listed below.

|  |  |  |
| --- | --- | --- |
| **Report** | | |
| JVET-AD0008 | JVET AHG report: Optimization of encoders and receiving systems for machine analysis of coded video content (AHG8) | C. Hollmann, S. Liu, S. Wang, M. Zhou (AHG chairs) |
| **Proposal** | | |
| [JVET-AD0042](https://jvet-experts.org/doc_end_user/current_document.php?id=12589) | [AHG8] Proposed text for optimization of encoders and receiving systems for machine analysis of coded video content | J. Chen (Alibaba), C. Hollmann (Ericsson), S. Liu (Tencent) |
| [JVET-AD0043](https://jvet-experts.org/doc_end_user/current_document.php?id=12590) | [AHG8] Clean-ups for the reporting template | C. Hollmann (Ericsson) |
| [JVET-AD0047](https://jvet-experts.org/doc_end_user/current_document.php?id=12594) | AHG8: A preprocessing software implementation for OFM | B. Li, S. Wang, J. Chen, Y. Ye (Alibaba), S. Wang (CityU) |
| [JVET-AD0060](https://jvet-experts.org/doc_end_user/current_document.php?id=12607) | AHG8/AHG9: Indications related to suboptimal user viewing | M. M. Hannuksela, F. Cricri, H. Zhang (Nokia) |
| [JVET-AD0113](https://jvet-experts.org/doc_end_user/current_document.php?id=12664) | AHG8: Adaptive Mask Pre-Process algorithm for Video Coding for Machines | [Z. Huang](mailto:zmhuang@pku.edu.cn), Z. Wang, C. Jia, S. Wang, S. Ma |
| [JVET-AD0122](https://jvet-experts.org/doc_end_user/current_document.php?id=12673) | [AHG8] Configuration changes for random access and low delay | C. Hollmann, R. Sjöberg, J. Ström (Ericsson) |
| [JVET-AD0135](https://jvet-experts.org/doc_end_user/current_document.php?id=12686) | [AHG8] Additional details on RoI-based adaptive QP for TR | C. Hollmann, R. Sjöberg, J. Ström (Ericsson) |
| [JVET-AD0137](https://jvet-experts.org/doc_end_user/current_document.php?id=12688) | [AHG8] SEI for encoder optimization information | C. Kim, Hendry, D. Gwak, J. Lim(LGE) |
| [JVET-AD0138](https://jvet-experts.org/doc_end_user/current_document.php?id=12689) | [AHG8] QPA with low activity threshold for machine task | C. Kim, D. Gwak, J. Lim (LGE) |
| [JVET-AD0181](https://jvet-experts.org/doc_end_user/current_document.php?id=12734) | AHG8: Update on TVD object tracking dataset | Z. Liu, L. Wang, X. Xu, S. Liu (Tencent) |
| [JVET-AD0186](https://jvet-experts.org/doc_end_user/current_document.php?id=12748) | AHG8: VVC tool analysis for Machines Vision Tasks | Z. Liu, L. Wang, X. Xu, S. Liu (Tencent) |
| **Information** | | |
| [JVET-AD0110](https://jvet-experts.org/doc_end_user/current_document.php?id=12661) | [AHG8] Evaluating and Improving Coding Performance for General Image Classification Models | Qi Zhang, Zhao Wang, Shanshe Wang, Siwei Ma |
| **Crosscheck** | | |
| JVET-AD0252 | Cross-check of JVET-AD0181 (AHG8: Update on TVD object tracking dataset) | C. Hollmann (Ericsson) |
| JVET-AD0307 | Crosscheck of JVET-AD0122 ([AHG8] Configuration changes for random access and low delay) | Z. Liu (Tencent) |

1. **Recommendations**

The AHG recommends:

* Review all input contributions.
* Discuss and refine test conditions, evalution and reporting procedures.
* Discuss and refine anchor generation processes and results.
* Discuss existing and continue collecting new test materials.
* Continue investigating non-normative technologies and their suitability for machine analysis applications.
* Continue developing draft technical report on optimization of encoders and receiving systems for machine analysis of coded video content.

Contributions to be reviewed in main track. Scheduling to be coordinated with WG 4 activities on VCM.

[JVET-AD0009](https://jvet-experts.org/doc_end_user/current_document.php?id=12741) JVET AHG report: SEI message studies (AHG9) [S. McCarthy, Y.-K. Wang (co-chairs), T. Chujoh, S. Deshpande, C. Fogg, Hendry, P. de Lagrange, G. J. Sullivan, A. Tourapis, S. Wenger (vice-chairs)]

1. **Related contributions**

A total of 41 contributions are identified relating to the mandates of AHG9. Some contributions also relate to the work of other AHGs, specifically AHG8, AHG11, and AHG13.

The number of contributions relating to each AHG9 mandate is as follows

* 36 contributions relate to the mandate to study the SEI messages in VSEI, VVC, HEVC, and AVC. Some contributions relate to more than one SEI message.
  + 32 contributions relate to the neural-network post-filter SEI messages, including 1 summary of proposals on NNPF and SEI processing order SEI messages.
  + 5 contributions relate to the SEI processing order SEI message, including 1 summary of proposals on NNPF and SEI processing order SEI messages.
  + 1 contribution relates to the post filter hint SEI message.
  + 1 contribution relates to the annotated region SEI message
  + 1 contribution relates to the film grain characteristics SEI message
* 0 contributions relate to the mandate to collect software and showcase information for SEI messages;
* 6 contributions relate to the mandate to identify potential needs for additional SEI messages.

The following is a list of contributions related to the mandates of AHG9.

* 1. ***Study*** ***the SEI messages in VSEI, VVC, HEVC and AVC***

[JVET-AD0258](https://jvet-experts.org/doc_end_user/current_document.php?id=12822) AHG9: A summary of proposals on NNPF and SEI processing order SEI messages [Y.-K. Wang (Bytedance)]

* + 1. **Neural-network post filter characteristics and activation SEI messages**
       1. **Proposals on NNPF SEI messages**

[JVET-AD0052](https://jvet-experts.org/doc_end_user/current_document.php?id=12599) AHG9: NNPFC SEI extension mechanism to enable usages beyond user viewing [M. M. Hannuksela, F. Cricri, H. Zhang (Nokia)]

[JVET-AD0053](https://jvet-experts.org/doc_end_user/current_document.php?id=12600) AHG9: On NNPFC SEI for filtering input pictures and upsampling picture rate [M. M. Hannuksela, F. Cricri, M. Santamaria (Nokia)]

[JVET-AD0054](https://jvet-experts.org/doc_end_user/current_document.php?id=12601) AHG9: On NNPFC SEI for picture rate upsampling [M. M. Hannuksela, F. Cricri, M. Santamaria (Nokia)]

[JVET-AD0055](https://jvet-experts.org/doc_end_user/current_document.php?id=12602) AHG9: On buffering requirements for multi-picture NNPFC SEI [M. M. Hannuksela, F. Cricri (Nokia)]

[JVET-AD0056](https://jvet-experts.org/doc_end_user/current_document.php?id=12603) AHG9: Miscellaneous VSEI changes on neural-network post-filter SEI messages [M. M. Hannuksela, F. Cricri, M. Santamaria (Nokia)]

[JVET-AD0057](https://jvet-experts.org/doc_end_user/current_document.php?id=12604) AHG9: Miscellaneous VVC changes on SEI messages [M. M. Hannuksela, F. Cricri, M. Santamaria (Nokia)]

[JVET-AD0058](https://jvet-experts.org/doc_end_user/current_document.php?id=12605) AHG9: Approaches for region-based neural-network post-filtering [M. M. Hannuksela, F. Cricri (Nokia)]

[JVET-AD0059](https://jvet-experts.org/doc_end_user/current_document.php?id=12606)AHG9: Indicating processing order of NNPFs and SEI messages [M. M. Hannuksela, F. Cricri (Nokia)]

(JVET-AD0059 also relates to the SEI processing order SEI message)

[JVET-AD0065](https://jvet-experts.org/doc_end_user/current_document.php?id=12613) AHG9: On NNPFC Auxiliary Input Information [S. Deshpande (Sharp)]

[JVET-AD0066](https://jvet-experts.org/doc_end_user/current_document.php?id=12614) AHG9: On NNPFC Description and Identification [S. Deshpande (Sharp)]

[JVET-AD0067](https://jvet-experts.org/doc_end_user/current_document.php?id=12615) AHG9: Comments on Neural-Network Post-Filter Characteristics Message [S. Deshpande (Sharp)]

[JVET-AD0078](https://jvet-experts.org/doc_end_user/current_document.php?id=12626) AHG9: On comments for the draft of VSEI [T. Chujoh, Y. Yasugi, T. Ikai (Sharp)]

(JVET-AD0078 also relates to the post filter hint SEI message)

[JVET-AD0079](https://jvet-experts.org/doc_end_user/current_document.php?id=12627) AHG9: On the SEI processing order SEI message [P. Yin, S. McCarthy, W. Husak, K. Konstantinides, T. Lu, F. Pu, A. Arora, T. Shao (Dolby)]

(JVET-AD0078 also relates to the SEI processing order SEI message)

[JVET-AD0087](https://jvet-experts.org/doc_end_user/current_document.php?id=12638) AHG9: On cascading of post-processing filters [Y.-K. Wang, L. Zhang, J. Xu, C. Lin, Y. Li, J. Li, K. Zhang (Bytedance) Preparation of FDAM/FDIS text of VVC 2nd Ed.]

(JVET-AD0087 also relates to the SEI processing order SEI message)

[JVET-AD0088](https://jvet-experts.org/doc_end_user/current_document.php?id=12639)AHG9: Overall post-processing filtering process using NNPFs [Y.-K. Wang, J. Xu, L. Zhang (Bytedance)]

[JVET-AD0089](https://jvet-experts.org/doc_end_user/current_document.php?id=12640) AHG9: NNPF activation parameters [Y.-K. Wang, Y. Li, J. Xu, C. Lin, J. Li, L. Zhang, K. Zhang (Bytedance)]

[JVET-AD0090](https://jvet-experts.org/doc_end_user/current_document.php?id=12641) AHG9: On input pictures to an NNPF [Y.-K. Wang, L. Zhang, C. Lin (Bytedance)]

[JVET-AD0091](https://jvet-experts.org/doc_end_user/current_document.php?id=12642) AHG9: Miscellaneous NNPF topics (set 1) [Y.-K. Wang, J. Xu, C. Lin, Y. Li, J. Li, L. Zhang, K. Zhang (Bytedance)]

[JVET-AD0093](https://jvet-experts.org/doc_end_user/current_document.php?id=12644) AHG9: Neural-network post-processing filter with downsampling capabilities [Y. Li, J. Xu, Y.-K. Wang, C. Lin, J. Li, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0094](https://jvet-experts.org/doc_end_user/current_document.php?id=12645) AHG9: On the NNPFC SEI message involving depth pictures [C. Lin, Y.-K. Wang, J. Xu, Y. Li, J. Li, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0104](https://jvet-experts.org/doc_end_user/current_document.php?id=12655) AHG9: On NNPF Overlap [A. Sidiya, S. Deshpande (Sharp)]

[JVET-AD0141](https://jvet-experts.org/doc_end_user/current_document.php?id=12692) AHG9: On discardable and non-output pictures for NNPF SEI messages [Hendry, J. Nam, H. Moon, S. Kim, J. Lim (LGE)]

[JVET-AD0143](https://jvet-experts.org/doc_end_user/current_document.php?id=12694) AHG9: On picture size for input and output pictures of NNPFC SEI message [Hendry, J. Nam, H. Moon, S. Kim, J. Lim (LGE)]

[JVET-AD0145](https://jvet-experts.org/doc_end_user/current_document.php?id=12696) AHG9: On non-consecutive input pictures for NNPFC SEI message [Hendry, J. Nam, H. Moon, S. Kim, J. Lim (LGE)]

[JVET-AD0149](https://jvet-experts.org/doc_end_user/current_document.php?id=12700) AHG9: On carriage of NNPF bitstream only in NNPFC SEI message [Hendry, J. Nam, H. Moon, S. Kim, J. Lim (LGE)

[JVET-AD0151](https://jvet-experts.org/doc_end_user/current_document.php?id=12702) AHG9: On output picture design in NNPFC SEI message [Hendry, J. Nam, H. Moon, S. Kim, J. Lim (LGE)]

[JVET-AD0154](https://jvet-experts.org/doc_end_user/current_document.php?id=12705) AHG9: Additional purposes for the NNPFC SEI message [M. Pettersson, M. Damghanian, R. Sjöberg (Ericsson)]

[JVET-AD0159](https://jvet-experts.org/doc_end_user/current_document.php?id=12710) AHG9: Explicit identification of NNPF input pictures [Rickard Sjöberg, Martin Pettersson, Mitra Damghanian (Ericsson)]

[JVET-AD0163](https://jvet-experts.org/doc_end_user/current_document.php?id=12714) AHG11: Updating NNPFC and NNPFA SEI messages for the NNPF [M. Santamaria, M. M. Hannuksela, F. Cricri, R. Yang (Nokia)]

[JVET-AD0233](https://jvet-experts.org/doc_end_user/current_document.php?id=12797) AHG9: Miscellaneous NNPF topics (set 2) [J. Xu, Y.-K. Wang, C. Lin, Y. Li, J. Li, L. Zhang, K. Zhang (Bytedance)]

[JVET-AD0240](https://jvet-experts.org/doc_end_user/current_document.php?id=12804) AHG9: Support more NNPF purposes [J. Xu, Y.-K. Wang, L. Zhang, J. Li, C. Lin (Bytedance)]

* + 1. **SEI processing order SEI message**

[JVET-AD0059](https://jvet-experts.org/doc_end_user/current_document.php?id=12606)AHG9: Indicating processing order of NNPFs and SEI messages [M. M. Hannuksela, F. Cricri (Nokia)]

(JVET-AD0059 also relates to the NNPF SEI messages)

[JVET-AD0061](https://jvet-experts.org/doc_end_user/current_document.php?id=12608) AHG9: On the SEI processing order SEI message [Y. He, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-AD0079](https://jvet-experts.org/doc_end_user/current_document.php?id=12627) AHG9: On the SEI processing order SEI message [P. Yin, S. McCarthy, W. Husak, K. Konstantinides, T. Lu, F. Pu, A. Arora, T. Shao (Dolby)]

(JVET-AD0079 also relates to the NNPF SEI messages)

[JVET-AD0087](https://jvet-experts.org/doc_end_user/current_document.php?id=12638) AHG9: On cascading of post-processing filters [Y.-K. Wang, L. Zhang, J. Xu, C. Lin, Y. Li, J. Li, K. Zhang (Bytedance)

(JVET-AD0087 also relates to the NNPF SEI messages)

* + 1. **Post filter hint SEI message**

[JVET-AD0078](https://jvet-experts.org/doc_end_user/current_document.php?id=12626) AHG9: On comments for the draft of VSEI [T. Chujoh, Y. Yasugi, T. Ikai (Sharp)]

(JVET-AD0078 also relates to the post filter hint SEI message)

* + 1. **Annotated regions SEI message**

[JVET-AD0042](https://jvet-experts.org/doc_end_user/current_document.php?id=12589) [AHG8] Proposed text for optimization of encoders and receiving systems for machine analysis of coded video content [J. Chen (Alibaba), C. Hollmann (Ericsson), S. Liu (Tencent)]

(Clause 8 discusses the annotated region SEI message)

* + 1. **Film grain characteristics SEI message**

[JVET-AD0241](https://jvet-experts.org/doc_end_user/current_document.php?id=12805) AHG13: On Film Grain Objective Metrics [X. Meng, W. Zhang, S. Labrozzi (Disney Streaming)]

* 1. ***Identify potential needs for additional SEI messages***

[JVET-AD0051](https://jvet-experts.org/doc_end_user/current_document.php?id=12598) AHG9: Common SEI Message of Generative Face Video [B. Chen, J. Chen, Y. Ye (Alibaba), S. Wang (CityU)]

[JVET-AD0060](https://jvet-experts.org/doc_end_user/current_document.php?id=12607) AHG8/AHG9: Indications related to suboptimal user viewing [M. M. Hannuksela, F. Cricri, H. Zhang (Nokia)]

[JVET-AD0121](https://jvet-experts.org/doc_end_user/current_document.php?id=12672) AHG9: Attenuation Map Information SEI for reducing energy consumption of displays [O. Le Meur, C.H. Demarty, F. Aumont, E. François, L. Blonde, E. Reinhard (InterDigital)]

[JVET-AD0137](https://jvet-experts.org/doc_end_user/current_document.php?id=12688) [AHG8] SEI for encoder optimization information [C. Kim, Hendry, D. Gwak, J. Lim(LGE)]

[JVET-AD0161](https://jvet-experts.org/doc_end_user/current_document.php?id=12712) AHG9: Alternative Output Timing Hint SEI [H.-B. Teo, J. Gao, C.-S. Lim, K. Abe (Panasonic)]

[JVET-AD0175](https://jvet-experts.org/doc_end_user/current_document.php?id=12726) AHG9: On object mask auxiliary picture and object mask information SEI message for VSEI and HEVC [J. Chen, S. Wang, Y. Ye (Alibaba)]

1. **Activities**

The regular JVET e-mail reflector was used for discussions ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de)) with [AHG9] in message headers. There were no emails sent to the JVET reflector during the AHG period with [AHG9] in the message header.

1. **Recommendations**

The AHG recommends to:

* Review all related contributions; and
* Continue SEI messages studies.

BoG (Y.-K. Wang. M. Hannuksela, S. Deshpande) to review the contributions on NNPF SEIs, and relationship with processing order SEI. The “additional SEI messages” and non-NNPF from the ongoing amendment are to be discussed in main track.

[JVET-AD0010](https://jvet-experts.org/doc_end_user/current_document.php?id=12742) JVET AHG report: Encoding algorithm optimization (AHG10) [P. de Lagrange, A. Duenas, R. Sjöberg, A. Tourapis (AHG chairs)]

1. **Related contributions**

A total of 7 contributions, not including cross-checks, are identified relating to AHG10, and summarized in the following sections.

It is noted that some of the mandates of AHG8 are related to test conditions and encoder optimization, so some of the contribution relating to AHG8 can also be of interest for AHG10.

***Visual optimization***

**JVET-AD0045 - AHG10: Encoder MV selections and DMVR revisited**

This contribution describes an encoder method to decrease visual artefacts related to DMVR on sub-block boundaries, with lower BDRate impact than what was proposed in JVET-W0061. It consists in avoiding usage of DMVR when motion derivation is more likely to be unreliable and problems could propagate, e.g. in low temporal layers when reference pictures are far, and/or frame rate is low, and when artefacts are likely (spatial activity at boundaries). There are also conditions related to block size and QP. Compared to JVET-W0061, BDRate losses are reduced from 0.2% to around 0.04% (SDR CTCs) / 0.08% (HDR CTCs). In the context of GOP-based RPR and higher QPs, losses are around 0.5% compared to 2.3% for DMVR-off.

***Bug fix***

**JVET-AD0129 - AHG10: Improvement of Input Video Padding in VTM**

This contribution describes a bug fix in the VTM when the right side of the image is padded to reach a multiple of 8 or minimum CU size, before entering the encoder. This condition is not triggered by the CTCs. When tested with relevant picture sizes (cropped from the CTC sequences), impact on BDRate is significant (around -0.35% for RA).

***Lambda adjustment (RDO)***

**JVET-AD0133 - AHG10: Lambda-QP Relationship Fix for Slice-level Multi-QP Optimization**

This contribution proposes fixes to the frame lambda computation in case of slice-level QP RDO. The lambda is derived from m\_vdRdPicLambda instead of a (potentially inconsistent) formula, and is made independent from the QP sweep. Also a conflict with CU results cache is solved by disabling the cache in that case. BDRate impact as high as -10% is reported in random access.

**JVET-AD0136 - AhG10: Lagrange multiplier optimization for chroma ALF and CCALF**

This contribution proposes to adjust the lambda for the RDO of chroma ALF when luma ALF coefficients are to be transmitted, to account for a reduced overhead of the combined signalling, and also encourage combined signalling (resulting in more chroma filter diversity). Chroma gains are reported.

***Low-delay, GDR***

**JVET-AD0206 - AHG 12: CABAC Initialization for GDR Pictures**

This contribution reports that inter-picture CABAC state inheritance as implemented in ECM8.0 is currently incompatible with GDR as it can cause mismatch at recovery point. It is proposed to enable that feature by always forcing CABAC initialization for GDR pictures. BDRate difference of around -0.5% is reported over TempCabacInit=0 (in low delay configuration with GDR enabled).

***Local QP adaptation***

**JVET-AD0138 - [AHG8] QPA with low activity threshold for machine task**

This contribution proposes a method to prevent the local QP adaptation to lower the QP too much on smooth area, by applying a low-activity threshold. This type of technique is generally useful, even outside of machine analysis tasks, for example to avoid catching noise in intra picture, causing intra pumping or “dirty window” effect.

***Adaptive resolution***

**JVET-AD0169 - AHG12: RPR filters for scale factors below 1.5x**

This contribution proposes to:

* Change non-normative downscaling filters for scaling ratios below 1.33x to larger bandwidth filters, providing sharper downscaled input picture (beneficial to upscale RPR)
* Replace the normative downscale RPR filters in a similar way (beneficial to downscale RPR)

Reported combined BD-Rate difference with ECM-8.0 is around -9% (for 1.25x) and -13% (for 1.33x), using RPR random-access test conditions, whereas non-normative changes alone result in around -8% (for 1.25x) and -10.5% (for 1.33x), which seem to indicate that sharp downscaled pictures are of primary importance for adaptive resolution performance.

The proposed downscale filters could be used in the general case, even for the VTM and scalability cases.

1. **Recommendation**

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

[JVET-AD0011](https://jvet-experts.org/doc_end_user/current_document.php?id=12743) JVET AHG report: Neural network-based video coding (AHG11) [E. Alshina, S. Liu, A. Segall (co-chairs), F. Galpin, J. Li, R.-L. Liao, D. Rusanovskyy, T. Shao, M. Wien, P. Wu (vice-chairs)]

***Common Test Conditions***

**Document**

The AHG released revised common test conditions as decided at the 29th meeting. The final version was uploaded as document JVET-AC2016 on February 15, 2023.

**Anchor Encoding**

Anchors for the NN-based video coding activity made available on the Git repository used for the AHG activity: <https://vcgit.hhi.fraunhofer.de/jvet-ahg-nnvc/nnvc-ctc/-/tree/master>.

***EE Coordination***

The AHG finalized, conducted and discussed the EE on NN based video coding. The final version of the EE description was uploaded to the document repository on February 6, 2023.

A summary report for the EE is available at this meeting as:

|  |  |  |
| --- | --- | --- |
| JVET-AD0022 | EE1: Summary report of exploration experiment on neural network-based video coding | E. Alshina, F. Galpin, Y. Li, D. Rusanovskyy, M. Santamaria, J. Ström, L. Wang, Z. Xie (EE coordinators) |

***Performance Evaluation***

The performance of the NNVC-4.0 anchor compared to NNVC-3.0 is reported below.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |  |
|  | **BD-rate Over NNVC-3.0** | | | | | | | |  |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU | PSNR Overlap |
| Class A1 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 102% | 107% | 100% |
| Class A2 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 102% | 106% | 100% |
| Class B | 0.01% | 0.03% | 0.05% | 0.02% | 0.06% | 0.06% | 103% | 108% | 100% |
| Class C | 0.00% | 0.00% | -0.01% | 0.00% | 0.00% | 0.00% | 102% | 108% | 100% |
| Class E | - | - | - | - | - | - | - | - | - |
| **Overall** | 0.00% | 0.01% | 0.01% | 0.01% | 0.02% | 0.02% | 102% | 107% | 100% |
| Class D | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 103% | 107% | 100% |
| Class F | 0.00% | 0.01% | 0.00% | 0.00% | 0.00% | 0.00% | 103% | 108% | 100% |
| Class H | - | - | - | - | - | - | - | - | - |
|  |  |  |  |  |  |  |  |  |  |
|  | **Low delay B Main10** | | | | | | | |  |
|  | **BD-rate Over NNVC-3.0** | | | | | | | |  |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU | PSNR Overlap |
| Class A1 | - | - | - | - | - | - | - | - | - |
| Class A2 | - | - | - | - | - | - | - | - | - |
| Class B | 0.00% | 0.05% | -0.03% | 0.01% | 0.03% | -0.01% | 102% | 107% | 100% |
| Class C | 0.03% | -0.03% | -0.01% | 0.01% | -0.04% | 0.00% | 101% | 104% | 100% |
| Class E | 0.00% | 0.00% | -0.03% | 0.00% | -0.01% | -0.02% | 103% | 108% | 100% |
| **Overall** | 0.01% | 0.01% | -0.02% | 0.01% | 0.00% | -0.01% | 102% | 106% | 100% |
| Class D | 0.00% | -0.06% | 0.00% | 0.00% | -0.03% | -0.03% | 101% | 105% | 100% |
| Class F | 0.02% | -0.18% | -0.08% | -0.04% | -0.27% | 0.07% | 102% | 109% | 100% |
| Class H | - | - | - | - | - | - | - | - | - |
|  |  |  |  |  |  |  |  |  |  |
|  | **All Intra Main10** | | | | | | | |  |
|  | **BD-rate Over NNVC-3.0** | | | | | | | |  |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU | PSNR Overlap |
| Class A1 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 106% | 106% | 100% |
| Class A2 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 106% | 106% | 100% |
| Class B | 0.00% | 0.01% | 0.02% | 0.00% | 0.01% | 0.02% | 106% | 108% | 100% |
| Class C | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% | 106% | 103% | 100% |
| Class E | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 105% | 102% | 100% |
| **Overall** | 0.00% | 0.01% | 0.01% | 0.00% | 0.00% | 0.01% | 106% | 105% | 100% |
| Class D | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 106% | 105% | 100% |
| Class F | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 103% | 109% | 100% |
| Class H | - | - | - | - | - | - | - | - | - |

***Technical Evaluation***

The AHG made meaningful progress on the mandate to evaluate and quantify potential NN based video coding technologies. A summary of AHG11 related non-EE1 contributions provided as input to the 30th meeting is provided below:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Title** | **Common Test Conditions** | **Results** | | | **Training Data** | |
| **RA** | **LDB** | **AI** | **CTC** | **Additional** |
| **Loop Filter** | | | | | | | |
| [JVET-AD0050](file:////Users/asegall/Downloads/current_document.php%3fid=12597) | AHG11/AHG14: Fix input QP for NN filter set #1 | Yes | Yes | Yes | No | N/A | N/A |
| [JVET-AD0109](file:////Users/asegall/Downloads/current_document.php%3fid=12660) | AHG11: Neural network loop filter | No | Partial | No | No | BVI-DVC | DIV2K |
| **Post Filtering** | | | | | | | |
| [JVET-AD0163](file:////Users/asegall/Downloads/current_document.php%3fid=12714) | AHG11: Updating NNPFC and NNPFA SEI messages for the NNPF | Yes | Yes | No | No | N/A | N/A |
| **Intra-Prediction** | | | | | | | |
| [JVET-AD0212](file:////Users/asegall/Downloads/current_document.php%3fid=12776) | AhG11 : neural network-based intra prediction with reduced complexity | Yes | Yes | Yes | No | BVI-DVC, TVD, UVG | ILSVCR2012, DIV2K |
| **EE Related** | | | | | | | |
| [JVET-AD0107](file:////Users/asegall/Downloads/current_document.php%3fid=12658) | EE1-related: Simplified parameter selection for filter set #1 | Yes | Yes | Yes | No | N/A | N/A |
| [JVET-AD0157](file:////Users/asegall/Downloads/current_document.php%3fid=12708) | EE1-related: Neural-network loop filters in EE1-1.1.2 with further complexity reduction | Yes | Yes | No | Yes | BVI-DVC | DIV2K |
| [JVET-AD0162](file:////Users/asegall/Downloads/current_document.php%3fid=12713) | EE1-2.1-related: DRF Model without QP Input | No | Yes | No | No | BVI-DVC, TVD | DIV2K |
| [JVET-AD0170](file:////Users/asegall/Downloads/current_document.php%3fid=12721) | EE1 related: Performance Improvement of AC0052 filter for RPR-based SR in RA configuration | No | Yes | No | No | BVI-DVC, TVD | DIV2K |
| [JVET-AD0189](file:////Users/asegall/Downloads/current_document.php%3fid=12753) | EE1-related: A simplified NN-based RDO model for filter set #1 | No | Yes | Yes | Yes | N/A | N/A |
| [JVET-AD0207](file:////Users/asegall/Downloads/current_document.php%3fid=12771) | EE1-Related: Additional results for EE1-1.3.1 and EE1-1.3.5 | Yes | Yes | No | Yes | BVI-DVC | DIV2K |
| [JVET-AD0211](file:////Users/asegall/Downloads/current_document.php%3fid=12775) | EE1-Related: Combination test of EE1-1.3.5 and multi-scale component of EE1-1.6 | Yes | Yes | No | Yes | BVI-DVC | DIV2K |
| [JVET-AD0237](file:////Users/asegall/Downloads/current_document.php%3fid=12801) | EE1-related: Residue input for filter set #1 | No | Yes | Yes | Yes | BVI-DVC | DIV2K |

1. **Input contributions**

There are 52 input contributions related to the AHG mandates. Twenty-three of the contributions are part of the EE activity, while the remaining 29 contributions are related to AHG11 but not part of the EE. The list of input contributions is provided below.

***EE and Related Input Contributions***

|  |  |  |
| --- | --- | --- |
| **Reporting** | | |
| [JVET-AD0022](file:////Users/asegall/Downloads/current_document.php%3fid=12749) | EE1: Summary report of exploration experiment on neural network-based video coding | E. Alshina, F. Galpin, Y. Li, D. Rusanovskyy, M. Santamaria, J. Ström, L. Wang, Z. Xie (EE coordinators) |
| **EE Technology** | | |
| [JVET-AD0106](file:////Users/asegall/Downloads/current_document.php%3fid=12657) | EE1-1.6: In-loop filter with wide activation and large receptive field | [Y. Li](mailto:yue.li@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com) |
| [JVET-AD0156](file:////Users/asegall/Downloads/current_document.php%3fid=12707) | EE1-1.1: Complexity Reduction on Neural-Network Loop Filter | [J. N. Shingala](mailto:jay.shingala@ittiam.com), A. Shyam, A. Suneja, S. Badya (Ittiam), [T. Shao](mailto:tshao@dolby.com), A. Arora, [P. Yin](mailto:pyin@dolby.com), F. Pu, T. Lu, S. McCarthy (Dolby) |
| [JVET-AD0160](file:////Users/asegall/Downloads/current_document.php%3fid=12711) | EE1-2.1: Deep Reference Frame Generation for Inter Prediction Enhancement | [J. Jia](mailto:jiajh2021@whu.edu.cn), [Y. Zhang](mailto:yuantongzhang@whu.edu.cn), [H. Zhu](mailto:zhuhanlyx@whu.edu.cn), [Z. Chen (Wuhan Univ.)](mailto:zzchen@whu.edu.cn), [Z. Liu](mailto:zizhengliu@tencent.com), [X. Xu](mailto:xiaozhongxu@tencent.com), [S. Liu (Tencent)](mailto:shanl@tencent.com) |
| [JVET-AD0166](file:////Users/asegall/Downloads/current_document.php%3fid=12717) | EE1-1.7: Optimization of training and network for NNVC filter set 0 | [R. Chang](mailto:renjiechang@tencent.com), [L. Wang](mailto:liqiangwang@tencent.com), [X. Xu](mailto:xiaozhongxu@tencent.com), [S. Liu (Tencent)](mailto:shanl@tencent.com) |
| [JVET-AD0167](file:////Users/asegall/Downloads/current_document.php%3fid=12718) | EE1-1.7-related: Combination test for NNVC based on filter set 0 | [R. Chang](mailto:renjiechang@tencent.com), [L. Wang](mailto:liqiangwang@tencent.com), [X. Xu](mailto:xiaozhongxu@tencent.com), [S. Liu (Tencent)](mailto:shanl@tencent.com) |
| [JVET-AD0168](file:////Users/asegall/Downloads/current_document.php%3fid=12719) | EE1-1.4 Channel redistribution for luma and chroma | [P. Wennersten](mailto:per.wennersten@ericsson.com), [J. Ström](mailto:jacob.strom@ericsson.com), [D. Liu (Ericsson)](mailto:du.liu@ericsson.com) |
| [JVET-AD0205](file:////Users/asegall/Downloads/current_document.php%3fid=12769) | EE1-1.3: Reduced complexity CNN-based in-loop filtering | [S. Eadie](mailto:seadie@qti.qualcomm.com), [Y. Li](mailto:yli30@qti.qualcomm.com), [D. Rusanovskyy](mailto:dmytror@qti.qualcomm.com), [M. Karczewicz (Qualcomm)](mailto:martak@qti.qualcomm.com) |
| [JVET-AD0226](file:////Users/asegall/Downloads/current_document.php%3fid=12790) | EE1-1.5: Ablation Study and Minor Improvements on RTNN | [H. Zhang](mailto:13227706628@163.com), [C. Jung (Xidian Univ.)](mailto:zhengzk@xidian.edu.cn), [Y. Liu](mailto:serena@oppo.com), [M. Li (OPPO)](mailto:myron.li@oppo.com) |
| **EE Related** | | |
| [JVET-AD0107](file:////Users/asegall/Downloads/current_document.php%3fid=12658) | EE1-related: Simplified parameter selection for filter set #1 | [Y. Li](mailto:yue.li@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com) |
| [JVET-AD0157](file:////Users/asegall/Downloads/current_document.php%3fid=12708) | EE1-related: Neural-network loop filters in EE1-1.1.2 with further complexity reduction | [T. Shao](mailto:tshao@dolby.com), A. Arora, [P. Yin](mailto:pyin@dolby.com), F. Pu, T. Lu, S. McCarthy (Dolby), [J. N. Shingala](mailto:jay.shingala@ittiam.com), A. Shyam, A. Suneja, S. Badya (Ittiam) |
| [JVET-AD0162](file:////Users/asegall/Downloads/current_document.php%3fid=12713) | EE1-2.1-related: DRF Model without QP Input | [J. Jia](mailto:jiajh2021@whu.edu.cn), [D. Ding](mailto:dingding@whu.edu.cn), [W. Meng](mailto:whmeng@whu.edu.cn), [Z. Chen (Wuhan Univ.)](mailto:zzchen@whu.edu.cn), [Z. Liu](mailto:zizhengliu@tencent.com), [X. Xu](mailto:xiaozhongxu@tencent.com), [S. Liu (Tencent)](mailto:shanl@tencent.com) |
| [JVET-AD0170](file:////Users/asegall/Downloads/current_document.php%3fid=12721) | EE1 related: Performance Improvement of AC0052 filter for RPR-based SR in RA configuration | [S. Huang](mailto:shimin_huang2022@163.com), [C. Jung (Xidian Univ.)](mailto:zhengzk@xidian.edu.cn), [Y. Liu](mailto:serena@oppo.com), [M. Li (OPPO)](mailto:myron.li@oppo.com) |
| [JVET-AD0189](file:////Users/asegall/Downloads/current_document.php%3fid=12753) | EE1-related: A simplified NN-based RDO model for filter set #1 | [Y. Li](mailto:yue.li@bytedance.com), [J. Li](mailto:lijunru@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com) |
| [JVET-AD0207](file:////Users/asegall/Downloads/current_document.php%3fid=12771) | EE1-Related: Additional results for EE1-1.3.1 and EE1-1.3.5 | [Y. Li](mailto:yli30@qti.qualcomm.com), [S. Eadie](mailto:seadie@qti.qualcomm.com), [D. Rusanovskyy](mailto:dmytror@qti.qualcomm.com), [M. Karczewicz (Qualcomm)](mailto:martak@qti.qualcomm.com) |
| [JVET-AD0211](file:////Users/asegall/Downloads/current_document.php%3fid=12775) | EE1-Related: Combination test of EE1-1.3.5 and multi-scale component of EE1-1.6 | [Y.Li](mailto:yli30@qti.qualcomm.com), [S.Eadie](mailto:seadie@qti.qualcomm.com), [D.Rusanovskyy](mailto:dmytror@qti.qualcomm.com), [M.Karczewicz (Qualcomm)](mailto:martak@qti.qualcomm.com) |
| [JVET-AD0237](file:////Users/asegall/Downloads/current_document.php%3fid=12801) | EE1-related: Residue input for filter set #1 | [Y. Li](mailto:yue.li@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com) |
| **Cross Checks** | | |
| [JVET-AD0248](file:////Users/asegall/Downloads/current_document.php%3fid=12812) | Cross-check of JVET-AD0226 (EE1-1.5: Ablation Study and Minor Improvements on RTNN) | [M. Santamaria (Nokia)](mailto:maria.santamaria_gomez@nokia.com) |
| [JVET-AD0250](file:////Users/asegall/Downloads/current_document.php%3fid=12814) | Crosscheck of JVET-AD0156 (EE1-1.1: Complexity Reduction on Neural-Network Loop Filter) | [J. Ström](mailto:jacob.strom@ericsson.com), [M. Damghanian (Ericsson)](mailto:mitra.damghanian@ericsson.com) |
| [JVET-AD0253](file:////Users/asegall/Downloads/current_document.php%3fid=12817) | Crosscheck of JVET-AD0162 (EE1-2.1: Deep Reference Frame Generation for Inter Prediction Enhancement) | [N. GIULIANI](mailto:nicola.giuliani@huawei.com) |
| [JVET-AD0270](file:////Users/asegall/Downloads/current_document.php%3fid=12834) | Crosscheck of JVET-AD0106 (EE1-1.6: In-loop filter with wide activation and large receptive field) | [C. Zhou (vivo)](mailto:chuan.zhou@vivo.com) |
| [JVET-AD0282](file:////Users/asegall/Downloads/current_document.php%3fid=12846) | Crosscheck of EE1-1.6: In-loop filter with wide activation and large receptive field (JVET-AD0106) | [Y. Li (Qualcomm)](mailto:yli30@qti.qualcomm.com) |
| [JVET-AD0284](file:////Users/asegall/Downloads/current_document.php%3fid=12848) | Crosscheck of JVET-AD0205 (EE1-1.3: Reduced complexity CNN-based in-loop filtering) | [Y. Li (Bytedance)](mailto:yue.li@bytedance.com) |

***Non-EE Input Contributions***

|  |  |  |
| --- | --- | --- |
| **Reporting** | | |
| [JVET-AD0011](file:////Users/asegall/Downloads/current_document.php%3fid=12743) | JVET AHG report: Neural network-based video coding (AHG11) | E. Alshina, S. Liu, A. Segall (co chairs), F. Galpin, J. Li, R.-L. Liao, D. Rusanovskyy, T. Shao, M. Wien, P. Wu (vice chairs) |
| **Loop Filtering** | | |
| [JVET-AD0050](file:////Users/asegall/Downloads/current_document.php%3fid=12597) | AHG11/AHG14: Fix input QP for NN filter set #1 | [D. Liu](mailto:du.liu@ericsson.com), [J. Ström](mailto:jacob.strom@ericsson.com), [K. Andersson (Ericsson)](mailto:kenneth.r.andersson@ericsson.com) |
| [JVET-AD0109](file:////Users/asegall/Downloads/current_document.php%3fid=12660) | AHG11: Neural network loop filter | R. Yang, [M. Santamaria](mailto:maria.santamaria_gomez@nokia.com), N. Zou, F. Cricri, R. G. Youvalari, J. Lainema, H. Zhang, M. M. Hannuksela (Nokia) |
| **Post Filtering** | | |
| [JVET-AD0163](file:////Users/asegall/Downloads/current_document.php%3fid=12714) | AHG11: Updating NNPFC and NNPFA SEI messages for the NNPF | [M. Santamaria](mailto:maria.santamaria_gomez@nokia.com), M. M. Hannuksela, F. Cricri, R. Yang (Nokia) |
| [*JVET-AD0052*](file:////Users/asegall/Downloads/current_document.php%3fid=12599) | *AHG9: NNPFC SEI extension mechanism to enable usages beyond user viewing* | [*M. M. Hannuksela*](mailto:miska.hannuksela@nokia.com)*, F. Cricri, H. Zhang (Nokia)* |
| [*JVET-AD0053*](file:////Users/asegall/Downloads/current_document.php%3fid=12600) | *AHG9: On NNPFC SEI for filtering input pictures and upsampling picture rate* | [*M. M. Hannuksela*](mailto:miska.hannuksela@nokia.com)*, F. Cricri, M. Santamaria (Nokia)* |
| [*JVET-AD0054*](file:////Users/asegall/Downloads/current_document.php%3fid=12601) | *AHG9: On NNPFC SEI for picture rate upsampling* | [*M. M. Hannuksela*](mailto:miska.hannuksela@nokia.com)*, F. Cricri, M. Santamaria (Nokia)* |
| [*JVET-AD0055*](file:////Users/asegall/Downloads/current_document.php%3fid=12602) | *AHG9: On buffering requirements for multi-picture NNPFC SEI* | [*M. M. Hannuksela*](mailto:miska.hannuksela@nokia.com)*, F. Cricri (Nokia)* |
| [*JVET-AD0059*](file:////Users/asegall/Downloads/current_document.php%3fid=12606) | *AHG9: Indicating processing order of NNPFs and SEI messages* | [*M. M. Hannuksela*](mailto:miska.hannuksela@nokia.com)*, F. Cricri (Nokia)* |
| [*JVET-AD0065*](file:////Users/asegall/Downloads/current_document.php%3fid=12613) | *AHG9: On NNPFC Auxiliary Input Information* | [*S. Deshpande (Sharp)*](mailto:sdeshpande@sharplabs.com) |
| [*JVET-AD0066*](file:////Users/asegall/Downloads/current_document.php%3fid=12614) | *AHG9: On NNPFC Description and Identification* | [*S. Deshpande (Sharp)*](mailto:sdeshpande@sharplabs.com) |
| [*JVET-AD0088*](file:////Users/asegall/Downloads/current_document.php%3fid=12639) | *AHG9: Overall post-processing filtering process using NNPFs* | *[Y.-K. Wang](mailto:yekui.wang@bytedance.com), [J. Xu](mailto:xujizheng@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com)* |
| [*JVET-AD0089*](file:////Users/asegall/Downloads/current_document.php%3fid=12640) | *AHG9: NNPF activation parameters* | *[Y.-K. Wang](mailto:yekui.wang@bytedance.com), [Y. Li](mailto:yue.li@bytedance.com), [J. Xu](mailto:xujizheng@bytedance.com), [C. Lin](mailto:linchaoyi.cy@bytedance.com), [J. Li](mailto:lijunru@bytedance.com), [L. Zhang](mailto:lizhang.idm@bytedance.com), [K. Zhang (Bytedance)](mailto:zhangkai.video@bytedance.com)* |
| [*JVET-AD0090*](file:////Users/asegall/Downloads/current_document.php%3fid=12641) | *AHG9: On input pictures to an NNPF* | *[Y.-K. Wang](mailto:yekui.wang@bytedance.com), [L. Zhang](mailto:lizhang.idm@bytedance.com), [C. Lin (Bytedance)](mailto:linchaoyi.cy@bytedance.com)* |
| [*JVET-AD0091*](file:////Users/asegall/Downloads/current_document.php%3fid=12642) | *AHG9: Miscellaneous NNPF topics (set 1)* | *[Y.-K. Wang](mailto:yekui.wang@bytedance.com), [J. Xu](mailto:xujizheng@bytedance.com), [C. Lin](mailto:linchaoyi.cy@bytedance.com), [Y. Li](mailto:yue.li@bytedance.com), [J. Li](mailto:lijunru@bytedance.com), [L. Zhang](mailto:lizhang.idm@bytedance.com), [K. Zhang (Bytedance)](mailto:zhangkai.video@bytedance.com)* |
| [*JVET-AD0094*](file:////Users/asegall/Downloads/current_document.php%3fid=12645) | *AHG9: On the NNPFC SEI message involving depth pictures* | *[C. Lin](mailto:linchaoyi.cy@bytedance.com), [Y.-K. Wang](mailto:yekui.wang@bytedance.com), [J. Xu](mailto:xujizheng@bytedance.com), [Y. Li](mailto:yue.li@bytedance.com), [J. Li](mailto:lijunru@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com)* |
| [*JVET-AD0104*](file:////Users/asegall/Downloads/current_document.php%3fid=12655) | *AHG9: On NNPF Overlap* | *A. Sidiya,* [*S. Deshpande (Sharp)*](mailto:sdeshpande@sharplabs.com) |
| [*JVET-AD0141*](file:////Users/asegall/Downloads/current_document.php%3fid=12692) | *AHG9: On discardable and non-output pictures for NNPF SEI messages* | *[Hendry](mailto:dr.hendry@lge.com), [J. Nam](mailto:junghak.nam@lge.com), H. Jang, S. Kim, J. Lim (LGE)* |
| [*JVET-AD0143*](file:////Users/asegall/Downloads/current_document.php%3fid=12694) | *AHG9: On picture size for input and output pictures of NNPFC SEI message* | *[Hendry](mailto:dr.hendry@lge.com), [J. Nam](mailto:junghak.nam@lge.com), H. Jang, S. Kim, J. Lim (LGE)* |
| [*JVET-AD0145*](file:////Users/asegall/Downloads/current_document.php%3fid=12696) | *AHG9: On non-consecutive input pictures for NNPFC SEI message* | *[Hendry](mailto:dr.hendry@lge.com), [J. Nam](mailto:junghak.nam@lge.com), H. Jang, S. Kim, J. Lim (LGE)* |
| [*JVET-AD0149*](file:////Users/asegall/Downloads/current_document.php%3fid=12700) | *AHG9: On carriage of NNPF bitstream only in NNPFC SEI message* | *[Hendry](mailto:dr.hendry@lge.com), [J. Nam](mailto:junghak.name@lge.com), H. Jang, S. Kim, J. Lim (LGE)* |
| [*JVET-AD0151*](file:////Users/asegall/Downloads/current_document.php%3fid=12702) | *AHG9: On output picture design in NNPFC SEI message* | *[Hendry](mailto:dr.hendry@lge.com), [J. Nam](mailto:junghak.nam@lge.com), H. Jang, S. Kim, J. Lim (LGE)* |
| [*JVET-AD0154*](file:////Users/asegall/Downloads/current_document.php%3fid=12705) | *AHG9: Additional purposes for the NNPFC SEI message* | [*M. Pettersson*](mailto:martin.m.pettersson@ericsson.com)*,* [*M. Damghanian*](mailto:mitra.damghanian@ericsson.com)*,* [*R. Sjöberg (Ericsson)*](mailto:rickard.sjoberg@ericsson.com) |
| [*JVET-AD0159*](file:////Users/asegall/Downloads/current_document.php%3fid=12710) | *AHG9: Explicit identification of NNPF input pictures* | [*Rickard Sjöberg*](mailto:rickard.sjoberg@ericsson.com)*,* [*Martin Pettersson*](mailto:martin.m.pettersson@ericsson.com)*,* [*Mitra Damghanian (Ericsson)*](mailto:mitra.damghanian@ericsson.com) |
| [*JVET-AD0233*](file:////Users/asegall/Downloads/current_document.php%3fid=12797) | *AHG9: Miscellaneous NNPF topics (set 2)* | *[J. Xu](mailto:xujizheng@bytedance.com), [Y.-K. Wang](mailto:yekui.wang@bytedance.com), [C. Lin](mailto:linchaoyi.cy@bytedance.com), [Y. Li](mailto:yue.li@bytedance.com), [J. Li](mailto:lijunru@bytedance.com), [L. Zhang](mailto:lizhang.idm@bytedance.com), [K. Zhang (Bytedance)](mailto:zhangkai.video@bytedance.com)* |
| [*JVET-AD0240*](file:////Users/asegall/Downloads/current_document.php%3fid=12804) | *AHG9: Support more NNPF purposes* | *[J. Xu](mailto:xujizheng@bytedance.com), [Y.-K. Wang](mailto:yekui.wang@bytedance.com), [L. Zhang](mailto:lizhang.idm@bytedance.com), [J. Li](mailto:lijunru@bytedance.com), [C. Lin (Bytedance)](mailto:linchaoyi.cy@bytedance.com)* |
| [*JVET-AD0258*](file:////Users/asegall/Downloads/current_document.php%3fid=12822) | *AHG9: A summary of proposals on NNPF and SEI processing order SEI messages* | [*Y.-K. Wang (Bytedance)*](mailto:yekui.wang@bytedance.com) |
| **Intra Prediction** | | |
| [JVET-AD0212](file:////Users/asegall/Downloads/current_document.php%3fid=12776) | AhG11 : neural network-based intra prediction with reduced complexity | [T. Dumas](mailto:thierry.dumas@interdigital.com), F. Galpin, P. Bordes (Interdigital) |
| **Cross Checks** | | |
| [JVET-AD0314](file:////Users/asegall/Downloads/current_document.php%3fid=12878) | Crosscheck of JVET-AD0163 (AHG11: Updating NNPFC and NNPFA SEI messages for the NNPF) | [H. Zhang](mailto:13227706628@163.com), [C. Jung (Xidian Univ.)](mailto:zhengzk@xidian.edu.cn), [Y. Liu](mailto:serena@oppo.com), [M. Li (OPPO)](mailto:myron.li@oppo.com) |

1. **Recommendations**

The AHG recommends:

* Review all input contributions.
* Continue investigating neural network-based video coding tools, including coding performance and complexity.

[JVET-AD0012](https://jvet-experts.org/doc_end_user/current_document.php?id=12744) JVET AHG report: Enhanced compression beyond VVC capability (AHG12) [M. Karczewicz, Y. Ye, L. Zhang (co-chairs), B. Bross, R. Chernyak, X. Li, K. Naser, H. Yang (vice-chairs)]

JVET-AD0146, "EE2-releated: EE2-1.15a improvement", S. Peng, X. Zhang, C. Fang, D. Jiang, J.-C. Lin, K.Fu, P.Zhang (Dahua)

JVET-AD0148, "Non-EE2: SGPM combined with multiple IntraTMP predictors", C. Fang, S. Peng, D. Jiang, J.-C. Lin, X. Zhang, H.Jin, X.-M.Shi, F.Ye (Dahua)

JVET-AD0150, "Non-EE2: combination of JVET-AD0146 and JVET-AD0148", C. Fang, S. Peng, X. Zhang, D. Jiang, J.-C. Lin, H.Jin, X.-M.Shi, K.Fu, P.Zhang, F.Ye (Dahua)

JVET-AD0155, "Non-EE2: High-Accuracy template matching", Y. Wang, K. Zhang, L. Zhang (Bytedance)

JVET-AD0178, "non EE2-4.3: IntraTMP Padding", K. Naser, T. Poirier, A. Robert, H. Guermoud (InterDigital)

JVET-AD0179, "[AHG12] Extending TIMD with IntraTMP", K. Naser, P. Bordes, K. Reuze, F. Galpin (InterDigital)

JVET-AD0184, "Non-EE2: Removal of Division Operations", W. Jia, K. Zhang, Z. Deng, L. Zhang (Bytedance)

JVET-AD0203, "EE2-related: Reconstruction-Reordered TMP based on lineal filter model for screen content coding (RRTMP-LFM)", D. Ruiz Coll, O. Patino, P. Andrivon, (Ofinno)

JVET-AD0214, "Non-EE2: On search region of intra template matching in ECM8.0", X. Xiu, N. Yan, C. Ma, H.-J. Jhu, C.-W. Kuo, W. Chen, X. Wang (Kwai)

JVET-AD0239, "Non-EE2: Fixes for IntraTMP template availability", G. Verba, Z. Zhang, V. Seregin, M. Karczewicz (Qualcomm)

JVET-AD0308, "Non-EE2: Extension of unified PDPC", Gagan Rath, Thierry Dumas, Fabrice Le Leannec, Kevin Reuze (InterDigital)

* 1. ***IntraBC (9)***

JVET-AD0127, "Non-EE2: Harmonization between IBC HMVP and IBC-LIC", N. Zhang, K. Zhang, L. Zhang (Bytedance)

JVET-AD0134, "Non-EE2: Bi-predictive IBC for natural and screen content", Y. Kidani, H. Kato, K. Kawamura (KDDI)

JVET-AD0083, "Non-EE2: Improvement over IBC-LIC", Z. Xie, Y. Yu, H. Yu, D. Wang (OPPO)

JVET-AD0215, "Non-EE2: Extension of IBC-GPM", C. Ma, X. Xiu, W. Chen, H.-J. Jhu, C.-W. Kuo, N. Yan, X. Wang (Kwai)

JVET-AD0216, "Non-EE2: IBC with non-adjacent spatial candidates", C. Ma, X. Xiu, W. Chen, H.-J. Jhu, C.-W. Kuo, N. Yan, X. Wang (Kwai)

JVET-AD0217, "Non-EE2: Filtered Intra Block Copy (FIBC)", H.-J. Jhu, X. Xiu, C.-W. Kuo, W. Chen, N. Yan, C. Ma, X. Wang (Kwai)

JVET-AD0223, "Non-EE2: Filtering for IBC predicted block", B. Ray, M. Coban, V. Seregin, M. Karczewicz (Qualcomm)

JVET-AD0224, "AHG12: IBC Merge list construction modification based on the candidates' Reconstruction-Reordered type", D. Ruiz Coll, O. Patino, (Ofinno)

JVET-AD0231, "Non-EE2: Non-adjacent spatial candidates for IBC", Y. Wang, K. Zhang, L. Zhang (Bytedance)

* 1. ***CCCM (4)***

JVET-AD0048, "EE2-related: Cross-component merge mode with temporal candidates", H.-Y. Tseng, C.-M. Tsai, C.-Y. Chuang, C.-W. Hsu, C.-Y. Chen, T.-D. Chuang, O. Chubach, Y.-W. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)

JVET-AD0080, "Non-EE2: Chroma-to-chroma convolutional cross-component model (C2C-CCCM) for intra prediction", Y. Huo, Y. Liu (Transsion)

JVET-AD0100, "AHG12: Block vector guided CCCM", R. G. Youvalari, D. Bugdayci Sansli, P. Astola, J. Lainema (Nokia)

JVET-AD0108, "AHG12: Cross-component residual model (CCRM) for inter prediction”, P. Astola, J. Lainema (Nokia)

* 1. ***Inter (8)***

JVET-AD0064, "AHG12: Enhanced geometrical prediction mode", R. Yu, P. Wennersten, J. Enhorn, K. Andersson (Ericsson)

JVET-AD0114, "Non-EE2: Modification of MV redundancy/similarity check considering LIC during merge candidate list construction", K. Kim, D. Kim, J.-H. Son, J.-S. Kwak (WILUS)

JVET-AD0174, "Non-EE2: CIIP with more combination candidates", C. Zhou, Z. Lv, J. Zhang (vivo)

JVET-AD0176, "Non-EE2: Improvements on multi-pass DMVR", J. Chen, R.-L. Liao, X. Li, Y. Ye (Alibaba)

JVET-AD0180, "Non-EE2: Affine AMVP mode with one MVD", H. Huang, V. Seregin, Z. Zhang, M. Karczewicz (Qualcomm)

JVET-AD0183, "Non-EE2: SIF flag and BCW weight usage in OBMC", A. Robert, F. Galpin, T. Poirier, Y. Chen (InterDigital)

JVET-AD0196, "EE2-related: On Iterative BDOF and EE2-2.6 Improvement", M. Salehifar, Y. He, K. Zhang, H. Liu, L. Zhang (Bytedance)

JVET-AD0235, "Non-EE2: Enhanced subblock-based motion compensation", L. Zhao, K. Zhang, L. Zhang (Bytedance)

* 1. ***RPR (1)***

JVET-AD0169, "AHG12: RPR filters for scale factors below 1.5x", J. Samuelsson-Allendes, S. Deshpande (Sharp)

* 1. ***Partitioning (2)***

JVET-AD0130, "AhG12: On ECM partitioning prediction", G. Laroche, P. Onno (Canon)

JVET-AD0185, "Non-EE2: ISP Extension for Chroma", W. Jia, K. Zhang, Y. Wang, L. Zhang (Bytedance)

* 1. ***In Loop Filters (4)***

JVET-AD0218, "AHG12: CCSAO with extended edge classifiers and history offsets", C.-W. Kuo, X. Xiu, W. Chen, H.-J. Jhu, N. Yan, C. Ma, X. Wang (Kwai)

JVET-AD0220, "Non-EE2: Improved fixed filters for ALF", M. Karczewicz, N. Hu, V. Seregin (Qualcomm)

JVET-AD0234, "Non-EE2: Extensions of Residual-based Taps in ALF and CCALF", W. Yin, K. Zhang, L. Zhang (Bytedance)

JVET-AD0236, "Non-EE2: On Classification of In-Loop Filters", W. Yin, K. Zhang, L. Zhang (Bytedance)

* 1. ***Transform (3)***

JVET-AD0172, " AHG12: Adaptation of LFNST/NSPT for low-delay configuration", C. Bonnineau, F. Le Léannec, K. Naser, T. Poirier, S. Puri (InterDigital)

JVET-AD0187, " Non-EE2: On large NSPT", M. Koo, J. Zhao, J. Lim, S. Kim (LGE)

JVET-AD0200, " EE2-related: InterMTS for IBC and IntraTMP", P. Garus, M. Coban, B. Ray, V. Seregin, M. Karczewicz (Qualcomm)

* 1. ***Coefficients and Entropy Coding (3)***

JVET-AD0204, "AHG12: Context modeling for transform coefficients for LFNST/NSPT", P. Nikitin, M. Coban, B. Ray, V. Seregin, M. Karczewicz (Qualcomm)

JVET-AD0251, "AhG12: Shifting Quantizer Center", M. Balcilar, K. Naser, F. Galpin, F. Le Léannec (InterDigital)

JVET-AD0206, "AHG 12: CABAC Initialization for GDR Pictures", S. Hong, L. Wang, K. Panusopone (Nokia)

* 1. ***Other (5)***

JVET-AD0105, "Modifications of common test condition and ECM software", Y. Yasugi, T. Ikai (Sharp)

JVET-AD0128, "Ahg12: modified CTC proposal for low-delay configurations", F. Le Léannec, F. Galpin, K. Naser, T. Poirier, E. François (InterDigital)

JVET-AD0197, "EE2-related: Worst-Case Timing Reduction for ECM RA Simulations", M. Salehifar, Y. Wang, Y. He, K. Zhang, L. Zhang (Bytedance)

JVET-AD0229, "AHG4/AHG12/AHG7: Mixed-Content Sequences for ECM CTC or Tool Assessment", X. Li (Google), Z. Deng, K. Zhang, L. Zhang (Bytedance)

JVET-AD0242, "On Common Test Conditions document", R. Chernyak, L.-F. Chen, X. Xu, S. Liu (Tencent)

1. Recommendations

The AHG recommends to:

* To review all the related contributions.

[JVET-AD0013](https://jvet-experts.org/doc_end_user/current_document.php?id=12745) JVET AHG report: Film grain technologies (AHG13) [W. Husak, M. Radosavljević, W. Wan (co-chairs), D. Grois, Y. He, P. de Lagrange, A. Segall, A. Tourapis, W. Zhang (vice-chairs)]

1. **Discussion**

The group focused its efforts on preparing the technical report for the issuance of the CD ballot. The editors met on a biweekly cadence throughout the period. The editorial process consisted of resolving many editorial issues without any major changes in the structure of the document.

Additional discussions were related to development of multiple software packages for synthesis of film grain technologies by multiple sources. Informal subjective testing results were also discussed. Finally, content for film grain testing was discussed with efforts underway to select content and how to prepare content. Several companies have been approaching this topic.

1. **Related contributions**

Four contributions related to AHG13 were identified as of 04/21/2023. One additional document related to film grain testing was uploaded for AHG4.

* One was the AHG report:
  + JVET-AD0013 JVET AHG report: Film grain technologies (AHG13)
* Three were related to film grain testing and software development:
  + JVET-AD0238 On Film Grain Synthesis Subjective Evaluation and Further Work
  + JVET-AD0241 AHG13: On Film Grain Objective Metrics
  + JVET-AD0332 AHG13/AHG3: software development related to FGC SEI message
* One was related to AHG4 and explore film grain testing:
  + JVET-AD0276 AHG4: experiments in preparation of film grain visual tests

***Contributions***

**JVET-AD0238 On Film Grain Synthesis Subjective Evaluation and Further Work**

This contribution would like to encourage the group to prioritize the use case that tries to preserve the artistic intent, this is considered of great potential, and it is also a harder goal to achieve.

In JVET-AC0199 [3], it was claimed by some of the authors of this contribution that after subjective evaluation of the current shared tools that the current algorithm may not be optimized, which leads to significant artifacts. It was noted that the MCTF-based denoising may also not be optimum and an alternative filtering process could be developed. It was also mentioned that for heavy grain sequences, the synthesized grain is rather coarse, and there are obvious repetitive patterns. Parameters are recommended to control the granularity of synthesized film grain, and the frequency-based FGS method and auto-regressive (AR) based method shows different results under different circumstances. Better implementations of the denoiser and film grain modeling are recommended to show the effectiveness of the current FGS SEI message and film grain synthesis method.

This contribution would like to encourage the group to further develop and make available tools and methodologies that facilitate the usage of the FGS techniques under development in JVET.

**JVET-AD0241 AHG13: On Film Grain Objective Metrics**

The subjective evaluation of film grain synthesis is recommended in the last JVET meeting. However, there are no widely used metrics for the evaluation of film grain synthesis results, which highly limits the development of film grain related technologies. This document provides the evaluation of metrics, i.e., NSS (Natural Scene Statistics), for the film grain synthesis. The main observations and conclusions are as follows,

1. For images with relatively simple content, the NSS is highly correlated with the subjective perception of the human eye.

2. For images with complex content and film grain characteristics, the NSS has a poor relationship with subject results.

3. For videos, the NSS shows even worse results.

4. NSS is not suitable to be the film grain synthesis objective metric of videos. An improved NSS or other methods are recommended to be studied for the film grain evaluation.

**JVET-AD0332 AHG13/AHG3: software development related to FGC SEI message**

This contribution describes the contents of the newly created JVET gitlab group called “JVET AHG Film Grain Technologies”, its connections with reference software, and the plans for future developments.

**JVET-AD0276 AHG4: experiments in preparation of film grain visual tests**

This document reports about some experiments in preparation of visual tests planned in JVET-AC2022 for FGC SEI visual tests on top of VVC, more specifically the first category which goal is to assess the visual improvement brought by film grain synthesis over a wide range of coding quality. Internal testing in InterDigital labs were performed and indicate that the test planned can show a measurable impact of film grain synthesis on visual quality, which can be translated to bitrate savings.

It is further recommended to add tests at a higher quality range using a direct comparison method, since film grain synthesis at high quality is expected to have a much larger impact on bitrate than for the quality range commonly used for DCR tests.

This document will be reviewed by AHG4.

***Recommendations***

The AHG recommends:

* the related input contributions are reviewed;
* testing of FGC be discussed; and
* continue the study of film grain technologies in JVET.

[JVET-AD0014](https://jvet-experts.org/doc_end_user/current_document.php?id=12609) JVET AHG report: NNVC software development (AHG14) [S. Eadie, F. Galpin, Y. Li, L. Wang, Z. Xie (AHG chairs)]

1. **Software development**
   1. ***Location***

NNVC repository is located at <https://vcgit.hhi.fraunhofer.de/jvet-ahg-nnvc/VVCSoftware_VTM>

NNVC software is based on VTM-11.0 with enabled MCTF including the update from JVET-V0056, GOP32, and enabling deblocking in the RDO.

NNVC-4.0 anchor at <https://vcgit.hhi.fraunhofer.de/jvet-ahg-nnvc/VVCSoftware_VTM> is used for NNVC performance evaluation.

* 1. ***Software changes***

The following changes were integrated:

* Integration of JVET-AC0057 – SADL v4
* Integration of JVET-AC0089 – Combined intra/inter model filterset1
* Integration of JVET-AC0116 – Intra Prediction NN
* Integration of JVET-AC0177 – Flip input+Temporal filtering filterset1
* Integration of JVET-AC0194 – improve NN model/training filterset0
* Integration of JVET-AC0328 – AC0194+encoder optimization filterset0
* Integration of JVET-AC0055 – content adaptive NN post-filter
* Integration of JVET-AC0196 – GOP adaptive NN super-resolution

The following fixes:

* Fix aggressive global floating-point optimization leading to slight encoding differences on some compiler/platforms
* Correct issue with EncDbOpt from VTM
* Various fixes (20 issues resolved)

Other changes:

* The repository now uses git LFS to store the model to lower the burden on the server. In order to add/update models, git lfs should be installed locally.
* Improvement of the data loader for training
* Added configuration files to test intra/post-filters/super-resolution
  1. ***Software version***

NNVC-4.0 was tagged March 8th, 2023.

NNVC-3.0 (a.k.a VTM-11.0\_nnvc3.0) was tagged December 1st 2022.

NCS-1.0 (a.k.a NNVC-3.0wip2) was tagged September 4th 2022 (first release containing the FilterSets, using NNVC 2.0 as a base).

VTM-11.0\_nnvc-2.0 was tagged August 4th 2022 (add deblocking in RDO).

VTM-11.0\_nnvc-1.0 was tagged May 6th 2021 (VTM-11.0 base with MCTF enabled).

1. **CTC performance**

See configurations section for naming convention.

* 1. ***NNVC-3.0-EE1 vs NNVC-4.0-EE1***

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over nnvc3.0-allNnToolsOff** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 102% | 107% |
| Class A2 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 102% | 106% |
| Class B | 0.01% | 0.03% | 0.05% | 0.02% | 0.06% | 0.06% | 103% | 108% |
| Class C | 0.00% | 0.00% | -0.01% | 0.00% | 0.00% | 0.00% | 102% | 108% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | 0.00% | 0.01% | 0.01% | 0.01% | 0.02% | 0.02% | 102% | 107% |
| Class D | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 103% | 107% |
| Class F | 0.00% | 0.01% | 0.00% | 0.00% | 0.00% | 0.00% | 103% | 108% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B Main10** | | | | | | | |
|  | **BD-rate Over nnvc3.0-allNnToolsOff** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| Class A2 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| Class B | 0.00% | 0.05% | -0.03% | 0.01% | 0.03% | -0.01% | 102% | 107% |
| Class C | 0.03% | -0.03% | -0.01% | 0.01% | -0.04% | 0.00% | 101% | 104% |
| Class E | 0.00% | 0.00% | -0.03% | 0.00% | -0.01% | -0.02% | 103% | 108% |
| **Overall** | 0.01% | 0.01% | -0.02% | 0.01% | 0.00% | -0.01% | 102% | 106% |
| Class D | 0.00% | -0.06% | 0.00% | 0.00% | -0.03% | -0.03% | 101% | 105% |
| Class F | 0.02% | -0.18% | -0.08% | -0.04% | -0.27% | 0.07% | 102% | 109% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | |
|  | **BD-rate Over nnvc3.0-allNnToolsOff** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 106% | 106% |
| Class A2 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 106% | 106% |
| Class B | 0.00% | 0.01% | 0.02% | 0.00% | 0.01% | 0.02% | 106% | 108% |
| Class C | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% | 106% | 103% |
| Class E | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 105% | 102% |
| **Overall** | 0.00% | 0.01% | 0.01% | 0.00% | 0.00% | 0.01% | 106% | 105% |
| Class D | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 106% | 105% |
| Class F | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 103% | 109% |

* 1. ***NNVC-4.0-EE1 vs set0***

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -9.99% | -16.19% | -20.23% | -11.08% | -19.20% | -21.59% | 160% | 51849% |
| Class A2 | -10.19% | -19.85% | -15.94% | -9.89% | -19.43% | -13.27% | 151% | 49894% |
| Class B | -9.20% | -22.08% | -21.09% | -8.70% | -22.06% | -20.31% | 153% | 51772% |
| Class C | -9.92% | -24.44% | -23.53% | -9.60% | -21.79% | -20.97% | 132% | 42818% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -9.75% | -21.09% | -20.54% | -9.65% | -20.89% | -19.34% | 148% | 48868% |
| Class D | -10.97% | -23.77% | -23.47% | -8.43% | -21.17% | -19.82% | 131% | 37770% |
| Class F | -4.62% | -14.46% | -12.77% | -4.91% | -14.84% | -13.81% | 183% | 21741% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #DIV/0! | #DIV/0! |
| Class A2 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #DIV/0! | #DIV/0! |
| Class B | -8.40% | -17.94% | -19.07% | -8.04% | -18.48% | -21.04% | 148% | 49113% |
| Class C | -9.55% | -19.05% | -20.70% | -9.50% | -14.07% | -17.16% | 131% | 41520% |
| Class E | -9.01% | -15.76% | -17.24% | -8.12% | -16.36% | -17.92% | 220% | 42542% |
| **Overall** | -8.93% | -17.76% | -19.16% | -8.55% | -16.48% | -18.97% | 157% | 44801% |
| Class D | -10.96% | -20.88% | -20.72% | -9.17% | -16.74% | -18.41% | 128% | 37255% |
| Class F | -5.13% | -12.70% | -10.43% | -6.03% | -12.04% | -14.06% | 184% | 21762% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -6.99% | -15.27% | -17.94% | -8.51% | -17.44% | -18.76% | 189% | 36450% |
| Class A2 | -6.52% | -16.95% | -14.22% | -7.30% | -16.95% | -12.21% | 146% | 29599% |
| Class B | -6.67% | -16.85% | -17.02% | -6.62% | -18.35% | -18.66% | 137% | 27698% |
| Class C | -7.77% | -17.63% | -19.66% | -7.36% | -19.35% | -20.52% | 119% | 18695% |
| Class E | -10.11% | -17.09% | -17.84% | -10.31% | -16.57% | -18.87% | 144% | 31435% |
| **Overall** | -7.52% | -16.82% | -17.43% | -7.83% | -17.89% | -18.05% | 143% | 27438% |
| Class D | -7.69% | -16.96% | -19.44% | -6.80% | -18.98% | -19.87% | 114% | 17342% |
| Class F | -4.71% | -13.65% | -12.65% | -4.42% | -15.60% | -14.52% | 117% | 23319% |

* 1. ***NNVC-4.0-EE1 vs set1***

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -8.73% | -16.46% | -20.68% | -9.13% | -20.29% | -23.16% | 183% | 34448% |
| Class A2 | -9.89% | -20.16% | -16.07% | -9.78% | -20.93% | -14.94% | 176% | 32708% |
| Class B | -9.10% | -22.24% | -22.94% | -8.61% | -23.41% | -24.26% | 178% | 33397% |
| Class C | -10.66% | -23.19% | -24.34% | -9.58% | -21.46% | -22.22% | 154% | 29864% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -9.60% | -20.92% | -21.49% | -9.21% | -21.77% | -21.63% | 172% | 32482% |
| Class D | -12.75% | -24.00% | -27.26% | -9.05% | -23.07% | -23.30% | 147% | 26666% |
| Class F | -5.49% | -14.31% | -12.50% | -6.15% | -16.03% | -12.72% | 229% | 14355% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #DIV/0! | #DIV/0! |
| Class A2 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #DIV/0! | #DIV/0! |
| Class B | -7.37% | -19.78% | -20.34% | -7.06% | -22.14% | -25.79% | 173% | 31774% |
| Class C | -9.22% | -21.73% | -21.89% | -8.66% | -19.88% | -18.88% | 153% | 29343% |
| Class E | -8.59% | -17.09% | -19.69% | -8.85% | -20.21% | -23.23% | 286% | 23513% |
| **Overall** | -8.29% | -19.76% | -20.69% | -8.04% | -20.90% | -22.85% | 188% | 28698% |
| Class D | -10.98% | -24.75% | -27.81% | -8.61% | -23.31% | -25.79% | 147% | 25684% |
| Class F | -5.36% | -14.16% | -10.75% | -6.21% | -17.49% | -11.46% | 231% | 15907% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -6.55% | -16.45% | -18.07% | -6.39% | -18.98% | -21.02% | 174% | 24110% |
| Class A2 | -6.70% | -19.07% | -14.98% | -7.13% | -20.20% | -14.41% | 146% | 19376% |
| Class B | -6.69% | -17.69% | -21.26% | -6.67% | -20.76% | -23.39% | 140% | 18375% |
| Class C | -7.43% | -18.91% | -21.75% | -7.41% | -21.28% | -23.44% | 127% | 12432% |
| Class E | -10.01% | -19.82% | -22.18% | -10.43% | -20.16% | -24.60% | 143% | 20712% |
| **Overall** | -7.39% | -18.34% | -19.94% | -7.49% | -20.39% | -21.71% | 143% | 18142% |
| Class D | -7.30% | -18.83% | -22.69% | -6.54% | -22.66% | -23.70% | 123% | 11234% |
| Class F | -5.17% | -15.17% | -13.89% | -5.28% | -17.91% | -16.35% | 120% | 15540% |

* 1. ***NNVC-4.0-EE1 vs intra***

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -2.32% | -0.70% | -1.55% | -2.23% | -0.29% | -1.23% | 114% | 178% |
| Class A2 | -1.45% | -0.03% | -0.76% | -1.36% | 0.35% | 0.01% | 113% | 157% |
| Class B | -1.82% | -0.23% | -0.52% | -1.75% | 0.14% | 0.47% | 115% | 178% |
| Class C | -1.69% | -0.99% | -0.98% | -1.63% | -0.04% | 0.11% | 117% | 210% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -1.81% | -0.49% | -0.90% | -1.74% | 0.05% | -0.06% | 115% | 181% |
| Class D | -1.42% | -0.92% | -1.13% | -1.50% | -0.47% | -0.18% | 115% | 216% |
| Class F | -1.11% | -0.66% | -0.59% | -1.13% | -0.01% | 0.34% | 116% | 151% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #DIV/0! | #DIV/0! |
| Class A2 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #DIV/0! | #DIV/0! |
| Class B | -0.46% | 0.29% | -0.43% | -0.37% | 0.62% | -0.41% | 107% | 134% |
| Class C | -0.33% | -0.64% | -0.25% | -0.34% | -0.70% | 0.91% | 106% | 144% |
| Class E | -0.37% | 0.22% | 0.33% | -0.49% | 0.76% | 0.49% | 102% | 105% |
| **Overall** | -0.39% | -0.04% | -0.18% | -0.39% | 0.21% | 0.25% | 106% | 129% |
| Class D | -0.15% | -0.74% | -0.67% | -0.12% | -0.14% | -1.52% | 106% | 138% |
| Class F | -0.27% | 0.06% | -0.19% | -0.06% | 0.25% | -0.25% | 106% | 123% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -4.31% | -3.67% | -4.03% | -4.55% | -3.57% | -3.88% | 172% | 547% |
| Class A2 | -2.82% | -2.35% | -2.77% | -2.85% | -1.95% | -2.30% | 179% | 664% |
| Class B | -3.24% | -2.79% | -3.00% | -3.09% | -2.47% | -2.37% | 179% | 712% |
| Class C | -3.20% | -2.78% | -3.01% | -3.22% | -2.26% | -2.13% | 171% | 765% |
| Class E | -4.89% | -4.58% | -3.82% | -4.94% | -4.32% | -2.39% | 175% | 740% |
| **Overall** | -3.61% | -3.16% | -3.27% | -3.63% | -2.83% | -2.56% | 175% | 689% |
| Class D | -3.00% | -2.68% | -2.88% | -2.94% | -2.07% | -2.22% | 164% | 844% |
| Class F | -2.21% | -1.77% | -1.88% | -2.11% | -1.47% | -1.57% | 141% | 443% |

* 1. ***NNVC-4.0-EE1 vs sr***

Note: Tool is activated only for A1/A2 classes. Overall shows results on classes A1/A2 only.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -7.45% | -8.36% | -8.06% | -42.44% | -29.45% | -28.71% | 121% | 11654% |
| Class A2 | -3.22% | 3.20% | 3.71% | -41.43% | -24.09% | #VALUE! | 117% | 1748% |
| **Overall** | -5.34% | -2.58% | -2.17% | -41.94% | -26.77% | #VALUE! | 119% | 4513% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -5.54% | -7.19% | -7.10% | -41.44% | -21.28% | -20.83% | 174% | 5620% |
| Class A2 | -1.26% | -9.31% | -3.10% | -65.10% | -56.66% | -51.26% | 126% | 11038% |
| **Overall** | -3.40% | -8.25% | -5.10% | -53.27% | -38.97% | -36.05% | 148% | 7876% |

* 1. ***NNVC-4.0-EE1 vs pf***

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -6.40% | -13.70% | -20.30% | -8.34% | -16.26% | -21.23% | 115% | 9400% |
| Class A2 | -4.22% | -18.38% | -13.60% | -3.41% | -18.19% | -12.22% | 110% | 8846% |
| Class B | -5.13% | -20.59% | -16.95% | -3.22% | -20.82% | -16.41% | 131% | 11294% |
| Class C | -3.59% | -18.92% | -15.99% | -2.38% | -17.57% | -15.72% | 121% | 9864% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -4.79% | -18.32% | -16.69% | -4.06% | -18.52% | -16.35% | 121% | 10000% |
| Class D | -3.60% | -18.30% | -17.35% | 0.24% | -16.72% | -15.51% | 122% | 10503% |
| Class F | -1.42% | -13.15% | -10.64% | -1.09% | -14.48% | -12.55% | 146% | 6831% |

* 1. ***NNVC-4.0-EE1 vs set0+intra***

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -11.84% | -17.13% | -21.39% | -12.77% | -20.16% | -22.57% | 174% | 51790% |
| Class A2 | -11.35% | -20.38% | -16.60% | -11.08% | -19.78% | -13.84% | 163% | 49848% |
| Class B | -10.65% | -22.70% | -21.81% | -10.11% | -22.66% | -20.84% | 168% | 51875% |
| Class C | -11.25% | -25.45% | -24.54% | -10.80% | -22.37% | -21.24% | 149% | 42909% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -11.19% | -21.86% | -21.41% | -11.02% | -21.51% | -19.90% | 163% | 48908% |
| Class D | -12.12% | -24.67% | -24.43% | -9.78% | -21.62% | -20.35% | 146% | 37837% |
| Class F | -5.53% | -15.02% | -13.11% | -5.87% | -15.49% | -14.04% | 198% | 21659% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #DIV/0! | #DIV/0! |
| Class A2 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #DIV/0! | #DIV/0! |
| Class B | -8.75% | -18.13% | -19.25% | -8.41% | -18.33% | -20.99% | 155% | 49074% |
| Class C | -9.80% | -19.62% | -20.38% | -9.61% | -14.37% | -16.18% | 136% | 41467% |
| Class E | -9.11% | -15.60% | -17.14% | -8.15% | -16.35% | -17.85% | 222% | 42892% |
| **Overall** | -9.19% | -17.99% | -19.10% | -8.74% | -16.51% | -18.60% | 162% | 44859% |
| Class D | -11.10% | -21.47% | -20.33% | -9.42% | -17.87% | -17.62% | 134% | 37315% |
| Class F | -5.34% | -12.58% | -10.62% | -5.85% | -10.90% | -15.06% | 189% | 21713% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -10.69% | -18.44% | -21.28% | -12.47% | -21.03% | -21.84% | 269% | 37178% |
| Class A2 | -9.02% | -19.19% | -16.09% | -9.94% | -18.93% | -13.98% | 226% | 30198% |
| Class B | -9.46% | -19.53% | -19.85% | -9.38% | -20.70% | -20.98% | 217% | 28415% |
| Class C | -10.44% | -20.77% | -22.48% | -10.17% | -21.93% | -22.83% | 190% | 19401% |
| Class E | -14.08% | -21.34% | -21.59% | -14.25% | -20.64% | -22.12% | 219% | 31993% |
| **Overall** | -10.58% | -19.87% | -20.34% | -10.97% | -20.72% | -20.55% | 220% | 28130% |
| Class D | -10.16% | -19.66% | -22.09% | -9.36% | -21.15% | -22.07% | 178% | 18126% |
| Class F | -6.65% | -15.30% | -14.32% | -6.39% | -16.84% | -16.28% | 159% | 23705% |

* 1. ***NNVC-4.0-EE1 vs set1+intra***

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -10.53% | -17.71% | -22.20% | -10.80% | -21.37% | -24.58% | 199% | 34485% |
| Class A2 | -11.01% | -20.76% | -16.93% | -10.76% | -21.58% | -15.62% | 189% | 32691% |
| Class B | -10.54% | -23.00% | -23.69% | -9.97% | -24.04% | -24.87% | 194% | 33462% |
| Class C | -11.98% | -24.24% | -25.39% | -10.82% | -22.34% | -22.75% | 171% | 30036% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -11.02% | -21.82% | -22.49% | -10.52% | -22.56% | -22.40% | 187% | 32556% |
| Class D | -13.89% | -25.07% | -28.38% | -10.22% | -23.83% | -24.33% | 162% | 26827% |
| Class F | -6.41% | -15.05% | -13.28% | -6.98% | -16.66% | -12.63% | 245% | 14516% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #DIV/0! | #DIV/0! |
| Class A2 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #DIV/0! | #DIV/0! |
| Class B | -7.81% | -20.15% | -21.10% | -7.52% | -22.54% | -26.45% | 180% | 31857% |
| Class C | -9.52% | -22.02% | -22.29% | -8.83% | -20.25% | -19.26% | 158% | 29405% |
| Class E | -8.68% | -17.61% | -19.52% | -9.05% | -19.64% | -23.52% | 289% | 23176% |
| **Overall** | -8.60% | -20.14% | -21.10% | -8.34% | -21.05% | -23.32% | 194% | 28646% |
| Class D | -11.15% | -24.97% | -27.84% | -8.85% | -23.18% | -26.47% | 153% | 25745% |
| Class F | -5.58% | -14.05% | -11.31% | -6.58% | -17.56% | -11.84% | 236% | 15845% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -10.19% | -19.78% | -21.27% | -10.20% | -22.30% | -23.92% | 253% | 24688% |
| Class A2 | -9.17% | -21.15% | -17.07% | -9.65% | -22.09% | -16.24% | 228% | 20053% |
| Class B | -9.40% | -21.05% | -23.91% | -9.31% | -23.57% | -25.56% | 223% | 19164% |
| Class C | -10.10% | -21.71% | -24.47% | -10.15% | -23.89% | -25.90% | 200% | 13194% |
| Class E | -13.88% | -23.81% | -25.97% | -14.29% | -23.68% | -28.09% | 220% | 21282% |
| **Overall** | -10.40% | -21.46% | -22.80% | -10.53% | -23.20% | -24.23% | 223% | 18866% |
| Class D | -9.81% | -21.40% | -25.43% | -9.03% | -24.89% | -26.43% | 188% | 12048% |
| Class F | -7.14% | -16.85% | -15.75% | -7.17% | -19.19% | -17.86% | 162% | 15994% |

* 1. ***NNVC-4.0-EE1 vs set0+ rdo+intra***

Note: additional test with RDO on (default setting is RDO off when using filterset0)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -11.90% | -17.13% | -21.45% | -12.87% | -20.35% | -22.72% | 180% | 51946% |
| Class A2 | -11.61% | -20.41% | -16.79% | -11.26% | -19.72% | -13.89% | 173% | 49928% |
| Class B | -10.86% | -22.79% | -21.94% | -10.22% | -22.56% | -20.87% | 177% | 51878% |
| Class C | -11.57% | -25.21% | -24.46% | -11.13% | -22.01% | -21.35% | 158% | 42997% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -11.41% | -21.83% | -21.48% | -11.20% | -21.40% | -19.97% | 172% | 48981% |
| Class D | -12.50% | -24.63% | -24.11% | -10.14% | -21.99% | -19.58% | 156% | 37876% |
| Class F | -5.77% | -15.20% | -13.30% | -6.16% | -16.03% | -14.11% | 206% | 21764% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #DIV/0! | #DIV/0! |
| Class A2 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #DIV/0! | #DIV/0! |
| Class B | -8.91% | -17.75% | -19.05% | -8.56% | -17.95% | -20.59% | 166% | 49224% |
| Class C | -9.92% | -19.57% | -20.67% | -9.45% | -14.59% | -16.75% | 147% | 41492% |
| Class E | -9.26% | -15.83% | -17.16% | -8.67% | -16.16% | -17.85% | 235% | 42613% |
| **Overall** | -9.33% | -17.88% | -19.12% | -8.89% | -16.38% | -18.62% | 173% | 44852% |
| Class D | -11.21% | -20.83% | -21.08% | -9.34% | -16.88% | -18.38% | 145% | 37402% |
| Class F | -5.45% | -12.29% | -11.01% | -6.25% | -11.53% | -14.86% | 196% | 21714% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -11.00% | -18.60% | -21.31% | -12.77% | -21.00% | -21.63% | 295% | 37356% |
| Class A2 | -9.45% | -19.27% | -16.44% | -10.26% | -18.82% | -14.22% | 252% | 30208% |
| Class B | -9.87% | -19.48% | -19.86% | -9.85% | -20.56% | -20.88% | 243% | 28413% |
| Class C | -10.88% | -20.26% | -22.32% | -10.62% | -21.86% | -22.82% | 214% | 19486% |
| Class E | -14.53% | -21.44% | -21.72% | -14.71% | -20.43% | -22.08% | 243% | 32181% |
| **Overall** | -10.99% | -19.80% | -20.39% | -11.39% | -20.61% | -20.53% | 246% | 28208% |
| Class D | -10.61% | -19.09% | -21.63% | -9.79% | -20.99% | -21.63% | 201% | 18100% |
| Class F | -6.97% | -15.34% | -14.38% | -6.90% | -17.17% | -16.31% | 168% | 23743% |

* 1. ***NNVC-4.0-EE1 vs set1+rdo+intra+temporal filter***

Note: additional test with temporal filter and RDO on (default setting is RDO and temporal filter off when using filterset1)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -11.31% | -17.65% | -22.12% | -11.46% | -21.38% | -24.28% | 208% | 33077% |
| Class A2 | -12.13% | -20.90% | -16.85% | -11.64% | -21.47% | -15.44% | 204% | 31897% |
| Class B | -11.46% | -23.03% | -23.91% | -10.84% | -23.98% | -24.96% | 209% | 32792% |
| Class C | -12.87% | -24.28% | -25.62% | -11.92% | -22.28% | -23.00% | 186% | 29441% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -11.94% | -21.86% | -22.59% | -11.41% | -22.50% | -22.40% | 201% | 31742% |
| Class D | -14.76% | -25.00% | -28.30% | -11.35% | -23.91% | -24.30% | 179% | 26312% |
| Class F | -6.83% | -14.99% | -13.38% | -7.47% | -16.46% | -13.30% | 256% | 13084% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #DIV/0! | #DIV/0! |
| Class A2 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #DIV/0! | #DIV/0! |
| Class B | -8.24% | -19.74% | -20.64% | -7.85% | -22.00% | -25.57% | 200% | 31615% |
| Class C | -10.11% | -21.74% | -21.71% | -9.29% | -19.61% | -17.74% | 177% | 29301% |
| Class E | -9.49% | -17.15% | -20.33% | -9.34% | -19.38% | -23.08% | 312% | 23441% |
| **Overall** | -9.18% | -19.76% | -20.92% | -8.70% | -20.55% | -22.34% | 215% | 28603% |
| Class D | -11.71% | -25.05% | -27.55% | -9.38% | -23.31% | -26.25% | 172% | 25714% |
| Class F | -6.12% | -14.10% | -10.81% | -6.93% | -16.98% | -11.77% | 249% | 15810% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -10.31% | -19.86% | -21.35% | -10.40% | -22.21% | -23.81% | 300% | 24684% |
| Class A2 | -9.42% | -21.31% | -17.38% | -9.91% | -22.25% | -16.55% | 275% | 19996% |
| Class B | -9.62% | -21.13% | -24.24% | -9.59% | -23.64% | -25.70% | 272% | 19089% |
| Class C | -10.39% | -21.75% | -24.68% | -10.34% | -23.89% | -26.04% | 246% | 13173% |
| Class E | -14.14% | -23.95% | -26.05% | -14.50% | -24.03% | -27.80% | 265% | 21236% |
| **Overall** | -10.63% | -21.56% | -23.02% | -10.76% | -23.29% | -24.28% | 270% | 18822% |
| Class D | -10.10% | -21.46% | -25.39% | -9.25% | -24.99% | -26.26% | 232% | 11997% |
| Class F | -7.31% | -17.10% | -15.94% | -7.55% | -19.70% | -17.83% | 180% | 15986% |

* 1. ***NNVC-4.0-EE1 vs sr+intra***

Note: Tool is activated only for A1/A2 classes. Overall shows results on classes A1/A2 only.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -9.34% | -9.50% | -9.44% | -43.57% | -29.57% | -29.09% | 267% | 123% |
| Class A2 | -4.69% | 2.81% | 2.71% | -42.38% | -23.78% | -33.28% | 189% | 144% |
| **Overall** | -7.01% | -3.34% | -3.36% | -42.97% | -26.68% | -31.19% | #NUM! | #NUM! |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **BD-rate Over NNVC-4.0 AI** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -9.09% | -10.92% | -10.51% | -43.69% | -24.44% | -23.28% | 480% | 665% |
| Class A2 | -3.93% | -12.03% | -5.96% | -65.93% | -57.39% | -52.44% | 356% | 723% |
| **Overall** | -6.51% | -11.47% | -8.23% | -54.81% | -40.92% | -37.86% | #NUM! | #NUM! |

* 1. ***NNVC-4.0-EE1 vs intra+pf***

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -8.46% | -14.47% | -21.66% | -10.21% | -17.01% | -22.43% | 144% | 9988% |
| Class A2 | -5.55% | -18.71% | -14.37% | -4.75% | -18.09% | -12.29% | 140% | 9438% |
| Class B | -6.79% | -21.05% | -17.39% | -4.84% | -20.98% | -16.58% | 143% | 10573% |
| Class C | -5.15% | -19.98% | -16.90% | -3.92% | -18.24% | -16.05% | 139% | 9719% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -6.44% | -18.98% | -17.51% | -5.65% | -18.88% | -16.75% | 142% | 9992% |
| Class D | -4.90% | -19.33% | -18.31% | -1.15% | -17.62% | -15.98% | 140% | 10854% |
| Class F | -2.45% | -13.84% | -11.19% | -2.46% | -14.48% | -12.44% | 163% | 6819% |

* 1. ***Overview***

The table below shows the sum-up results for RA configuration, PSNR BD-rates.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | + intra |  |  | +intra+rdo(+filter only for set1) | |  |
|  | Y | U | V | Y | U | V | Y | U | V |
| set0 | -9.75% | -21.09% | -20.54% | -11.19% | -21.86% | -21.41% | -11.41% | -21.83% | -21.48% |
| set1 | -9.60% | -20.92% | -21.49% | -11.02% | -21.82% | -22.49% | -11.94% | -21.86% | -22.59% |
| intra | -1.81% | -0.49% | -0.90% |  |  |  |  |  |  |
| sr (A1/A2) | -5.34% | -2.58% | -2.17% | -7.01% | -3.34% | -3.36% |  |  |  |
| pf | -4.79% | -18.32% | -16.69% | -6.44% | -18.98% | -17.51% |  |  |  |

The table below shows the sum-up results for RA configuration, Ms-SSIM BD-rates.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | + intra |  |  | +intra+rdo(+filter only for set1) | |  |
|  | Y | U | V | Y | U | V | Y | U | V |
| set0 | -9.65% | -20.89% | -19.34% | -11.02% | -21.51% | -19.90% | -11.20% | -21.40% | -19.97% |
| set1 | -9.21% | -21.77% | -21.63% | -10.52% | -22.56% | -22.40% | -11.41% | -22.50% | -22.40% |
| intra | -1.74% | 0.05% | -0.06% |  |  |  |  |  |  |
| sr (A1/A2) | -5.34% | -2.58% | -2.17% | -42.97% | -26.68% | -31.19% |  |  |  |
| pf | -4.79% | -18.32% | -16.69% | -5.65% | -18.88% | -16.75% |  |  |  |

1. **Discussions**
   1. ***Previous discussions***

The following points were pending at last meeting:

* SOLVED using git lfs: The setting of a better solution for models’ storage in order to avoid repository excess size.
* SOLVED: manual update when needed. Upgrade the VTM version to benefit from bug corrections from AhG3.
* PARTIALLY ENFORCED: To enforce adopted contributions to merge into existing code, including for the training scripts if they exist (see issue with [MR 21/23]).
* SOLVED: Issue raised on the encoder invariance: likely due to an aggressive optimization compilation option affecting all float operations in the encoder.
  1. ***New discussions***

The following points were discussed or are still discussed in the group:

* Official configuration files for NNVC software and official configuration files for EE1 anchors:
  + Current EE1 anchors files are based on all tools off, i.e. anchor is essentially VTM-11.0
  + One official set of configuration files cannot be decided because some tools are mutually exclusive.
  + It raised some issues:
    - Progress of NNVC can be difficult to demonstrate without any official configuration.
    - With all tools off, new integrated tools do not take into account existing integrated tools and conflict might appear.
    - Synergy of tools are not easily shown when adopting a new tool.
    - It increases a lot the number of combinations to generate.
* To enforce adopted contributions to provide training scripts to train a model from scratch (issue with AC0055). It raised the following issues:
  + Fine-tuned models are not modifiable by other proponents (architecture, training policy etc.)
  + Training is not officially cross-check.
* A MR (MR68) was submitting after the software release deadline, modifying the results. The MR consists in one line change and improve the results, but the changes were not in the cross-checked software. No consensus has been reached to integrate the modification in the next software version.

1. **Configurations**

The following configurations is used to generate the different NNVC results.

The column “tested” is read as follow:

* Y: the configuration has been tested using the new NNVC-4.0 software
* P: the results are the ones from the previous NNVC-3.0 software basis
* N: not tested.

The column “xcheck” is read as follow:

* Y: the test has been cross-checked
* P: no cross-checked performed but results are consistent with previous version on NNVC-3.0
* N: no cross-check available

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Tools | Configuration | Tested | Xcheck |
| EE1 | All NN tools off | encoder\_xxx\_vtm.cfg | Y | Y |
| set0 | Loop filter set #0 | encoder\_xxx\_vtm.cfg + nn-based/NnlfOption\_1.cfg | Y | Y |
| set1 | Loop filter set #1 | encoder\_xxx\_vtm.cfg + nn-based/NnlfOption\_2.cfg | Y | Y |
| intra | Intra prediction | nn-based/encoder\_xxx\_nnvc.cfg | Y | Y |
| set0+intra | Loop filter set #0+ Intra prediction | nn-based/encoder\_xxx\_nnvc.cfg + nn-based/NnlfOption\_1.cfg | Y | Y |
| set1+intra | Loop filter set #1+ Intra prediction | nn-based/encoder\_xxx\_nnvc.cfg + nn-based/NnlfOption\_2.cfg | Y | Y |
| set0+rdo+intra | Loop filter set #0 + Rdo + Intra prediction | nn-based/encoder\_xxx\_nnvc.cfg + nn-based/NnlfOption\_1.cfg + --EncNnlfOpt=1 | Y | Y |
| set1+rdo+intra+temporal filter | Loop filter set #1 + Rdo + Intra prediction + Temporal filter | nn-based/encoder\_xxx\_nnvc.cfg + nn-based/NnlfOption\_2.cfg + --EncNnlfOpt=1 + --NnlfSet1Multiframe=1 | Y | Y |
| sr | Super-resolution | encoder\_xxx\_vtm.cfg + nn-based/nnsr.cfg + nn-based/nnsr\_classAx.cfg | Y | N |
| set0+sr | Loop filter set #0+Super-resolution | encoder\_xxx\_vtm.cfg + nn-based/NnlfOption\_1.cfg + nn-based/nnsr.cfg + nn-based/nnsr\_classAx.cfg | N | N |
| set1+sr | Loop filter set #1+Super-resolution | encoder\_xxx\_vtm.cfg + nn-based/NnlfOption\_2.cfg + nn-based/nnsr.cfg + nn-based/nnsr\_classAx.cfg | N | N |
| sr+intra | Super-resolution +Intra prediction | nn-based/encoder\_xxx\_nnvc.cfg + nn-based/nnsr.cfg + nn-based/nnsr\_classAx.cfg | Y | Y |
| set0+sr+intra | Loop filter set #0+Super-resolution+Intra prediction | nn-based/encoder\_xxx\_nnvc.cfg + nn-based/NnlfOption\_1.cfg + nn-based/nnsr.cfg + nn-based/nnsr\_classAx.cfg | N | N |
| set1+sr+intra | Loop filter set #01+Super-resolution+Intra prediction | nn-based/encoder\_xxx\_nnvc.cfg + nn-based/NnlfOption\_2.cfg + nn-based/nnsr.cfg + nn-based/nnsr\_classAx.cfg | N | N |
| pf | Adaptive post-filters | encoder\_xxx\_vtm.cfg + nn-based/nnpf\_int16.cfg | Y | P |
| Intra+pf | Intra prediction + adaptive post-filter | nn-based/encoder\_xxx\_nnvc.cfg + nn-based/nnpf\_int16.cfg | Y | N |

Combination of loop filtering (or post filtering) with super resolution was not tested. It is verbally reported that gains found were not additive, but would need more investigation what reasons are.

It is noted that training scripts allowing re-training from scratch are not available for one of the models, (from JVET-AC0055) as sequence-adaptive training is starting from an initial pre-trained model. It would be desirable to get that provided. Revisit.

1. **Recommendations**

The AHG recommends to:

* Continue to develop NNVC software.
* Improve the software documentation.
* Encourage people to report all (potential) bugs that they are finding using GitLab Issues functionality <https://vcgit.hhi.fraunhofer.de/jvet-ahg-nnvc/VVCSoftware_VTM/-/issues>
* Encourage people to submit merge requests fixing identified bugs.

# Project development (36)

## AHG1: Deployment and advertisement of standards (2)

Contributions in this area were discussed at 1120–1145 on Wednesday 26 April 2023 (chaired by JRO).

[JVET-AD0020](https://jvet-experts.org/doc_end_user/current_document.php?id=12629) Deployment status of the HEVC standard [G. J. Sullivan (SC 29 Chair & Q6/16 Rapporteur)]

This information contribution contains a survey of deployed products and services using the HEVC standard and the formal specifications in which it is supported, along with a brief introduction to the standard written for broad readership. Revision marking is included to show changes relative to JVET-AC0020-v1 of January 2023.

1. Starting in September 2022 with the release of HEVC decoding support in the Google Chrome browser, the availability of HEVC decoding support in web browsers rose substantially. The following statistics are reported by the “Can I use” website, which tracks feature support in web browsers:
   1. Up to May 2022, the percentage of browser support had been at or below 19% [35].
   2. As of December 2022, the reported support in browsers had risen to 84% [36].
   3. As of March 29, 2023, the reported support in browsers had further risen to 88% for “all users” (88% for “all tracked”, “82% for tracked desktop”, and 92% for “tracked mobile”) [37].
2. As of October–December 2022, ScientiaMobile reported statistics for video capabilities of mobile devices, based on a sampling of 1.6 billion device events, reporting that 87% of smartphone usage was from devices with hardware support for HEVC decoding, most typically supporting level 5 for 4096×2160 @ 30.0 fps [38][39][40].

[JVET-AD0021](https://jvet-experts.org/doc_end_user/current_document.php?id=12630) Deployment status of the VVC standard [G. J. Sullivan (SC 29 Chair & Q6/16 Rapporteur)]

This contribution contains a survey of deployed products and services, publicly available software source code, related tools, and formal specifications supporting the VVC standard (Rec. ITU-T H.266 | ISO/IEC 23090-3).

Revision marking is included to show changes relative to JVET-AC0021-v4 of January 2023.

1. Version 1.8.0 of VVenC was released in April 2023 and version 1.6.1 of VVdeC was released in January 2023 [35]. The main changes for VVenC v1.8.0 since version 1.7.0 included faster presets (~10% for “faster”, ~5% for “fast” and “slow” presets), improved coding efficiency for multi-threaded operation (using temporal ALF APS prediction), extended block importance mapping, and various bugfixes and cleanups [35].
2. **LG** included VVC capability in its **webOS TV 22** Developer Specifications for 8K Ultra HD (“7680x4320@60P Main/Main10@L6.1 Maximum 60Mbps”) as of January 2023 [63][65]. As of April 2023, the LG **QNED99** “Quantum Dot NanoCell” 75-inch and 86-inch 8K television models include VVC support in their listed specifications (“Up to 3840x2160 @120p / 7680x4320 @ 60p”) [66].
3. Updated information for the BVC encoder was provided in April 2023 [69]. The encoder had been further optimized for live streaming usage. Its capabilities included preprocessing (video type detection for camera versus screen content, adaptive GOP size determination, motion complexity analysis, scene cut detection, noise detection and noise reduction), rate control, SIMD optimization and multi-threading with several types of parallelism. The encoding speed of BVC for 720p and 1080p was reported to be 115 fps and 56 fps on average with 16 threads. Multiple coding and rate control modes, including Constant QP (CQP), Constant Rate Factor (CRF), CBR, ABR, and two predefined quality/speed presets were provided, with encoder usage support for both production users and experts. When compared to x265 (v3.4) and HM-17.0, the corresponding global BD-rate gain and speedup factors under the Random Access configuration were summarized as follows: 1) compared to x265 for HEVC encoding (16 threads): there was a 53% bit rate savings with 10% faster operation, and 2) compared to the HEVC HM reference software, there was a 4% bit rate savings and ~1000x speed improvement (for HD and UHD, there was a 6% bit rate savings and ~1100x speed improvement).
4. **MainConcept** (a subsidiary of Endeavor Streaming) announced a real-time VVC encoder and SDK with real-time 8K 10-bit capability for a public Beta release in August 2022 [86]. The official non-Beta release of the live encoder application and SDK were announced in April 2023 [87].
5. **DASH Industry Forum** approved inclusion of VVC in its *DASH-IF Interoperability Points; Part 7: Video* specification of May 2022 [91].
6. **CTA** included VVC in its ***CTA-5001-E*** *Web Application Video Ecosystem (WAVE) – Content Specification* of December 2022 [92].
7. **IETF** issued its **RFC 9328** *RTP Payload Format for Versatile Video Coding (VVC)* in December 2022 [93]. The specification includes the definition of a media type registration and session description protocol (SDP) parameters.
8. **ATSC** announced in December 2022 that VVC will be included in the **ATSC 3.0** suite of standards [94].
9. **SCTE** issued its specifications **SCTE 281-1** *VVC Video Constraints for Cable Television Part 1 – Coding* [95] and SCTE 281-2 *VVC Video Constraints for Cable Television Part 2 – Transport* [96] in March 2023. Formats up to 8K (7680×4320) 10 bit and frame rates up to 120 fps are specified, based on the Main 10 profile (Main tier up to level 6.2).
10. **Interra Systems** supports VVC in its **VEGA Media Analyzer** as of early 2023 [100][101].
11. **DVB** issued a set of VVC test bitstream content in February 2023 and DASH packages with VVC content in March 2023 [106].

## AHG2: Text development and errata reporting (1)

Contributions in this area were discussed at 1145–1205 on Wednesday 26 April 2023 (chaired by JRO).

[JVET-AD0077](https://jvet-experts.org/doc_end_user/current_document.php?id=12625) AHG2: On num\_l0\_weights and num\_l1\_weights for VVC specification [T. Aono, T. Chujoh, T. Ikai (Sharp)]

This contribution proposes an improvement for the new revision of VVC. The syntax elements, num\_l0\_weights and num\_l1\_weights, specify the number of weights signalled for entries in the reference picture lists on the weighted prediction syntax table. Those values are greater than or equal to 0. However, there is an implicit condition that num\_l0\_weights and num\_l1\_weights always can never be set to 0 because there is a condition that the number of reference pictures is greater than 0 in the P slice and B slice. Therefore, this contribution proposes that the syntax elements, num\_l0\_weights and num\_l1\_weights, explicitly should change the values greater than 0. These specifications should be included in the draft document for the new revision of VVC.

From the discussion, it is understood that due to restrictions in other places, sending a value of zero would be illegal. However, it is better understandable defining the legal value range of the syntax element directly with its semantics rather than later in the decoding process. Basically, this is an editorial change for better readability.

Decision(ed.): Adopt JVET-AD0077. To be integrated in the text of preliminary FDIS of VVC

## AHG3: Test conditions (0)

This section is kept as a template for future use.

## AHG3: Software development (1)

Contributions in this area were discussed at XXXX–XXXX on XXday 2X April 2023 (chaired by JRO).

[JVET-AD0332](https://jvet-experts.org/doc_end_user/current_document.php?id=12896) AHG13/AHG3: software development related to FGC SEI message [P. de Lagrange, F. Urban (InterDigital)] [late]

## AHG4: Subjective quality testing and verification testing (5)

Contributions in this area were discussed at 1620–1710 on Saturday 22 April 2023 (chaired by JRO).

[JVET-AD0062](https://jvet-experts.org/doc_end_user/current_document.php?id=12610) AHG4: Report on AHG meeting on subjective quality testing of FGC SEI message [M. Wien]

This document contains the report on the AhG meeting held on 2023-04-13 in preparation of subjective testing for film grain synthesis.

Summary of current status: Three candidate sequences are under consideration including rate points and film grain parameters. Internal testing was verbally reported by the proponent. It was suggested to conduct an expert viewing at the upcoming meeting may be possible. The conduction of such tests was assessed to be subject to the possibility to playout 10bit video at stable frame rate. Calling for more test content might be indicated.

First test (“goal 1”) comparing same encoded sequences (film grain sequences, input to encoder without removing film grain), once with and once without film grain synthesis.

Relevant message would be possibility for bit rate reduction. This could be achieved by (ideally) comparing the non-synthesized case at somewhat lower range of QPs vs. synthesized case at somewhat higher range of QPs.

Expert viewing planned for Sunday afternoon (16:00).

Later tests (“goal 2”) (including ground truth when available) could show other benefit, in particular how natural the synthetic film grain is perceived

[JVET-AD0063](https://jvet-experts.org/doc_end_user/current_document.php?id=12611) AHG4: Report on AHG meeting on verification testing for VVC multilayer coding [M. Wien]

This document contains the report on the AhG meeting held on 2023-04-13 in preparation of subjective testing for VVC multilayer coding.

AhG recommendations:

* To review JVET-AD0102 at the meeting
* To assess the provided bitstreams for the spatial scalability category by experts viewing at the meeting site.
* To study the design of quality ladders for streaming with VVC.
* To identify an extended set of test sequences and generate corresponding anchors for the quality ladder category.
* To further study possible configuration and anchors for the dual-view (stereo) category.

After availability of sequences, expert viewing should be done later in the week.

[JVET-AD0102](https://jvet-experts.org/doc_end_user/current_document.php?id=12653) Proposed verification test plan for content layering [S. Iwamura, S. Nemoto, A. Ichigaya (NHK)]

Was presented in joint meeting Wednesday 14:00

This contribution contains an update of a verification test plan of multilayer coding for a content layering use case.

A total of four categories of verification tests are considered for VVC multilayer coding: spatial scalability, quality ladder, content layering, and stereo coding. Content layering is the use case where the main content is encoded as base layer and additional content overlaid on top of the main content, which is called sub-content, is encoded as enhancement layer.

In 28th JVET meeting, it was suggested to conduct a functional test of content layering in the 31st JVET meeting planned in Geneva.

It was commented that this is not a traditional verification test, but rather demonstrating functionality. It was asked if it would be possible to provide a video demo on this functionality on a public site which would demonstrate the effect much more clearly than a paper document. This can be in a compressed format, or contain some copyright protection marks, such that the original content would not publicly provided. The session in Geneva, rather than being an expert viewing for quality, could be done to collect ideas what to demonstrate.

It was commented that much of the functionality shown here could also be done at the systems layer, and it also benefit of doing this in the video layer should be demonstrated or explained.

It was suggested that perhaps more focus should be put on specific functionality possible with video-layer approach.

[JVET-AD0276](https://jvet-experts.org/doc_end_user/current_document.php?id=12840) AHG4: experiments in preparation of film grain visual tests [P. de Lagrange, T. Filoche, F. Urban (InterDigital)] [late]

This document reports about some experiments in preparation of visual tests planned in JVET-AC2022 for FGC SEI visual tests on top of VVC, more specifically the first category which goal is to assess the visual improvement brought by film grain synthesis over a wide range of coding quality. Internal testing in InterDigital labs were performed and indicate that the test planned can show a measurable impact of film grain synthesis on visual quality, which can be translated to bitrate savings.

It is further recommended to add tests at a higher quality range using a direct comparison method, since film grain synthesis at high quality is expected to have a much larger impact on bitrate than for the quality range commonly used for DCR tests.

It is suggested in the contribution to perform two A/B comparison tests, one at transparent point of the coding without FGS, and one at slightly less quality. With regard to the expert viewing in JVET-AD0382, this would mean to identify a “without FGS” coding point which is slightly worse than original, similar to the FGS case.

[JVET-AD0382](https://jvet-experts.org/doc_end_user/current_document.php?id=12946) Results of expert viewing for testing of FGC SEI message [M. Wien]

This document reports the results of an on-site expert viewing performed at the 30th JVET meeting in Antalya. The evaluation targets at goal 1 of the test plan document JVET-AC2022, i.e., the assessment of subjective quality improvement with and without film grain synthesis. This assessment evaluates the benefits of film grain synthesis as a tool for improving the visual quality of a compressed video sequence. The results of two tests are reported: A DCR test of test points selected to cover the MOS range, and an A-B comparison in the high-quality range where the film grain is just preserved by coding or synthetically added.

The results of this assessment indicate a potentially significant visual benefit by applying film grain synthesis for improving the visual quality of a compressed video sequence. In the evaluated set of bitrates, gains are specifically observer for mid- to high-bitrate ranges. At low bitrates, the capability of masking compression artifacts by FGS is decreasing. In the DCR test, it is observed that the impact of FGS is strongly dependent on the test sequence. For CrowdRun (scanned from film), a tendency towards improvement is observed but the confidence intervals overlap for all rate points. OldTownCross shows early saturation when FGS is applied. The distance of the MOS curves indicates significant improvements for this sequence. The test sequence DinnerScene has be acquired by a digital camera. For this sequence, significant improvements are indicated with the confidence intervals between the two curves being just non-overlapping for the two middle rate points.

The A-B comparison of the uncompressed sequence against a low QP for each sequence indicates that the preservation of the original filmgrain has been achieved. For all three sequences, both were considered equal within the confidence interval by the viewers. The comparison of the selected rate points with FGS indicate a bitrate saving of more than 90% at a marginal subjective quality loss.

Was presented in joint meeting with AG 5 Tue 9:00.

The results of the test can be interpreted as a proof that the method of assessment intended for “goal 1” in principle works. It is however pointed out that the sequences used might not be optimum, and definitely more sequences are needed. In particular, “Old Town Cross” seems to have some artifacts due to non-perfect scanning.

## AHG4: Test material (4)

Contributions in this area were discussed at 1430–1515 on Wednesday 26 April 2023 (joint meeting chaired by JRO and MW).

[JVET-AD0044](https://jvet-experts.org/doc_end_user/current_document.php?id=12591) AHG4: Volumetric video-based coding (V3C) test content [S. Schwarz, M. M. Hannuksela (Nokia)]

This document introduces seven visual volumetric video-based coding (V3C) video test sequences. Four sequences for V3C V-PCC applications, and three sequences for V3C MIV applications. Together they covering various V3C use cases and content scenarios. It is asserted that these test sequences allow for easy development and verification of video coding tools targeted at volumetric video applications. Therefore, it is proposed to include these sequences as optional test content.

*V3C content coding performance overview ECM8.0 over VTM19.0*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Random Access Main10** | **BD-Rate [%]** | | |  |  |
| **Y** | **U** | **V** | **EncT** | **DecT** |
| **V-PCC texture** | -14.68% | -28.00% | -27.53% |  |  |
| **V-PCC geometry** | -13.78% |  |  |  |  |
| **MIV texture** | -14.43% | -28.87% | -25.80% |  |  |
| **MIV geometry** | -9.31% |  |  |  |  |
| **Average** | -12.81% | -27.33% | -25.34% | 677.63% | 493.67% |
|  |  |  |  |  |  |
| **All Intra**  **Main10** | **BD-Rate [%]** | | |  |  |
| **Y** | **U** | **V** | **EncT** | **DecT** |
| **V-PCC texture** | -5.60% | -24.88% | -23.73% |  |  |
| **V-PCC geometry** | -4.98% |  |  |  |  |
| **MIV texture** | -9.71% | -27.51% | -23.82% |  |  |
| **MIV geometry** | -10.43% |  |  |  |  |
| **Average** | -8.16% | -24.71% | -22.20% | 778.92% | 378.58% |

Gain of ECM compared to VTM is lower for these types of content, compared to the gain in conventional video (except for MIV in AI). It was commented that this may be due to the fact that motion compensation is less regular, and intra structures might have less regularity. Likewise, the gain of VVC over HEVC is lower for this type of content.

Though the CTC of ECM should not be overloaded (also not in “optional”), contributions about performance with other types of content are always welcome.

The proposal is to provide preprocessed versions of these types of content, which appear just as a video, such that anybody not knowledgeable with this type of content may readily use it without knowing dedicated processing tools.

It was asked if the PSNR-based bit rates (based on encoder input compared to decoder output) tell a lot about the actual quality, which should better be measured end-to-end.

It was also asked if it might be better to measure PSNR only over occupancy map. The proponents report that at least in case of point clouds, the correlation of measuring only in occupancy map is relatively high with that of measuring end-to-end.

At this point, this does not have any priority for JVET. At least, it would also require some coordination at level of parent bodies if it is desirable to extend the ECM exploration for other types of content.

Any experts interested in that type of content can of course get it from the contributors of JVET-AD0044.

[JVET-AD0201](https://jvet-experts.org/doc_end_user/current_document.php?id=12765) [AHG4] Availability and copyright status of 3DV test materials [K. Sühring (HHI)]

For updating the “Common test conditions of 3DV experiments” as output document JVET-AC1013, the availability of test sequences and the associated license statements were reviewed. It was found that four of the five download locations listed in the previous CTC document JCT3V-G1100 are no longer available. It was also found that the license statements of three test sequences seem to be unsuitable for use in JVET.

Draft recommendation about putting 3V sequences into JVET ftp.

In terms of potentially critical copyright statements, communication with the owner companies will be sought.

[JVET-AD0229](https://jvet-experts.org/doc_end_user/current_document.php?id=12793) AHG4/AHG12: Mixed-Content Sequences for Enhanced Compression Tool Testing [X. Li (Google), Z. Deng, K. Zhang, L. Zhang (Bytedance)]

See notes in 5.2.5

[JVET-AD0369](https://jvet-experts.org/doc_end_user/current_document.php?id=12933) Creation of New Film Grain Content using a Ground Truth Approach [D. Podborski, B. Williams, L. Levinson, R. Molholm, A. M. Tourapis (Apple)] [late]

See notes under 4.12

## AHG4: Subjective quality assessment methodology (0)

This section is kept as a template for future use.

## AHG5: Conformance test development (1)

Contributions in this area were discussed at 1205–1225 on Wednesday 26 April 2023 (chaired by JRO).

[JVET-AD0101](https://jvet-experts.org/doc_end_user/current_document.php?id=12652) Additional conformance tests of scaling window functionality for multilayer coding [S. Iwamura, S. Nemoto, A. Ichigaya (NHK)]

This contribution proposes additional conformance test of scaling window functionality for multilayer coding. In 28th JVET meeting, it was decided to issue additional conformance bitstreams for VVC multilayer configurations. Content layering is one of the practical multilayer coding use cases reported in JVET-AB0087, where main content is coded as base layer and main content with overlaying sub-content is coded as enhancement layer. When the main content is scaled down and the L-shaped content is placed in the margin as the input for the enhancement layer, scaling window functionality might work quite efficiently. The proposed conformance bitstreams are attached in the contribution and the merge request for the software package for supporting scaling window will be submitted during meeting.

It is reported that the scaling window functionality is not supported by current VTM encoder. The software implementation is basically ready, however a problem still exists when combining scaling window in multi-layer coding with RPR in the base layer (which could be either an encoder or decoder problem). Therefore, no merge request was issued yet. The conformance streams proposed in this contribution are not affected by this.

It is noted that also a plain combination of RPR and multi-layer is currently not tested in the conformance test set (but supported by VTM encoder and decoder).

Decision: Adopt JVET-AD0101 into JVET-AD2028.

## AHG7: ECM tool assessment (4)

Contributions in this area were discussed at 1445–1545 on Tuesday 25 April 2023 (chaired by JRO).

[JVET-AD0041](https://jvet-experts.org/doc_end_user/current_document.php?id=12587) AHG7: Report on AHG meeting on ECM tool assessment [X. Li]

Was already subsumed under the AHG7 report – no need for separate review

[JVET-AD0082](https://jvet-experts.org/doc_end_user/current_document.php?id=12633) [AHG7] A configuration option for TMRL mode [L. Xu, J. Gan, Y. Yu, H. Yu, D. Wang (OPPO)]

This contribution proposes a configuration option for the template-based multiple reference line (TMRL) intra-prediction mode. The configuration option is added on top of ECM-8.0 reference software. The simulation results of TMRL tool-off tests are summarized as follow,

AI: 0.11%/0.04%/0.07%, Y/U/V

RA:

Decision(SW): Add an SPS flag for disabling TMRL as proposed in JVET-AD0082

[JVET-AD0272](https://jvet-experts.org/doc_end_user/current_document.php?id=12836) Crosscheck of JVET-AD0082 ([AHG7] A configuration option for TMRL mode) [C. Zhou (vivo)] [late] [miss]

[JVET-AD0131](https://jvet-experts.org/doc_end_user/current_document.php?id=12682) AHG 7: Coding efficiency/runtime tradeoff metrics [P. Onno, G. Laroche (Canon)]

The purpose of this contribution is to introduce metrics that can be used to assess the tradeoff between the coding performance and the runtime by computing the corresponding slope angle between the BDR measure and the encoder/decoder runtime. The main goal is to introduce this metrics in the Excel sheet of the ECM results provided in the ECM Common Test Conditions to rapidly obtain a measure representative of the performance of one given technical proposal. This performance metrics could be useful to compare proposals in particular in the scope of the EE2 or of the AhG 7. It would indeed enable to rank rapidly the different proposals in addition to the traditional encoding/decoding runtime and BDR measure. This metrics could be also useful in order to set a minimum value to further consider a technology in an Exploration Experiment.

The approach had originally been proposed in JVET-B0044 for JEM tool assessment

It was commented that this metric is just one example of tool complexity assessment metrics that were used historically in JVET, and specifically this one only relies on runtime. In the VVC development, there were other criteria such as number of worst-case memory accesses, number of operations, number of cycles before a certain value would be available, etc.

It is unlikely that the relationship between runtime and BD rate reduction is linear when considered over a larger range. It might be useful to investigate this with the different groups that were defined, and also between the different groups. One expert said this might rather be a log relationship.

BoG (X. Li) to discuss how to proceed on defining better metrics (not only encoder run time, see above) for tool complexity assessment (plan meeting for Thursday)

[JVET-AD0246](https://jvet-experts.org/doc_end_user/current_document.php?id=12810) [AHG7] ECM tool assessment with HDR dataset [Z. Fan, Y. Yausig, T. Chujoh, T. Ikai (Sharp)] [late]

This contribution reports the experimental results of AHG7 on the HDR dataset. The experimental results are reported to show that the following BD-rate differences are observed on the HDR dataset.

group1:

(IO) 0.00% 0.00% 0.00% in PSNR, -0.01% -0.01% -0.01% in WPSNR

(RA) XX% XX% XX% in PSNR, 2.58% 3.55% 4.03% in WPSNR

group2:

(IO) 0.44% 0.74% 0.76% in PSNR, 0.43% 0.79% 0.76% in WPSNR

(RA) XX% XX% XX% in PSNR, 0.71% 0.40% 0.65% in WPSNR

group3:

(IO) 0.89% 0.96% 0.99% in PSNR, 0.98% 1.08% 1.08% in WPSNR

(RA) XX% XX% XX% in PSNR, 0.50% 0.45% 0.23% in WPSNR

group4:

(IO) 0.86% 4.37% 5.37% in PSNR, 0.85% 4.91% 5.88% in WPSNR

(RA) XX% XX% XX% in PSNR, 0.45% 3.83% 3.98% in WPSNR

By tendency, ECM has less gain for HDR than for non-HDR. However, RA is not yet finished

It was observed that the benefit (in terms of compression) of the different groups of tools is highly sequence dependent within the HDR classes. This may however also be the case for other classes

## AHG8: Optimization of encoders and receiving systems for machine analysis of coded video content (13)

Contributions in this area were discussed at 1600–2010 on Monday 24 April 2023 (chaired by JRO).

[JVET-AD0042](https://jvet-experts.org/doc_end_user/current_document.php?id=12589) [AHG8] Proposed text for optimization of encoders and receiving systems for machine analysis of coded video content [J. Chen (Alibaba), C. Hollmann (Ericsson), S. Liu (Tencent)]

This document provides a description of optimization techniques for video encoders and receiving systems for machine consumption. It provides a concept-level overview of recent practices and references to technical articles that describe further details. It also provides comments on some technical aspects and identifies situations where cautions should be taken when interpreting the results.

It was recommended to remove reference to the WG 2 use cases doc which should not be referenced in a TR.

Convert into draft 2, and new version of preliminary WD in WG 5.

It was commented that there are various other SEI messages beyond annotated regions which could be useful for post processing tasks before feeding the decoder output into the machine vision task, for example post filter hints. A question is whether we would require implementation of anything to be put into the technical report.

[JVET-AD0043](https://jvet-experts.org/doc_end_user/current_document.php?id=12590) [AHG8] Clean-ups for the reporting template [C. Hollmann (Ericsson)]

In this contribution several bugfixes and formatting alignments for the reporting template used in the context of optimizations for encoders and receiving systems for machine analysis of coded video content are reported and addressed.

To be in included in new version of CTC.

[JVET-AD0047](https://jvet-experts.org/doc_end_user/current_document.php?id=12594) AHG8: A preprocessing software implementation for OFM [B. Li, S. Wang, J. Chen, Y. Ye (Alibaba), S. Wang (CityU)]

At the January meeting, it was agreed to create a software repository for AHG8 and to include preprocessing software based on JVET-AC0086 in this code repository. A software repository has been created since then and is referred to as optimization for machines (OFM). This contribution provides a description of the preprocessing part of the OFM software package, including the code architecture, instruction for installation, configuration and encoding/decoding scripts, and performance compared to VVC. This contribution suggests to add sections on the OFM software implementation to the technical report for the optimization of encoders and receiving systems for machine analysis of coded video content.

In version 3 of this contribution, it is further suggested to add some technical details of the pre-processing implementation to section 6.1 (Region of Interest-based methods) and section 6.2 (Pre-processing methods of foreground and background) in this contribution.

Table 1. Performance of the preprocessing software for OFM on SFU-HW Dataset for object detection task. (The ‘/’ means non-monotonous performance.)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | RA | | | LD | | | AI | | |
|  | BD-Rate | BD-Rate Pareto | BD-mAP | BD-Rate | BD-Rate Pareto | BD-mAP | BD-Rate | BD-Rate Pareto | BD-mAP |
| Class A | / | -52.04% | 3.35 | -13.83% | -13.83% | 2.14 | / | -36.98% | 6.56 |
| Class B | / | -29.55% | 4.71 | -24.95% | -24.95% | 3.84 | -33.96% | -34.25% | 6.74 |
| Class C | -4.95% | -4.95% | 0.76 | / | -6.49% | 0.19 | -16.47% | -16.81% | 2.49 |
| Class D | 0.03% | 0.03% | -0.55 | -2.60% | -2.60% | -0.22 | -13.78% | -10.91% | 2.33 |
| Average | / | -14.61% | 1.77 | / | -11.54% | 1.34 | / | -21.91% | 4.06 |

Table 2. Performance of the preprocessing software for OFM on TVD video dataset for object tracking task. (The ‘/’ means non-monotonous performance.)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | RA | | | LD | | | AI | | |
|  | BD-Rate | BD-Rate Pareto | BD-MOTA | BD-Rate | BD-Rate Pareto | BD-MOTA | BD-Rate | BD-Rate Pareto | BD-MOTA |
| TVD-01\_1 | / | -82.98% | 12.78 | / | -65.38% | 14.33 | -87.72% | -87.57% | 24.79 |
| TVD-01\_2 | -76.08% | -76.83% | 9.06 | / | -71.77% | 8.54 | -85.77% | -86.03% | 22.67 |
| TVD-01\_3 | -56.02% | -56.80% | 8.25 | / | -25.57% | 4.10 | -74.59% | -74.06% | 14.26 |
| TVD-02\_1 | 0.00% | 0.00% | 0.00 | 0.00% | 0.00% | 0.00 | 0.00% | 0.00% | 0.00 |
| TVD-03\_1 | -51.21% | -48.61% | 7.58 | -29.31% | -23.89% | 5.31 | -56.68% | -54.29% | 12.42 |
| TVD-03\_2 | -68.08% | -65.60% | 6.70 | / | -45.67% | 5.82 | -65.84% | -66.14% | 10.77 |
| TVD-03\_3 | -68.89% | 0.00% | 7.96 | -65.14% | -62.43% | 6.14 | -76.10% | -76.08% | 14.58 |
| Average | / | -57.68% | 7.48 | / | -42.86% | 6.32 | -63.82% | -63.45% |  |

As a general remark, it was asked if an evaluation methodology that transfer traditional BD metrics into classification tasks is appropriate. For example, an increase of mAP by 2 is almost useless if the mAP is low, but valuable when mAP is >95.

This preprocessing software is operated completely independent from encoding and machine analysis task. It is not aware of the quality of encoding, and of the machine analysis task (though it might have been somewhat optimized for the dedicated tasks defined in CTC).

It is noted that hypothetically a preprocessing algorithm could be aware of the encoder’s operating point (bit rate, QP), it could feed parameters into encoder (local QP adaptation, adaptation of temporal levels), or it could also invoke some post processing before machine analysis task, e.g. via an SEI message.

About the contribution:

* Encoding/decoding time is not reported
* The method could take more benefit by controlling the encoder

The software is already available in the repository.

The contribution comes with a text proposal for the draft of the TR.

It was discussed to which level of detail the TR should describe algorithms in the repository. One idea mentioned was to establish an annex with example algorithms. The proposed text goes in various aspects too much into level of detail about implementation, and how to run the software, which should better be put to the software repository as a kind of software manual (which alredy exists).

[JVET-AD0052](https://jvet-experts.org/doc_end_user/current_document.php?id=12599) AHG9: NNPFC SEI extension mechanism to enable usages beyond user viewing [M. M. Hannuksela, F. Cricri, H. Zhang (Nokia)]

This contribution also fits under section 6.1.

Was reviewed in BoG JVET-AD0362

[JVET-AD0060](https://jvet-experts.org/doc_end_user/current_document.php?id=12607) AHG8/AHG9: Indications related to suboptimal user viewing [M. M. Hannuksela, F. Cricri, H. Zhang (Nokia)]

This contribution also fits under section 6.2.

To be discussed Tuesday morning together with SEI experts

[JVET-AD0110](https://jvet-experts.org/doc_end_user/current_document.php?id=12661) [AHG8] Evaluating and Improving Coding Performance for General Image Classification Models [Q. Zhang, Z. Wang, S. Wang, S. Ma (Peking Univ.)]

This contribution shares information about evaluating and improving the coding performance for general image classification models with a proposed Satisfied Machine Ratio (SMR) model, which could also be extended to other tasks like object detection, segmentation, and tracking. SMR is an evaluation metric, which is calculated as the proportion of machine vision models that have same or similar outputs on pristine and compressed image/video frame. By collecting many machine vision models and obtaining SMR of the compressed image/video frame, the coding performance for general models instead of one specific model can be evaluated accurately. A learning-based SMR prediction model is also proposed to predict SMR of any compressed image/video frame to avoid the time cost of running every model for obtaining SMR. The SMR prediction model can be used to select the appropriate QP for compression to achieve a pre-defined SMR target and improve the coding performance in terms of SMR. Preliminary experiments are conducted on TVD (image) dataset and a basic BDBR-SMR gain of 31.9% can be observed.

Contribution well noted and, as it may resolve issues of our current evaluation method.

The SMR predictor is basically itself a classifier, as it tries to predict how dozens of other classifiers would perform, or how correct they would be in their output.

Model was trained with HEVC encodings, but should in principle work with VVC as well.

Among the different classifiers considered in the model, transformers are included.

Could an implementation of SMR prediction be made available, such that the AHG might try it out? To be sorted out between AHG chairs and proponents.

Further study and follow-up contributions welcome.

[JVET-AD0113](https://jvet-experts.org/doc_end_user/current_document.php?id=12664) AHG8: Adaptive Mask Pre-Process algorithm for Video Coding for Machines [Z. Huang, Z. Wang, C. Jia, S. Wang, S. Ma (Peking Univ.)]

This contribution presents an encoder-only pre-process algorithm for video coding for machine, which utilizes pre-analysis results to adaptively guide input video pre-processing. The proposed technique reportedly achieves BD-rate savings of –28.96%, -10.35% and –3.84% for object detection tasks on Class AB, Class C, and Class D of SFU-HW, respectively.

Are run-time data available? Not in the current contribution.

Plain pre-processing, no control of encoder.

Masking had also been used by at least one other proposal, but this proposal has also some aspect of object detection.

Results not complete yet, cannot be compared against other known methods currently.

Further study recommended, more details about run time, complete results.

For future contributions, it would be interesting to compare results against methods that were included in the software repository as implementation examples for “optimization of encoders …” The results for these can be found in the JVET contributions which have the same file name as the corresponding branch of the repository.

Action item for AHG: Put the performance spread sheets into the repository brach of the respective proposal. For example, for proposal JVET-AD0113, JVET-AD0047 which follows a similar approach of plain pre-processing would be reasonable to compare against.

[JVET-AD0122](https://jvet-experts.org/doc_end_user/current_document.php?id=12673) [AHG8] Configuration changes for random access and low delay [C. Hollmann, R. Sjöberg, J. Ström (Ericsson)]

In this contribution results for modified configurations for random access and low delay for the area of optimizations for machine analysis of coded video content are described. The results state that increasing the QP offset by 5 for certain temporal layers can give a BD-rate result of −7.3%/−7.0% (SFU-HW/TVD) for random access and −9.6%/−13.3% for low delay. It is proposed to include the detailed description in the draft for the technical report.

Results are relatively homogeneous over different classes and sequences.

It was suggested to potentially use this as config setting for the VVC anchor, as it is a simple change of config file, and does not require any change of VTM.

It was pointed out that for machine analysis tasks outside of the current scope these config settings might not be appropriate (e.g. for detailed motion analysis of fast moving objects). However, for current CTC it seems appropriate.

To be discussed with WG 4 – revisit.

[JVET-AD0307](https://jvet-experts.org/doc_end_user/current_document.php?id=12871) Crosscheck of JVET-AD0122 ([AHG8] Configuration changes for random access and low delay) [Z. Liu (Tencent)] [late]

[JVET-AD0135](https://jvet-experts.org/doc_end_user/current_document.php?id=12686) [AHG8] Additional details on RoI-based adaptive QP for TR [C. Hollmann, R. Sjöberg, J. Ström (Ericsson)]

In this contribution technical details regarding the implementation of JVET-AB0275 are proposed for inclusion in the technical report on optimizations of encoders and receiving systems for machine analysis of coded video content.

The contribution claims to be responding to a comment at the previous meeting that more detailed descriptions are desirable for the draft TR.

The contribution includes added details to sections 6.1 (Region of Interest-based methods) and 7.1 (Quantization Parameter adaption for Region of Interest coding) of JVET-AC2030.

The proposed changes to the TR can be found in an attachment to the contribution.

This is an example of an algorithm which modifies the VTM encoder.

It was pointed out that details such as performance should not be part of the TR. Also, referencing external software packages such as Yolo is questionable, this should rather be described in the software manual when necessary for operating the software.

It was agreed to establish an annex to the TR which describes example implementations of certain elements of “optimization of encoders and receiving systems for machine analysis”, but the descriptions should describe algorithms at a relatively high level, e.g. that QP adaptation is used and how it is used to emphasize regions, but not with implementation details, and not how to operate the software. For now, the descriptions from JVET-AD0047 and JVET-AD0135 would be put into that annex (in an appropriately condensed way). Rules about selecting future candidates to be added to that annex need to be developed; beyond the availability and operational proof of software, it is ultimately up to the judgement of JVET whether something has sufficient value to shed some light about how things are practically done.

[JVET-AD0137](https://jvet-experts.org/doc_end_user/current_document.php?id=12688) [AHG8] SEI for encoder optimization information [C. Kim, Hendry, D. Gwak, J. Lim (LGE)]

This contribution also fits under section 6.2.

To be discussed Tuesday morning together with SEI experts

[JVET-AD0138](https://jvet-experts.org/doc_end_user/current_document.php?id=12689) [AHG8] QPA with low activity threshold for machine task [C. Kim, D. Gwak, J. Lim (LGE)]

This contribution proposes a low activity threshold for QPA to reduce bit rate increases in less important areas for machine task. From experimental results, 1.19% performance improvement is observed on average.

At the previous JVET meeting, the impact of the perceptual QP adaptation (QPA) on object detection task performance for Open Images dataset was reported JVET-AC0079. This contribution reports on the object detection performance of the perceptual QP adaptation (QPA) on the SFU-HW video dataset, as well as the object detection performance using QPA with a low activity threshold.

The 1.19% average performance improvement is reported compared to QPA which is in the software repository.

It is however commented that the results are inhomogeneous: In some cases, the results are better compared to current QPA, in other cases worse. Fluctuations are significant.

Further study recommended to make the improvement more homogeneous.

It was also commented that BD rate changes in the range of 1% are not indicating much in this activity.

[JVET-AD0181](https://jvet-experts.org/doc_end_user/current_document.php?id=12734) AHG8: Update on TVD object tracking dataset [Z. Liu, L. Wang, X. Xu, S. Liu (Tencent)]

This contribution provides some updates on the TVD object tracking dataset.

In the v2 version, the missed TVD-03\_03 results and the link of dataset are added.

The TVD video dataset contains three videos, i.e., TVD-01, TVD-02 and TVD-03, with different content and the corresponding tracking ground truth. In previous version, the videos are compressed in lossy mode. In this contribution, the lossless raw sequence for each video are provided.

Q: Does this impact the performance of machine analysis tasks. According to cross-checker, the impact is minor (< 3% BD rate, which may still be in the range of uncertainty in this activity)

It is agreed in principle that it is approproiate to exchange the sequences, but the new sequences should get another name (e.g., “\_a”), and this new name should also appear in the CTC document.

To be discussed with WG 4 in the joint meeting. Revisit.

[JVET-AD0252](https://jvet-experts.org/doc_end_user/current_document.php?id=12816) Cross-check of JVET-AD0181 (AHG8: Update on TVD object tracking dataset) [C. Hollmann (Ericsson)] [late]

[JVET-AD0175](https://jvet-experts.org/doc_end_user/current_document.php?id=12726) AHG8/AHG9: On object mask auxiliary picture and object mask information SEI message for VSEI and HEVC [J. Chen, S. Wang, Y. Ye (Alibaba)]

To be discussed Tuesday morning together with SEI experts

[JVET-AD0186](https://jvet-experts.org/doc_end_user/current_document.php?id=12748) AHG8: VVC tool analysis for Machines Vision Tasks [Z. Liu, L. Wang, X. Xu, S. Liu (Tencent)]

This contribution analyses of the new tools in VVC in terms of the impact on the coding efficiency for machine tasks and the encoding/decoding complexity. Based on the experimental results, it is shown that the VTM can be configured with 70% complexity off while maintaining the detection accuracy on the object detection task.

In the v2 version, the results are updated.

Interesting information with very detailed per-tool analysis.

It was commented that it is interesting to see that with some tools switched off, the machine analysis performance is increasing. However, some differences are small, and in some cases tools are beneficial for for object detection, ans not beneficial for object tracking. ALF is one example that is not beneficial for both (at least in RA). Further study is needed

* To potentially re-define anchor configuration
* To potentially identify which tools might be recommended to be switched off for machine analysis tasks (in the TR)

Further study in AHG.

## AHG10: Encoding algorithm optimization (4)

Contributions in this area were discussed at 1840–2015 on Tuesday 25 April 2023 (chaired by Y. Ye).

[JVET-AD0045](https://jvet-experts.org/doc_end_user/current_document.php?id=12592) AHG10: Encoder MV selections and DMVR revisited [K. Andersson, R. Yu (Ericsson)]

In JVET-W0061 it was pointed out that DMVR can cause visual artifacts at subblock boundaries when it fails to find the correct motion and an encoder only fix was proposed. The solution at that time was deemed to give too much objective overhead. In this contribution additional criterions to disable DMVR on the encoder side are proposed to reduce the overhead while removing visual artifacts. Firstly, the use of DMVR is always restricted for temporal layers lower than the highest temporal layer. When frame rate is equal or lower than 30Hz the use of DMVR is also restricted for the highest temporal layer. In higher temporal layers and when frame rate is higher than 30Hz it is generally better coherence between reference pictures which gives less problem to find the correct motion. If artifacts happen in the highest temporal layer they can not propagate to other pictures. Secondly, it is avoided to disable DMVR when average absolute subblock boundary differences are small when possible DMVR artifacts are less prominent.

The BDR effect on random access for VTM-20.0:

SDR CTC RA Y/Cb/Cr: 0.04%/0.06%/0.05%

HDR CTC RA DeltaE/PSNRL wY/wCb/wCr/: 0,07%/0,09% 0,08%/0,09%/0,13%

Similar encoding and decoding time as anchor.

This is an encoder only proposal that reportedly brings subjective quality improvement with some objective performance penalty, where the objective performance penalty has been reduced compared to the related previous contribution JVET-W0061.

One visual example in still picture form is provided in the PPT file attachment of this proposal.

Cross checker reported that the objective results are matched, and that visual check was performed. It was reported that most of the videos looked similar, and one specific case of visual quality improvement was found and included in the crosscheck report.

It is suggested to confirm the reported subjective quality improvement in video mode.

It was asked if the proposed method has been tried on BDOF or on ECM (which has a more complicated DMVR process). It was reported that no visual artifacts associated with BDOF have been observed, and that this has not been tried on ECM.

The proponent does not suggest to enable the method in the CTC, but suggest to enable the method by default when GOP-based RPR (which is already supported by VTM) is enabled.

It is suggested to organize an informal viewing session to confirm the visual benefits.

Revisit.

[JVET-AD0343](https://jvet-experts.org/doc_end_user/current_document.php?id=12907) Crosscheck of JVET-AD0045 (AHG10: Encoder MV selections and DMVR revisited) [J. Samuelsson-Allendes (Sharp)] [late]

[JVET-AD0129](https://jvet-experts.org/doc_end_user/current_document.php?id=12680) AHG10: Improvement of Input Video Padding in VTM [J. Liao, L. Li, D. Liu, H. Li, F. Wu (USTC)]

This contribution proposes to fix the input video padding implementation in VTM software. In order to handle inputs of various sizes, VTM pads the input video. In the original padding implementation, compared with the normal replicate padding in the bottom side, the pixels in the right side are padded with the upper right pixel without any sense. This contribution proposes to fix the right-side padding as a replicate padding.

Since the normal size of CTC sequences does not trigger the implementation of padding, this contribution tests the performance on CTC sequences cropped with a reduction of 4 in both original width and height. Moreover, this contribution demonstrates the test results on CTC sequences cropped respectively with the center point (CT) and upper left corner (UL) as the center.

The test results show that the fix brings significant performance improvement compared with the original implementation as follows:

CT:

AI: {-0.17%, -0.41%, -0.36%}; RA: {-0.33%, -0.72%, -0.64%};

LDB: {-0.31%, -0.62%, -0.63%}

UL:

AI: {-0.16%, -0.41%, -0.45%}; RA: {-0.36%, -0.65%, -0.31%};

LDB: {-0.28%, -0.39%, -0.74%}

This is related to paddig the input pictures to a size that can be handled by VVC. This condition is not triggered by our CTC sequences.

It was commented that class C shows some consistent luma loss for LD and RA. The proponent suggests that this is mainly due to the RaceHorse sequence which has moving objects along the rightside border of the picture.

Cross checker confirmed the results and the implementation.

It was commented that this looks like an obvious bug, and could be taken into the VTM after the VTM software coordinators perform a code review and confirm the implementation.

Revisit.

[JVET-AD0300](https://jvet-experts.org/doc_end_user/current_document.php?id=12864) Crosscheck of JVET-AD0129 (AHG10: Improvement of Input Video Padding in VTM) [N. Yan (Kwai)] [late]

[JVET-AD0133](https://jvet-experts.org/doc_end_user/current_document.php?id=12684) AHG10: Lambda-QP Relationship Fix for Slice-level Multi-QP Optimization [J. Liao, L. Li, D. Liu, H. Li, F. Wu (USTC)]

This contribution proposes to fix the problems of slice-level multi-QP optimization in VTM software. The main modifications this contribution proposes to the slice-level multi-QP optimization of the original version in VTM are as follows:

1. This contribution proposes to modify the QP-lambda relationship in slice-level multi-QP RDO.
2. This contribution proposes to fix the slice-level lambda while traversing the QP within a predefined range.
3. It is proposed in this contribution to disable CU-level mode reuse when multi-QP optimization is enabled.

The test results show that the fix brings significant performance improvement compared with the original implementation as follows:

AI: {-8.25%, -5.68%, -6.00%}; RA: {xx%, xx%, xx%}; LDB: {-5.28%, -3.96%, -3.34%}

This is only for frame-level QP optimization mode.

It was asked how much benefit frame-level multi-QP optimization provides in current VTM. JVET-AB0228 compared frame-level multi-QP optimization on/off based on VTM-17.0. Partial results show little benefit from frame-level multi-QP optimization in VTM-17.0, and given nothing has changed between VTM-17.0 and VTM-20.0 in this aspect, it is likely that in our latest VTM, frame-level multi-QP is still not providing any benefits.

This contribution is implemented based on VTM-19.2, which was the latest version of VTM when this work started.

The cross checker confirmed that the results are matched.

The gains reported in JVET-AB0228 were much higher than reported here, e.g. gain in AI was reported to be ~12% in JVET-AB0228 (on top of VTM-17.2), but was reduced to only 8.25% in this contribution (on top of VTM-19.2).

It was commented that between VTM-17.2 and VTM-19.2, rate distortion performance for CTC was not significantly changed. However, performance reported in this contribution is outside of CTC.

It was commented that this contribution brings good coding gain for multi-QP optimization, and it is generally desirable to have software function correctly when this feature is used.

VTM software has a REUSE\_CU\_RESULTS macro that is turned on by default in our main branch. However, the current software implementation of this contribution needs to turn off this REUSE\_CU\_RESULTS macro in order to avoid crash. This is not desirable and should be resolved before any action can be taken.

It was commented this work is valuable, and some of the software issues identified by this proposal can be resolved via the VTM software bug tracker system.

Further study is recommended.

[JVET-AD0302](https://jvet-experts.org/doc_end_user/current_document.php?id=12866) Crosscheck of JVET-AD0133 (AHG10: Lambda-QP Relationship Fix for Slice-level Multi-QP Optimization) [N. Yan (Kwai)] [late]

[JVET-AD0136](https://jvet-experts.org/doc_end_user/current_document.php?id=12687) AHG10: Lagrange multiplier optimization for chroma ALF and CCALF [W.-J. Zou, Y. Zhou, C.-M. Gu, J.-W. Fan (Xidian Univ.), S.-W. Xie, G. Ying, M.-H. Jia, Y.-L. H, C. Huang (ZTE)]

This contribution presents an RDO Optimization in ALF. The chroma Lagrange multiplier will be adjusted by a scaling factor when the luma ALF APS transmission flag is ON and the number of history chroma ALF APS is insufficient. It is reported that, with VTM19.0 as anchor and test platform, the overall performance are as follows:

* LDB: 0.02%, -0.87%, -1.19%

Class B: 0.07%,-0.91%,-1.43% Class C: 0.03%,-0.31%,-0.67%

Class E: -0.09%,-1.55%,-1.48%

The cross checker reported that the proposed changes will cause a drop in performance for class F, and commented that the proposed change should not be used on screen content.

The proposed method will affect our CTC performance.

The proposed method is asserted to bring more benefit to the LDB config because the APS buffer is never reset, and the identified problem would occur more. The proponent suggests to only consider this method to LDB.

The cross checker reported that encoding and decoding runtime are not affected (both 100%).

It was commented that LDP would also be in a similar situation as LDB, but no results for LDP are available. It was commented by VTM software coordinator that it is more desirable to keep LDB and LDP aligned with regard to this proposed method.

It was commented that the proposed method causes some performance loss on top of ECM. It was suggested to investigate this and improve the way this method operates on ECM.

Further study recommended.

[JVET-AD0358](https://jvet-experts.org/doc_end_user/current_document.php?id=12922) Crosscheck of JVET-AD0136 (AhG10: Lagrange multiplier optimization for chroma ALF and CCALF) [X. Li (Alibaba)] [late]

## AHG13: Film grain synthesis (2)

Contributions in this area were discussed at 1515–1715 on Wednesday 26 April 2023 (chaired by JRO).

[JVET-AD0238](https://jvet-experts.org/doc_end_user/current_document.php?id=12802) On Film Grain Synthesis Subjective Evaluation and Further Work [X. Meng, W. Zhang (Disney Streaming), A. Norkin, J. Sole (Netflix), A. Duenas (Discovery)]

At the last meeting, it was decided to recommend for publication a technical report on Film grain synthesis technology for video applications and its draft text was presented on JVET-AC015[1].

In addition, the subjective evaluation of film grain synthesis was recommended in the last JVET meeting, and the current plan is captured on JVET-AC2022[2].

The authors of this contribution believe that those two activities are of great value and encourage JVET to continue with the current plan.

As part of this work, in the subjective test preparation for film grain synthesis and the technical report on Film grain synthesis technology for video applications, two use cases are being considered and supported:

* Film grain synthesis can be used to recreate a grain that is visually similar to the original, which could otherwise be lost due to compression, thus preserving the **artistic intent**.
* Film grain/noise can also be used, to some extent, to **mask coding defects**.

This contribution would like to encourage the group to prioritize the use case that tries to preserve the artistic intent, this is considered of great potential, and it is also a harder goal to achieve.

In JVET-AC0199 [3], it was claimed by some of the authors of this contribution that after subjective evaluation of the current shared tools that the current algorithm may not be optimized, which leads to significant artifacts. It was noted that the MCTF-based denoising may also not be optimum and an alternative filtering process could be developed. It was also mentioned that for heavy grain sequences, the synthesized grain is rather coarse, and there are obvious repetitive patterns. Parameters are recommended to control the granularity of synthesized film grain, and the frequency-based FGS method and auto-regressive (AR) based method shows different results under different circumstances. Better implementations of the denoiser and film grain modeling are recommended to show the effectiveness of the current FGS SEI message and film grain synthesis method.

This contribution would like to encourage the group to further develop and make available tools and methodologies that facilitate the usage of the FGS techniques under development in JVET.

Some aspects are mentioned that are relevant in practical usage of film grain:

* Adaptive streaming, including change in resolution
* Low bit rates require better de-noising

A weak part is the analysis – providing parameters for the synthesis. The synthesis as such should work satisfactorily, but removal of film grain and parameter extraction are weak in current software. Contributions in this area would be highly welcome.

Broader variety of content is also necessary for better testing.

Recommendation requesting for more materials and improved software tools for FG removal and analysis.

[JVET-AD0241](https://jvet-experts.org/doc_end_user/current_document.php?id=12805) AHG13: On Film Grain Objective Metrics [X. Meng, W. Zhang, S. Labrozzi (Disney Streaming)]

This proposal aims to explore the feasibility of NSS (Natural Scene Statistics) as an objective metric in the film grain related studies in JVET. Specifically, the capability of NSS on measuring the quality and fidelity of video with film grain was evaluated. Given the fact that there is no widely adopted objective metric specific to film grain, the investigation in this proposal was designed to address the following questions,

• Can the characteristics of film grain be abstracted and represented by NSS in a quantitive way?

• How are the NSS results related to the subjective perception of human eyes?

• Does the NSS work universally, or with limitations and/or conditions?

According to the experimental results, NSS based method showed promising outcomes to measure the film grain, especially when the content is relatively simple, and the film grain characteristics are consistent. Reliable results correlated to subjective perception were obtained.

However, it’s also observed that NSS is prone to be disturbed if the content is with high spatial complex regions. Besides, it’s also sensitive to the pooling method when applying NSS to video. For example, averaged NSS among multiple frames didn’t work well in the tests.

Comparisons were performed when modifying parameters such as strength and cutoff frequency of the synthesis, but in some cases no differences were identified by the metric, even though visually different.

Experiments mostly done with small cropped regions.

Current input of the metric is pictures with film grain. Could the similarity check potentially be improved when content and film grain would be available separately, like in the ground truth approach? Would need to be investigated.

It would be interesting to investigate how reliable the metric is in its assessment, which could however only be assessed with more material.

How was precisely the modification of the SEI message parameters performed? Were the parameters originally extracted appropriately reconstructing the film grain? This should be taken into account when concluding about the benefit of the metric.

More study and future contributions welcome.

[JVET-AD0276](https://jvet-experts.org/doc_end_user/current_document.php?id=12840) AHG4: experiments in preparation of film grain visual tests [P. de Lagrange, T. Filoche, F. Urban (InterDigital)] [late]

See notes under 4.5

[JVET-AD0332](https://jvet-experts.org/doc_end_user/current_document.php?id=12896) AHG13/AHG3: software development related to FGC SEI message [P. de Lagrange, F. Urban (InterDigital)] [late]

This contribution describes the contents of the newly created JVET gitlab group called “JVET AHG Film Grain Technologies”, its connections with reference software, and the plans for future developments.

As announced on the JVET email reflector, following the mandates of AHG13 to “coordinate development of film grain technology software and configuration files” and to “coordinate with AHG3 for software support of the FGC SEI message”, a new group called “JVET AHG Film Grain Technologies” has been created on gitlab (https://vcgit.hhi.fraunhofer.de/jvet-ahg-fgt). This group is publicly accessible.

This contribution describes the current repositories within this group and the work in progress or planned.

Software developed in this group can be released independently from HM or VTM revisions, and could be merged into HM and VTM when relevant and mature enough.

Three publicly accessible repositories have been created:

* VFGS (which includes support for AR model but is not in VTM/HM)
* VTM (fork of jvet/VVCSoftware\_VTM)
* HM (fork of jvet/HM)

In the contribution,

* It is recommended to continue developing FGC SEI message related software in the jvet-ahg-fgt gitlab group, merge it to the reference software when relevant and mature, and consider extra tools that enable testing and usage of film grain technologies.
* It is also recommended to study with AHG9 and AHG3 if all software related to VSEI could go into a separate repository, used as a git submodule in both HM and VTM, so that code duplication is avoided and separate versioning could be possible. This approach is currently used for SADL library in the NNVC software.

For the second recommendation above, this has nothing to do with FG synthesis, and was not discussed in this context. The first recommendation was generally agreed.

It was commented that duplication of code is undesirable. Tools that could be operated independent from HM/VTM could nevertheless become part of reference software if mature enough (which would be possible as far as they stick to the SW licensing rules). Nothing to be decided at this meeting

[JVET-AD0369](https://jvet-experts.org/doc_end_user/current_document.php?id=12933) Creation of New Film Grain Content using a Ground Truth Approach [D. Podborski, B. Williams, L. Levinson, R. Molholm, A. M. Tourapis (Apple)] [late]

In recent years there has been an increased interest in the use of Film Grain Synthesis techniques for video compression. This is especially due to the desire of further reducing the bitrates required for certain applications. The technical report on film grain synthesis technologies for video applications, that is currently being prepared by JVET, attempts in documenting some of the related technologies as well as some of their benefits.

Nevertheless, one of the main challenges in the development and evaluation of such technologies is the lack of appropriate test content. Ideally, such content should assist in the easy tuning of a particular film grain synthesis technology under development and should allow to easily evaluate the benefits of not only a particular film grain synthesis technique but of also other related methods, such as motion compensated temporal denoising. Unfortunately, content with embedded film grain is quite limited, while, given the lack of aa ground truth for either the characteristics of the film grain noise in these video signals or of the video signal itself without any noise, it can be quite challenging to assess the effectiveness of any related film grain techniques. There is currently also no well-defined objective method, which can properly measure the similarity of the synthesized noise versus the original noise that was present in the video sequence.

Instead, in this document, a particular process for the creation of new film grain content is presented, which can potentially avoid, if not eliminate such problems. This is done through the generation and availability of also an original “ground truth” video signal that is created in parallel to any new content with film grain. This “ground truth” video signal is devoid of any film grain, which permits a mathematical, if desired, evaluation of not only the similarity of the grain synthesized through any film grain modelling method, but of also of the performance of any associated encoding/preprocessing techniques, such as motion compensated temporal filtering, which is commonly used in combination with film grain synthesis models. The “ground truth” video signals also enable the creation of multiple film grain content with different characteristics, e.g. with grain of different strength or granularity/coarseness, which can help evaluate the effectiveness of particular techniques in different film grain scenarios.

Generally, this is a viable approach for getting better assessment of the quality of film grain analysis and synthesis.

It was suggested to preferably generate the different film grain models by different software packages.

It was asked if details about the parameters used to generate the film grain would be made available.

Extend the recommendation mentioned under JVET-AD0238 such that it also requests for content that could be used as ground truth to add artistic film grain, as well as the synthetic film grain itself.

W. Husak was asked to coordinate drafting of such a recommendation.

## Implementation studies (2)

Contributions in this area were discussed at 1225–1245 on Wednesday 26 April 2023 (chaired by JRO).

[JVET-AD0266](https://jvet-experts.org/doc_end_user/current_document.php?id=12830) Update on open, optimized VVC implementations VVenC and VVdeC [A. Wieckowski, J. Brandenburg, C. Bartnik, V. George, J. Güther, G. Hege, C. Helmrich, A. Henkel, T. Hinz, C. Lehmann, C. Stoffers, B. Bross, H. Schwarz, D. Marpe, T. Schierl (HHI)] [late]

This document provides updated information on features, coding efficiency and runtime for version 1.8.0 of the open VVC software encoder VVenC released in April 2023 and version 1.6.1 of the open VVC software decoder VVdeC released in January 2023. In addition, an example implementation of a web-based player that enables to use VVdeC for VVC playback in a web browser has been made available on GitHub. Furthermore, a 3rd party effort has been started in October 2022 to add VVC encoding and decoding support to FFmpeg with VVenC and VVdeC. The patches are currently under review.

Main changes for VVenC v1.8.0 since version 1.7.0 include:

* Improved presets:
  + Speedup: ~10% for faster, ~5% for fast and slow
  + Minor BD-rate improvements: -0.3% for medium and slower, -0.6% for slow
* New features and improvements:
  + Added temporal ALF APS prediction (closing the efficiency gap between single- and multi-threaded operation)
  + Extended Block Importance Mapping (BIM) by extrapolating parameters to non MCTF-filtered frames
  + Improved error messages
* Various bugfixes and cleanups

Without QP adaptation for subjective optimization and 8 threads the following PSNR-based YUV BD-rates compared to HM-17.0 (GOP16+MCTF) as well as speedup factors compared to HM-17.0 and VTM-19.2 (GOP32+MCTF) are reported for different presets and JVET class B (HD), class A (UHD) as well as both (HD4K) test sequences:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Preset | HD |  |  | UHD |  |  | HD4K |  |  |
| PSNRYUV BD-rate vs. HM‑17.0 | Speedup vs.  HM‑17.0 | Speedup vs. VTM-19.2 | PSNRYUV BD-rate vs. HM‑17.0 | Speedup vs. HM‑17.0 | Speedup vs. VTM-19.2 | PSNRYUV BD-rate vs. HM‑17.0 | Speedup vs. HM‑17.0 | Speedup vs. VTM-19.2 |
| FASTER | -10.5% | 320x | 2100x | -14.9% | 380x | 2300x | -12.9% | 350x | 2200x |
| FAST | -24.3% | 140x | 890x | -26.5% | 160x | 950x | -25.5% | 150x | 920x |
| MEDIUM | -33.8% | 29x | 190x | -36.5% | 44x | 270x | -35.3% | 36x | 230x |
| SLOW | -38.0% | 10.0x | 68x | -40.0% | 15x | 91x | -39.1% | 13x | 79x |
| SLOWER | -41.0% | 2.3x | 15x | -43.0% | 3.3x | 20x | -42.1% | 2.8x | 18x |

With QP adaptation for subjective optimization and 8 threads, the following MS-SSIM-based YUV BD-rates compared to HM-17.0 (GOP16+MCTF) as well as speedup factors compared to HM-17.0 and VTM-19.2 (GOP32+MCTF) are reported for different presets:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Preset | HD |  |  | UHD |  |  | HD4K |  |  |
| MS-SSIMYUV BD-rate vs.  HM‑17.0 | Speedup vs.  HM‑17.0 | Speedup vs.  VTM-17.2 | MS-SSIMYUV BD-rate vs. HM‑17.0 | Speedup vs.  HM-17.0 | Speedup vs. VTM-19.2 | MS-SSIMYUV BD-rate vs.  HM‑17.0 | Speedup vs.  HM-17.0 | Speedup vs. VTM-19.2 |
| FASTER | -20.2% | 310x | 2200x | -20.3% | 370x | 2500x | -20.2% | 340x | 2400x |
| FAST | -31.4% | 130x | 990x | -31.0% | 160x | 1100x | -31.2% | 150x | 1000x |
| MEDIUM | -38.3% | 29x | 210x | -40.2% | 45x | 300x | -39.3% | 37x | 260x |
| SLOW | -41.9% | 10.0x | 76x | -43.5% | 16x | 110x | -42.8% | 13x | 91x |
| SLOWER | -44.3% | 2.3x | 17x | -46.3% | 3.4x | 23x | -45.4% | 2.8x | 20x |

Are there plans for “superfast”? Would need significantly re-writing the software.

[JVET-AD0361](https://jvet-experts.org/doc_end_user/current_document.php?id=12925) Update on optimized VVC encoder implementation BVC for live-streaming [X. Gao, Y. He, X. Jiang, Y. Li, J. Wang, Y. Wu, L. Zhang, W. Zhang, W. Zhu (Bytedance)] [late]

This contribution reports the recent progress of an optimized VVC encoder for live-streaming usecase, BVC, developed by Bytedance. Specifically, BVC is further optimized for the live-streaming case. To better utilize the advategs of VVC, majority of the coding tools and features introduced in VVC have been integrated and optimized in the BVC encoder. In addition, it also includes real-world encoder features like preprocessing, rate control, and multi-threading. The encoding speed of BVC for 720p and 1080p is 115fps and 56fps on average with 16 threads, respectively. When compared to x265 (v3.5) and HM-17.0, the corresponding global BD-rate gain and speedup factors under the Random Access configuration are summarized as follows:

* Compared to x265 CBR(16 threads): -54.57%, 0.9x
* Compared to HM RA CTC: -9.47%, ~928x; -12.18%, ~1011x for HD+UHD
* Compared to HM LDB CTC: -3.62%, 513x;

Comparison is made against x265 medium preset.

Adaptive GOP structures? Decided by pre-analysis at sequence level.

## Profile/tier/level specification (1)

Contributions in this area were discussed at 1245–1300 on Wednesday 26 April 2023 (chaired by JRO).

[JVET-AD0232](https://jvet-experts.org/doc_end_user/current_document.php?id=12796) HEVC Multiview Profiles: Implementation Status [S. Paluri, D. Podborksi, [A.Tourapis (Apple)](mailto:atourapis@apple.com)] [late]

This contribution aims to provide an update on the implementation status of the new HEVC Multiview profiles described in [JVET-AA0239](https://jvet-experts.org/doc_end_user/current_document.php?id=11929). An implementation in the HM reference software for the Multiview Main 10 profile is provided in this contribution. An implementation for the other Multiview profiles that are specified in [JVET-AA0239](https://jvet-experts.org/doc_end_user/current_document.php?id=11929) is still in progress.

No action to be taken at this moment.

It was commented that it might be good to have a complete implementation ready by the next meeting, as then the benefit of the new profiles could be assessed, work on conformance could be started. Potentially, the new profiles might be included in the next edition of H.265 which is planned for July 2023. For 23008-2, a new amendment would be necessary.

## Proposed modification of system interface (0)

This section is kept as a template for future use.

## General aspects of standards development and applications of standards (0)

This section is kept as a template for future use.

# Low-level tool technology proposals

## AHG11/AHG14: Neural network-based video coding (28)

### Summary, BoG reports, and information documents

Contributions in this area were discussed at 0910–1035 on Saturday 22 April 2023 (chaired by JRO).

[JVET-AD0022](https://jvet-experts.org/doc_end_user/current_document.php?id=12749) EE1: Summary report of exploration experiment on neural network-based video coding [E. Alshina, F. Galpin, Y. Li, D. Rusanovskyy, M. Santamaria, J. Ström, L. Wang, Z. Xie (EE coordinators)]

In this EE1 round ***NNVC common SW base*** (NNVC-4.0) ***was mandatory*** to be used for proposals modifying NNVC technologies already included into NNVC-4.0 (in-loop filters: filter set#0, filter set# 1, NN-based filter for super-resolution, NN-based Intra or NN-based post-filter). EE contributions code should be built on top of the official NNVC-4.0 tag when released. Due to significant delay in NNVC-4.0 release some tests are based on NNVC-3.0, but difference in performance of NNVC-3.0 and NNVC-4.0 (in absence of tools) is minor [1].

The most promising technologies recommended by JVET **will undergo a procedure of cross-check for the training**.

Tests will be conducted in two categories: enhancement in-loop filters and NN-based Inter coding.

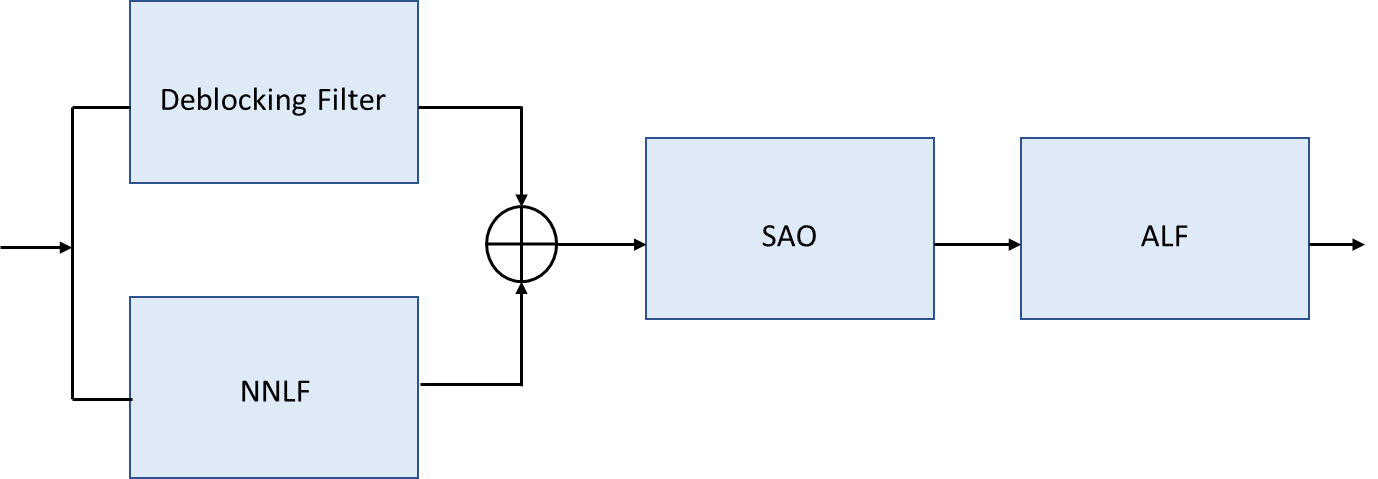
All proponents **must** report results relatively to the default configuration of the AhG11 anchor as specified by JVET-AC2016[2] and use the reported template recommended by AhG11.

Additional test results which can be produced with NNVC-4.0 (Table 1) can be included in EE1 report for informational purposes. Testing of NNVC-4.0 falls into the AhG14 scope. Configurations settings for the different variants can be found in JVET-AD0014. Performance – complexity trade-off for NNVC-4.0 tools is show on plots in excel and presentation attached to this contribution.Proponents are encouraged to report both CPU and GPU decoding run time, PSNR and MS-SSIM metrics.

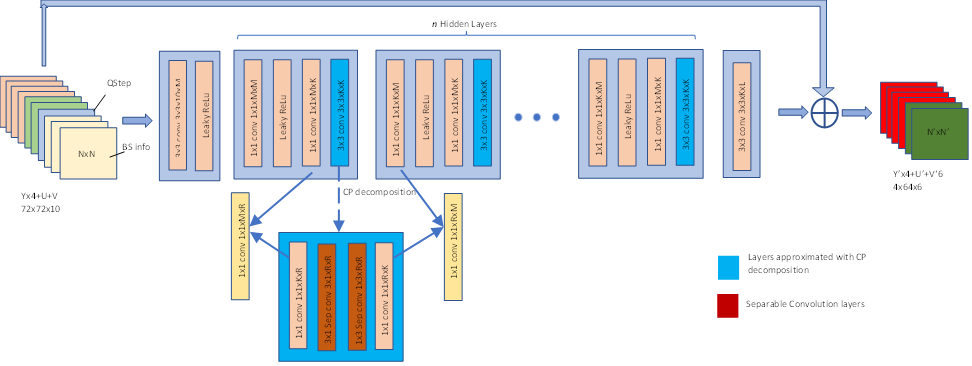
* **Exploration** experiments **on Enhancement filters**

***1.1*** [**JVET-AD0156**](https://jvet-experts.org/doc_end_user/current_document.php?id=12707) **EE1-1.1: Complexity Reduction on Neural-Network Loop Filter [**[**J. N. Shingala**](mailto:jay.shingala@ittiam.com)**, A. Shyam, A. Suneja, S. Badya (Ittiam),**[**T. Shao**](mailto:tshao@dolby.com)**, A. Arora,**[**P. Yin**](mailto:pyin@dolby.com)**, F. Pu, T. Lu, S. McCarthy (Dolby)]**

This test investigates the complexity reduction techniques on neural network-based loop filter originally proposed in JVET-AA0080 and JVET-AB0136, with the introduction of parallel fusion of deblocked samples and NNLF outputs for further improvement (Figure 1, a). Key elements of two variants of low complexity NN-based filter design are decomposition if 2D convolution (3x3) to the sequence of two 1D convolution (3x1 and 1x3) separable convolutions with same number of channels (R=K) coupled with linear fusion of adjacent 1x1 convolutions with increased number of channels (Figure 1, b).



(a)



(b)

**Figure 1** Diagram of **Test 1.1.1: (a)** parallel fusion of deblocked samples and NNLF outputs **(b)** CP Decomposition + fusion of 1x1 conv layers of JVET-X0140 Baseline Model

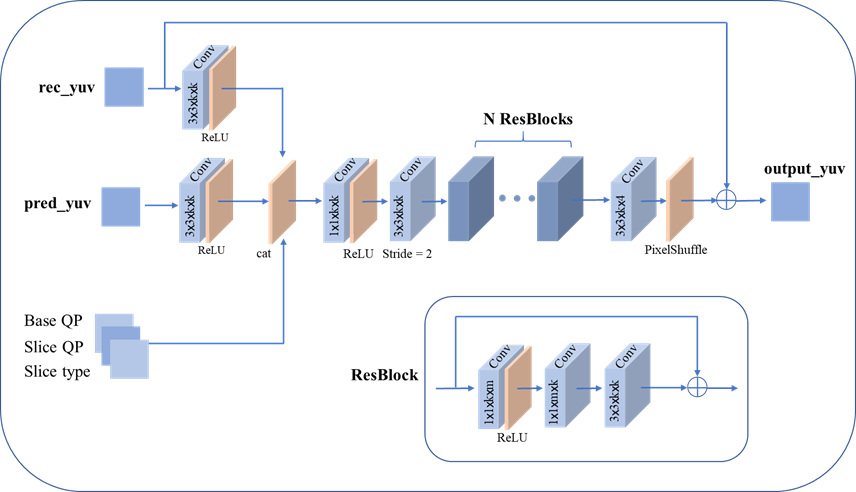
**Test 1.1.1:** Training cross-check. Test the model with CP decomposition and fusing adjacent 1x1 convolution with following model parameters:

* Number of hidden layers: n = 11
* Feature maps and rank: K = 24, R = 24, M = 72
* Model complexity = 16.2 kMAC/pixel

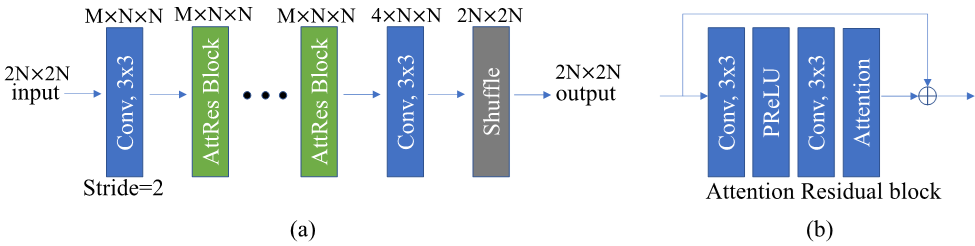
Key aspects: very low complexity (16kMAC/pxl) was achieved by decomposition of convolutions; 5.2% (int 16) gain RA cfg.

**1.2** [***JVET-AD0068***](https://jvet-experts.org/doc_end_user/current_document.php?id=12616) **EE1-1.2: On adjustment of residual for NNLF [Z. Dai, Y. Yu, H. Yu, D. Wang (OPPO)]**

This test evaluates the residual offset adjustment and combination with chroma order adjustment on top of both Filter Set #0 and Filter Set #1. A frame level residual offset can be used to adjust the output of the NNLF in the inference stage. More specifically, the residual is adjusted by reducing the magnitude of the residual at each pixel by a small offset value, and the offset candidates are {1, 2}. Also, a frame level chroma order adjustment method can be used to allow the input/output order switch between the U and V components of the neural network-based loop filters in the inference stage.

**

**Figure 3** Network architecture of Filter Set #0



**Figure 2** Network architecture of Filter Set #1

Tests to be studied in EE:

**Test 1.2.1:** Test the residual offset adjustment on top of Filter Set #0.

**Test 1.2.2:** Test the residual offset adjustment on top of Filter Set #1.

**Test 1.2.3:** Test the combination of residual offset and chroma order adjustment on top of Filter Set #0.

**Test 1.2.4:** Test the combination of residual offset and chroma order adjustment on top of Filter Set #1.

Key aspects: Content additivity provides 0.5% gain in LD-B cfg, decoder run time increment 10-15% (due to more frequent use of NN-based filter). Method efficient for both filter architectures in NNVC-4.0. Gain for RA and AI is minor.

***1.3*** [***JVET-AD0205***](https://jvet-experts.org/doc_end_user/current_document.php?id=12769) ***EE1-1.3: Reduced complexity CNN-based in-loop filtering [***[***S. Eadie***](mailto:seadie@qti.qualcomm.com)***,***[***Y. Li***](mailto:yli30@qti.qualcomm.com)***,***[***D. Rusanovskyy***](mailto:dmytror@qti.qualcomm.com)***,***[***M. Karczewicz (Qualcomm)***](mailto:martak@qti.qualcomm.com)***]***

This test studies CNN-based in-loop filtering method originally proposed in JVET-AB0164. Proposed NN ILF architecture combining design elements from filter sets #0 and #1 and incorporates multiple techniques of the complexity reduction. Simplified block diagram of the method combining studied techniques (sub-test 1.3.5b) is shown in Figure 3.

Diagram

Description automatically generated with medium confidence

**Figure 3** Network architecture of NN for combination test Test 1.3.5b

The following subtest comprising the EE1-1.3:

**EE1-1.3.1** reports the baseline performance of the original architecture (from JVET-AC0155) with NNVC-4.0 (K=64, M=160,

**EE1-1.3.2a** removes the redundant spatial processing of constant inputs (e.g. QP),

**EE1-1.3.2b** removes the partitioning input from the intra-frame models,

**EE1-1.3.3** unifies the intra- and inter-frame models for luma and chroma, respectively,

**EE1-1.3.5a** decomposes expensive 3x3 convolutions into separable 3x1 and 1x3 convolutions (R=0.8K),

**EE1-1.3.5b** proposes a model combining simplifications from these sub-tests.

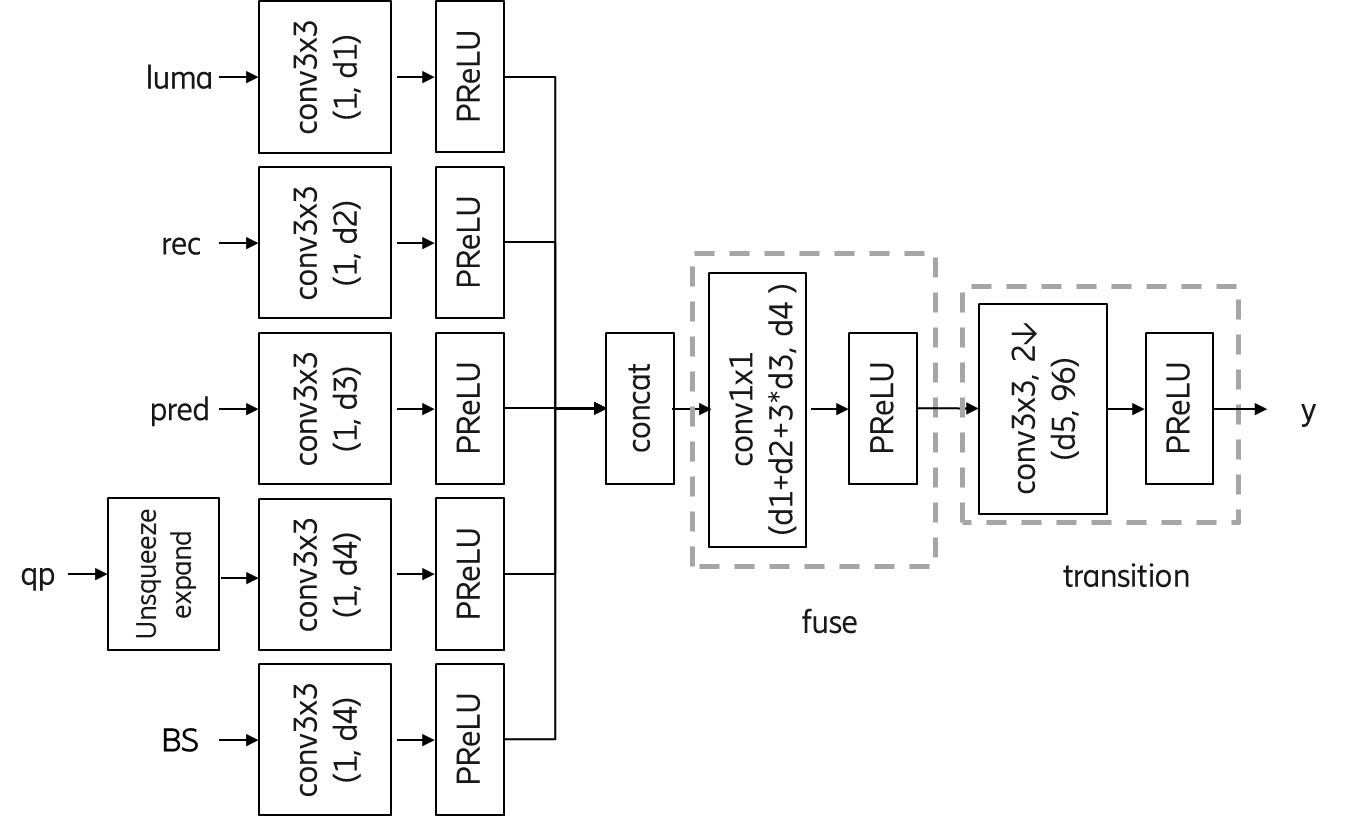
It is noted that sub-test EE1-1.3.5b features high penalty from model quantization. The problem of quantization error is reportedly addressed in the related contribution JVET-AD0207.

Key aspects: Proponents combine multiple ideas: starting from filter set#1 (separate Luma and Chroma filtering), add ”long-activation from filter set#0, removes partitioning information, unify intra-inter models; further simplify by decomposing 3×3 convolutions (like in EE1-1.1.1) and achieve 9.9% (9% with quantized model) luma gain (RA cfg) with 439 kMAC/pxl (34% reduction comparing to filter set #1). Further coding gain improvement w/o filter architecture change are reported in EE1-related contribution.

***1.4*** [**JVET-AD0168**](https://jvet-experts.org/doc_end_user/current_document.php?id=12719) ***EE1-1.4 Channel redistribution for luma and chroma [P. Wennersten, J. Ström, D. Liu (Ericsson)]***



(a)



(b)

**Figure 4** *Head of network: (a) luma, (b) chroma*

Original contribution JVET-AC0126 presented results on top of EE1-1.5 “Combined intra and inter models for luma and chroma” (JVET-AC0089). The basic idea is that some inputs are more important than others, and therefore an uneven distribution of channels for the different inputs is preferrable to having the same number of channels for every input. Furthermore, the number of channels in the first fuse layer is lowered. Taken together, these changes lowers the kMACs/pix by 9% with a penalty over EE1-1.5 of just 0.01% in RA.

Figure 4 shows the NN head architecture. Number of channels for luma and chroma networks tested in this EE1 are shown below.

Number of channels for luma network

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | d1 | d2 | d3 | d4 | kmacs/pixel | #parameters |
| Test EE1-1.4.1 | 192 | 24 | 12 | 48 | 480 | 1471k |
| Test EE1-1.4.2 | 192 | 16 | 8 | 48 | 478 | 1470k |
| Test EE1-1.4.3 | 128 | 16 | 8 | 64 | 481 | 1483k |
| **Filter set #1** | **96** | **96** | **96** | **96** | **538** | **1549k** |

Number of channels for chroma network

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | d1 | d2 | d3 | d4 | d5 | kmacs/pixel | #parameters |
| Test EE1-1.4.4 | 96 | 192 | 24 | 12 | 48 | 123 | 1482k |
| Test EE1-1.4.5 | 64 | 128 | 16 | 8 | 64 | 123 | 1492k |
| **Filter set #1** | **96** | **96** | **96** | **96** | **96** | **135** | **1555k** |

Key aspects: redistribution the number of channels in the head of NNLF allows reduction of computational complexity by ~10% with ~0.1% performance drop (filter set#1 architecture).

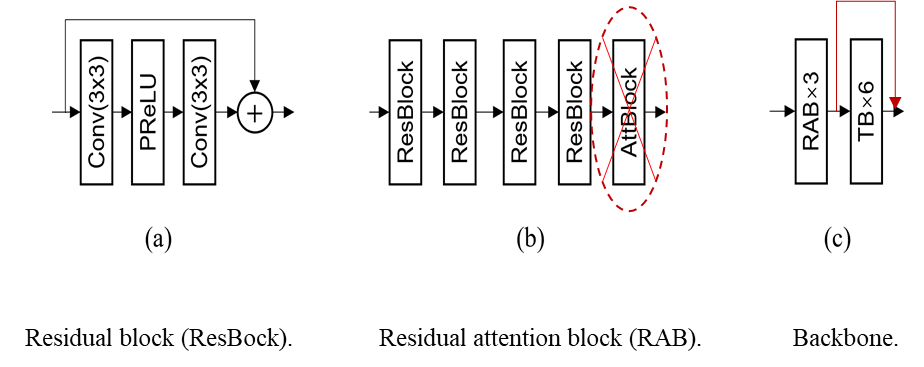
***1.5*** [**JVET-AD0226**](https://jvet-experts.org/doc_end_user/current_document.php?id=12790) **EE1-1.5: Ablation Study and Minor Improvements on RTNN [H. Zhang, C. Jung (Xidian Univ.), Y. Liu, M. Li (OPPO)]**

This test investigates the NN-based in-loop filtering method proposed in JVET-AC0156. The model explores the combination of residual attention block (RAB) and transformer block (TB) into a loop filter network, and introduces a new attention module to better refine features by introducing auxiliary information.

For EE1 study: possibility to implement in SADL, show gain of each individual element: transformer block, new attention mechanism. Basic elements of NNLF used in this test are illustrated on Figure 5 and Figure 6.



**Figure 5** Network architectures of the proposed RTNN network backbone. (a) Residual block. (b) Residual attention block (RAB). (c) Backbone. TB: Transformer block.



**Figure 6** Network architectures of the modified RTNN network backbone. (a) Residual block. (b) Residual attention block (RAB). (c) Backbone. TB: Transformer block.

Key aspects: transformers contribute ~1.2% gain (all intra cfg), many tests are not yet finished. Inference uses PyTorch and float models (would be interesting to see an effect of quantization).

***1.6*** [**JVET-AD0106**](https://jvet-experts.org/doc_end_user/current_document.php?id=12657) ***EE1-1.6: In-loop filter with wide activation and large receptive field [Y. Li, K. Zhang, L. Zhang (Bytedance), S. Eadie, Y. Li, D. Rusanovskyy, M. Karczewicz (Qualcomm)]***

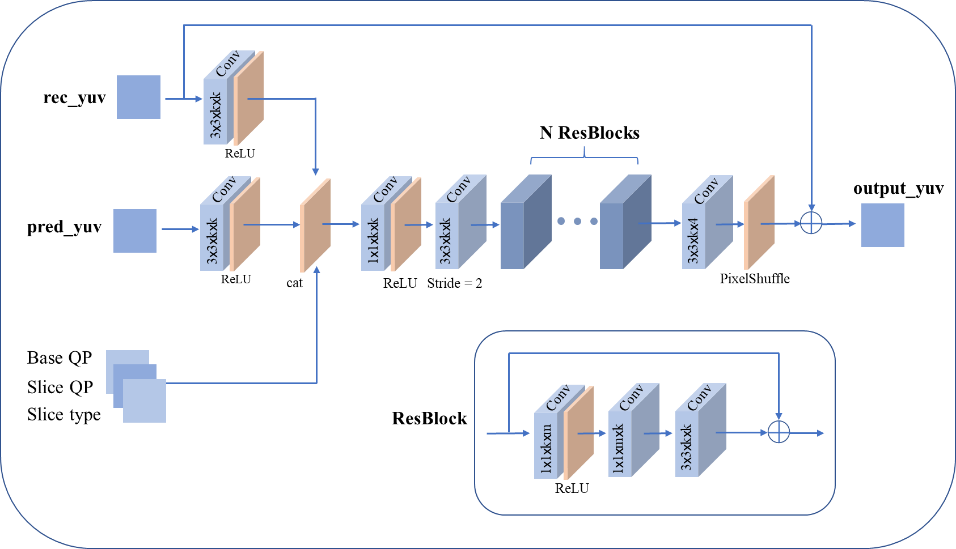
This test investigates the neural network-based in-loop filtering method proposed in JVET-AC0178. The deep in-loop filter is built based on basic residual blocks with wide activation and large receptive field as shown in Fig. 7. A unified model is designed to deal with both intra slices and inter slices. In addition, the chroma model is simplified by using a smaller number of feature maps and layers. Other designs of the proposed method such as parameter selection, residual scaling, combination with deblocking, etc. remain the same as the NN-based filter set #1 in NNVC-4.0. 

**Figure 7** Network architecture in EE1-1.6: wide activation and large receptive field

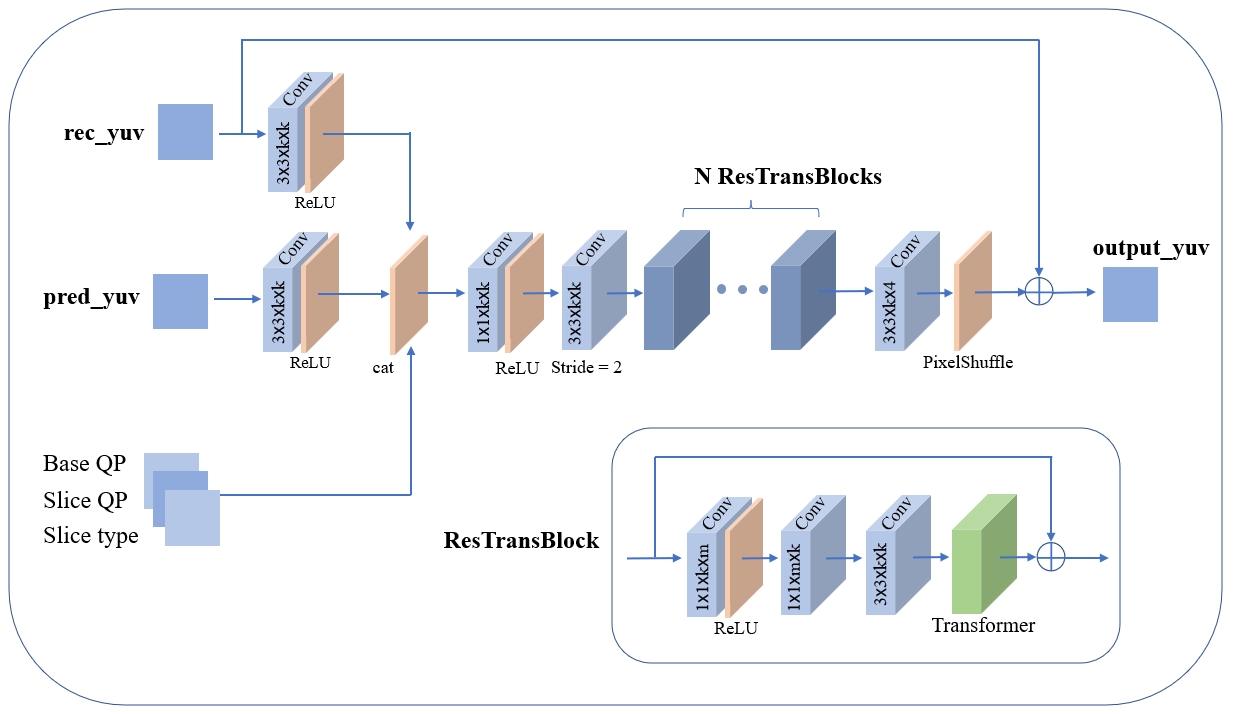
Key aspects: proponents combine the strengths of residual blocks in filter set #1 (large receptive field) and filter set #0 (wide activation), process intra and inter with unified model, aggressively simplify the chroma model. EE1-1.6.1 achieves 1.6% (RA), 3.0% (LDB), and 1.1% (all intra) better performance than current filter set#1 with 16% lower kMAC/pxl and 34% lower model memory (total params). EE1-1.6.2 takes BS as extra input for NNLF, providing additional 0.2% gain in RA, 0.1% gain in all-intra, and 0.2% loss in LDB.

***1.7*** [**JVET-AD0166**](https://jvet-experts.org/doc_end_user/current_document.php?id=12717) ***EE1-1.7: Optimization of training and network for NNVC filter set 0 [R. Chang, L. Wang, X. Xu, S. Liu (Tencent)]***

This contribution reports more refinements on NN based in-loop filter set#0. In Tests EE1-1.7a and EE1-1.7b filter architecture is preserved as in NNVC-4.0 (Figure 8), only training strategy was changed. In test EE1-1.7a training set is updated using recent scripts from NNVC-4.0, in test EE1-1.7b additional training data of I slices was added.



**Figure 8 Filter set#0 architecture**



**Figure 9 Filter set#0 architecture with transformer in residual block (EE1-1.7c)**

Key aspects: 0.6% (RA), 0.8% (LDB), and 0.4% (all intra) performance improvement for filter set#0 demonstrated with modified training strategy. Addition transformers to the residual block of filterset#0 improved performance further by {1.2%, 11.2%, 10.9%} for YUV under RA configuration with almost 14% lower kMAC/pxl and 16% lower model memory (total params). Test c is based on transformer network and is implemented in PyTorch in float.

***1.8*** [**JVET-AD0069**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0069-v1.zip) ***EE1-1.8: On flipping of input and output of model in NNVC filter set0 [Z. Xie, Y. Yu, H. Yu, D. Wang (OPPO)]***

Flipping operations applied to the inputs and output of the NNVC filter set 0 neural network are proposed to further improve the performance in this contribution. The input of filter set 0 includes reconstructed samples, prediction samples, BaseQP, SliceQP and SliceType. When a flipping operation is applied, only the reconstructed samples and prediction samples are flipped and fed into the network with the other inputs to perform the inference. Then the output of network is flipped back to restore the order of the filtered samples. Both horizontal and vertical flip can be applied to input and output of network. One slice-level flag is needed to indicate the usage of this flipping method, and if the flag is true, additional index is singled to indicate the flipping type. Fast encoder decision is proposed (Figure 10).

|  |  |
| --- | --- |
| CTU | CTU |

**Figure 10 Speed-up for encoder decision: left – CTUs used for encoder decision in previous design, right – CTUs used for encoder decision in this EE1 test.**

Key aspects: ~0.2% (RA), 0.4% (LDB) performance improvement for filter set#0 demonstrated with content adaptation with flipping, encoder run-time compared to anchor 102% (RA), 104% (LDB).

***1.9*** [**JVET-AD0070**](https://jvet-experts.org/doc_end_user/current_document.php?id=12618) ***EE1-1.9: Improvement over multi-frame model for NNVC filter set1 [***[***Z. Xie***](mailto:xiezhihuang@oppo.com)***,***[***Y. Yu***](mailto:yue.yu@oppo.com)***,***[***H. Yu***](mailto:v-yuhaoping@oppo.com)***,***[***D. Wang (OPPO)***](mailto:wangdong7@oppo.com)***]***

In JVET-AC0355, two aspects were proposed to further improve the coding efficiency for filter set#1.

In the first aspect, it is proposed that the original inter-intra luma model and the multiple frame-based model may be switched at the slice level for temporal layer slices with tid <= 2. For higher temporal layer slices, which is the same as nnvc-4.0 filter set#1, the multiple frame-based model remains used in B slices by default. A slice-level flag is signalled for lower temporal layer B slices to indicate which model is used. If the flag is true, all CTUs in the slice use the multiple frame-based model. Otherwise, all CTUs in the slice use the default inter-intra luma model.

In the second aspect, if the picture POC from RPL0 is equal to the picture POC from RPL1 and there are at least two reference pictures in RPL1, then the second reference picture is taken as Col\_1.



**Figure 11** Architecture of multiple frame-based CNN model which is used in test EE1-1.9.

Key aspects: ~1.4% (LDB) performance improvement for filter set#1 demonstrated with encoder run-time increment by 3%, no performance improvement in RA cfg.

* **Exploration** experiments **on NN-based inter coding**

***2.1*** [**JVET-AD0160**](https://jvet-experts.org/doc_end_user/current_document.php?id=12711) ***EE1-2.1: Deep Reference Frame Generation for Inter Prediction Enhancement [J. Jia, Y. Zhang, H. Zhu, Z. Chen (Wuhan Univ.), Z. Liu, X. Xu, S. Liu (Tencent)]***

This test investigates the neural network-based reference frame generation method proposed in JVET-AC0114. In this method, two reconstructed frames selected from DPB together with the corresponding QP maps are fed into the deep reference frame generation network to synthesize a new frame. The generated frame will be consequently inserted to both Reference List0 and List1 with the same POC of the current encoding frame as an alternative reference (Figure 12). Deep Reference Frame (DRF) network is used for pictures generation.



**Figure 12** Deep Reference Frame Generation for Inter Prediction Enhancement

Key aspects: ~4.3% (RA), 3.2% (LDB) gain over AhG11 anchor. Tests use PyTorch in float for inference.

* **Comments** from **cross-checks**

|  |  |  |  |
| --- | --- | --- | --- |
| Test | proposal | Cross-check | Comment |
| EE1-1.1 | [JVET-AD0156](https://jvet-experts.org/doc_end_user/current_document.php?id=12707) | [JVET-AD0250](https://jvet-experts.org/doc_end_user/current_document.php?id=12814)  Shao, Tong <Tong.Shao@dolby.com> | For EE1-1.1.1, intra networks have been trained and give a very close match.    Results over NNVC-4.0:                  AI: BDR -4.69% (Y) -5.92% (U) -5.70% (V)  Results over proponent’s:             AI: BDR -0.04% (Y) -0.06% (U) +0.27% (V)  For EE1-1.1.2, inter networks have been trained and also give a very close match.    Results over NNVC-4.0:                  AI: BDR -5.06% (Y) -7.34% (U) -7.25% (V)  Results over proponent’s:             AI: BDR -0.08% (Y) 0.15% (U) -0.24% (V)  Inference only. All classes complete. Results match proponent’s results. |
| EE1-1.2 | [JVET-AD0068](https://jvet-experts.org/doc_end_user/current_document.php?id=12616) | [JVET-AD0333](https://jvet-experts.org/doc_end_user/current_document.php?id=12897) R. Chang (Tencent) | There are 4 tests (only inference crosscheck) in EE1-1.2. All the test results can exactly match proponent's. |
| EE1-1.3 | [JVET-AD0205](https://jvet-experts.org/doc_end_user/current_document.php?id=12769) | JVET-AD0284  T. Shao (Dolby) | EE1-1.3.5b (int): inference results match, training completed. EE1-1.3.1 (int): inference results match, training completed.  Inference only. Class C and D complete. Partial results match proponent’s results. |
| EE1-1.4 | [JVET-AD0168](https://jvet-experts.org/doc_end_user/current_document.php?id=12719) | [JVET-AD0321](https://jvet-experts.org/doc_end_user/current_document.php?id=12885) T. Shao (Dolby) | Inference only. Class C and D complete. Partial results match proponent’s results. |
| EE1-1.5 | [JVET-AD0226](https://jvet-experts.org/doc_end_user/current_document.php?id=12790) | [JVET-AD0248](https://jvet-experts.org/doc_end_user/current_document.php?id=12812) | Minor differences which may be due to the usage of floating-point arithmetic and different hardware. |
| EE1-1.6 | [JVET-AD0106](https://jvet-experts.org/doc_end_user/current_document.php?id=12657) | JVET-AD0270  JVET-AD0282  T. Shao (Dolby) | EE1-1.6.1: training crosscheck finished. performance gap is 0.0x%  EE1-1.6.2: training crosscheck is in progress  JVET-AD0282: Inference cross-check completed, results match; partial training cross-check is ongoing.  Training and inference. Due to limited time and computing resource. I only performed and finished Intra training and AI inference. BD-Rate difference is less than 0.1%, Intra training/AI inference passes training crosscheck |
| EE1-1.7 | [JVET-AD0166](https://jvet-experts.org/doc_end_user/current_document.php?id=12717) | [JVET-AD0329](https://jvet-experts.org/doc_end_user/current_document.php?id=12893) Z. Xie  (OPPO) | * EE1-1.7.a (training crosscheck): the training is done and we get most of the inference results, so far only several QPs for RA are still running. Probably we can get full results of this test in one or two days.   The crosschecker's results over NNVC-4.0-EE1:   -7.69%(Y), -17.03%(U), -18.14%(V)  for AI.     x.xx% for RA.  The crosschecker's results over proponent's:      +0.02%(Y), -0.40%  (U), -0.13%  (V)  for AI.      x.xx% for RA.   * EE1-1.7.b (training crosscheck): the training process is close to the target epochs. After the training is completed, inference test will be launched immediately. Crosscheck results are expected during the meeting. * EE1-1.7.c (inference crosscheck): available partial results match proponent's. |
| EE1-1.8 | [JVET-AD0069](https://jvet-experts.org/doc_end_user/current_document.php?id=12617) | [JVET-AD0334](https://jvet-experts.org/doc_end_user/current_document.php?id=12898) R. Chang (Tencent) | 1.8.1: All the test results can exactly match.  1.8.2: Most of existing data can exactly match. |
| EE1-1.9 | [JVET-AD0070](https://jvet-experts.org/doc_end_user/current_document.php?id=12618) | [JVET-AD0340](https://jvet-experts.org/doc_end_user/current_document.php?id=12904) R. Chang (Tencent) | 1.9.1: All the test results can exactly match.  1.9.2: Most of existing data can exactly match. |
| EE1-2.1 | [JVET-AD0160](https://jvet-experts.org/doc_end_user/current_document.php?id=12711) | [JVET-AD0253](https://jvet-experts.org/doc_end_user/current_document.php?id=12817)  [JVET-AD0330](https://jvet-experts.org/doc_end_user/current_document.php?id=12894) | Minor performance deviation (likely due to float point arithmetic), decoder crash – issue reported to proponent, under clarification. |

* Recommendation
* In this round of EE1 two types of tests for NN-filter were conducted:
  + “**Architectural changes**” defines filter architecture:
    - Tests EE1-1.1, 1.3, 1.4, 1.5, 1.6, 1.7  - trade-off between complexity and performance
      * Decomposed convolution, large (wide) activation, redistribution for number of channels, different type of attention, transformers, residual block with enlarged receptive field....
    - “low operation point” ~5% gain vs VVC (RA), ~20 kMac/Pxl
    - “high operation point” ~10% gain vs VVC (RA), ~500 kMac/pxl
    - Recommendation: define default configuration of filter in NNVC, no more than 2: low and high operating point (BoG in needed)
  + **Content adaptivity design elements**” applicable to any filter architecture:
    - Tests EE1-1.2, 1.8, 1.9
      * flipping, swapping Chroma, offsets, extra input from different POC, RDO...
    - Main improvements in this EE round visible in LDB cfg (~0.5%)
    - Recommendation: Consider adoption for design elements applicable to any filter type independent from filter architecture change (can be added to NNV later, after default filter configuration is defined)
* Not NN-filter tests:
  + **NN-Inter**:
    - ~5% gain vs VVC (RA), ~900 kMac/Pxl
    - Inference successfully cross-checked, float point implementation
    - Recommendation: Continue investigation of NN-Inter, focusing on kMAC/pxl reduction.

Discussion in JVET how to proceed on loop filters:

* Goal to have at most two filter architectures at significantly different complexity/performance levels, high point with clearly reduced complexity relative to current sets 0/1; in future EEs, further optimizing the tradeoffs of both (low and high operation points) should be targeted.
* For the low-complexity point, EE1-1.1 (JVET-AD0156) is an obvious candidate for adoption, for the high-complexity point, further analysis is necessary.
* Optimally, this could be selected from the current EE results, or perhaps a combination if straightforward.
* In that case, adoption could be done conditionally upon successful re-training from scratch in the interim period (to be agreed in interim AHG meeting).
* If no agreement can be reached, or further tests are necessary (e.g., interesting non-EE ideas) the up-coming EE should be performed only on achieving that goal of unified solution(s), not considering “small” improvements of filter set 0/1 any more.

BoG (E. Alshina, F. Galpin) to work on analysing EE proposals

EE1-2 (generation of additional reference pictures): 4.3% gain. Continuation of EE, implementation in SADL (including integerization), further reduction of complexity, training crosscheck, combination with loop filter to investigate if the gain is retained.

### EE1 contributions: Neural network-based video coding (10)

Selected contributions in this area (as far as not covered in the EE summary report) were discussed at XXXX–XXXX on XXday 2X April 2023 (chaired by JRO).

For actions decided to be taken, see section 5.2.1, unless otherwise noted.

[JVET-AD0068](https://jvet-experts.org/doc_end_user/current_document.php?id=12616) EE1-1.2: On adjustment of residual for NNLF [Z. Dai, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AD0333](https://jvet-experts.org/doc_end_user/current_document.php?id=12897) Crosscheck of JVET-AD0068 (EE1-1.2: On adjustment of residual for NNLF) [R. Chang (Tencent)] [late]

[JVET-AD0069](https://jvet-experts.org/doc_end_user/current_document.php?id=12617) EE1-1.8: On flipping of input and output of model in NNVC filter set0 [Z. Xie, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AD0334](https://jvet-experts.org/doc_end_user/current_document.php?id=12898) Crosscheck of JVET-AD0069 (EE1-1.8: On flipping of input and output of model in NNVC filter set0) [R. Chang (Tencent)] [late]

[JVET-AD0070](https://jvet-experts.org/doc_end_user/current_document.php?id=12618) EE1-1.9: Improvement over multi-frame model for NNVC filter set1 [Z. Xie, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AD0340](https://jvet-experts.org/doc_end_user/current_document.php?id=12904) Crosscheck of JVET-AD0070 (EE1-1.9: Improvement over multi-frame model for NNVC filter set1) [R. Chang (Tencent)] [late]

[JVET-AD0106](https://jvet-experts.org/doc_end_user/current_document.php?id=12657) EE1-1.6: In-loop filter with wide activation and large receptive field [Y. Li, K. Zhang, L. Zhang (Bytedance), S. Eadie, Y. Li, D. Rusanovskyy, M. Karczewicz (Qualcomm)]

[JVET-AD0270](https://jvet-experts.org/doc_end_user/current_document.php?id=12834) Crosscheck of JVET-AD0106 (EE1-1.6: In-loop filter with wide activation and large receptive field) [C. Zhou (vivo)] [late]

[JVET-AD0282](https://jvet-experts.org/doc_end_user/current_document.php?id=12846) Crosscheck of EE1-1.6: In-loop filter with wide activation and large receptive field (JVET-AD0106) [Y. Li (Qualcomm)] [late]

[JVET-AD0322](https://jvet-experts.org/doc_end_user/current_document.php?id=12886) Crosscheck of JVET-AD0106 (EE1-1.6: In-loop filter with wide activation and large receptive field) [T. Shao (Dolby)] [late]

[JVET-AD0156](https://jvet-experts.org/doc_end_user/current_document.php?id=12707) EE1-1.1: Complexity Reduction on Neural-Network Loop Filter [J. N. Shingala, A. Shyam, A. Suneja, S. Badya (Ittiam), T. Shao, A. Arora, P. Yin, F. Pu, T. Lu, Sean McCarthy (Dolby)]

[JVET-AD0250](https://jvet-experts.org/doc_end_user/current_document.php?id=12814) Crosscheck of JVET-AD0156 (EE1-1.1: Complexity Reduction on Neural-Network Loop Filter) [J. Ström, M. Damghanian (Ericsson)] [late] [miss

[JVET-AD0160](https://jvet-experts.org/doc_end_user/current_document.php?id=12711) EE1-2.1: Deep Reference Frame Generation for Inter Prediction Enhancement [J. Jia, Y. Zhang, H. Zhu, Z. Chen (Wuhan Univ.), Z. Liu, X. Xu, S. Liu (Tencent)]

[JVET-AD0330](https://jvet-experts.org/doc_end_user/current_document.php?id=12894) Crosscheck of JVET-AD0160 (EE1-2.1: Deep Reference Frame Generation for Inter Prediction Enhancement) [Z. Xie (OPPO)] [late]

[JVET-AD0166](https://jvet-experts.org/doc_end_user/current_document.php?id=12717) EE1-1.7: Optimization of training and network for NNVC filter set 0 [R. Chang, L. Wang, X. Xu, S. Liu (Tencent)]

[JVET-AD0329](https://jvet-experts.org/doc_end_user/current_document.php?id=12893) Crosscheck of JVET-AD0166 (EE1-1.7: Optimization of training and network for NNVC filter set 0) [Z. Xie (OPPO)] [late]

[JVET-AD0168](https://jvet-experts.org/doc_end_user/current_document.php?id=12719) EE1-1.4 Channel redistribution for luma and chroma [P. Wennersten, J. Ström, D. Liu (Ericsson)]

[JVET-AD0321](https://jvet-experts.org/doc_end_user/current_document.php?id=12885) Crosscheck of JVET-AD0168 (EE1-1.4 Channel redistribution for luma and chroma) [T. Shao (Dolby)] [late]

[JVET-AD0205](https://jvet-experts.org/doc_end_user/current_document.php?id=12769) EE1-1.3: Reduced complexity CNN-based in-loop filtering [S. Eadie, Y. Li, D. Rusanovskyy, M. Karczewicz (Qualcomm)]

[JVET-AD0284](https://jvet-experts.org/doc_end_user/current_document.php?id=12848) Crosscheck of JVET-AD0205 (EE1-1.3: Reduced complexity CNN-based in-loop filtering) [Y. Li (Bytedance)] [late] [miss]

[JVET-AD0339](https://jvet-experts.org/doc_end_user/current_document.php?id=12903) Crosscheck of JVET-AD0205 (EE1-1.3: Reduced complexity CNN-based in-loop filtering) [T. Shao (Dolby)] [late]

[JVET-AD0226](https://jvet-experts.org/doc_end_user/current_document.php?id=12790) EE1-1.5: Ablation Study and Minor Improvements on RTNN [H. Zhang, C. Jung (Xidian Univ.), Y. Liu, M. Li (OPPO)]

[JVET-AD0248](https://jvet-experts.org/doc_end_user/current_document.php?id=12812) Cross-check of JVET-AD0226 (EE1-1.5: Ablation Study and Minor Improvements on RTNN) [M. Santamaria (Nokia)] [late]

### EE1 related contributions: Neural network-based video coding (11)

Contributions in this area were discussed at XXXX–XXXX on XXday 2X April 2023 (chaired by JRO).

[JVET-AD0107](https://jvet-experts.org/doc_end_user/current_document.php?id=12658) EE1-related: Simplified parameter selection for filter set #1 [Y. Li, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0346](https://jvet-experts.org/doc_end_user/current_document.php?id=12910) Crosscheck of JVET-AD0107 (EE1-related: Simplified parameter selection for filter set #1) [D. Liu (Ericsson)] [late]

[JVET-AD0157](https://jvet-experts.org/doc_end_user/current_document.php?id=12708) EE1-related: Neural-network loop filters in EE1-1.1.2 with further complexity reduction [T. Shao, A. Arora, P. Yin, F. Pu, T. Lu, Sean McCarthy (Dolby), J. N. Shingala, A. Shyam, A. Suneja, S. Badya (Ittiam)]

[JVET-AD0162](https://jvet-experts.org/doc_end_user/current_document.php?id=12713) EE1-2.1-related: DRF Model without QP Input [J. Jia, D. Ding, W. Meng, Z. Chen (Wuhan Univ.), Z. Liu, X. Xu, S. Liu (Tencent)]

TBP

[JVET-AD0253](https://jvet-experts.org/doc_end_user/current_document.php?id=12817) Crosscheck of JVET-AD0162 (EE1-2.1: Deep Reference Frame Generation for Inter Prediction Enhancement) [N. Giuliani, E. Alshina (Huawei)] [late]

[JVET-AD0167](https://jvet-experts.org/doc_end_user/current_document.php?id=12718) EE1-1.7-related: Combination test for NNVC based on filter set 0 [R. Chang, L. Wang, X. Xu, S. Liu (Tencent)]

[JVET-AD0366](https://jvet-experts.org/doc_end_user/current_document.php?id=12930) Crosscheck of JVET-AD0167 (EE1-1.7-related: Combination test for NNVC based on filter set 0) [Z. Xie (OPPO)] [late] [miss]

[JVET-AD0170](https://jvet-experts.org/doc_end_user/current_document.php?id=12721) EE1 related: Performance Improvement of AC0052 filter for RPR-based SR in RA configuration [S. Huang, C. Jung (Xidian Univ.), Y. Liu, M. Li (OPPO)]

TBP

[JVET-AD0189](https://jvet-experts.org/doc_end_user/current_document.php?id=12753) EE1-related: A simplified NN-based RDO model for filter set #1 [Y. Li, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0389](https://jvet-experts.org/doc_end_user/current_document.php?id=12953) Cross-check of JVET-AD0189: a simplified NN-based RDO model for Filter-Set #1 [T. Dumas (InterDigital)] [late]

[JVET-AD0207](https://jvet-experts.org/doc_end_user/current_document.php?id=12771) EE1-Related: Additional results for EE1-1.3.1 and EE1-1.3.5 [Y. Li, S. Eadie, D. Rusanovskyy, M. Karczewicz (Qualcomm)]

[JVET-AD0320](https://jvet-experts.org/doc_end_user/current_document.php?id=12884) Crosscheck of JVET-AD0207 (EE1-Related: Additional results for EE1-1.3.1 and EE1-1.3.5) [T. Shao (Dolby)] [late]

[JVET-AD0211](https://jvet-experts.org/doc_end_user/current_document.php?id=12775) EE1-Related: Combination test of EE1-1.3.5 and multi-scale component of EE1-1.6 [Y. Li, S. Eadie, D. Rusanovskyy, M. Karczewicz (Qualcomm)]

[JVET-AD0347](https://jvet-experts.org/doc_end_user/current_document.php?id=12911) Crosscheck of JVET-AD0211 (EE1-Related: Combination test of EE1-1.3.5 and multi-scale component of EE1-1.6) [D. Liu (Ericsson)] [late]

[JVET-AD0237](https://jvet-experts.org/doc_end_user/current_document.php?id=12801) EE1-related: Residue input for filter set #1 [Y. Li, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0377](https://jvet-experts.org/doc_end_user/current_document.php?id=12941) On unified NN filter design for NNVC high performance tier [Y. Li, J. Li, C. Lin, K. Zhang, L. Zhang (Bytedance), S. Eadie, Y. Li, D. Rusanovskyy, M. Karczewicz (Qualcomm)] [late]

[JVET-AD0379](https://jvet-experts.org/doc_end_user/current_document.php?id=12943) AHG11: Unified NNLF solution for high operation point [R. Chang, L. Wang, X. Xu, S. Liu (Tencent)] [late]

### Improvements of NNVC software beyond EE1 (7)

Contributions in this area were discussed at 1100–1250 on Saturday 22 April 2023 (chaired by JRO).

[JVET-AD0050](https://jvet-experts.org/doc_end_user/current_document.php?id=12597) AHG11/AHG14: Fix input QP for NN filter set #1 [D. Liu, J. Ström, K. Andersson (Ericsson)]

In the current NNVC-4.0 software, the input QP to the filter set #1 network uses the sequence QP for inter slices and the slice QP for intra slices. However, the NN models of filter set #1 general filter from JVET-AC0089 were trained in the opposite way. Therefore, this contribution proposes a fix for the input QP of the filter set #1 general filter, which is to use the slice QP for inter slices and the sequence QP for intra slices. The fix does not affect the AI results.

Fix over of NNVC-4.0 filter set #1

RA {-0.23%, 0.44%, 0.52%}, LDB { -0.92%, -0.62%, -0.73%}

Fix over of NNVC-4.0

RA {-9.81%, -20.57%, -21.06%}, LDB { -9.13%, -21.24%, -21.29%}

V2 updates the result excel sheets by using the new template from JVET-AC2016.

It is reported by the cross-checker that the results have been verified, No re-training is needed. Obvious bug fix of implementation, since the filter was trained as if the NN would use the QP input in this way..

Decision(SW/BF): Adopt JVET-AD0050

[JVET-AD0109](https://jvet-experts.org/doc_end_user/current_document.php?id=12660) AHG11: Neural network loop filter [R. Yang, M. Santamaria, N. Zou, F. Cricri, R. G. Youvalari, J. Lainema, H. Zhang, M. M. Hannuksela (Nokia)]

This document describes a multi-scale attention-based neural network loop filter. It is reported that the proposed NN-based loop filter achieves x.xx% (Y), x.xx% (Cb), x.xx% (Cr) BD-Rate gains compared to NNVC 3.0 in the RA configuration.

The proposed NN loop-filter is a multi-scale convolutional neural network (Figure 1) that includes Attention Splitting Blocks (ASB), described in Figure 2. Three scales are utilized.

Diagram, schematic

Description automatically generated

*Figure 1. NN architecture. ASB stands for Attention Splitting Block. The mid number of channels is 16.*

Diagram, schematic

Description automatically generated

*Figure 2. Architecture of an ASB.*

The input to the network is made of reconstructed samples, predicted samples, boundary strength, splitting signal computed as the average CU value, sequence QP, slice QP, slice type and temporal layer id.

*Table I. Network Information for NN-based Video Coding Tool Testing in Training Stage*

|  |  |  |
| --- | --- | --- |
| **Network Information in Training Stage** | | |
| Mandatory | GPU Type | Nvidia A100-SXM-80GB |
| Framework: | PyTorch v1.12.1 |
| Number of GPUs per Task | 1 |
|  |  |
| Epoch: | 60 |
| Batch size: | 128 |
| Loss function: | L1 |
| Training time (for 1 model): | 2d 4h |
| Training data information: | BVI-DVC & DIV2K |
| Training configurations for generating compressed training data (if different to VTM CTC): | 17, 19, 22, 27, 32, 37, 42 |
| Optional |  |  |
| Number of iterations |  |
| Patch size | 128x128 luma, 64x64 chroma  (random positions) |
| Learning rate: | 1,00E-03 |
| Learning rate update strategy | Every 10 epochs, the LR is drop by 0,1 |
| Optimizer: | ADAM |
| Preprocessing: | Top-left patch is not considered |
| Mini-batch selection process: |  |
| Training data update strategy: | None. Single stage training |
| Other information: |  |
|  |  |

*Table II. Network Information for NN-based Video Coding Tool Testing in Inference Stage*

|  |  |  |
| --- | --- | --- |
| **Network Information in Inference Stage** | | |
| Mandatory | HW environment: | |
| GPU Type | N/A |
| Framework: | LibTorch v1.12.1 CPU |
| Number of GPUs per Task | N/A |
|  |  |
| Number of Parameters (Each Model) | 164481 for luma model  166354 for chroma model |
| Total Number of Parameters (All Models) | 330835 |
| Parameter Precision (Bits) | Float 32 |
| Memory Parameter (MB) | 1,26203537 |
| Multiply Accumulate (kMAC/pixel) | Luma 169  Chroma 45 |
| Calculation Method | Block basis |
| Optional |  |  |
| Total Conv. Layers | 60 |
| Total FC Layers |  |
| Total Memory (MB) |  |
| Batch size: | 1 |
| Patch size | CTU |
| Changes to network configuration or weights required to generate rate points |  |
| Peak Memory Usage (Total) |  |
| Peak Memory Usage (per Model) |  |
| Border handling |  |
| Other information: |  |
|  |  |

*Table III. BD-rate over NNVC 3.0 in RA config (partial results)*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **BD-rate Over NNVC-3.0** | | | | | | | |  |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU | PSNR Overlap |
| Class A1 |  |  |  |  |  |  |  |  |  |
| Class A2 |  |  |  |  |  |  |  |  |  |
| Class B | -3,42 % | -14,57 % | -12,38 % | -3,00 % | -14,31 % | -12,58 % | 711 % | 96834 % | 99 % |
| Class C | -4,21 % | -14,04 % | -12,90 % | -2,84 % | -11,39 % | -10,54 % | 152 % | 89186 % | 99 % |
| Class E |  |  |  |  |  |  |  |  |  |
| **Overall** |  |  |  |  |  |  |  |  |  |
| Class D | -6,16 % | -14,78 % | -14,81 % | -3,09 % | -12,29 % | -10,25 % | 155 % | 85752 % | 99 % |
| Class F | -2,07 % | -9,75 % | -7,65 % | -1,46 % | -10,10 % | -8,68 % | 755 % | 51046 % | 99 % |
| Class H |  |  |  |  |  |  |  |  |  |

It was pointed out that quantization of the softmax operation would be necessary.

Complexity/performance-wise, this would be somewhat between the “low” and “high” architecture configurations that are intended to be defined.

Interest is expressed to study the multi-scale aspect further, also in context of other architectures, but would be premature for the EE after the current meeting.

[JVET-AD0111](https://jvet-experts.org/doc_end_user/current_document.php?id=12662) AHG14: Guidelines for NNVC reference software development [F. Galpin, S. Eadie, L. Wang, Z. Xie, Y. Li (software coordinators)]

This report establishes the common code development practices for the NNVC reference software.

Comments:

It was recommended to give more examples for providing dumper, training scripts, etc. It was also suggested to avoid usage of full data pathes in the command line.

It was suggested to point to the SADL guidelines that come with the SADL package rather than W0181.

It was requested to make such improvements and upload as a new version of JVET-AD0111.

It was agreed to be converted into an output document (could be JVET-AD2007)

[JVET-AD0163](https://jvet-experts.org/doc_end_user/current_document.php?id=12714) AHG11: Updating NNPFC and NNPFA SEI messages for the NNPF [M. Santamaria, M. M. Hannuksela, F. Cricri, R. Yang (Nokia)]

This document describes the usage of the most recent NNPFC and NNPFA SEI messages for the NNPF in NNVC 4.0. It is reported that the overall coding gains are -4.92% (Y), -18.36% (Cb), -16.67% (Cr) when all the NN tools are disabled.

It is proposed to update the NNVC software to match with the latest NNPFC and NNPFA SEI messages and the method of applying the base and updated filters as described in this document.

Updates to the implementation of the SEI messages according to latest state (more changes could occur at current meeting).

Model of filter was not changed – improvements due to further encoder optimization, and reduction of parameter signalling.

Training of models is not included in encoding time

It was reported that the base model (which is used to re-train on a per-sequence adaptation level) wsas one of the previous loop filter architecture from Qualcomm which was further generally fine-tuned (before re-training on sequence level). The Qualcomm model was never cross-checked, but the general fine-tuning (as well as sequence adaptive training) was cross-checked by Ericsson in the last meeting. This was agreed to be sufficient as a proof of concept.

Numbers are confirmed by cross-checker.

Decision(SW/align/encoder): Adopt JVET-AD0163

[JVET-AD0314](https://jvet-experts.org/doc_end_user/current_document.php?id=12878) Crosscheck of JVET-AD0163 (AHG11: Updating NNPFC and NNPFA SEI messages for the NNPF) [H. Zhang, C. Jung (Xidian Univ.), Y. Liu, M. Li (OPPO)] [late]

[JVET-AD0164](https://jvet-experts.org/doc_end_user/current_document.php?id=12715) AHG14: SADL v5 changes [F. Galpin, T. Dumas, P. Bordes, E. François (InterDigital)]

This contribution presents updates in the Small AdHoc Deep Learning (SADL) library. The update contains both some fixes and new features.

The new version better supports dynamic changes of networks, removes some constraints on conv2D as required by recent NN implementations, and various other improvements

Agreed to use as next version of SADL.

[JVET-AD0212](https://jvet-experts.org/doc_end_user/current_document.php?id=12776) AhG11: neural network-based intra prediction with reduced complexity [T. Dumas, F. Galpin, P. Bordes (InterDigital)] [late]

Initial version rejected as “placeholder”.

Following the 29th JVET meeting, 11-20 January 2023, three additional neural network-based coding tools have been integrated into VTM-11-NNVC [4]. Firstly, a content-adaptive post-filter takes reconstructed luma and chroma samples of a given reconstructed frame, along with the slice QP, to return a filtered version of these samples. This post-filter consists of four stacks of convolutional layers trained offline. At the encoder side, the multipliers of one of these stacks, which are the coefficients multiplying the result of a convolution before applying the non-linearity, are fine-tuned on the current video sequence. Then, the multipliers update, i.e. the difference between the initial multipliers and their fine-tuned version, are coded using Neural Network compression and Representation (NNR) and sent to the decoder. Second, two neural networks are used as upsamplers in RPR. For a given luma channel, its low-resolution reconstruction, its low-resolution prediction, the slice QP, and the base QP are fed into the first neural network, and the neural network output is added to the result of the RPR upsampling of the low-resolution reconstruction to obtain the high-resolution reconstruction. For a given pair of chroma channels, the neural network-based upsampling is almost identical to that in luma, but using the second neural network. Third, a neural network-based intra prediction mode is added to the set of intra prediction modes in VVC.

To limit the complexity of the neural network-based intra prediction mode, each neural network in this mode features a relatively small architecture and weight sparsity is enforced. However, the architecture and weight sparsity policy has not been tuned to each neural network yet. This contribution thus proposes a refined architecture and weight sparsity policy to reach a new tradeoff between mean BD-rate gains and complexity.

It is reported that, on top of VTM-11-NNVC-4, whereas the original neural network-based intra prediction mode yields -3.61%, -3.16%, -3.27% and -1.81%, -0.49%, -0.90% in AI and RA respectively for worst-case complexity of 7.8 kMACs/pixel, the neural network-based intra prediction mode with the refined policy yields -3.38%, -3.00%, -3.18% and -1.72%, -0.61%, -0.99% in AI and RA respectively for worst-case complexity of 4.8 kMACs/pixel.

Parameter memory is reduced from 5.6 MB to 4.9 MB.

It was asked if 4x4 is needed, as this still has highest number of kMAC/pixel.

Investigate in EE, including training crosscheck.

[JVET-AD0365](https://jvet-experts.org/doc_end_user/current_document.php?id=12929) AHG14: The extension of SADL library [W. Bao, D. Ding, J. Wang, J. Jia, Z. Chen (Wuhan Univ.)] [late]

This contribution presents extensions in the Small AdHoc Deep Learning (SADL) library version 3.0. Extended features include Conv2DTranspose, Slicing, and PReLU. New features include GridSample, ScatterND, and Resize (Bilinear Interpolation).

Some of the features are needed for SADL implementation of inter prediction (as planned for next EE). Currently only floating point, verified by comparing against PyTorch, no other packages. Would further be required to work on integer implementation.

Contribution highly welcome, to be coordinated with SADL coordinators (one merge request per feature) which parts are already mature to be integrated, and which parts require further improvements, which could likely be developed along with the ongoing EE.

### Other aspects of neural network-based video coding (0)

Contributions in this area were discussed at XXXX–XXXX on XXday 2X April 2023 (chaired by JRO).

## AHG6/AHG12: Enhanced compression beyond VVC capability (103)

### Summary and BoG reports

Contributions in this area were discussed at 1410–1950 on Friday 21 April 2023 (chaired by JRO).

[JVET-AD0023](https://jvet-experts.org/doc_end_user/current_document.php?id=12750) EE2: Summary report of exploration experiment on enhanced compression beyond VVC capability [V. Seregin, J. Chen, R. Chernyak, K. Naser, J. Ström, F. Wang, M. Winken, X. Xiu, K. Zhang (EE coordinators)]

This document provides a summary report of Exploration Experiment on Enhanced Compression beyond VVC capability. The tests are categorized as intra prediction, inter prediction, screen content coding, transform, and in-loop filtering.

The software basis for this EE is ECM-8.0, released at <https://vcgit.hhi.fraunhofer.de/ecm/ECM/-/tags/ECM-8.0>. ECM-8.0 is used as an anchor in the tests.

Software for EE tests is released in the corresponding branches at <https://vcgit.hhi.fraunhofer.de/ecm/jvet-ac-ee2/ECM/-/branches>.

Test results can be found in input JVET contributions, cross-check results are uploaded to <https://vcgit.hhi.fraunhofer.de/ecm/jvet-ac-ee2/simulation-results> if cross-check reports are not submitted as they are optional for EE tests.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Tests** | **Tester** | **Cross-checker** |
| **1 Intra prediction** | | | |
| 1.1 | Extends the CCCM template selection to six | InterDigital  P. Bordes  [JVET-AD0147](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0147-v1.zip) | Kwai  H.-J. Jhu |
| 1.2 | CCCM using multiple downsampling filters | Qualcomm  Y.-J. Chang  [JVET-AD0202](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0202-v1.zip) | Nokia  J. Lainema |
| 1.3a | MM-CCLM/MM-CCCM filtering with neighbouring samples | Bytedance  K. Zhang  [JVET-AD0120](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0120-v1.zip) | vivo  Z. Lv |
| 1.3b | Cross-component prediction usage is determined by template cost | Bytedance  K. Zhang  [JVET-AD0120](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0120-v1.zip) | vivo  Z. Lv |
| 1.3c | Cross-component prediction signalling modification | Bytedance  K. Zhang  [JVET-AD0120](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0120-v1.zip) | vivo  Z. Lv |
| 1.3d | Test 1.3a + Test 1.3b + Test 1.3c | Bytedance  K. Zhang  [JVET-AD0120](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0120-v1.zip) | vivo  Z. Lv |
| 1.4a | Non-adjacent cross-component prediction | Bytedance  K. Zhang | withdrawn |
| 1.4b | History-based cross-component prediction | Bytedance  K. Zhang | withdrawn |
| 1.4c | Test 1.4a + Test 1.4b | Bytedance  K. Zhang | withdrawn |
| 1.5 | Inherit cross-component prediction model from neighbours | MediaTek  C.-M. Tsai | withdrawn |
| 1.6a | Cross-component prediction merge list includes spatial adjacent, non-adjacent, and default candidates | MediaTek  C.-M. Tsai  Bytedance  K. Zhang  [JVET-AD0188](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0188-v1.zip) | Kwai  C.-W. Kuo |
| 1.6b | Cross-component prediction merge list includes spatial adjacent, history-based, and default candidates | MediaTek  C.-M. Tsai  Bytedance  K. Zhang  [JVET-AD0188](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0188-v1.zip) | Qualcomm  Y.-J. Chang |
| 1.6c | Cross-component prediction merge list includes spatial adjacent, non-adjacent, history-based, and default candidates | MediaTek  C.-M. Tsai  Bytedance  K. Zhang  [JVET-AD0188](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0188-v1.zip) | Alibaba  J. Chen |
| 1.7 | TIMD using selectable template regions | Sharp Y. Yasugi  [JVET-AD0103](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0103-v1.zip) | Qualcomm  H. Wang |
| 1.8a | HLS tool control with encoder optimization for IBC for camera captured content | Qualcomm  B. Ray  [JVET-AD0208](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0208-v1.zip) | KDDI  Y. Kidani |
| 1.8b | Test 1.8a + fractional pel BV | Qualcomm  B. Ray | withdrawn |
| 1.8c | Test 1.8a + fractional pel IBC | Qualcomm  C.-C. Chen  Kwai  W. Chen  [JVET-AD0208](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0208-v1.zip) | KDDI  Y. Kidani |
| 1.9a | Fractional pel IBC | Kwai  W. Chen | withdrawn |
| 1.9b | Test 1.9a (fractional pel IBC) + Test 1.8a | Kwai  W. Chen  Qualcomm  B. Ray | withdrawn |
| 1.10a | Multi-candidate IntraTMP without search procedure change | OPPO  F. Wang  [JVET-AD0073](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0073-v1.zip) | Qualcomm  P.-H. Lin  JVET-AD0327 |
| 1.10b | Multi-candidate IntraTMP with search procedure change | OPPO  F. Wang  [JVET-AD0073](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0073-v1.zip) | Qualcomm  P.-H. Lin  JVET-AD0327 |
| 1.11a | Intra template-matching prediction fusion | OPPO  L. Zhang  [JVET-AD0072](https://jvet-experts.org/doc_end_user/current_document.php?id=12620) | Dolby  F. Pu  JVET-AD0309 |
| 1.11b | Intra template-matching prediction fusion with no change to the IntraTMP search procedure | OPPO  L. Zhang  [JVET-AD0072](https://jvet-experts.org/doc_end_user/current_document.php?id=12620) | Dolby  F. Pu  JVET-AD0309 |
| 1.11c | Intra template-matching prediction fusion with different number of candidates | OPPO  L. Zhang  [JVET-AD0072](https://jvet-experts.org/doc_end_user/current_document.php?id=12620) | Dolby  F. Pu  JVET-AD0309 |
| 1.12 | IntraTMP with sub-pel precision | Alibaba  X. Li  [JVET-AD0125](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0125-v1.zip) | Dolby  F. Pu |
| 1.13 | Fusion of intra template matching | Ittiam  J. R. Arumugam    Dolby  F. Pu  [JVET-AD0158](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0158-v1.zip) | OPPO  F. Wang  Alibaba  X. Li |
| 1.14a | Extended the adjacent search area of IntraTMP | Xidian Univ.  Y. Ma  H. Du  [JVET-AD0115](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0115-v1.zip) | Alibaba  X. Li |
| 1.14b | Enlarged the search range for small blocks | OPPO  F. Wang  [JVET-AD0074](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0074-v1.zip) |  |
| 1.14c | Test 1.14a + Test 1.14b | Xidian Univ.  Y. Ma  H. Du  OPPO  F. Wang  [JVET-AD0075](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0075-v1.zip) |  |
| 1.15a | Intra template matching based on linear filter model | Xidian Univ.  J. Huo  W. Qiao  [JVET-AD0112](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0112-v1.zip) | Alibaba  X. Li |
| 1.15b | Filtered template matching based intra prediction | Nokia  R. Youvalari  [JVET-AD0099](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0099-v1.zip) | Alibaba  X. Li |
| 1.15c | Test 1.15a+Test 1.15b | Xidian Univ.  J. Huo  W. Qiao  Nokia  R. Youvalari | withdrawn |
| 1.16 | IntraTMP fusion with multiple reference blocks | Xidian Univ.  J. Huo  H. Du  [JVET-AD0116](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0116-v1.zip) | Alibaba  X. Li |
| 1.17 | IntraTMP fusion with intra prediction | Bytedance  Y. Wang  [JVET-AD0092](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0092-v1.zip) | Ericsson  R. Yu  [JVET-AD0305](https://jvet-experts.org/doc_end_user/current_document.php?id=12869) |
| 1.18 | CIIP extension with IntraTMP | InterDigital K. Naser  [JVET-AD0177](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0177-v1.zip) | OPPO F. Wang  [JVET-AD0259](https://jvet-experts.org/doc_end_user/current_document.php?id=12823) |
| 1.19a | IntraTMP left and above template modes | Qualcomm  P.-H. Lin  [JVET-AD0194](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0194-v1.zip) | OPPO  F. Wang  JVET-AD0263 |
| 1.19b | IntraTMP L-shape fusion mode | Qualcomm  P.-H. Lin  [JVET-AD0194](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0194-v1.zip) | OPPO  F. Wang  JVET-AD0263 |
| 1.19c | Test 1.19a + Test 1.19b | Qualcomm  P.-H. Lin  [JVET-AD0194](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0194-v1.zip) | OPPO  F. Wang  JVET-AD0263 |
| 1.20a | Test 1.10 + Test 1.11 | OPPO  F. Wang  [JVET-AD0076](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0076-v1.zip) | Qualcomm  P.-H. Lin  JVET-AD0328 |
| 1.20b | Test 1.10 + Test 1.11 + Test 1.14 | OPPO  F. Wang  [JVET-AD0076](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0076-v1.zip) | Qualcomm  P.-H. Lin  JVET-AD0328 |
| 1.20c | Test 1.14 + Test 1.19 | Qualcomm  P.-H. Lin  Xidian Univ.  J. Huo  OPPO  F. Wang  [JVET-AD0198](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0198-v1.zip) | Kwai  H.-J. Jhu  JVET-AD0279 |
| 1.20d | Test 1.10 + Test 1.12 + Test 1.14 + Test 1.15 + Test 1.19 | Qualcomm  P.-H. Lin  Xidian Univ.  J. Huo  OPPO  F. Wang  Alibaba  X. Li | withdrawn |
| 1.20e | Test 1.13 + Test 1.10 | Ittiam  J. R. Arumugam  OPPO  F. Wang  [JVET-AD0191](https://jvet-experts.org/doc_end_user/current_document.php?id=12755) | Alibaba  X. Li |
| 1.20f | Test 1.13 + Test 1.12 | Dolby  F. Pu  Alibaba  X. Li  [JVET-AD0192](https://jvet-experts.org/doc_end_user/current_document.php?id=12756) | OPPO  F. Wang |
| 1.20g | Test 1.13 + Test 1.17 | Dolby  F. Pu  Bytedance  Y. Wang | withdrawn |
| 1.20h | Test 1.14 + Test 1.15 + Test 1.16 | Xidian Univ.  Y. Ma  H. Zhang  [JVET-AD0118](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0118-v1.zip) | Alibaba  X. Li |
| 1.20i | Test 1.10 + Test 1.11 + Test 1.12 + Test 1.15 + Test 1.16 + Test 1.19 + Test 1.14a | OPPO  F. Wang  Xidian Univ.  Y. Ma  H. Zhang  Qualcomm  P.-H. Lin  Alibaba  X. Li  [JVET-AD0086](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0086-v2.zip) | Google  X. Li  JVET-AD0254 |
| 1.20j | Test 1.10 + Test 1.11 + Test 1.12 + Test 1.15 + Test 1.16 + Test 1.19 + Test 1.14c | OPPO  F. Wang  Xidian Univ.  Y. Ma  H. Zhang  Qualcomm  P.-H. Lin  Alibaba  X. Li  [JVET-AD0086](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0086-v2.zip) | Google  X. Li  JVET-AD0254 |
| 1.20k | Test 1.12 + Test 1.14c | Alibaba  X. Li  Xidian Univ.  Y. Ma  OPPO  F. Wang  [JVET-AD0126](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0126-v1.zip) | Dolby  F. Pu |
| 1.20m | Test 1.17 + Test 1.18 | Bytedance  Y. Wang  InterDigital K. Naser  [JVET-AD0119](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0119-v1.zip) | OPPO  F. Wang  [JVET-AD0260](https://jvet-experts.org/doc_end_user/current_document.php?id=12824) |
| 1.20n | Test 1.20f + Test 1.14c | Dolby  F. Pu  Alibaba  X. Li  JVET-AD0247 | Nokia  R. Youvalari |
| 1.21a | Checking more neighbouring positions with intra prediction modes replacement by partitioning angles for SGPM/GPM | OPPO  L.Xu  [JVET-AD0071](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0071-v1.zip) |  |
| 1.21b | Angular modes extension from 65 to 129 for TMRL | OPPO  L. Xu  [JVET-AD0071](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0071-v1.zip) |  |
| 1.21c | Test 1.21a + Test 1.21b | OPPO  L. Xu  [JVET-AD0071](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0071-v1.zip) |  |
| 1.22 | Template-based intra MPM list construction | vivo  C. Zhou  [JVET-AD0173](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0173-v1.zip) | Alibaba  J. Chen |
| 1.23 | Modification to MPM list derivation | Qualcomm  H. Wang  [JVET-AD0190](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0190-v1.zip) | Sharp Y. Yasugi |
| 1.24a | Test 1.21 + Test 1.22 | OPPO  L. Xu  vivo  C. Zhou  [JVET-AD0085](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0085-v1.zip) | Bytedance  Z. Deng |
| 1.24b | Test 1.21 + Test 1.23 | OPPO  L. Xu  Qualcomm  H. Wang  [JVET-AD0085](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0085-v1.zip) |  |
| 1.24c | Test 1.22 + Test 1.23 | vivo  C. Zhou  Qualcomm  H. Wang  [JVET-AD0085](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0085-v1.zip) |  |
| 1.24d | Test 1.21 + Test 1.22 + Test 1.23 | OPPO  L. Xu  vivo  C. Zhou  Qualcomm  H. Wang  [JVET-AD0085](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0085-v1.zip) | Sharp Y. Yasugi |
| 1.25 | Filtered template matching based intra prediction | Nokia  R. Youvalari | duplicate of 1.15b |
| **2** **Inter prediction** | | | |
| 2.1a | Step 1 of CPMV refinement with simplification | Xiaomi  M. Blestel  Qualcomm  Y. Zhang  [JVET-AD0182](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0182-v1.zip) | InterDigital  F. Le Léannec |
| 2.1b | Step 2 of CPMV refinement with simplification | Xiaomi  M. Blestel  Qualcomm  Y. Zhang  [JVET-AD0182](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0182-v1.zip) | InterDigital  F. Le Léannec |
| 2.1c | Adaptive DMVR for affine merge + affine DMVR for affine MMVD | Qualcomm  Y. Zhang  [JVET-AD0182](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0182-v1.zip) | Kwai  W. Chen |
| 2.1d | Affine parameter refinement | Alibaba  J. Chen  Xiaomi  M. Blestel  [JVET-AD0182](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0182-v1.zip) | MediaTek  C.-M. Tsai |
| 2.1e | Affine parameter refinement with simplification | Alibaba  J. Chen    Xiaomi  M. Blestel  [JVET-AD0182](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0182-v1.zip) | MediaTek  C.-M. Tsai |
| 2.1f | Test 2.1a + Test 2.1b | Xiaomi  M. Blestel  Qualcomm  Y. Zhang | withdrawn |
| 2.1g | Test 2.1a + Test 2.1c | Qualcomm  Y. Zhang  Xiaomi  M. Blestel | withdrawn |
| 2.1h | Test 2.1b+ Test 2.1c | Qualcomm  Y. Zhang  Xiaomi  M. Blestel | withdrawn |
| 2.1i | Test 2.1c+ Test 2.1f | Qualcomm  Y. Zhang  Xiaomi  M. Blestel | withdrawn |
| 2.1j | Test2.1d + Test 2.1a | Alibaba  J. Chen    Xiaomi  M. Blestel    Qualcomm  Y. Zhang | withdrawn |
| 2.1k | Test 2.1d + Test 2.1f | Alibaba  J. Chen    Xiaomi  M. Blestel    Qualcomm  Y. Zhang  [JVET-AD0182](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0182-v1.zip) | InterDigital  F. Le Léannec |
| 2.1l | Test 2.1d + Test 2.1c | Alibaba  J. Chen    Qualcomm  Y. Zhang  Xiaomi  M. Blestel  [JVET-AD0182](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0182-v1.zip) | ByteDance  L. Zhao |
| 2.1m | Test 2.1d + Test 2.1i | Alibaba  J. Chen    Qualcomm  Y. Zhang    Xiaomi  M. Blestel | withdrawn |
| 2.2 | AMVP with SbTMVP mode | Alibaba  R.-L. Liao  [JVET-AD0152](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0152-v1.zip) | Ofinno  V. Rufitskiy |
| 2.3a | SbTMVP with MMVD | Tencent L.-F. Chen  [JVET-AD0209](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0209-v1.zip) | Kwai  X. Xiu |
| 2.3b | SbTMVP with MMVD by using TM-based reordering | Tencent L.-F. Chen  [JVET-AD0209](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0209-v1.zip) | Kwai  X. Xiu |
| 2.4 | Template matching-based subblock motion refinement | Bytedance  L. Zhao  [JVET-AD0165](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0165-v1.zip) | Alibaba  R.-L. Liao |
| 2.5a | Test 2.2 + Test 2.4 | Alibaba  R.-L. Liao  Bytedance  L. Zhao  [JVET-AD0153](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0153-v1.zip) | Canon  G. Laroche |
| 2.5b | Test 2.2 + Test 2.3 | Alibaba  R.-L. Liao  Tencent  L.-F. Chen  [JVET-AD0210](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0210-v2.zip) | Google  X. Li |
| 2.6 | High precision MV refinement for BDOF | Bytedance  M. Salehifar  [JVET-AD0195](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0195-v1.zip) |  |
| 2.7a | LIC for bi-prediction | Kwai  X. Xiu  [JVET-AD0213](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0213-v1.zip) | Tencent  L.-F. Chen |
| 2.7b | Test2.7a + OBMC with LIC | Kwai  X.Xiu  [JVET-AD0213](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0213-v1.zip) | Tencent  L-F. Chen |
| 2.8a | OBMC flag inheritance in merge mode | Qualcomm  K. Cui | withdrawn |
| 2.8b | OBMC flag is signalled only for affine block without MHP | Qualcomm  K. Cui | withdrawn |
| 2.9a | OBMC boundary level decision based on prediction samples, keeping the existing CU level OBMC on/off flag | Google  X. Li | withdrawn |
| 2.9b | OBMC boundary level decision based on prediction samples, without the existing CU level OBMC on/off flag | Google  X. Li | withdrawn |
| 2.9c | OBMC boundary level decision based on reference samples, keeping the existing CU level OBMC on/off flag | Google  X. Li | withdrawn |
| 2.9d | OBMC boundary level decision based on reference samples, without the existing CU level OBMC on/off flag | Google  X. Li | withdrawn |
| 2.10a | OBMC on/off decision based on prediction samples and neighbouring information | Bytedance  Z. Deng | withdrawn |
| 2.10b | Using reference samples rather than prediction samples for OBMC on/off decision | Bytedance  Z. Deng | withdrawn |
| 2.11a | OBMC on/off decision at CU level and boundary level based on prediction samples and neighbouring information, with existing CU level OBMC on/off flag | Google  X. Li  Bytedance  Z. Deng | withdrawn |
| 2.11b | OBMC on/off decision at CU level and boundary level based on prediction samples and neighbouring information, without existing CU level OBMC on/off flag | Google  X. Li  Bytedance  Z. Deng | withdrawn |
| 2.11c | OBMC on/off decision at CU level and boundary level based on reference samples, with existing CU level OBMC on/off flag | Google  X. Li  Bytedance  Z. Deng | withdrawn |
| 2.11d | OBMC on/off decision at CU level and boundary level based on reference samples, without existing CU level OBMC on/off flag | Google  X. Li  Bytedance  Z. Deng | withdrawn |
| 2.11e | Adaptive OBMC control | Qualcomm  K. Cui  Google  X. Li  Bytedance  Z. Deng  [JVET-AD0193](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0193-v1.zip) | Kwai  X. Xiu  OPPO  J. Gan |
| 2.12a | Prediction of MVD magnitude suffix bins (up to 6 bins for blocks with width and height larger than 4, and up to 2 bins otherwise) | Ofinno  A. Filippov  [JVET-AD0140](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0140-v1.zip) | Xiaomi  M. Blestel |
| 2.12b | Prediction of MVD magnitude suffix bins (up to 6 bins for blocks with width and height larger than 4, and up to 4 bins otherwise) | Ofinno  A. Filippov | withdrawn |
| 2.12c | Prediction of MVD magnitude suffix bins (up to 6 bins per block) | Ofinno  V. Rufitskiy | withdrawn |
| 2.12d | Prediction of MVD magnitude suffix bins (up to 8 bins for blocks with width and height larger than 4, and up to 4 bins otherwise) | Ofinno  V. Rufitskiy | withdrawn |
| 2.12e | Prediction of MVD magnitude suffix bins (up to 8 bins for blocks with width and height larger than 4, and up to 6 bins otherwise) | Ofinno  V. Rufitskiy | withdrawn |
| 2.12f | Tool-off test for MVD sign prediction as implemented in ECM | Ofinno  V. Rufitskiy  [JVET-AD0140](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0140-v1.zip) | Xiaomi  M. Blestel |
| 2.12g | Test 2.2 + Test 2.12 | Ofinno  V. Rufitskiy  Alibaba  R.-L. Liao  [JVET-AD0256](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0256-v1.zip) | Xiaomi  M. Blestel |
| 2.12h | Test 2.7 + Test 2.12 | Ofinno  A. Filippov  Kwai  X. Xiu  [JVET-AD0257](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0257-v1.zip) | Xiaomi  M. Blestel |
| **3 Screen content coding** | | | |
| 3.1 | IntraTMP using reconstruction-reordered for screen content coding | Ofinno  D. Ruiz Coll  [JVET-AD0171](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0171-v1.zip) |  |
| 3.2a | IBC MBVD list derivation with max BVD offset 128-pel | Qualcomm  Z. Zhang  [JVET-AD0199](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0199-v1.zip) | Ofinno  D. Ruiz Coll |
| 3.2b | IBC MBVD list derivation with max BVD offset 256-pel | Qualcomm  Z. Zhang  [JVET-AD0199](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0199-v1.zip) | Ofinno  D. Ruiz Coll |
| 3.3 | Temporal block vector prediction | Bytedance  N. Zhang  [JVET-AD0095](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0095-v1.zip) | Qualcomm  Z. Zhang |
| 3.4a | Copy-padding for IBC | Bytedance  N. Zhang  [JVET-AD0096](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0096-v1.zip) | Hanbat National University  H. Han  [JVET-AD0139](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0139-v1.zip)  Qualcomm  Z. Zhang |
| 3.4b | Test 3.4a + Test 3.3 | Bytedance  N. Zhang  [JVET-AD0096](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0096-v1.zip) | Qualcomm  Z. Zhang |
| 3.5 | Template matching for IBC BVD suffix derivation | Qualcomm  P. Nikitin | withdrawn |
| 3.6 | IBC-CIIP with adaptive weights | Kwai  C. Ma | withdrawn |
| 3.7a | Test 3.2 + Test 3.4b | Bytedance  N. Zhang  Qualcomm  Z. Zhang  [JVET-AD0097](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0097-v1.zip) | MediaTek  C.-M. Tsai |
| 3.7b | Test 3.2b + Test 3.4b | Bytedance  N. Zhang  Qualcomm  Z. Zhang  [JVET-AD0097](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0097-v1.zip) | MediaTek  C.-M. Tsai |
| **4 In-loop filtering** | | | |
| 4.1 | Additional fixed and signalled filters for ALF | Bytedance  W. Yin  [JVET-AD0221](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0221-v1.zip) | Qualcomm  N. Hu |
| 4.2 | ALF classifier based on residual data | Qualcomm  I. Jumakulyyev  [JVET-AD0219](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0219-v1.zip) | BytedanceW. Yin |
| 4.3 | ALF filter shape with more taps applied to fixed filter results | Qualcomm  I. Jumakulyyev  [JVET-AD0219](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0219-v1.zip) | BytedanceW. Yin |
| 4.4a | Test 4.2 + Test 4.3 | Qualcomm  I. Jumakulyyev  [JVET-AD0219](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0219-v1.zip) | BytedanceW. Yin |
| 4.4b | Test 4.1 + Test 4.2 + Test 4.3 | Qualcomm  I. Jumakulyyev  Bytedance  W. Yin  [JVET-AD0222](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0222-v1.zip) | Ericsson  K. Andersson |
| 4.4c | Test 4.1 + Test 4.2 | Qualcomm  I. Jumakulyyev  Bytedance  W. Yin  [JVET-AD0222](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0222-v1.zip) | Ericsson  K. Andersson |
| **5 GDR** | | | |
| 5.1 | Reference picture padding for GDR | InterDigital  T. Poirier  [JVET-AD0123](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0123-v1.zip) | Nokia  S. Hong |

**Inter prediction**

**Test 1.1 Extends the CCCM template selection to six (**[**JVET-AD0147**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0147-v1.zip)**)**

In this test, the number of CCCM templates is extended (in addition to top and left, only left, and only top) to 6 as shown in the below figure in the second row. When one of the 3 extended templates is selected, the model is derived selecting the samples of the template with the reconstructed luma value within the range of the reconstructed current CU luma values. Also, the CCCM parameters are applied with 32-bits precision. If CCCM mode is selected, similarly to GL-CCCM, a flag is coded to indicate whether regular or extended template is used.



**Test 1.2 CCCM using multiple downsampling filters (**[**JVET-AD0202**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0202-v1.zip)**)**

It the test, multiple downsampling filters are applied to a group of reconstructed luma samples in a CCCM. The linear combination of these downsampled reconstructed samples is multiplied by derived filter coefficients to form the final chroma predictor. The horizontal or vertical location of the center luma sample are also considered in the tested model. The cross-component models shown below are tested as additional CCCM modes with a mode index signalled in the bitstream:

1. Model 1: predChroma = c0 \* H(C) + c1 \* G1(C) + c2 \* G2(C) + c3 \* G3(C) + c4 \* P(H(C)) + c5 \* P(G1(C)) + c6 \* P(G2(C)) + c7 \* X + c8 \* Y + c9 \* B
2. Model 2: predChroma = c0 \* H(C) + c1 \* H(W) + c2 \* H(E) + c3 \* G1(C) + c4 \* G1(W) + c5 \* G1(E) + c6 \* P(H(C)) + c7 \* P(H(W)) + c8 \* P(H(E)) + c9 \* X + c10 \* B
3. Model 3: predChroma = c0 \* H(C) + c1 \* H(NE) + c2 \* H(SW) + c3 \* G3(C) + c4 \* G3(NE) + c5 \* G3(SW) + c6 \* P(H(C)) + c7 \* P(H(NE)) + c8 \* P(H(SW)) + c9 \* Y + c10 \* B

where H(·), G1(·), G2(·), G3(·) are various downsampling filters as indicated in Figure 1, C denotes the current chroma sample position, and N, S, W, E, NE, SW are the positions around C as indicated in Figure 2, ci are filter coefficients, P and B are nonlinear term and bias term, and X and Y are the horizontal and vertical locations of the center luma sample with respect to the top-left coordinates of the block.

A picture containing text, pool ball, sport

Description automatically generated

Figure 1. Various downsampling filters used in the tested cross-component models

Table

Description automatically generated

Figure 2. The positions of chroma samples

**Test 1.3: Local-boosting cross-component prediction (**[**JVET-AD0120**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0120-v1.zip)**)**

In this method, the local information including neighbouring and prediction samples are considered for cross-component prediction (CCCM and CCLM). The aspects are included.

Aspect #1: Prediction samples of MM-CCLM/MM-CCCM can be filtered with neighbouring samples with a 3×3 low-pass filter. At a top/left boundary, the filtering window involves neighbouring reconstructed samples. For inner samples, the filtering window only involves prediction samples, which are padded. A flag is signalled to indicate whether filtering is applied or not for a block coded with MM-CCLM/MM-CCCM.

Aspect #2: Template costs are calculated to implicitly determine the usage of the cross-component prediction. The template cost is derived by applying the candidate cross-component mode on the template and calculating the SAD between the prediction samples and reconstruction samples in the template. The mode with a lower template cost is selected as the final method for the current block.

Aspect #3: The binarization of the mode signalling is modified. Instead of signaling CCLM-L/CCLM-T/MM-CCLM-L/MM-CCLM-T (or CCCM-L/CCCM-T/MM-CCCM-L/MM-CCCM-T) with a truncated unary code, two syntax elements are coded: multi\_mode\_flag indicates whether multiple or single model is applied, and ccp\_dir\_flag indicates whether left or above direction is applied.

All aspects are tested individually and in a combination as follows.

Test 1.3a: Aspect #1 (MM-CCLM/MM-CCCM filtering with neighbouring samples).

Test 1.3b: Aspect #2 (cross-component prediction usage is determined by template cost).

Test 1.3c: Aspect #3 (cross-component prediction signalling modification).

Test 1.3e: Aspects 1 and 2.

Test 1.3d: Aspects 1, 2, and 3.

**Test 1.6: Non-local cross-component prediction and cross-component merge mode (**[**JVET-AD0188**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0188-v1.zip)**)**

In the test, a cross-component prediction merge candidate list is constructed from the spatial adjacent, spatial non-adjacent, or history-based candidates. After including these candidates, default models are further included to fill the remaining empty positions in the merge list. Pruning is applied to remove redundant candidates. After constructing the list, the models in the list are reordered depending on the SAD costs, which are obtained using the neighbouring template of the current block.

**Spatial adjacent and non-adjacent candidates**

The positions and inclusion order of the spatial adjacent and non-adjacent candidates are the same as those defined in ECM for regular inter merge prediction candidates.

**History-based candidates**

A history-based table is maintained to include the recently used cross-component models, and the table is reset at the beginning of each CTU row. If the current list is not full after including spatial adjacent and non-adjacent candidates, the models from the history-based table are added into the list.

**Default candidates**

CCLM candidates with default scaling parameters are considered, only when the list is not full after including the spatial adjacent, spatial non-adjacent, or history-based candidates. If the current list has no candidates with the single model CCLM mode, the default scaling parameters are {0, 1/8, -1/8, 2/8, -2/8, 3/8, -3/8, 4/8, -4/8, 5/8, -5/8, 6/8}. Otherwise, the default scaling parameters are {0, the scaling parameter of the first CCLM candidate + {1/8, -1/8, 2/8, -2/8, 3/8, -3/8, 4/8, -4/8, 5/8, -5/8, 6/8}}. The offset parameter is derived according to the default scaling parameter, average neighbouring reconstructed luma sample value, and average neighbouring reconstructed Cb/Cr sample value.

A flag is signalled to indicate whether the cross-component prediction merge mode is applied or not. If it is applied, an index is signalled to indicate which candidate model is used by the current block. The mode is not allowed when the current CU is coded by intra subpartitions (ISP) with single tree, or the current chroma coding block size is less than or equal to 16.

The following tests are performed:

Test 1.6a: the merge list includes spatial adjacent, non-adjacent, and default candidates.  
Test 1.6b: the merge list includes spatial adjacent, history-based, and default candidates.  
Test 1.6c: the merge list includes spatial adjacent, non-adjacent, history-based, and default candidates.

In Test 1.6a and Test 1.6b, the maximum allowed list size is 6. In Test 1.6c, the size is changed to 12 to accommodate more potential candidates. Besides, the maximum allowed history-based table size is 6 in Test 1.6b and Test 1.6c.

**Test 1.7: TIMD using selectable template regions (**[**JVET-AD0103**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0103-v1.zip)**)**

In ECM, the templates for TIMD mode are implicitly selected from the left, top, or top and left templates depending on the coordinates for the current block. If x=0, only top template is used, if y=0 only left template is used, otherwise left and top templates are applied.

In the test, a syntax element is signalled to explicitly indicate one of the three types of template regions, even for CUs that are not located at the top or left boundary of the frame.

Test 1.8 IBC adaptation for camera captured content ([JVET-AD0208](https://jvet-experts.org/doc_end_user/current_document.php?id=12772))

In the tests, there are two main aspects: to provide encoder optimization for IBC and extending IBC to use fractional pel BVs.

Aspect #1. This aspect involves high level tool control of various IBC coding tools and encoder optimization, which is applied to camera captured content (non-SCC) classes:

* IBC merge modes are disabled by using an SPS level flag to indicate that. So, only IBC AMVP mode is activated.
* RR-IBC, TM-IBC, and IBC-CIIP are disabled. For RR-IBC and TM-IBC, corresponding SPS flags are implemented (as ECM-8.0 does not have SPS control for these tools).
* IBC is applied to intra slices only which is indicated by HLS.
* At encoder, IBC block vector search is optimized, and the RDO process may be skipped for an IBC AMVP mode if its SAD cost is much worse than the lowest SAD cost of all intra modes.
* IBC AMVP modes may not be evaluated when the best intra mode has less than 3 nonzero coefficients.
* In ECM-8.0 encoder, some partitioning depth in an inter slice is skipped depending on the POC distance between the current picture and its nearest reference picture. When IBC is enabled from SPS level, ECM-8.0 always sets this POC distance equal to 0, while in this test, for inter slices, the true POC distance is used instead of setting to 0.

Aspect #2. Fractional pel BVs for IBC as follows:

* The option of block vector resolutions is extended to include quarter-pel resolution in additional to full-pel and 4-pel. Like inter AMVR syntax, the first bin is signalled to indicate whether BV is in quarter-pel resolution, and the second bin is signalled to switch between full-pel and 4-pel resolutions.
* The interpolation filters applied to the luma (8-tap) and chroma (6-tap existed inter interpolation) components of an IBC block. For template-based IBC tools, a 2-tap bilinear interpolation filter is applied to generate template prediction blocks.
* Reference sample padding is performed when some of them are located outside IBC reference area. When needed, it performs in horizontal direction first and then vertical direction.

Two tests are performed:

Test 1.8a: HLS tool control with encoder optimization for IBC for camera captured content (aspect #1)

Test 1.8c: Test 1.8a with fractional pel BVs (aspect #2, applied for all classes)

**Test 1.10: Multi-candidate IntraTMP (**[**JVET-AD0073**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0073-v1.zip)**)**

In the test, a candidate list is constructed, and the candidate BVs are ranked in ascending order of their template matching costs. An index is signalled in the bit-stream to indicate which candidate BV is used for current block.

To build a BV candidate list of size N, in the sparse search, the sub-sampling factor is set to 3 instead of 2 used in ECM-8.0 and 2N BVs with the smallest template matching costs are maintained. Then, in the refinement search, each 3x3 block around each of the 2N BVs is checked and N BVs with the smallest cost are selected to form the candidate list.

N equal to 15 and 19 is tested.

Test 1.10a: Multi-candidate IntraTMP without search procedure change.

Test 1.10b: Multi-candidate IntraTMP with search procedure change.

**Test 1.11: Intra template matching prediction fusion (**[**JVET-AD0072**](https://jvet-experts.org/doc_end_user/current_document.php?id=12620)**)**

The tested fusion method includes the following aspects:

1. Generate multiple matched blocks during the IntraTMP search.

During the subsampled IntraTMP search process with the step size 3 instead of the current 2, a candidate list is initially generated for 30 matched blocks with the smallest template SAD. For each candidate, a full 3x3 pixel refinement search around each of the 30 matched blocks is performed and the best 3 candidate matched blocks measured by template SAD are selected.

1. Select candidate matched blocks for fusion.

For each of the best 3 candidate matched blocks, a threshold equal to *2 \* SAD1* is used to select candidates for fusion, *SAD1* is the smallest template SAD of the three candidate matched blocks. Candidates SAD <= Threshold are used for fusion.

1. Calculate fusion weight for each of the selected matched blocks.

Once blocks to be fused are decided, they are fused with the weights calculated by their SAD as follows:

To reduce the implementation cost, the division operations are replaced by an integer look-up table.

1. The final fused predictor is determined by

where is the matched block, and n is the number of blocks selected for fusion. In a special case, when only one matched block remains after step b), the final predictor is calculated as

where is the single matched block and is the planar intra predictor, where the weights are set as and .

A CU level flag is added to signal whether an IntraTMP CU is predicted by the proposed fusion method or by the original method.

Test 1.11a: Intra template-matching prediction fusion with 3 candidates

Test 1.11b: Intra template-matching prediction fusion with no change to search procedure

Test 1.11c: Intra template-matching prediction fusion with 5 candidates

**Test 1.12: IntraTMP with sub-pel precision (**[**JVET-AD0125**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0125-v1.zip)**)**

In the test, three sub-pel precisions, including half-pel, quarter-pel and three quarter-pel, with eight directions around the integer-pel position are tested as shown in Figure 3. Furthermore, the eight directions are sorted by template cost with half-pel precision for each CU, and only the first four directions can be used for each sub-pel precision.



Figure 3. The adjacent half-pel positions in 8 directions.

If Intra TMP mode is selected for the current block, a precision index is signalled to indicate which of the integer-pel and three sub-pel precisions is used. If one of the three sub-pel precisions is used, a direction index is signalled to indicate which of the four directions is used.

Four-tap DCT-IF interpolation filters in ECM are used for sub-pel interpolation in Intra TMP.

**Test 1.13: Fusion of intra template matching (**[**JVET-AD0158**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0158-v1.zip)**)**

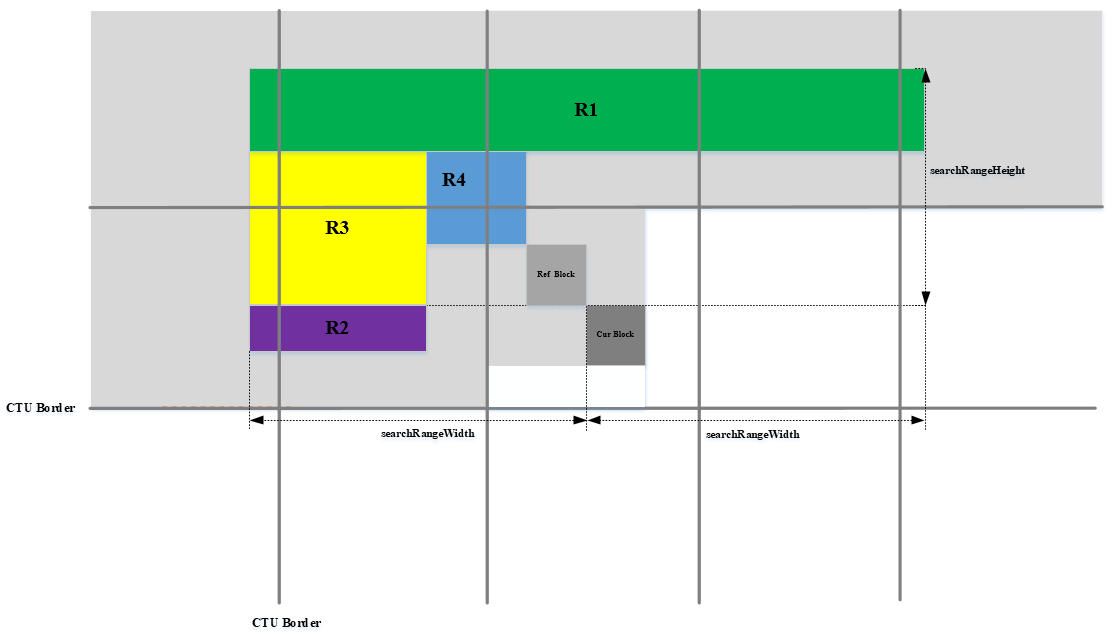
In the first search pass, the best matching block with the lowest TM cost is selected, specified its template as . Then in the second search pass, the template is modified as .A separate flag is signalled to indicate whether the second search with the template update is used at decoder.

Test 1.13a: Adaptive IntraTMP fusion with up to two prediction blocks.

Test 1.13b: Test 1.13a + search process from Test 1.10

**Test 1.14a: Extended the adjacent search area of IntraTMP (**[**JVET-AD0115**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0115-v1.zip)**)**

In this test, R3 and R4 regions are extended shown in Figure 4 as vertical upper side and horizontal left side of the current block that are also reconstructed and can be used for prediction.



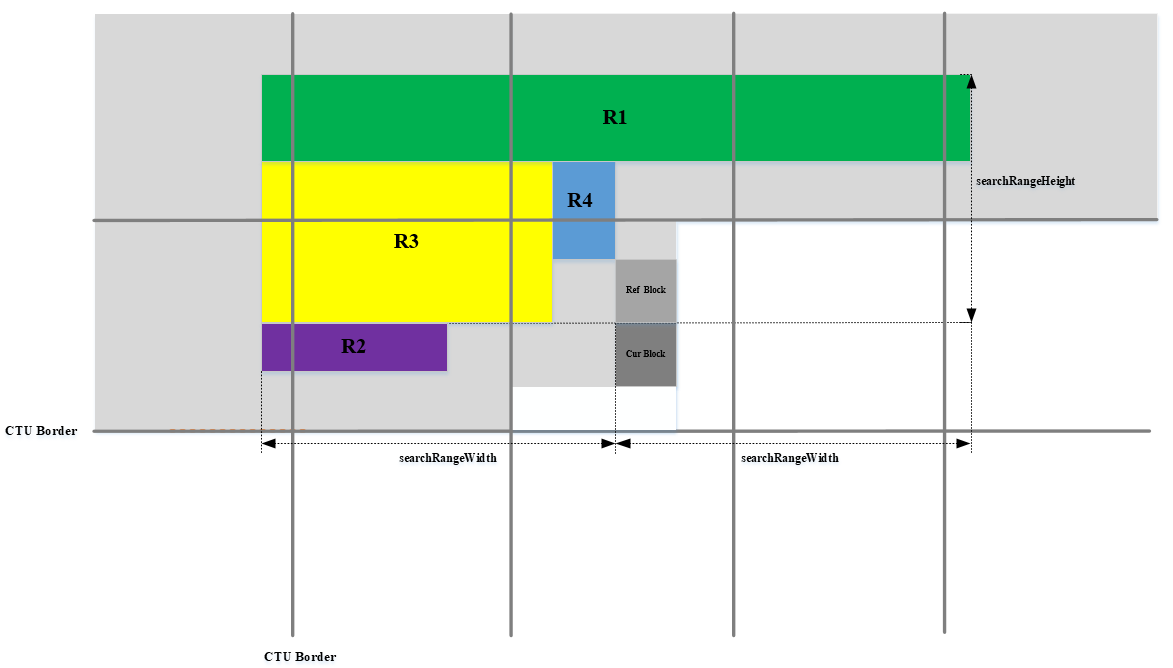


Figure 4. IntraTMP search regions in ECM-8.0 (top) and extended regions (bottom)

**Test 1.14b: Enlarged the search range for small blocks (**[**JVET-AD0074**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0074-v1.zip)**)**

In ECM, IntraTMP search range is based on the current block size:

SearchRangeWidth = a \* BlkWidth

SearchRangeHight = a \* BlkHeight,

where *a* is equal to 5.

In the test, IntraTMP search range for small blocks is enlarged as follows:

SearchRangeWidth = max(a \* BlkWidth, minSearchRange)

SearchRangeHight = max(a \* BlkHeight, minSearchRange),

where minSearchRange is set as 64.

**Test 1.14c: Combination of Test 1.14a and Test 1.4b (**[**JVET-AD0075**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0075-v1.zip)**)**

**Test 1.15a: Intra template matching based on linear filter model (**[**JVET-AD0112**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0112-v1.zip)**)**

In this method, a linear model is derived between the reference and current templates, the derived model is applied to the IntraTMP predictor. Similar to CCCM, a model is represented by 6-tap filter consisting of a 5-tap spatial and a bias terms.

A picture containing text, shoji, crossword puzzle

Description automatically generated

predLumaVal = c0C + c1N + c2S + c3E + c4W + c5 \* (1<<(bitdepth – 1) )

The template size is 4, and the method is applied to the best BV candidate. A flag is signalled to indicate the mode usage.

**Test 1.15b: Filtered template matching based intra prediction (**[**JVET-AD0099**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0099-v1.zip)**)**

Similar to 1.15a, the same 6-tap filter model applied to IntraTMP is tested. The template size used for training is 4 lines above and to the left of the current block depending on their availability.

The filtered method uses the current IntraTMP’s SAD based search in ECM-8.0 for creating a list of four candidate reference blocks to be filtered. Entry to the candidate list is based on SAD cost of the unfiltered template.

The filter parameters are calculated for each candidate in the list and the best performing one in terms of template cost after filtering is selected and used as the final candidate. The final prediction of the block is then generated by applying the derived filter for the best candidate.

**Test 1.16: IntraTMP fusion with multiple reference blocks (**[**JVET-AD0116**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0116-v1.zip)**)**

IntraTMP fusion is tested, N best BVs are derived during the subsampled search with step size of 2, then those N best predictors are fused with the weights as follows.

where predSamples represent the final predicted block, is one of the N candidate reference blocks. The weights are derived from the candidate matching templates and current template using the decomposition method from CCCM.

A flag is signalled to indicate the mode usage.

**Test 1.17: IntraTMP fusion with intra prediction (**[**JVET-AD0092**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0092-v1.zip)**)**

In IntraTMP fusion with intra prediction, the prediction block is the weighted sum of the two prediction signals generated by IntraTMP and intra prediction derived by TIMD. A CU flag is signalled to indicate whether the tested method is used.

**Test 1.18: CIIP extension with IntraTMP (**[**JVET-AD0177**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0177-v1.zip)**)**

The tested method is similar to inter CIIP, where the inter part is replaced by IntraTMP prediction, while the intra prediction and weights calculation is kept unchanged. A flag is signalled to indicate the mode usage.

Test 1.18b: CIIP extension with IntraTMP

Test 1.18a: Test 1.18b + Test 1.14c (search range modification)

**Test 1.19: IntraTMP with multiple modes (**[**JVET-AD0194**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0194-v1.zip)**)**

In Test-1.19a, 3 template types are defined. In addition to L-shape (left and above templates), using only left and only above templates as shown in the below figure is tested. For each template type, the best 4 candidates are derived in the template matching process and selected by HAD cost. To signal the selected candidate (template type and candidate index), a flag is signalled to indicate which template type is used followed by the candidate index.

A picture containing logo

Description automatically generated

In Test-1.19b, a fusion method is used to combine multiple candidates, the fusion weights are derived by template matching costs or using the derivation method of MSE minimization existed in CCCM. A flag is signalled to indicate which weight derivation method is used. The candidates to be fused are the best 2 L-shape candidates or the best 5 L-shape candidates. Another flag is signalled to indicate the number of candidates to be fused (2 or 5).

Test 1.19c is the combination of tests 1.19a and 1.19b.

**Tests 1.20: Combination of IntraTMP related tests**

In the tests, there are the following elements:

* Extended IntraTMP search range
* Enlarged search range for small blocks
* Modified IntraTMP search process
* Multiple candidates for IntraTMP
* Fusion candidates for IntraTMP (TM cost and MSE based weights derivation)
* Filtered IntraTMP mode
* Fractional pel IntraTMP
* Fusion of intra template matching
* Combination of IntraTMP and intra prediction

A combination Test 1.20j includes all aspects except the last two.

Test 1.20a ([JVET-AD0076](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0076-v1.zip)): Test 1.10b (19 candidates) + Test 1.11c (without fusion with intra)

Test 1.20b ([JVET-AD0076](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0076-v1.zip)): Test 1.10b (19 candidates) + Test 1.11c (without fusion with intra) + Test 1.14c

Test 1.20c ([JVET-AD0198](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0198-v1.zip)): Test 1.14c + Test 1.19c

Test 1.20e ([JVET-AD0191](https://jvet-experts.org/doc_end_user/current_document.php?id=12755)): Test 1.13b + Test 1.10b (15 candidates)

Test 1.20f ([JVET-AD0192](https://jvet-experts.org/doc_end_user/current_document.php?id=12756)): Test 1.13b + Test 1.12

Test 1.20h ([JVET-AD0118](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0118-v1.zip)): Test 1.14a + Test 1.15a + Test 1.16

Test 1.20i ([JVET-AD0086](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0086-v2.zip)): Test 1.10b(19 candidates) + Test 1.11c + Test 1.12 + Test 1.15a + Test 1.16 + Test 1.19c + Test 1.14a

Test 1.20j ([JVET-AD0086](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0086-v2.zip)): Test 1.10b(19 candidates) + Test 1.11c + Test 1.12 + Test 1.15a + Test 1.16 + Test 1.19c + Test 1.14c

Test 1.20k ([JVET-AD0126](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0126-v1.zip)): Test 1.12 + Test 1.14c

Test 1.20m ([JVET-AD0119](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0119-v1.zip)): Test 1.17 + Test 1.18b

Test 1.20m\* ([JVET-AD0119](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0119-v1.zip)): Test 1.17 + Test 1.18a (includes search range modification of Test 1.14c)

Test 1.20n ([JVET-AD0247](https://jvet-experts.org/doc_end_user/current_document.php?id=12811)): Test 1.20f + Test 1.14c

**Test 1.21: Modifications on template-based multiple reference line intra prediction (**[**JVET-AD0071**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0071-v1.zip)**)**

Two aspects are tested modifying TMRL prediction.

In Test 1.21a, the construction of intra candidate list for MPM and TMRL is modified as follows:

* Non-adjacent positions are added as candidates in constructing the intra candidate list.
* If the neighbouring or non-adjacent blocks are coded with SGPM or GPM modes, the intra modes of the blocks are replaced by the partitioning angles.

In Test 1.21b, the precision of angular prediction is extended from 65 to 129 for TMRL.

Test 1.21c is a combination of Test 1.21a and Test 1.21b.

**Test 1.22: Template-based intra MPM list construction (**[**JVET-AD0173**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0173-v1.zip)**)**

In ECM, the regular MPM list consists of primary MPMs, secondary MPMs, and DIMD modes. There is no ordering of the modes based on template cost.

In the test, the regular MPM list is constructed by the following three steps:

1. The first entry in the general MPM list is always planar mode.
2. The next entries are composed of the intra modes of neighboring blocks, and DIMD modes, which are sorted in ascending order of SAD cost. Up to 5 modes with the smallest SAD cost are added. The SAD cost is computed between the prediction and the reconstruction samples of the template.
3. The sorted directional modes with added offset are added into the general MPM list, and then the default modes, until the general MPM list with 22 entries is constructed.

For the signaling part, MPM list is equally divided into four groups and the group index is parsed first. Then, a mode index is further parsed to indicate which mode in the selected group is used.

**Test 1.23: Modification to MPM list derivation (**[**JVET-AD0190**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0190-v1.zip)**)**

In ECM, there are two methods to construct regular MPM and TMRL MPM lists. In the tests, one MPM list derivation method is introduced for both cases as follows:

1. For the spatial neighbors of the current block, if a neighbor block is coded by MIP/IntraTMP/Planar mode, the first non-planar mode from the spatial MPM modes of the neighbour block is selected as the derived mode and the derived mode is tagged as ‘reserved’ for the partial MPM reordering performed in ECM-8.0 when generating MPM list for the current block.
2. Secondary MPM modes are derived by adding offset to all primary angular modes, this process is the same as in ECM-8.0 for TMRL modes, where the offset is added to DIMD modes first.
3. If MPM list is incomplete, the same default modes are added as in ECM-8.0.

**Tests 1.24: Combinations of MPM related tests (**[**JVET-AD0085**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0085-v1.zip)**)**

Test 1.24a: Test 1.21c + Test 1.22

Test 1.24b: Test 1.21c + Test 1.23

Test 1.24c: Test 1.22 + Test 1.23

Test 1.24d: Test 1.21c + Test 1.22 + Test 1.23



Note: The “\*” marking in the table above expresses that test are not finished yet, and rate gain is estimated by using anchor results. Likely, final results could be better (cannot be worse).

1.1: Small benefit in compression, more templates. No action.

1.2: Some complexity increase (in some cases, multiple downsampling filters). Cross-checker and other experts supported this as an interesting extension of CCCM. Decision: Adopt JVET-AD0202.

1.3: Gain is asserted to be independent of 1.2. The complexity increase (except for test b which does additional template matching) is small according to cross-checker. Several opinions were expressed about whether 1.3e (comb. of a and b) or 1.3a standalone would be more preferable, also as gain of 1.3b for RA appears negligible (however it has gain in AI). It was reported that test 1.3b in RA case was only applied to I slices, which might explain. Decision: Adopt JVET-AD0120 test 1.3e.

1.6: All three solutions have similar increase in encoder/decoder run times. The full combination of all additional candidates (adjacent, non-adjacent, history based & default) 1.6c has best compression benefit, both for AI and RA. Some concern was expressed if there might be a conflict with 1.3b, as both 1.6c and 1.3b rely on TM, where 1.3b is relying on template cost, and 1.6c uses it for list reordering. It was asserted that in worst case a combination could mean that they cannot be used together. Decision: Adopt JVET-AD0188 test 1.6c.

1.7: No good tradeoff, in AI 13% encoder run time increase. No action.

1.8: Significant gain in particular for 1.8c which uses fractional pel compensation in addition with the modified search and other encoder optimization of 1.8a, in particular for camera captured content, but with fractional pel also for screen content. Good tradeoff with slightly increased runtime increase. It was asked why 8-tap interpolation was used? It was reported that the gain by using 12-tap was extremely small, so they were not used considering complexity. Decision: Adopt JVET-AD0208 test 1.8c.

The contributors are asked to provide a similar software implementation with appropriate encoder optimization for VTM (in the context of AHG10) such that IBC could be also be enabled for camera captured content in VTM.

Tests 1.10ff. relate to modifications of IntraTMP

From the results, test 1.20j provides best gain (>1% in AI), with acceptable tradeoff (5% encoder, 6% decoder run time increase) Decision: Adopt-JVET-AD0086 test 1.20j

1.21ff relate to modifications of list construction which are also tested in combination. The best combination is 1.24a, which however comes with a decoder run time increase of 2% (most likely caused by 1.21a). It is reported by the proponents that the number of TM operations is not increased which makes it difficult to understand where the runtime increase comes from. Without this runtime increase, 1.24a would be attractive for adoption, but more explanation about the decoder runtime increase and possibility to reduce that is expected. Revisit.

**Inter prediction**

**Tests 2.1: Affine DMVR (**[**JVET-AD0182**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0182-v1.zip)**)**

Several aspects related to affine DMVR are tested.

1. Affine DMVR extension.

The refinement of the translational of the affine motion existed in DMVR is further extended to affine MMVD and adaptive BM merge modes. For affine MMVD mode, the MMVD offset is added to the affine DMVR refined affine merge base candidate if the base candidate meets the affine DMVR refinement condition. For adaptive BM merge mode, an affine merge list that only contains affine merge candidates that meet the affine DMVR conditions are constructed and then refined.

2. CPMV search.

For each control-point, perform bilateral matching for a block that centered by the control-points coordinates to derive the refined CPMVs. Loop over combinations of initial and refined CPMVs to derive the best set of CPMVs that minimize the bilateral matching cost of the current block.

3. CPMV refinement.

For CPMV refinement, an iterative search process is applied to further refine the CPMVs to minimize the bilateral matching cost of the current block. In each iteration, only one CPMV is refined while the others are fixed.

4. Affine parameters refinement.

In this refinement process, wherein each of CPMVs is fixed as base MV in turn, and an offset is added to the non-translation parameter of affine model by minimizing the bilateral matching cost, and then the other two CPMVs are calculated according to the base MV and refined non-translation parameters. To reduce the complexity, different number of search rounds and search directions are set for different stages with cost based early termination.

5. Simplifications.

Early termination based on the best PU distortion is applied. If initial distortion before CPMV refinement is lower than a threshold, then the iterative CPMVs refinement is bypassed.

The affine CPMV refinement is disabled if one of the following conditions is true:

* If block is square and is large than 128x128
* If block is non-square and width or height is greater than 64

The following tests are performed.

In Test 2.1a, CPMV search with simplification is tested.

In Test 2.1b, CPMV refinement with simplification is tested.

In Test 2.1c, affine DMVR extension is tested. Affine DMVR extension includes applying affine DMVR and affine regression to affine MMVD mode and adaptive BM merge mode.

In Test 2.1d, affine parameters refinement is tested.

In Test 2.1e, Test 2.1d with simplification is tested.

In Test 2.1k, a combination of Test 2.1a, Test 2.1b, and Test 2.1d is tested.

In Test 2.1l, a combination of Test 2.1e and Test 2.1c is tested.

**Test 2.2: AMVP with SbTMVP mode (**[**JVET-AD0152**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0152-v1.zip)**)**

In the test, SbTMVP is applied to AMVP mode. When the mode is applied, a CU is split into 4x4 subblocks, and each subblock derives its own motion from a corresponding subblock in the collocated picture. The corresponding subblock is obtained using MVP with a signalled MVD. The MVP is derived in the same way to that of MVP of normal AMVP mode. The number of MVDs is determined according to the following rules:

* If the POC distance between current picture and its collocated picture is larger than 2, the number of MVD is set to 16 which comprises 4 motion directions and 4 motion magnitudes (Figure 5);
* Otherwise, if the current picture is a low delay picture, the number of MVD is set to 32 which comprises 4 motion directions and 8 motion magnitudes (Figure 6);
* Otherwise, the number of MVD is set to 64 which comprises 8 motion directions and 8 motion magnitudes (Figure 7).

Shape

Description automatically generated with medium confidence

Figure 5. 16 candidates for picture whose POC distance between current picture and collocated picture is larger than 2

Shape

Description automatically generated with medium confidence

Figure 6. 32 candidates for low delay picture

Shape

Description automatically generated with medium confidence

Figure 7. 64 candidates for non-low delay picture whose POC distance between current picture and collocated picture is smaller than or equal to 2

The adaptive motion vector resolution (AMVR), local illumination compensation (LIC) and multi-hypothesis prediction (MHP) are not applied to the proposed mode. The OBMC is always applied to the proposed mode without signalling.

When a CU is coded using AMVP mode, a flag is signalled to indicate whether the CU is predicted with SbTMVP. If the SbTMVP is used, another flag is signalled to indicate whether MVD exists, and an MVD index is signalled to indicate the motion direction and motion magnitude if MVD exists. The inter prediction direction and reference picture index are directly set to the collocated picture instead of being signalled.

**Test 2.3: SbTMVP with MMVD (**[**JVET-AD0209**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0209-v1.zip)**)**

In the test, MVD offsets are applied to SbTMVP candidate in subblock MMVD merge list, an index is signalled to indicate the MVD offset, and this offset is used to derive the offset value of the displacement vector (DV) for each SbTMVP-MMVD candidate. The final DV for each SbTMVP-MMVD candidate is calculated from the DV of SbTMVP merge candidate with the selected offset.

The spiral scanning order is used to scan all MMVD candidates and the available candidate, which has the valid center motion vector, will be added into the candidate list.

Picture level mode flag is used to indicate whether the SbTMVP-MMVD is enabled, it is determined based on the temporal ID and the mode is only enabled at the highest two temporal layers for RA.

In Test 2.3a, MMVD offset is the integer pel step size of {4, 8, 12, 16, 20}, the number of directions is kept as 8 which is used in affine MMVD as well. Like the affine MMVD, the total number of the SbTMVP-MMVD candidates is less than or equal to 16. The spiral scanning order is applied and up to 16 available candidates are added into the candidate list.

In Test 2.3b, all 40 MMVD candidates will be scanned in spiral order and available candidates are added to the candidate list. Then, the subblock-based template-matching is used to reorder all SbTMVP-MMVD candidates by using template-matching cost in ascending order and up to 16 candidates with the smallest template-matching cost will be kept. The constraint of the size of collocated position is extended from one CTU row to three CTU rows. This extension is applied for SbTMVP-MMVD only, and there is no size extension for TMVP and SbTMVP.

**Test 2.4: Template matching-based subblock motion refinement (**[**JVET-AD0165**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0165-v1.zip)**)**

Two aspects are included in the test.

Firstly, after the candidate list is constructed for affine merge mode, uni-directional affine candidates will perform CPMV refinement based on TM, where the same MV offset is applied to all the CPMVs of an affine candidate, and the TM cost of the affine candidate is calculated accordingly. The optimal CPMV offset with the minimum TM cost is used to refine the corresponding affine candidate if , where *CRefined*denotes the TM cost after CPMVs are refined by the optimal offset, *COrig* is the TM cost calculated by the original CPMVs, and *T* is a constant threshold.

Secondly, the initial motion shift to specify SbTMVP is further refined with TM.

**Test 2.5: Combination of SbTMVP related tests**

Test 2.5a ([JVET-AD0153](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0153-v1.zip)): Test 2.2 + Test 2.4 (enabled for larger than 720p at encoder).

Test 2.5b ([JVET-AD0210](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0210-v2.zip)): Test 2.2 + Test 2.3a

Test 2.5c ([JVET-AD0210](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0210-v2.zip)): Test 2.2 + Test 2.3b

**Test 2.6: High precision MV refinement for BDOF (**[**JVET-AD0195**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0195-v1.zip)**)**

In the test, high-precision equations to derive the BDOF MV refinement parameters are used:

Gx.Gx \* vx + Gx.Gy \* vy = dI . Gx  s1 \* vx + s2 \* vy = s3

Gx.Gy \* vx + Gy.Gy \* vy = dI . Gy  s2 \* vx + s5 \* vy = s6

where Gx/Gy are the summation of the 2 horizontal/vertical gradients derived for each reference block.

Summations () are weighted sums, where weights depend on the position in the summation window, higher weights are given for center samples.

The subblock size of BDOF DMVR is adaptively selected depending on the width×height. For blocks smaller than 256, subblock size of 4×4, and otherwise 8×8 is used.

**Test 2.7: LIC for bi-prediction (**[**JVET-AD0213**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0213-v1.zip)**)**

In the first aspect, LIC mode is extended to bi-predictive CUs, where two different linear models are applied to the two prediction blocks which are then combined to generate the bi-prediction samples of the current CU, i.e.,

and

where and , and and indicate the scales and the offsets in L0 and L1, respectively; indicates the weight (as indicated by the CU-level BCW index) for the weighted combination of L0 and L1 predictions.

The method firstly derives the L0 parameters by minimizing difference between L0 template prediction and the template and the samples in are updated by subtracting the corresponding samples in . Then, the L1 parameters are calculated that minimizes the difference between L1 template prediction and the updated template. Finally, the L0 parameter is refined again in the same way.

Following the current LIC design, one flag is signalled for AMVP bi-predicted CUs for the indication of the LIC mode while the flag is inherited for merge related inter CUs. Additionally, the LIC is disabled for DMVR and BDOF.

In the second aspect, the OBMC is enabled for the inter blocks that are coded with the LIC mode. And, to reduce the complexity, the OBMC is only applied to the top and left CU boundaries while being always disabled for the boundaries of the internal sub-blocks of one LIC CU. Additionally, when one neighboring block is coded with the LIC, its LIC parameters are applied to generate the corresponding prediction samples for the OBMC of one current block.

Test 2.7a: LIC for bi-prediction

Test 2.7b: Test 2.7a + OBMC with LIC

**Test 2.11e: Adaptive OBMC control (**[**JVET-AD0193**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0193-v1.zip)**)**

In the test, in addition to the existed SPS flag, OBMC is adaptively controlled on a block level as follows:

1. OBMC flag is inherited from a neighboring affine block for affine merge mode.
2. OBMC is not applied to a block if there is a neighbor block coded with IBC, palette, or BDPCM modes.
3. When applying OBMC to a block, block boundary check whether OBMC is applied to the boundary is further made based on the reference samples of the current block. If any absolute difference between the prediction sample and non-interpolated (integer pel) reference sample is greater than a threshold, the OBMC is not applied to that boundary.

In the test, addition results are provided for the mixed context sequences from JVET-AC1015 “Common test conditions for SCM screen content coding” denoted as class M.

**Test 2.12: Prediction of MVD magnitude suffix bins (**[**JVET-AD0140**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0140-v1.zip)**)**

In ECM, MVD sign prediction is utilized. In the test, the most important difference between the MVD sign prediction and the tested method is in removing the restriction of predicting just MVD signs whereas the number of bins to be predicted is kept the same.

Most significant bins of MVD remainder suffixes are predicted using template matching and the correctness of prediction hypotheses are indicated by corresponding MVD suffix bins that are coded in the bitstream using regular CABAC mode. The proposed method is applied for MVDs of translational motion, including SMVD and affine modes. Candidates for template matching used to predict bin values are shown in Figure 8. The less significant bins of magnitude suffixes of horizontal and vertical MVD components may be coded in by-pass mode.

|  |
| --- |
| Figure 8. Prediction of MVD sign and magnitude suffix bins |

Test 2.12a: Prediction of MVD magnitude suffix bins

Test 2.12f: ECM-8.0 with MVD sign prediction disabled

Test 2.12a\*: Test 2.12 with MVD sign prediction disabled

Test 2.12h ([JVET-AD0256](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0256-v1.zip)): Test 2.12a + Test 2.7a

Test 2.12g ([JVET-AD0257](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0257-v1.zip)): Test 2.12a + Test 2.2

Results RA/LB

2.1: It was verbally reported that an original test 2.1f had been planned which combined 2.1a and 2.1b, and gave approv. 0.07% luma gain in RA without runtime increase. This was withdrawn.

From the current results, various experts expressed that test 2.1l gives the most attractive benefit in terms of compression vs. runtime tradeoff. Decision: Adopt JVET-AD0182 test 2.1l.

Tests 2.2 … 2.4 are all related to SbTMVP modifications (some may also have other aspects), Test 2.5 investigates combinations.

In 2.5a, test 2.2\* is used (different from the table above)

It is asserted that tests 2.2 … 2.5 do not provide attractive benefit in terms of compression, compared to the increased encoder (and partially decoder run time). No significant support by other experts. No action.

Test 2.6 (modifications of BDOF) provides attractive tradeoff (0.2% gain in RA vs. 1% decoding time increase). Support by independent experts. Decision: Adopt JVET-AD0195.

Test 2.7: Both variants (and in particular 2.7b which has higher compression gain of > 0.35% in RA and LB) are attractive, though increasing encoder runtime by 2-3% (and decoder 1%). It was confirmed that LIC is invoked in LDB in combination with CIIP as well (not mentioned in the proposal). Supported by various independent experts. Decision: Adopt JVET-AD0213 test 2.7b.

Test 2.11: It is clarified that class “M” stands for mixed content (non-CTC class from old SCC test conditions). It was asked what the benefit of the three elements of the proposal (see description above) are. It was asked in particular how important the third element (block boundary gain) is. It was reported to provide roughly 0.5% out of 1.32% in LB for mixed content. Independent experts expressed that this is a good supplement to the high-level disabling of OBMC, in particular for mixed content (where also class F where also significant gain is reported, which also has some mixed-content sequences). Decision: Adopt JVET-AD0193 test 2.11e.

Test 2.12a is a straightforward extension of existing MVD sign prediction, giving similar gain as the latter, also in combination with it. The other sub-experiments are comninations with various other EE tests which show that the gain is retained. Several experts expressed support. Decision: Adopt JVET-AD0140 test 2.12a.

**Screen content coding**

**Test 3.1: IntraTMP using reconstruction-reordered for screen content coding (**[**JVET-AD0171**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0171-v1.zip)**)**

In ECM, there is a reconstruction-reordered IBC mode. In the test, reconstruction-reordered IntraTMP mode is tested. When this mode is applied, the encoder and decoder search for the most similar template to the flipped current template in a predefined area of the search region. Only the current CTU (R1) and a portion of the left region (R4) are explored for the horizontal flip type. Otherwise, only the current CTU (R1) and a part of the above region (R3) are explored in the vertical flip mode.

The dimensions of search regions in R3 and R4 regions are five times of block dimension (CbHeight, CbWidth) as it is determined for the regular IntraTMP, as shown in Figure 9.

The flip type is selected among the regular TMP (non-flip), horizontally flipped, and vertical flipped TMP modes according to the lowest TM cost. Consequently, no additional signaling is required. The corresponding block is flipped according to flip type, horizontal or vertical flip, and used as a prediction block.

Graphical user interface, application

Description automatically generated

Figure 9. RR-IntraTMP search region for (a) horizontal and (b) vertical flip.

For horizontal flipping, in case the neighboring block is coded with a horizontal flip of RR-TMP, the horizontal component of is calculated by adding a motion shift to the horizontal component of (denoted as , and the vertical component remains the same:

Similarly, in case the neighboring block is coded with a vertical flip, the vertical component of is calculated by adding a motion shift to the vertical component of (denoted as ), and the horizontal component remains invariant:

Where and represent the coordinates of the center sample of the neighboring block and the current block, respectively, and denotes the BV of the neighboring block and the current block, respectively.

**Test 3.2: IBC MBVD list derivation (**[**JVET-AD0199**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0199-v1.zip)**)**

In the test, MBVD offsets are searched starting from fixed offsets defined by the initial step size along the MBVD direction. At every search step, the best 8 candidates are identified based on TM SAD cost and the search process repeats with the MVBD offsets checked around the identified candidates with the reduced step size by half. The search process stops when the step size reaches 1-pel resulting in the best 8 MBVD offset candidates.

When a MBVD candidate has a left or above template outside of the BV search area, the MBVD candidate is set to invalid candidate. When two BVP candidates have the same BV component in horizontal or vertical direction, the BV difference in other direction has to be larger than a threshold T.

The amount of MBVD candidates and MBVD index signaling is kept the same as ECM-8.0.

Test 3.2a: IBC MBVD list derivation with max BVD offset 128-pel.

The max BVD offset is 128-pel, initial search step size is 4-pel, BVP difference threshold T = 6-pel.

Test 3.2b: IBC MBVD list derivation with max BVD offset 256-pel.

The max BVD offset is equal to 256-pel, initial search step size is 4-pel, BVP difference threshold T = 32-pel.

**Test 3.3: Temporal block vector prediction (**[**JVET-AD0095**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0095-v1.zip)**)**

In ECM, IBC merge/AMVP candidates are derived from spatial, HMVP, pairwise average, and some predefined BV candidates. However, temporal BV candidates are not utilized.

In this test, a temporal BVP is introduced to mimic TMVP. Temporal BV candidates are added to IBC merge/AMVP candidate lists.

Temporal BV candidates are derived with the full pruning applied from the same temporal positions as TMVP, in the list they are added before the HMVP candidates.

**Test 3.4: Copy-padding for IBC (**[**JVET-AD0096**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0096-v1.zip)**)**

In this test, copy-padding can be applied to non-reconstructed area. With copy-padding, an unreconstructed sample in the overlapped with the current block region is padded by copying its prediction samples, as shown in Figure 10, and is represented as follows.

P’(x,y) = P(x+BVx, y+BVy)

wherein P’(x,y) is a padded sample at position (x, y), P(x+BVx, y+BVy) is a prediction sample, and (BVx, BVy) is the BV of the current block.

Copy-padding is performed only if the horizontal BV component is smaller than or equal to 0 and the vertical BV component is smaller than or equal to 0.

Graphical user interface, diagram

Description automatically generated

Figure 10. Unreconstructed samples (shaded) in the reference block are padded by copying their prediction samples

Test 3.4a: Copy-padding for IBC.

Test 3.4b: Test 3.4a + Test 3.3

**Test 3.7: Combination of Test 3.2 and Test 3.4b (**[**JVET-AD0097**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0097-v1.zip)**)**

The following tests are performed.

Test 3.7a: Test 3.2a + Test 3.4b

Test 3.7b: Test 3.2b + Test 3.4b

Results AI/RA/LB



Test 1.1 does not provide benefit (also loss for class F in AI) – no action.

Generally, with all proposals, gains are relatively low (compared to what is usually observed in screen content), and concern was raised that all of them increase complexity somehow (multiple search steps in 3.2x, access to reference picture BV for 3.3). 3.4 seems to have least impact on complexity, but in particular for class F, 3.4a which is the standalone version gives almost no gain. Non consensus about taking action on any of the proposals, no significant support by non-proponents.

**In-loop filtering**

**Test 4.1: Additional fixed-filter for ALF (**[**JVET-AD0221**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0221-v1.zip)**)**

In the test, one additional fixed filter with a diamond 7x7 shape and one signalled 7x7 cross filter shape are introduced to ALF shown in Figure 11 with turquoise colour, there is no classification for the newly added fixed filter.

The reconstructed samples before DBF are used as an input to the additional fixed filter to produce the filter output, then this filter output is used as an input to the introduced 7x7 cross signalled filter.

The coefficient signaling mechanism is the same as the current design in ECM. The proposed method is always enabled without any filter shape switching.

图示, 示意图

描述已自动生成

Figure 11. 7x7 cross signalled filter for ALF

**Test 4.2: ALF classifier based on residual data (**[**JVET-AD0219**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0219-v1.zip)**)**

In the test, a third classifier based on luma residual sample values is introduced. For each 2x2 luma block, the sum of absolute values of the residual samples in a neighbouring 8x8 window is calculated, and the class index is derived as:

classIdx = sum >> (sample bit depth – 4).

The value of classIdx is in the range of 0 to 24, same as in ECM-8.0. The classifier usage is signalled for each luma filter set in APS.

**Test 4.3: ALF filter shape with more taps applied to fixed filter results (**[**JVET-AD0219**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0219-v1.zip)**)**

In the test, the signalled ALF filter shape is modified, compared to the filter shape in ECM-8.0, the overall number of the filter coefficients for a signalled luma filter is increased by 2 as shown in Figure 12, the length of the filter that is applied to the neighboring reconstructed samples (taps #0-#9) is reduced and the length of the filter applied to the samples after the fixed-filter (taps #10-#29) is increased.

Diagram

Description automatically generated with medium confidence

**Figure 12. Modified filter shape of the signalled ALF filter.**

**Test 4.4: Combination of ALF related tests**

Test 4.4a ([JVET-AD0219](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0219-v1.zip)): Test 4.2 + Test 4.3

Test 4.4b ([JVET-AD0222](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0222-v1.zip)): Test 4.1 + Test 4.2 + Test 4.3

Test 4.4c ([JVET-AD0222](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0222-v1.zip)): Test 4.1 + Test 4.2

Results AI/RA/LB



It was confirmed that no additional buffer for residual data is required for 4.2 (relative to the residual buffer introduced in the last meeting).

4.3 requires four additional line buffers.

It can be expected that the combination 4.4b will end up with approximately 0.2% compression gain in RA. Already the 0.18% estimated from preliminary results appear attractive gain for RA, considering that encoder/decoder runtime is practically kept constant. Decision: Adopt JVET-AD0222 test 4.4b.

**GDR**

**Test 5.1: Reference picture padding for GDR (**[**JVET-AD0123**](https://jvet-experts.org/doc_end_user/documents/30_Antalya/wg11/JVET-AD0123-v1.zip)**)**

In ECM, CUs in the “clean area” use the reference pictures where all reconstructed samples in the “dirty area” are set to 2*bitdepth-1*.

In this test, the “dirty area” is padded using samples from the “clean area” of the reference as shown in Figure 13.

A picture containing sport, athletic game, indoor, floor

Description automatically generated

Figure 13. Padding of the "dirty area"

The test was conducted using LB configuration following GDR test conditions described in EE2 (JVET-AC2024).

Gain for LDB:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| -0,22% | -0,09% | -0,05% | 101% | 100% |

This is asserted to be a reasonable improvement of GDR. Decision: Adopt JVET-AD0123.

### EE2 contributions: Enhanced compression beyond VVC capability (53)

Selected contributions in this area (as far as not covered in the EE summary report) were discussed at XXXX–XXXX on XXday 2X April 2023 (chaired by JRO).

For actions decided to be taken, see section 5.3.1, unless otherwise noted.

[JVET-AD0071](https://jvet-experts.org/doc_end_user/current_document.php?id=12619) EE2-1.21: Modifications on template-based multiple reference line intra prediction [L. Xu, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AD0398](https://jvet-experts.org/doc_end_user/current_document.php?id=12962) Crosscheck of JVET-AD0071 (EE2-1.21: Modifications on template-based multiple reference line intra prediction) [X. Li (Alibaba)] ]late]

[JVET-AD0072](https://jvet-experts.org/doc_end_user/current_document.php?id=12620) EE2-1.11: Intra template matching prediction fusion [L. Zhang, F. Wang, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AD0309](https://jvet-experts.org/doc_end_user/current_document.php?id=12873) Crosscheck of JVET-AD0072 (EE2-1.11: Intra template matching prediction fusion) [F. Pu (Dolby)] [late]

[JVET-AD0073](https://jvet-experts.org/doc_end_user/current_document.php?id=12621) EE2-1.10 multi-candidate IntraTMP [F. Wang, L. Zhang, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AD0327](https://jvet-experts.org/doc_end_user/current_document.php?id=12891) Crosscheck of JVET-AD0073 (EE2-1.10 Multi-candidate IntraTMP) [P.-H. Lin (Qualcomm)] [late]

[JVET-AD0074](https://jvet-experts.org/doc_end_user/current_document.php?id=12622) EE2-1.14b Enlarge search range for small blocks in IntraTMP [F. Wang, L. Zhang, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AD0075](https://jvet-experts.org/doc_end_user/current_document.php?id=12623) EE2-1.14c combination test of EE2-1.14a and EE2-1.14b [Y. Ma, J. Huo, H. Du, H. Zhang, Z. Zhang, W. Qiao, F. Yang (Xidian Univ.), F. Wang, L. Zhang, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AD0303](https://jvet-experts.org/doc_end_user/current_document.php?id=12867) crosscheck of JVET-AD0075 (EE2-1.14c combination test of EE2-1.14a and EE2-1.14b) [K. Naser (InterDigital)] [late]

[JVET-AD0076](https://jvet-experts.org/doc_end_user/current_document.php?id=12624) EE2-1.20a/b: Combination of EE2-1.10, EE2-1.11 and EE2-1.14 [L. Zhang, F. Wang, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AD0328](https://jvet-experts.org/doc_end_user/current_document.php?id=12892) Crosscheck of JVET-AD0076 (EE2-1.20a/b: Combination of EE2-1.10, EE2-1.11 and EE2-1.14) [P.-H. Lin (Qualcomm)] [late]

[JVET-AD0085](https://jvet-experts.org/doc_end_user/current_document.php?id=12636) EE2-1.24: Combinations of MPM related tests [L. Xu, Y. Yu, H. Yu, D. Wang (OPPO), C. Zhou, Z. Lv, J. Zhang (vivo), H. Wang, Y. Chang, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AD0265](https://jvet-experts.org/doc_end_user/current_document.php?id=12829) Crosscheck of JVET-AD0085 EE2-1.24d: Combinations of MPM related tests [Y. Yasugi (Sharp)] [late]

[JVET-AD0287](https://jvet-experts.org/doc_end_user/current_document.php?id=12851) Crosscheck of JVET-AD0085 (EE2-1.24a: Combinations of MPM related tests) [Z. Deng (ByteDance)] [late]

[JVET-AD0086](https://jvet-experts.org/doc_end_user/current_document.php?id=12637) EE2-1.20i/j: Combination of IntraTMP tests [F. Wang, L. Zhang, Y. Yu, H. Yu, D. Wang (OPPO), Y. Ma, H. Zhang, J. Huo, F. Yang (Xidian Univ.), P. Lin, J. Lin, V. Seregin, M. Karczewicz (Qualcomm), X. Li, R. Liao, J. Chen, Y. Ye (Alibaba group)]

[JVET-AD0254](https://jvet-experts.org/doc_end_user/current_document.php?id=12818) Cross-check of JVET-AD0086 EE2-1.20i/j: Combination of IntraTMP tests [[X. Li (Google)](mailto:xlxiangli@google.com)] [late]

[JVET-AD0092](https://jvet-experts.org/doc_end_user/current_document.php?id=12643) EE2-1.17: IntraTMP fusion with intra prediction [Y. Wang, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0305](https://jvet-experts.org/doc_end_user/current_document.php?id=12869) Crosscheck of JVET-AD0092 (EE2-1.17: IntraTMP fusion with intra prediction) [R. Yu (Ericsson)] [late]

[JVET-AD0095](https://jvet-experts.org/doc_end_user/current_document.php?id=12646) EE2-3.3: Temporal block vector prediction [N. Zhang, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0304](https://jvet-experts.org/doc_end_user/current_document.php?id=12868) Crosscheck of JVET-AD0095 and JVET-AD0096 (EE2-3.3: Temporal block vector prediction and EE2-3.4: Copy-Padding for IBC) [Z. Zhang (Qualcomm)] [late]

[JVET-AD0096](https://jvet-experts.org/doc_end_user/current_document.php?id=12647) EE2-3.4: Copy-Padding for IBC [N. Zhang, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0304](https://jvet-experts.org/doc_end_user/current_document.php?id=12868) Crosscheck of JVET-AD0095 and JVET-AD0096 (EE2-3.3: Temporal block vector prediction and EE2-3.4: Copy-Padding for IBC) [Z. Zhang (Qualcomm)] [late]

[JVET-AD0139](https://jvet-experts.org/doc_end_user/current_document.php?id=12690) Cross-check of JVET-AD0096 (EE2-3.4a: Copy-Padding for IBC) [H. Han, H. Choi (HNU)]

[JVET-AD0097](https://jvet-experts.org/doc_end_user/current_document.php?id=12648) EE2-3.7: Combination tests of EE2-3.2+EE2-3.4b [N. Zhang, K. Zhang, L. Zhang (Bytedance), Z. Zhang, P. Nikitin, H. Huang, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AD0354](https://jvet-experts.org/doc_end_user/current_document.php?id=12918) Crosscheck of JVET-AD0097 (EE2-3.7: Combination tests of EE2-3.2+EE2-3.4b) [C.-M. Tsai (MediaTek)] [late]

[JVET-AD0099](https://jvet-experts.org/doc_end_user/current_document.php?id=12650) EE2-1.15b: Filtered template matching based intra prediction [R. G. Youvalari, D. Bugdayci Sansli, P. Astola, J. Lainema (Nokia)]

[JVET-AD0294](https://jvet-experts.org/doc_end_user/current_document.php?id=12858) Crosscheck of JVET-AD0099 (EE2-1.15b: Filtered template matching based intra prediction) [X. Li (Alibaba)] [late]

[JVET-AD0103](https://jvet-experts.org/doc_end_user/current_document.php?id=12654) EE2-1.7: TIMD using selectable template regions [Y. Yasugi, T. Ikai (Sharp)]

[JVET-AD0312](https://jvet-experts.org/doc_end_user/current_document.php?id=12876) Crosscheck of JVET-AD0103 (EE2-1.7: TIMD using selectable template regions) [H. Wang (Qualcomm)] [late]

[JVET-AD0112](https://jvet-experts.org/doc_end_user/current_document.php?id=12663) EE2-1.15a: Intra template matching (Intra TMP) based on linear filter model [J.-Y. Huo, W.-H. Qiao, X. Hao, Z.-Y. Zhang, H.-Q. Du, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.)]

[JVET-AD0293](https://jvet-experts.org/doc_end_user/current_document.php?id=12857) Crosscheck of JVET-AD0112 (EE2-1.15a: Intra template matching (Intra TMP) based on linear filter model) [X. Li (Alibaba)] [late]

[JVET-AD0115](https://jvet-experts.org/doc_end_user/current_document.php?id=12666) EE2-1.14a: Extend search area in Intra Template Matching Prediction (IntraTMP) [J.-Y. Huo, H.-Q. Du, H.-L. Zhang, Z.-Y. Zhang, W.-H. Qiao, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.)]

[JVET-AD0292](https://jvet-experts.org/doc_end_user/current_document.php?id=12856) Crosscheck of JVET-AD0115 (EE2-1.14a: Extend search area in Intra Template Matching Prediction (IntraTMP)) [X. Li (Alibaba)] [late]

[JVET-AD0116](https://jvet-experts.org/doc_end_user/current_document.php?id=12667) EE2-1.16: A Fusion method of Intra Template Matching Prediction (Intra TMP) [J.-Y. Huo, H.-Q. Du, H.-L. Zhang, W.-H. Qiao, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.)]

[JVET-AD0295](https://jvet-experts.org/doc_end_user/current_document.php?id=12859) Crosscheck of JVET-AD0116 (EE2-1.16: A Fusion method of Intra Template Matching Prediction (Intra TMP)) [X. Li (Alibaba)] [late]

[JVET-AD0118](https://jvet-experts.org/doc_end_user/current_document.php?id=12669) EE2-1.20h: Combination of EE2-1.14a, EE2-1.15a and EE2-1.16 for Intra TMP [J.-Y. Huo, N.-F. Qiu, H.-L. Zhang, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.), H. Yuan (Shandong Univ.)]

[JVET-AD0297](https://jvet-experts.org/doc_end_user/current_document.php?id=12861) Crosscheck of JVET-AD0118 (EE2-1.20h: Combination of EE2-1.14a, EE2-1.15a and EE2-1.16 for Intra TMP) [X. Li (Alibaba)] [late]

[JVET-AD0119](https://jvet-experts.org/doc_end_user/current_document.php?id=12670) EE2-1.20m: Combination test of Test 1.17 and Test 1.18 [Y. Wang, K. Zhang, L. Zhang (Bytedance), K. Naser, P. Bordes, F. Galpin, K. Reuzé, A. Robert (InterDigital)]

[JVET-AD0260](https://jvet-experts.org/doc_end_user/current_document.php?id=12824) Crosscheck of JVET-AD0119 (EE2-1.20m: Combination test of Test 1.17 and Test 1.18) [F. Wang (OPPO)] [late]

[JVET-AD0120](https://jvet-experts.org/doc_end_user/current_document.php?id=12671) EE2-1.3: Local-Boosting Cross-Component Prediction [Z. Deng, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0243](https://jvet-experts.org/doc_end_user/current_document.php?id=12807) Crosscheck of JVET-AD0120 EE2-1.3: Local-Boosting Cross-Component Prediction [Z. Lv (vivo)] [late]

[JVET-AD0123](https://jvet-experts.org/doc_end_user/current_document.php?id=12674) EE2-5.1: Reference frame padding for GDR [T. Poirier, S. Puri (InterDigital)]

[JVET-AD0351](https://jvet-experts.org/doc_end_user/current_document.php?id=12915) Cross Check of JVET-AD0123 (EE2-5.1: Reference frame padding for GDR) [S. Hong (Nokia)] [late]

[JVET-AD0125](https://jvet-experts.org/doc_end_user/current_document.php?id=12676) EE2-1.12: Intra TMP with sub-pel precision [X. Li, R.-L. Liao, J. Chen, Y. Ye (Alibaba)]

[JVET-AD0310](https://jvet-experts.org/doc_end_user/current_document.php?id=12874) Crosscheck of JVET-AD0125 (EE2-1.12: Intra TMP with sub-pel precision) [F. Pu (Dolby)] [late]

[JVET-AD0126](https://jvet-experts.org/doc_end_user/current_document.php?id=12677) EE2-1.20k: Combination of Test 1.12 and Test 1.14c [X. Li, R.-L. Liao, J. Chen, Y. Ye (Alibaba), Y. Ma, J. Huo, H. Du, H. Zhang, Z. Zhang, W. Qiao, F. Yang (Xidian Univ.), F. Wang, L. Zhang, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AD0311](https://jvet-experts.org/doc_end_user/current_document.php?id=12875) Crosscheck of JVET-AD0126 (EE2-1.20k: Combination of Test 1.12 and Test 1.14c) [F. Pu (Dolby)] [late]

[JVET-AD0140](https://jvet-experts.org/doc_end_user/current_document.php?id=12691) EE2-2.12: Prediction of MVD magnitude suffix bins [A. Filippov, V. Rufitskiy, K. Suverov (Ofinno)]

[JVET-AD0267](https://jvet-experts.org/doc_end_user/current_document.php?id=12831) Crosscheck of JVET-AD0140 (EE2-2.12: Prediction of MVD magnitude suffix bins) [M. Blestel (Xiaomi)] [late]

[JVET-AD0147](https://jvet-experts.org/doc_end_user/current_document.php?id=12698) EE2-1.1: Extends the CCCM template selection to six [P. Bordes, K. Naser, F. Galpin, E. François (InterDigital)]

[JVET-AD0278](https://jvet-experts.org/doc_end_user/current_document.php?id=12842) Crosscheck of JVET-AD0147 (EE2-1.1: Extends the CCCM template selection to six) [H.-J. Jhu (Kwai)] [late]

[JVET-AD0152](https://jvet-experts.org/doc_end_user/current_document.php?id=12703) EE2-2.2: AMVP with SbTMVP mode [R.-L. Liao, J. Chen, Y. Ye, X. Li (Alibaba)]

[JVET-AD0277](https://jvet-experts.org/doc_end_user/current_document.php?id=12841) Cross-check of JVET-AD0152 (EE2-2.2: AMVP with SbTMVP mode) [V. Rufitskiy, A. Filippov (Ofinno)] [late]

[JVET-AD0153](https://jvet-experts.org/doc_end_user/current_document.php?id=12704) EE2-2.5a: Combined test of Test 2.2 and Test 2.4 [R.-L. Liao, J. Chen, Y. Ye, X. Li (Alibaba), L. Zhao, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0326](https://jvet-experts.org/doc_end_user/current_document.php?id=12890) Cross-check of JVET-AD0153 on EE2-2.5a [G. Laroche (Canon)] [late]

[JVET-AD0158](https://jvet-experts.org/doc_end_user/current_document.php?id=12709) EE2-1.13: Test on Fusion of Intra Template Matching [J. R. Arumugam, A. Natesan, V. Valvaiker, A. Sarate, J. N. Shingala (Ittiam), F. Pu, T. Lu, P. Yin, T. Shao, A. Arora, S. McCarthy (Dolby)]

[JVET-AD0261](https://jvet-experts.org/doc_end_user/current_document.php?id=12825) Crosscheck of JVET-AD0158 (EE2-1.13: Test on Fusion of Intra Template Matching) [F. Wang (OPPO)] [late]

[JVET-AD0291](https://jvet-experts.org/doc_end_user/current_document.php?id=12855) Crosscheck of JVET-AD0158 (EE2-1.13: Test on Fusion of Intra Template Matching) [X. Li (Alibaba)] [late]

[JVET-AD0165](https://jvet-experts.org/doc_end_user/current_document.php?id=12716) EE2-2.4: Template matching-based subblock motion refinement [L. Zhao, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0290](https://jvet-experts.org/doc_end_user/current_document.php?id=12854) Crosscheck of JVET-AD0165 (EE2-2.4: Template matching-based subblock motion refinement) [R.-L. Liao (Alibaba)] [late]

[JVET-AD0171](https://jvet-experts.org/doc_end_user/current_document.php?id=12722) EE2-3.1: TMP using Reconstruction-Reordered for screen content coding (RR-TMP) [D. Ruiz Coll, O. Patino, P. Andrivon (Ofinno)]

[JVET-AD0306](https://jvet-experts.org/doc_end_user/current_document.php?id=12870) crosscheck of JVET-AD0171 (EE2-3.1: TMP using Reconstruction-Reordered for screen content coding (RR-TMP)) [K. Naser (InterDigital)] [late]

[JVET-AD0173](https://jvet-experts.org/doc_end_user/current_document.php?id=12724) EE2-1.22: Template-based intra MPM list construction [C. Zhou, Z. Lv, J. Zhang (vivo)]

[JVET-AD0337](https://jvet-experts.org/doc_end_user/current_document.php?id=12901) Crosscheck of JVET-AD0173 (EE2-1.22: Template-based intra MPM list construction) [J. Chen (Alibaba)] [late] [miss]

[JVET-AD0177](https://jvet-experts.org/doc_end_user/current_document.php?id=12728) EE2-1.18: CIIP Extension with IntraTMP [K. Naser, P. Bordes, F. Galpin, A. Robert (InterDigital)]

[JVET-AD0259](https://jvet-experts.org/doc_end_user/current_document.php?id=12823) Crosscheck of JVET-AD0177 (EE2-1.18: CIIP Extension with IntraTMP) [F. Wang (OPPO)] [late]

[JVET-AD0182](https://jvet-experts.org/doc_end_user/current_document.php?id=12737) EE2-2.1: On Affine DMVR [M. Blestel, M. Radosavljević (Xiaomi), [Y. Zhang](mailto:yzh@qti.qualcomm.com), H. Huang, V. Seregin, M. Karczewicz (Qualcomm), J. Chen, R. -L. Liao, X. Li, Y. Ye (Alibaba)]

[JVET-AD0255](https://jvet-experts.org/doc_end_user/current_document.php?id=12819) Cross-check of JVET-AD0182 ("EE2-2.1: On Affine DMVR", Test EE2-2.1g and Test EE2-2.1i) [V. Rufitskiy, A. Filippov (Ofinno)] [late]

[JVET-AD0281](https://jvet-experts.org/doc_end_user/current_document.php?id=12845) Cross-check of JVET-AD0182 ("EE2-2.1: On Affine DMVR", Test EE2-2.1c and Test EE2-2.1g) [W. Chen (Kwai)] [late]

[JVET-AD0283](https://jvet-experts.org/doc_end_user/current_document.php?id=12847) Cross-check of JVET-AD0182 ("EE2-2.1: On Affine DMVR", Test EE2-2.1l and Test EE2-2.1n) [L. Zhao (Bytedance)] [late]

[JVET-AD0323](https://jvet-experts.org/doc_end_user/current_document.php?id=12887) Cross-check of JVET-AD0182 (EE2-2.1: On Affine DMVR) tests 2.1a, 2.1b, 2.1f and 2.1k [F. Le Léannec (InterDigital)] [late]

[JVET-AD0353](https://jvet-experts.org/doc_end_user/current_document.php?id=12917) Crosscheck of JVET-AD0182 (EE2-2.1: On Affine DMVR) [C.-M. Tsai (MediaTek)] [late]

[JVET-AD0188](https://jvet-experts.org/doc_end_user/current_document.php?id=12752) EE2-1.6: Non-local cross-component prediction and cross-component merge mode [K. Zhang, L. Zhang, Z. Deng (Bytedance), C.-M. Tsai, H.-Y. Tseng, C.-Y. Chuang, C.-W. Hsu, C.-Y. Chen, T.-D. Chuang, O. Chubach, Y.-W. Chen, Y.-W. Huang, S.-M. Lei (Mediatek)]

[JVET-AD0324](https://jvet-experts.org/doc_end_user/current_document.php?id=12888) Crosscheck of JVET-AD0188 (EE2-1.6b: Non-local cross-component prediction and cross-component merge mode) [Y.-J. Chang (Qualcomm) [late]

[JVET-AD0336](https://jvet-experts.org/doc_end_user/current_document.php?id=12900) Crosscheck of JVET-AD0188 (EE2-1.6: Non-local cross-component prediction and cross-component merge mode) [J. Chen (Alibaba)] [late] [miss]

[JVET-AD0355](https://jvet-experts.org/doc_end_user/current_document.php?id=12919) Crosscheck of JVET-AD0188 (EE2-1.6a: Non-local cross-component prediction and cross-component merge mode) [C.-W. Kuo (Kwai)] [late]

[JVET-AD0190](https://jvet-experts.org/doc_end_user/current_document.php?id=12754) EE2-1.23: Modification to MPM list derivation [H. Wang, Y.-J. Chang, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AD0264](https://jvet-experts.org/doc_end_user/current_document.php?id=12828) Crosscheck of JVET-AD0190 EE2-1.23: Modification to MPM list derivation [Y. Yasugi (Sharp)] [late]

[JVET-AD0191](https://jvet-experts.org/doc_end_user/current_document.php?id=12755) EE2-1.20e: Combination Test of Test 1.10 + Test 1.13 [J. R. Arumugam, A. Natesan, V. Valvaiker, A. Sarate, J. N. Shingala (Ittiam), F. Pu, T. Lu, P. Yin, S. McCarthy (Dolby), F. Wan (OPPO)]

[JVET-AD0296](https://jvet-experts.org/doc_end_user/current_document.php?id=12860) Crosscheck of JVET-AD0191 (EE2-1.20e: Combination Test of Test 1.10 + Test 1.13) [X. Li (Alibaba)] [late]

[JVET-AD0192](https://jvet-experts.org/doc_end_user/current_document.php?id=12756) EE2-1.20f: Combination Test of Test 1.12 + Test 1.13b [F. Pu, T. Lu, P. Yin, S. McCarthy (Dolby), J. R. Arumugam, A. Natesan, V. Valvaiker, A. Sarate, J. N. Shingala (Ittiam), X. Li, R.-L. Liao, J. Chen (Alibaba)]

[JVET-AD0262](https://jvet-experts.org/doc_end_user/current_document.php?id=12826) Crosscheck of JVET-AD0192 (EE2-1.20f: Combination Test of Test 1.12 + Test 1.13b) [F. Wang (OPPO)] [late]

[JVET-AD0193](https://jvet-experts.org/doc_end_user/current_document.php?id=12757) EE2-2.11e: Combination of EE2-2.8, EE2-2.9 and EE2-2.10 [K. Cui, Z. Zhang, H. Huang, V. Seregin, M. Karczewicz (Qualcomm), X. Li (Google), Z. Deng, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0289](https://jvet-experts.org/doc_end_user/current_document.php?id=12853) Crosscheck of JVET-AD0193 (EE2-2.11e: Adaptive OBMC control) [X. Xiu (Kwai)] [late]

[JVET-AD0360](https://jvet-experts.org/doc_end_user/current_document.php?id=12924) Crosscheck of JVET-AD0193 on non-CTC mixed content sequences (EE2-2.11e: Adaptive OBMC control) [J. Gan (OPPO)] [late]

[JVET-AD0194](https://jvet-experts.org/doc_end_user/current_document.php?id=12758) EE2-1.19: IntraTMP with multiple modes [P.-H. Lin, J.-L- Lin, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AD0263](https://jvet-experts.org/doc_end_user/current_document.php?id=12827) Crosscheck of JVET-AD0194 (EE2-1.19: IntraTMP with multiple modes) [F. Wang (OPPO)] [late]

[JVET-AD0195](https://jvet-experts.org/doc_end_user/current_document.php?id=12759) EE2-2.6: High-Precision MV Refinement for BDOF [M. Salehifar, Y. He, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0198](https://jvet-experts.org/doc_end_user/current_document.php?id=12762) EE2-1.20c: Combination of Test1.14 and Test1.19 [P.-H. Lin, J.-L- Lin, V. Seregin, M. Karczewicz (Qualcomm), F. Wang, L. Zhang, Y. Yu, H. Yu, D. Wang (OPPO), [Y. Ma](mailto:yzma@mail.xidian.edu.cn), J. Huo, F. Yang (Xidian Univ.)]

[JVET-AD0279](https://jvet-experts.org/doc_end_user/current_document.php?id=12843) Crosscheck of JVET-AD0198 (EE2-1.20c: Combination of Test1.14 and Test1.19) [H.-J. Jhu (Kwai)] [late]

[JVET-AD0199](https://jvet-experts.org/doc_end_user/current_document.php?id=12763) EE2-3.2: IBC MBVD list derivation [Z. Zhang, P. Nikitin, H. Huang, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AD0244](https://jvet-experts.org/doc_end_user/current_document.php?id=12808) Crosscheck of JVET-AD0199 EE2-3.2: IBC MBVD list derivation [D. Ruiz Coll (Ofinno) [late] [miss]

[JVET-AD0202](https://jvet-experts.org/doc_end_user/current_document.php?id=12766) EE2-1.2: CCCM using multiple downsampling filters [Y.-J. Chang, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AD0349](https://jvet-experts.org/doc_end_user/current_document.php?id=12913) Crosscheck of JVET-AD0202 (EE2-1.2: CCCM using multiple downsampling filters) [J. Lainema (Nokia)] [late]

[JVET-AD0208](https://jvet-experts.org/doc_end_user/current_document.php?id=12772) EE2-1.8/1.9: IBC adaptation for coding of natural content [C.-C. Chen, B. Ray, M. Coban, V. Seregin, M. Karczewicz (Qualcomm), W. Chen, X. Xiu, C. Ma, H.-J. Jhu, C.-W. Kuo, N. Yan, X. Wang (Kwai)]

[JVET-AD0299](https://jvet-experts.org/doc_end_user/current_document.php?id=12863) Crosscheck of JVET-AD0208 (EE2-1.8/1.9: IBC adaptation for coding of natural content) [Y. Kidani, K. Kawamura (KDDI)] [late]

[JVET-AD0209](https://jvet-experts.org/doc_end_user/current_document.php?id=12773) EE2-2.3: SbTMVP with MMVD [L.-F. Chen, R. Chernyak, X. Zhao, X. Xu, S. Liu (Tencent)]

[JVET-AD0280](https://jvet-experts.org/doc_end_user/current_document.php?id=12844) Crosscheck of JVET-AD0209 (EE2-2.3: SbTMVP with MMVD) [X. Xiu (Kwai)] [late]

[JVET-AD0210](https://jvet-experts.org/doc_end_user/current_document.php?id=12774) EE2-2.5b: Combined test of Test 2.2 and Test 2.3 [L.-F. Chen, R. Chernyak, X. Zhao, X. Xu, S. Liu (Tencent), R.-L. Liao, J. Chen, Y. Ye, X. Li (Alibaba)]

[JVET-AD0230](https://jvet-experts.org/doc_end_user/current_document.php?id=12794) Crosscheck of JVET-AD0210 EE2-2.5b: Combined test of Test 2.2 and Test 2.3 [X. Li (Google)] [late]

[JVET-AD0213](https://jvet-experts.org/doc_end_user/current_document.php?id=12777) EE2-Test2.7: Improvements on local illumination compensation [X. Xiu, N. Yan, C. Ma, H.-J. Jhu, C.-W. Kuo, W. Chen, X. Wang (Kwai)]

[JVET-AD0225](https://jvet-experts.org/doc_end_user/current_document.php?id=12789) Crosscheck of JVET-AC0213 on EE2-Test2.7: Improvements on local illumination compensation [L.-F. Chen (Tencent)] [late] [miss]

[JVET-AD0219](https://jvet-experts.org/doc_end_user/current_document.php?id=12783) EE2-4.2/4.3/4.4a: Residual based classifier and modified filter shape for ALF [I. Jumakulyyev, N. Hu, Z. Zhang, V. Seregin, M. Karczewicz, H. Huang (Qualcomm)]

[JVET-AD0227](https://jvet-experts.org/doc_end_user/current_document.php?id=12791) Crosscheck of JVET-AD0219 (EE2-4.2/4.3/4.4a: Residual based classifier and modified filter shape for ALF) [W. Yin (Bytedance)] [late]

[JVET-AD0221](https://jvet-experts.org/doc_end_user/current_document.php?id=12785) EE2-4.1: Additional Fixed Filter for ALF [W. Yin, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0228](https://jvet-experts.org/doc_end_user/current_document.php?id=12792) Crosscheck of JVET-AD0221 (EE2-4.1: Additional Fixed Filter for ALF) [N. Hu (Qualcomm)] [late]

[JVET-AD0222](https://jvet-experts.org/doc_end_user/current_document.php?id=12786) EE2-4.4b and 4.4c: Combined Tests for ALF [I. Jumakulyyev, N. Hu, Z. Zhi, V. Seregin, M. Karczewicz, H. Huang (Qualcomm), W. Yin, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0341](https://jvet-experts.org/doc_end_user/current_document.php?id=12905) Cross-check of JVET-AD0222 (EE2-4.4b and 4.4c: Combined Tests for ALF) [K. Andersson (Ericsson)] [late]

[JVET-AD0247](https://jvet-experts.org/doc_end_user/current_document.php?id=12811) EE2-1.20n: Combination Test of Test 1.20f + Test 1.14c [F. Pu, T. Lu, P. Yin, S. McCarthy (Dolby), J. R. Arumugam, A. Natesan, V. Valvaiker, A. Sarate, J. N. Shingala (Ittiam), Xinwei Li, Ru-Ling Liao, Jie Chen (Alibaba), Y. Ma, J. Huo, H. Du, H. Zhang, Z. Zhang, W. Qiao, F. Yang (Xidian), F. Wang, L. Zhang, Y. Yu, H. Yu, D. Wang (OPPO)] [late]

[JVET-AD0269](https://jvet-experts.org/doc_end_user/current_document.php?id=12833) Crosscheck of JVET-AD0247 (EE2-1.20n: Combination Test of Test 1.20f + Test 1.14c) [R. G. Youvalari (Nokia)] [late]

[JVET-AD0256](https://jvet-experts.org/doc_end_user/current_document.php?id=12820) EE2-2.12h: Combined test of Test 2.7 and Test 2.12a [A. Filippov, V. Rufitskiy, K. Suverov (Ofinno), [X. Xiu](mailto:xiaoyuxiu@kwai.com), N. Yan, C. Ma, H.-J. Jhu, C.-W. Kuo, W. Chen, X. Wang (Kwai)] [late]

[JVET-AD0274](https://jvet-experts.org/doc_end_user/current_document.php?id=12838) Crosscheck of JVET-AD0256 (EE2-2.12h: Combined test of Test 2.7 and Test 2.12a) [M. Blestel (Xiaomi)] [late]

[JVET-AD0257](https://jvet-experts.org/doc_end_user/current_document.php?id=12821) EE2-2.12g: Combined test of Test 2.2 and Test 2.12a [V. Rufitskiy, A. Filippov, K. Suverov (Ofinno), R.-L. Liao, J. Chen, Y. Ye, X. Li (Alibaba)] [late]

[JVET-AD0275](https://jvet-experts.org/doc_end_user/current_document.php?id=12839) Crosscheck of JVET-AD0257 (EE2-2.12g: Combined test of Test 2.2 and Test 2.12a) [M. Blestel (Xiaomi)] [late]

### EE2 related contributions (10)

Contributions in this area were discussed at 1400–1530 on Saturday 22 April 2023 (chaired by JRO).

[JVET-AD0048](https://jvet-experts.org/doc_end_user/current_document.php?id=12595) EE2-related: Cross-component merge mode with temporal candidates [H.-Y. Tseng, C.-M. Tsai, C.-Y. Chuang, C.-W. Hsu, C.-Y. Chen, T.-D. Chuang, O. Chubach, Y.-W. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

In JVET-AC0315, a cross-component merge (CCMerge) mode was proposed to inherit cross-component model parameters from spatial adjacent and non-adjacent neighbors. In this contribution, a method of further inheriting cross-component model parameters from temporal candidates is proposed. The definitions of terms related to temporal candidates, such as inclusion order, position, and collocated picture, are the same as those in the ECM-8.0 inter merge mode.

On top of ECM-8.0, simulation results of including the proposed temporal candidates into CCMerge mode are reported as below:  
RA: {Y BD-rate = -0.xx%, Cb BD-rate = -0.xx%, Cr BD-rate = -0.xx%, EncT = 10x%, DecT = 10x%}

Gain mostly from A classes (but not finished yet).

Investigate in EE.

[JVET-AD0084](https://jvet-experts.org/doc_end_user/current_document.php?id=12635) EE2-related: On search range of intraTMP [Y. Yu, L. Zhang, F. Wang, J. Gan, H. Yu, L. Xu, Z. Xie, D. Wang (OPPO)]

No need for presentation – included in JVET-AD0342.

[JVET-AD0286](https://jvet-experts.org/doc_end_user/current_document.php?id=12850) Crosscheck of JVET-AD0084 (EE2-related: On search range of intraTMP) [X. Xiu (Kwai)] [late]

[JVET-AD0117](https://jvet-experts.org/doc_end_user/current_document.php?id=12668) EE2-related: Search area extension of bottom-left and top-right regions for IntraTMP mode [Y.-Z. Ma, H.-L. Zhang, H.-Q. Du, W.-H. Qiao, J.-Y. Huo, F.-Z. Yang (Xidian Univ.)]

No need for presentation – included in JVET-AD0342.

[JVET-AD0144](https://jvet-experts.org/doc_end_user/current_document.php?id=12695) EE2-related: FTMP multi-filter extend based on gradient and location information [X. Zhang, D. Jiang, J.-C. Lin, X.-H. Zhang, D.-Q. Cheng, C.-H. Zheng, Z.-Q. Wang, Y.-F. Lu (Dahua)]

This contribution introduces gradient information and location information to intraTMP as another filter method. In this method, gradient term and positional terms are included in the filter model, and one of 4 patterns is selected by template area SAD to calculate gradient. A flag is signalled to choose whether use FTMP or the proposed method. The proposed method was implemented with EE2-1.15a on top of ECM-8.0 and EE2-1.15a, it reportedly provides {Y, U, V} BD-rate reduction with encoder and decoder runtimes as follows:

On top of ECM-8.0:

AI: -0.16% -0.20% -0.18% xxx% (EncT), xxx% (DecT)

On top of EE-1.15a:

AI: -0.04% -0.06% -0.02% xxx% (EncT), xxx% (DecT)

Gain mostly from class E, and encoder runtime increase of 2%

Not much gain over 1.15a which was adopted, and due to other adoptions in the package 1.20j the gain may even be lower.

No action.

[JVET-AD0146](https://jvet-experts.org/doc_end_user/current_document.php?id=12697) EE2-related: EE2-1.15a improvement [S. Peng, X. Zhang, C. Fang, D. Jiang, J.-C. Lin, K. Fu, P. Zhang (Dahua)]

In EE2-1.15a, a linear filter method for the prediction of Intra TMP (FTMP) is proposed to improve compression efficiency of ECM, where the filter input consists of 5 spatial samples and a bias term. In this contribution, a gradient and location based filter method is proposed. The proposed method is implemented on top of EE2-1.15a, it reportedly provides {Y, U, V} BD-rate reduction with encoder and decoder runtimes as follows:

Results on EE2-1.15a anchor:

AI: -0.04%, -0.05%, 0.00%, 95% (EncT), 94% (DecT)

Results on ECM8.0 anchor:

AI: -0.16%, -0.19%, -0.17%, 97% (EncT), 93% (DecT)

It is noted that runtimes are not reliable.

Difference relative to AD0144 seems to be minor.

Not much gain over 1.15a which was adopted, and due to other adoptions in the package 1.20j the gain may even be lower.

No action.

[JVET-AD0178](https://jvet-experts.org/doc_end_user/current_document.php?id=12729) non EE2-4.3: IntraTMP Padding [K. Naser, T. Poirier, A. Robert, H. Guermoud (InterDigital)]

This contribution proposes extending IntraTMP process with candidates that are partially available and use padding for filling in non-available samples. Similar to EE2-3.4 that performs padding for IBC, it is further extended to IntraTMP mode. The following results are obtained:

* ClassF:
  + AI: {-0.10%, -1.40%, 0.00%; 98%, 98%}.
  + RA: {-0.04% -1.62% 0.20% 98% 98%}.
* ClassTGM:
  + AI: {-0.21% 0.27% -0.05% 102% 104%}.
  + RA: {-0.21% 0.32% 0.01% 102% 104%}.

Only beneficial for screen content? Mainly.

Why are runtimes decreased for class F, increased for TGM? May be unreliable.

Is padding sequential? Yes.

Results seem to be highly varying per sequence.

No clear benefit in compression, and might have complexity impact. No action.

[JVET-AD0196](https://jvet-experts.org/doc_end_user/current_document.php?id=12760) EE2-related: On Iterative BDOF and EE2-2.6 Improvement [M. Salehifar, Y. He, K. Zhang, H. Liu, L. Zhang (Bytedance)]

In test EE2-2.6 (JVET-AD0195), high-precision MV refinement for BDOF is introduced, which includes accurate BDOF parameter calculation, added weights, as well as adaptive BDOF DMVR subblock size.

This proposal introduces some improvement on top of EE2-2.6, including adding iteration for BDOF DMVR for qualified blocks.

On top of the ECM-8.0 and EE2-2.6, simulation result of the proposed method is reported as:

Compared with ECM-8.0:

RA: -0.33%, -0.34%, -0.38%, 103%, 106%.

Compared with EE2-2.6:

RA: -0.13%, -0.15%, -0.20%, 103%, 105%.

Most gain from iterative BDOF. One additional iteration was used

Increasing number of iterations gave more gain for some sequences, but would also increase runtimes.

Proponents see options to reduce runtime (current tradeoff with compression benefit not good)

Investigate in EE. Also investigate the benefit of the different elements, and possibility of runtime reduction (both encoder and decoder).

[JVET-AD0348](https://jvet-experts.org/doc_end_user/current_document.php?id=12912) Crosscheck of JVET-AD0196 (EE2-related: Iterative BDOF and EE2-2.6 Improvement) [Z. Lv (vivo)] [late]

[JVET-AD0200](https://jvet-experts.org/doc_end_user/current_document.php?id=12764) EE2-related: InterMTS for IBC and IntraTMP [P. Garus, M. Coban, B. Ray, V. Seregin, M. Karczewicz (Qualcomm)]

In EE2 Test-1.8, IBC with additional encoder optimizations is studied for camera captured content.

This contribution improves the coding gain on top of Test-1.8 further by enabling interMTS kernels for IBC predicted blocks. Furthermore, IBC and intraTMP MTS Kernels are being aligned, *i.e.* intraTMP is using interMTS instead of intraMTS kernels.

The following results are provided on top of EE2-Test1.8a:

AI: -0.07% (Y), -0.02% (U), -0.05 % (V), 100% (EncT), 100% (DecT).

Interest is expressed by various experts (including crosscheckers) to investigate in EE. The aspect of enabling MTS, and switching from intra to inter MTS kernels should be investigated separately.

[JVET-AD0203](https://jvet-experts.org/doc_end_user/current_document.php?id=12767) EE2-related: Reconstruction-Reordered TMP based on linear filter model for screen content coding (RRTMP-LFM) [D. Ruiz Coll, O. Patino, P. Andrivon (Ofinno)] [late]

This contribution proposes to extend the linear filter model for IntraTMP, presented in the EE-2-Test-1.15a and Test 1.15b (TMP-LFM), to the Reconstruction-Reordered TMP (RR-TMP) mode proposed in the EE2-Test.3.1. Instead of using the regular templates of the reference block and the current block, the horizontal or vertical flipped templates are used for the filter coefficients derivation. After that, the linear model is applied to the flipped reference block and used as a prediction block. When the IntraTMP mode is activated, the encoder signals using this mode with a flag. Simulation results on top of ECM-8.0 are reported below:

AI: Class F -0.12%, -0.49%, -0.17%, 102%, 102%; Class TGM -0.13%, -0.14%, -0.09%, 102%, 104%

RA: Class F -0.11%, -0.55%, -0.05%, 101%, 101%; Class TGM -0.10%, -0.19%, -0.21%, 100%, 101%

Basically this is a combination of EE2-1.15x and reconstruction-reordered IntraTMP mode from EE2-3.1

Gains are relatively low (compared to what is usually observed in screen content)

Due to the adoption of 1.15a and other IntraTMP elements in EE2-1.20j, it is likely that the additional gain of reconstruction-reordered IntraTMP mode would again be smaller than reported here in comparison to ECM8.

No action.

[JVET-AD0342](https://jvet-experts.org/doc_end_user/current_document.php?id=12906) EE2-related: Combination of JVET-AD0084, JVET-AD0117 and JVET-AD0214 [Y. Yu, L. Zhang, F. Wang, J. Gan, H. Yu, L. Xu, Z. Xie, D. Wang (OPPO), Y. Ma, H. Zhang, H. Du, W. Qiao, J. Huo, (Xidian University), X. Xiu, N. Yan, C. Ma, H. Jhu, C. Kuo, W. Chen, (Kwai)] [late]

This contribution reports the combination test results for the additional IntraTMP search areas proposed by JVET-AD0084, JVET-AD0117, and JVET-AD-214. IntraTMP employs a pre-defined template of the current block to search for a candidate template of the same shape that best matches the template of the current block within a pre-determined search area. The corresponding reference block with the best matched template is selected as the prediction block for the current block. Currently, the search region of the intraTMP mode is composed of four different areas which contain the reconstructed samples from the top and left CTUs and part of the reconstructed samples from the same CTU that the current block belongs to. This contribution proposes to include the bottom-left and top-right areas adjacent to the current block as additional search areas for intraTMP. In addition, this contribution proposes to restrict the intraTMP search with a specified search range for all pre-determined search areas. On top of ECM-8.0, the simulation results are reported as follows:

AI(Y/U/V): -0.21%/-0.28%/-0.27%, EncT 103%, DecT 102%

RA(Y/U/V): -0.12%/-0.08%/-0.05%, EncT 101%, DecT 100%

On top of EE2-Test1.20j, the simulation results are reported as follows (relative to ECM-8.0 anchor):

AI(Y/U/V): -1.35%/-1.32%/-1.37%, EncT 105%, DecT 108%

RA(Y/U/V): -0.xx%/-0.xx%/-0.xx%, EncT xx%, DecT xx%

The three proposals are conceptually identical, but implementation-wise slightly different, results are from JVET-AD0084

Results compared to EE2-1.20j as anchor: 0.34/0.33/0.37% gain in AI, RA was not final yet.

Very straightforward extension according to cross-checkers, results confirmed.

Investigate in EE.

[JVET-AD0359](https://jvet-experts.org/doc_end_user/current_document.php?id=12923) Crosscheck of JVET-AD0342 (EE2-related: Combination of JVET-AD0084, JVET-AD0117 and JVET-AD0214) [X. Li (Alibaba)] [late]

[JVET-AD0367](https://jvet-experts.org/doc_end_user/current_document.php?id=12931) Crosscheck of JVET-AD0342 (EE2-related: Combination of JVET-AD0084, JVET-AD0117 and JVET-AD0214) [P.-H. Lin (Qualcomm)] [late]

[JVET-AD0396](https://jvet-experts.org/doc_end_user/current_document.php?id=12960) EE2-related: IBC MBVD for coding of camera captured content [Z. Zhang, P. Nikitin, H. Huang, V. Seregin, M. Karczewicz (Qualcomm)] [late]

This contribution reports the experiment results of IBC MBVD for camera captured content. The anchor is ECM-8.0 and the test is EE2-3.2. For both anchor and test, IBC is enabled. It reports all intra configuration results as follows:

AI : -0.05% (Y), -0.04% (U), -0.05 (V), 100% (EncT), 100% (DecT)

Was presented Wed Apr 26 1115Some support was expressed to study the previous EE2-3,2 again in EE w.r.t. its benefit for camera-captured content.

Study in EE.

### ECM modifications and software improvements beyond EE2 (37)

Contributions in this area were discussed at 1530–1550 and 1710–2000 on Saturday 22 April 2023, 0900-1300 and 1400-1555 on Sunday 23 April 2023 (chaired by JRO) and 1620-1640 on Sunday 23 April 2023 (chaired by Y. Ye).

[JVET-AD0064](https://jvet-experts.org/doc_end_user/current_document.php?id=12612) AHG12: Enhanced geometrical prediction mode [R. Yu, P. Wennersten, J. Enhorn, K. Andersson (Ericsson)]

The existing GPM design in ECM relies on uni-predictive motion vectors to generate motion compensated prediction samples for each inter partition. In this contribution, it is proposed to extend the design to allow usage of bi-predictive motion vectors. Furthermore, the current ECM tools GPM-MMVD and GPM-TM are modified to incorporate such a modification. The proposed method is reported to be implemented on top of ECM-8.0. The BD-rate PSNR impact is reported to be -0.21% and -0.27% under RA and LDB common test configurations, respectively. The average encoding run time number for class B, C and D under RA is reported to be 101%. The average decoding run time number for all classes under RA is reported to be 100%. It is asserted that the proposed modifications are straightforward and provide a reasonable trade-off between BD-rate gains and run time impacts. It is proposed to include the proposed modifications into the next version of ECM.

It was commented that most gain may come due to enabling bi-prediction for inter GPM (and also enabling BDOF in that context). It was however pointed out that this increases the worst case number of reference memory accesses.

However, the restriction to uni prediction which was imposed when GPM was adopted to VVC has become obsolete, considering that other elements of ECM already have more reference memory access requirement.

Several experts supported to investigate in EE.

[JVET-AD0318](https://jvet-experts.org/doc_end_user/current_document.php?id=12882) Crosscheck of JVET-AD0064 (AHG12: Enhanced geometrical prediction mode) [Y. Ahn (LGE)] [late]

[JVET-AD0080](https://jvet-experts.org/doc_end_user/current_document.php?id=12628) Non-EE2: Chroma-to-chroma convolutional cross-component model (C2C-CCCM) for intra prediction [Y. Huo, Y. Liu (Transsion)]

This contribution introduces chroma-to-chroma convolutional cross-component model (C2C-CCCM) based on the proposal JVET-AA0057. The proposed method adds two new prediction modes that chroma red is predicted from chroma blue signals. The impacts on coding efficiency and runtimes over ECM-8.0 are reportedly {for Y, U, V, EncT, DecT}:

AI { xx.xx%, xx.xx%, xx.xx%, xxx%, xxx%}, RA { xx.xx%, xx.xx%, xx.xx%, xxx%, xxx%}

Preliminary results show small loss in luma, small gain in chroma. Also encoder runtime is increased.

Not mature for EE at this stage. Further study.

[JVET-AD0081](https://jvet-experts.org/doc_end_user/current_document.php?id=12632) Non-EE2: An extrapolation filter-based intra prediction mode [L. Xu, Y. Yu, H. Yu, D. Wang (OPPO)]

This contribution proposes an extrapolation filter-based Intra Prediction (EIP) mode. First, the extrapolation filter coefficients are obtained from the neighboring reconstructed pixels of the current block with a pre-determined template. Then, the extrapolation is processed position by position from top-left to bottom-right within the current block to form a prediction block. The proposed method was implemented on top of ECM-8.0 software. The simulation results are summarized as follows,

AI: -0.27%/-0.19%/-0.20% Y/U/V, 108%/101% EncT/DecT,

RA:

9 different configurations are possible (selecting the reconstructed area) for determining the coefficients (algorithm similar as CCCM). The selected set is signalled, and coefficients are determined at decoder for only the signalled one. Therefore, the encoder runtime is more increased than decoder.

MTS similar to MIP.

It is pointed out that a significant number of cycles may be needed to compute the prediction. It might be necessary to disable for large block sizes.

Study in EE. Also investigate restriction to smaller blocks. Reduction of encoding runtime should be studied,

[JVET-AD0271](https://jvet-experts.org/doc_end_user/current_document.php?id=12835) Crosscheck of JVET-AD0081 (Non-EE2: An extrapolation filter-based intra prediction mode) [C. Zhou (vivo)] [late] [miss]

[JVET-AD0357](https://jvet-experts.org/doc_end_user/current_document.php?id=12921) Crosscheck of JVET-AD0081 (Non-EE2: An extrapolation filter-based intra prediction mode) [H.-J. Jhu, X. Xiu (Kwai)] [late]

[JVET-AD0083](https://jvet-experts.org/doc_end_user/current_document.php?id=12634) Non-EE2: Improvement over IBC-LIC [Z. Xie, Y. Yu, H. Yu, D. Wang (OPPO)]

In this contribution, multiple new modes related to IBC-LIC are proposed to further improve the coding performance of IBC-LIC. In ECM8.0, IBC-LIC derives the linear model from both the top and left templates. Two new modes are proposed to allow only using the top or the left template, respectively. In addition, it is proposed to allow IBC-LIC to have multiple linear models in one CU, which is similar to MMLM.

The proposed method was implemented on top of ECM8.0 and the summarized test results are shown below:

AI: -0.50% (Y), -0.67% (U), -0.54% (V), 101% (EncT), 99% (DecT) for class F

-0.11% (Y), -0.10% (U), -0.07% (V), 102% (EncT), 101% (DecT) for class TGM

RA: -0.47% (Y), -0.74% (U), -0.48% (V), 100% (EncT), 99% (DecT) for class F

-0.03% (Y), -0.03% (U), -0.07% (V), 102% (EncT), 100% (DecT) for class TGM

Support for investigation in EE. The modification of removing the block size constraint should be studied independently. Should also be tested for camera-captured classes.

[JVET-AD0371](https://jvet-experts.org/doc_end_user/current_document.php?id=12935) Crosscheck of JVET-AD0083 (Non-EE2: Improvement over IBC-LIC) [Y. Wang (Bytedance)] [late]

[JVET-AD0100](https://jvet-experts.org/doc_end_user/current_document.php?id=12651) AHG12: Block vector guided CCCM [R. G. Youvalari, D. Bugdayci Sansli, P. Astola, J. Lainema (Nokia)] [late]

This contribution proposes a new convolutional cross-component model which uses block vector of the co-located IBC or intraTMP coded luma block to identify the reference area for deriving the CCCM model. The proposed block vector guided CCCM (BVG-CCCM) method uses the same 7-tap filter design of the CCCM method and the co-located luma block’s samples for prediction. The mode is signalled with a context coded flag which is conditioned on co-located luma block’s mode. The impact on coding efficiency and runtimes over ECM-8.0 is reportedly {for Y, U, V, EncT, DecT}:

CTC classes: AI { -0.00%, -0.10%, -0.10%, 100%, 100%}, RA { -0.xx%, -0.xx%, -0.xx%, 10x%, 10x%}

Class F: AI { -0.06%, -0.51%, -0.57%, 101%, 100%}, RA { -0.xx%, -0.xx%, -0.xx%, 10x%, 10x%}

Class TGM: AI { -0.64%, -1.20%, -1.03%, 101%, 100%}, RA { -0.09%, -0.27%, -0.26%, 97%, 10x%}

Combination with EE2-1.8 shows higher gain also for natural content.

Investigate in EE. A configuration using the method only for IBC should additionally be tested.

[JVET-AD0368](https://jvet-experts.org/doc_end_user/current_document.php?id=12932) Crosscheck of JVET-AD0100 (AHG12: Block vector guided CCCM) [Y.-J. Chang (Qualcomm)] [late]

[JVET-AD0108](https://jvet-experts.org/doc_end_user/current_document.php?id=12659) AHG12: Cross-component residual model (CCRM) for inter prediction [P. Astola, J. Lainema (Nokia)]

This contribution proposes to apply a cross-component residual model (CCRM) based chroma prediction to improve compression efficiency of inter slices in ECM. The proposed method uses 8-tap convolutional filter to map reconstructed luma into an improved chroma prediction when the CCRM prediction mode is activated by a TU level flag. The filter input consists of 6 spatial luma samples, a nonlinear term, and a bias term. Filter coefficients are derived for each block separately using the prediction signals and the filters are applied to the reconstructed luma signal. The impact on coding efficiency and runtimes over ECM-8.0 is reportedly {for Y, U, V, EncT, DecT}:

RA {-0.15%, -1.37%, -1.74%, 106%, 100%},

LD-B {0.03%, -3.21%, -3.20%, 106%, 100%},

LD-P {0.02%, -3.65%, -3.54%, 107%, 100%}.

The additional signalling could be the reason for the relative imbalance between luma loss and chroma gain in some classes and some sequences. Overall, several experts commented there is probably interesting gain.

Investigate in EE. Also study possibility of reducing encoding time. Also benefit for different block sizes should be studied

It was suggested to better use denomination as “inter CCCM”

[JVET-AD0288](https://jvet-experts.org/doc_end_user/current_document.php?id=12852) Crosscheck of JVET-AD0108 (AHG12: Cross-component residual model (CCRM) for inter prediction) [Z. Deng (ByteDance)] [late]

[JVET-AD0114](https://jvet-experts.org/doc_end_user/current_document.php?id=12665) Non-EE2: Modification of MV redundancy/similarity check considering LIC during merge candidate list construction [K. Kim, D. Kim, J.-H. Son, J.-S. Kwak (WILUS)]

This contribution proposes the modification of MV redundancy/similarity check procedure considering LIC usage during merge candidate list construction. A condition has been added to check whether the use of LIC is the same when performing MV redundancy/similarity check on the neighboring blocks with uni-prediction. The modification would allow LIC ON and OFF candidates with similar motion vectors to be included in the merge candidate list, providing an opportunity to selectively apply LIC in CUs using merge mode. Compared with ECM-8.0, the proposed methods achieve -0.03% and -0.04% gain in RA and LDB configurations, respectively, with 99% encoder and 98% decoder run time in LDB configurations of common test condition.

RA: {-0.03%, 0.05%, 0.03%, 100%, 100%}

LDB: {-0.04%, 0.02%, 0.12%, 99%, 98%}

Reason for encoding time reduction not obvious.

Benefit not obvious enough to investigate in EE.

[JVET-AD0124](https://jvet-experts.org/doc_end_user/current_document.php?id=12675) AHG 12: Fix related to template type selection in Intra TMP [D. Kim, K. Kim, J.-H. Son, J.-S. Kwak (WILUS)]

It was discovered that the condition of template type selection in Intra TMP was not aligned with the intention of JVET-W0069: On Intra TMP Boundary Conditions. Specifically, for left template type selection, the condition of isLeftAboveAvailable() was being used instead of isLeftAvailable(), which resulted in a categorization of NO\_TEMPLATE even when Left Template was available. To address this issue, it is proposed to replace the isLeftAboveAvailable() with the isLeftAvailable() for selecting the LEFT\_TEMPLATE in Intra TMP.

It is reported that on top of ECM-8.0, the overall coding performance is as below:

For AI configuration: x.xx%, x.xx % and x.xx % with xxx% EncT, xxx% DecT.

For RA configuration: x.xx%, x.xx% and x.xx% with xxx% EncT, xxx% DecT.

There is no significant difference in results. It is verbally reported by another expert that with new IntraTMP adoptions some gain is observed.

It was confirmed by the original proponents of W0069 that the implementation does not follow the original intent.

Decision (SW/BF): Adopt JVET-AD0124

It is noted that exactly the same bug (along with other bugs) is reported in JVET-AD0142 and JVET-AD0239.

[JVET-AD0127](https://jvet-experts.org/doc_end_user/current_document.php?id=12678) Non-EE2: Harmonization between IBC HMVP and IBC-LIC [N. Zhang, K. Zhang, L. Zhang (Bytedance)]

In ECM, the IBC-LIC flag is not inherited when the motion information from an IBC HMVP candidate is inherited. To harmonize IBC HMVP and IBC-LIC, it is proposed that the IBC-LIC flag can be inherited from an IBC HMVP candidate.

On top of the ECM8.0, simulation results of the proposed method are reported as below:

AI: Class F -0.31%,99% ,101%; Class TGM -0.05%,101%,101%

RA: Class F -0.26% ,99%,99%; Class TGM -0.02%,100%,99%

Investigate in EE along with JVET-AD0083

[JVET-AD0331](https://jvet-experts.org/doc_end_user/current_document.php?id=12895) Crosscheck of JVET-AD0127(Non-EE2: Harmonization between IBC HMVP and IBC-LIC) [Z. Xie (OPPO)] [late]

[JVET-AD0364](https://jvet-experts.org/doc_end_user/current_document.php?id=12928) Crosscheck of JVET-AD0127 (Non-EE2: Harmonization between IBC HMVP and IBC-LIC) [C. Ma (Kwai)] [late] [miss]

[JVET-AD0130](https://jvet-experts.org/doc_end_user/current_document.php?id=12681) AHG12: On ECM partitioning prediction [G. Laroche, P. Onno (Canon)]

This contribution presents a temporal prediction method of the partitioning parameters. The partitioning splits allowance and partitioning depths are derived for each block according to the partitioning parameters of the current frame and parameters obtained from a temporal area. It is reported that the proposed modifications give an average coding gain for both RA and LDB configurations and an average encoding time decrease.

Compared to ECM-8.0, the average BDR gains and runtimes reported in this contribution are as follows:

-0.09% -0.07% -0.07% - 98%, 101% for the RA configuration,

-0.05% 0.23% 0.17% - 99%, 102% for the Low Delay B configuration.

Another method is reported in the presentation that provides 0.14% gain in RA.

Bit rate saving due to partitioning prediction, no parsing dependency.

Prediction of partitioning over time has never been tried before

Parameters determined from an area within co-located CTU of reference frame, parameters need to be stored

Investigate in EE. Also report about additional memory needs for parameter storage.

[JVET-AD0134](https://jvet-experts.org/doc_end_user/current_document.php?id=12685) Non-EE2: Bi-predictive IBC for natural and screen content [Y. Kidani, H. Kato, K. Kawamura (KDDI)]

This contribution proposes a bi-predictive intra block copy (IBC) to enhance the coding performance of IBC for natural and screen content. EE2-1.8 and EE2-1.9 (JVET-AD0208) of this meeting tests IBC for natural content. In the EE2-1.8/1.9, VVC spec, and current ECM design, IBC generates prediction samples with only one block vector (BV), i.e., uni-predictive IBC, but it still has room to improve the prediction accuracy of IBC. Therefore, this contribution adds IBC with two BVs, i.e., bi-predictive IBC, besides uni-predictive IBC. The proposed method consists of two types of bi-predictive IBCs. Method 1, naming IBC BVP-merge mode, derives the two BVs from the existing IBC BVP mode and IBC merge mode in ECM-8.0. Method 2, naming bi-predictive IBC merge mode, derives the two BVs from IBC merge candidate list, utilizing two IBC merge indices.

The experimental results of the two methods implemented on the top of EE2-1.8a (without fractional IBC) and EE2-1.8c (with fractional IBC) in AI are reportedly {for Y, U, V, EncT, DecT}:

Test 1: IBC BVP-merge mode + bi-predictive IBC merge mode in EE2-1.8a

* Overall :{-0.51%, -0.59%, -0.62%, 109%, 100%} over EE2-1.8a
* TGM :{-0.51%, -0.19%, -0.17%, 103%, 98%} over ECM-8.0 / EE2-1.8a

Test 2: IBC BVP-merge mode + bi-predictive IBC merge mode in EE2-1.8c

* Overall :{%, %, %, %, %} over EE2-1.8c

Test 3: IBC BVP-merge mode over EE2-1.8a

* Overall :{-0.21%, -0.30%, -0.28%, 101%, 100%} over EE2-1.8a

Test 4: IBC BVP-merge mode over EE2-1.8c

* Overall :{%, %, %, %, %} over EE2-1.8c

Test 5: Test 2 + encoder optimization

* Overall :{%, %, %, %, %} over EE2-1.8c

Investigate in EE.

Encoder runtime significantly increased for method 2, reduction should be investigated. For method 2, it is also recommended to investigate the benefit of bi-prediction for IBC independent of the option of using IBC in both partitions of GPM.

[JVET-AD0313](https://jvet-experts.org/doc_end_user/current_document.php?id=12877) Crosscheck of JVET-AD0134 (Non-EE2: Bi-predictive IBC for natural and screen content) [C.-C. Chen (Qualcomm)] [late]

[JVET-AD0142](https://jvet-experts.org/doc_end_user/current_document.php?id=12693) Non-EE2: bugfix for intraTMP [X. Zhang, D. Jiang, J.-C. Lin, X.-H. Zhang, D.-Q. Cheng, C.-H. Zheng, Z.-Q. Wang, Y.-F. Lu (Dahua)]

Identical to JVET-AD0124.

[JVET-AD0148](https://jvet-experts.org/doc_end_user/current_document.php?id=12699) Non-EE2: SGPM combined with multiple IntraTMP predictors [C. Fang, S. Peng, D. Jiang, J.-C. Lin, X. Zhang, H. Jin, X.-M. Shi, F. Ye (Dahua)]

This contribution introduces multiple IntraTMP predictors to the SGPM design. In this method, the two geometric blocks can not only use intra prediction modes, but also use IntraTMP mode. Besides, it is proposed to use DIMD to derive an intra prediction mode based on the SGPM prediction samples, then the MTS transform set or the LFNST transform set is respectively determined by the derived intra mode. The proposed method was implemented on top of ECM-8.0, it reportedly provides {Y, U, V} BD-rate reduction with encoder and decoder runtimes as follows:

Test1:

AI: -0.07%, -0.10%, -0.05%, 102% (EncT), 108% (DecT)

Test2:

AI: -0.02%, -0.05%, 0.00%, 100% (EncT), 101% (DecT)

Questionable if the gain would be retained on top of new adoptions, no good tradeoff with encoder/decoder runtimes. No significant interest by other experts. No action.

[JVET-AD0150](https://jvet-experts.org/doc_end_user/current_document.php?id=12701) Non-EE2: combination of JVET-AD0146 and JVET-AD0148 [C. Fang, S. Peng, X. Zhang, D. Jiang, J.-C. Lin, H. Jin, X.-M. Shi, K. Fu, P. Zhang, F. Ye (Dahua)]

No need for presentation, as both combined proposals were not considered.

[JVET-AD0155](https://jvet-experts.org/doc_end_user/current_document.php?id=12706) Non-EE2: High-Accuracy template matching [Y. Wang, K. Zhang, L. Zhang (Bytedance)]

This contribution presents a method of high-accuracy template matching with two aspects. In aspect #1, an additional refinement is applied to TM for bi-prediction. In aspect #2, the diamond search pattern used in TM is modified from 8 points to 16 points. On top of ECM-8.0, simulation results of the proposed method are reported as below:

RA: {-0.06%, -0.09%, -0.07%; 100%, 100%};

LB: {-0.14%, -0.08%, -0.03%; 100%, 100%}.

It was asked why the encoder/decoder runtime is not increasing when duplicating the number of search points. The additional positions are only integer. In a real-world implementation, this would not come for free in terms of complexity.

A certain interest was expressed to investigate in EE, but the benefits of aspect1, aspect2, and the part of aspect 2 of “enabling TM for bi-prediction depending on DMVR condition” should be reported independently.

[JVET-AD0298](https://jvet-experts.org/doc_end_user/current_document.php?id=12862) Crosscheck of JVET-AD0155 (Non-EE2: High-Accuracy template matching) [X. Li (Alibaba)] [late]

[JVET-AD0169](https://jvet-experts.org/doc_end_user/current_document.php?id=12720) AHG12: RPR filters for scale factors below 1.5x [J. Samuelsson-Allendes, S. Deshpande (Sharp)]

This input document relates to Reference Picture Resampling (RPR) in ECM. The document includes a proposal to add new Motion Compensation (MC) filters for downsampling with scale factors in the range from 1.1x to 1.35x. It is also proposed to modify the non-normative downsampling included in the ECM software for the same range of scale factors, asserted to improve the quality of the downsampled pictures. Combined, these changes result in an average BD-Rate difference (Y/U/V) of ‑5.70%/‑3.31%‑2.81% for 1.25x RA, ‑7.16%/‑2.42%‑2.00% for 1.25x LD, ‑9.30%/‑4.17%‑3.49% for 1.33x RA, and ‑11.65%/‑2.79%‑1.86% for 1.33x LD. In the first version of the proposal these average numbers do not include class A1 and A2 for RA, and the BQTerrace sequence is not included in class B for the 1.25x LD test case since the results are not available yet. In the second version of the proposal, the awaited results have been added (except for ParkRunning3 which is still awaited for 1.33x RA). Additionally, run time numbers were corrected and the RA results have been updated for class B, C and D since the class specific settings were not used in the results presented in the first version.

Gains reported above are for combining non-normative and normative part of the proposal under RPR testimg condition. The aspect of downsampling for prediction a lower resolution in the loop would be normative, whereas the downsampling before input to the encoder is non-normative. Results for only doing a non-normative change are not complete yet.

Current downsampling filters of VTM and ECM (10-tap filters are used fore 1.5x, which were inherited from SHVC) may be too aggressive in cases of downsampling ratios <1.5x.

The non-normative change is definitely beneficial, as it is relevant to have suitable filters that accommodate any downsampling ratios, even if not used in any CTC. This should be done in both ECM and VTM.

For the normative change, which could only be applied to ECM, it would be relevant to know its additional benefit, which can assessed when the delta relative to the non-normative approach is known. It was further requested to also report the so-called “PSNR1” for the normative which measures the PSNR at coded resolution. In the results above, “PSNR2” is reported which is measuring before downsampling and after upsampling.

Revisit

[JVET-AD0345](https://jvet-experts.org/doc_end_user/current_document.php?id=12909) Cross-check of JVET-AD0169 (AHG12: RPR filters for scale factors below 1.5x) [K. Andersson (Ericsson)] [late]

[JVET-AD0172](https://jvet-experts.org/doc_end_user/current_document.php?id=12723) AHG12: Adaptation of LFNST/NSPT for low-delay configuration [C. Bonnineau, F. Le Léannec, K. Naser, T. Poirier, S. Puri (InterDigital)]

This contribution proposes to enable LFNST/NSPT in low-delay configuration with certain adaptation to balance the coding gain and run time. Specifically, it is proposed to activate LFNST/NSPT for the lower TiD slices in LDB configuration.

The following results are obtained compared to ECM-8.0 in LDB configuration:

Overall : -0.59% -1.03% -1.16% (Y Cb Cr) 102% (Enc) 98% (Dec)

The high-level flag is introduced to save signalling for higher TiDs where LFNST/NSPT don’t give benefit in LDB, to reduce encoder run time.

Such a change does not unveil better compression by introducing new tools. If LFNST/NSPT was enabled, it should also be enabled in VTM anchors.

It is interesting to have the information that enabling LFNST/NSPT brings higher gain in LDB for ECM than it had been the case for VTM; however the benefit does not justify the increase in encoder run time, and introducing another high-level flag just for the purpose of reducing encoder run time for a toll that already existed in VTM is not relevant at this stage of exploration.

It was also commented that potentially an encoding runtime reduction could be achieved in a non-normative way (but then a similar mechanism should also be enabled in the VTM anchor for a fair comparison).

[JVET-AD0325](https://jvet-experts.org/doc_end_user/current_document.php?id=12889) Crosscheck of JVET-AD0172 (AHG12: Adaptation of LFNST/NSPT for low-delay configuration) [M. Radosavljević (Xiaomi)] [late]

[JVET-AD0174](https://jvet-experts.org/doc_end_user/current_document.php?id=12725) On CIIP improvement [C. Zhou, Z. Lv, J. Zhang (vivo)]

This contribution proposes a new inter and intra combination method to optimize CIIP mode. Firstly, an intra prediction modes list is constructed. Then the prediction samples combined a pair of intra prediction mode in the obtained list and a merge candidate is generated using the weighting factors derived by a linear model-based weighted method, which is the LDL decomposition method same as CCCM. The experimental results are summarized as follows:

On top of ECM-8.0

LB : -0.10% (Y), 0.09% (U), 0.32% (V), 10x% (EncT), 10x% (DecT)

RA: -0.04% (Y), 0.03% (U), 0.02% (V), 10x% (EncT), 10x% (DecT)

Compression benefit small, current implementation has increase in encoding run time.

No relevant support by other experts for investigating the proposal in EE. Further study recommended.

[JVET-AD0249](https://jvet-experts.org/doc_end_user/current_document.php?id=12813) Crosscheck of JVET-AD0174: Non-EE2: CIIP with more combination candidates [L. Xu (OPPO)] [late]

[JVET-AD0317](https://jvet-experts.org/doc_end_user/current_document.php?id=12881) Crosscheck of JVET-AD0174 (Non-EE2: CIIP with more combination candidates) [Z. Deng (Bytedance)] [late]

[JVET-AD0176](https://jvet-experts.org/doc_end_user/current_document.php?id=12727) Non-EE2: Improvements on multi-pass DMVR [J. Chen, R.-L. Liao, X. Li, Y. Ye (Alibaba)]

In this contribution, it is proposed to extend the current multi-pass DMVR in ECM by adding a new pass (3rd pass) where 4x4 subblock level BDOF based motion refinement is applied. It is reported that the proposed method achieves {-0.14%(Y), -0.22%(U), -0.25%(V)} BD-rate performance on top of ECM-8.0.

Similar concept as in JVET-AD0196.

It is additionally reported that the gain when combining the proposal with EE2-2.6 is 0.31% in RA (with ECM8 anchor). Benefit is slightly smaller than for AD0196 which has some additional elements.

Investigate in EE together with JVET-AD0196.

[JVET-AD0179](https://jvet-experts.org/doc_end_user/current_document.php?id=12730) [AHG12] Extending TIMD with IntraTMP [K. Naser, P. Bordes, K. Reuze, F. Galpin (InterDigital)]

This contribution proposes including IntraTMP as a candidate among the intra modes in TIMD template analysis. The modified TIMD process can therefore yield a primary or secondary mode as IntraTMP. The following results are obtained:

* AI: {-0.08% -0.14% -0.03% 102% 102%}.
* RA: {-0.05% -0.07% 0.10% 102% 102%}

On top of EE2-1.14c, the following results are obtained:

* AI: {-0.28% -0.30% -0.29% 101% 103%}
* RA: {-0.14% -0.15% -0.11% 101% 102%}

.

Questionable if the gain would be retained on top of new adoptions, no good tradeoff with encoder/decoder runtimes. No significant interest by other experts. No action.

[JVET-AD0180](https://jvet-experts.org/doc_end_user/current_document.php?id=12731) Non-EE2: Affine AMVP mode with one MVD [H. Huang, V. Seregin, Z. Zhang, M. Karczewicz (Qualcomm)]

This contribution presents an affine AMVP mode that only signaled one MVD. The MVD is added to all the CPMVs of an affine MVP to generate the final CPMVs. The simulation on top of ECM-8.0 reports {-0.09%(Y), -0.07(U)%, -0.06%(V)} BD-rate change in RA, and {-0.09%(Y), 0.02%(U), -0.05%(V)} in LDB.

Was it also tried for 4-parameter affine? Yes, but benefit would be small.

Encoder runtime increase with up to 9% in the report, which may not be reliable, but definitely some additional encoder checking necessary. This would not be an acceptable tradeoff. Revisit after completion of cross-check and their report on encoding time.

[JVET-AD0385](https://jvet-experts.org/doc_end_user/current_document.php?id=12949) Cross-check of JVET-AD0180 (Non-EE2: Affine AMVP mode with one MVD) [L. Zhao (Bytedance)] [late] [miss]

[JVET-AD0395](https://jvet-experts.org/doc_end_user/current_document.php?id=12959) Cross-check of JVET-AD0180 (Non-EE2: Affine AMVP mode with one MVD) [X. Xiu (Kwai)] [late] [miss]

[JVET-AD0183](https://jvet-experts.org/doc_end_user/current_document.php?id=12740) Non-EE2: SIF flag and BCW weight usage in OBMC [A. Robert, F. Galpin, T. Poirier, Y. Chen (InterDigital)]

This contribution proposes to consider the SIF flags and BCW weights of the neighboring and current CUs into the OBMC process.

It is reported that this proposal achieves averagely, on top of ECM-8.0, -0.05% BD rate saving in RA and -0.08% BD rate saving in LDB without any encoding and decoding runtime increase.

Several experts expressed opinion that the proposal has interesting aspects and a reasonable tradeoff.

Investigate in EE

[JVET-AD0316](https://jvet-experts.org/doc_end_user/current_document.php?id=12880) Crosscheck of JVET-AD0183 (Non-EE2: SIF flag and BCW weight usage in OBMC) [Z. Deng (Bytedance)] [late]

[JVET-AD0184](https://jvet-experts.org/doc_end_user/current_document.php?id=12746) Non-EE2: Removal of Division Operations [W. Jia, K. Zhang, Z. Deng, L. Zhang (Bytedance)]

In designs of CCLM slope adjustment and chroma fusion, division operations are involved to compute the average luma value. In this contribution, it is proposed to replace the division operations in CCLM slope adjustment and chroma fusion by a look-up table-based method. Simulation results based on ECM-8.0 are reported as below:

AI: {0.00%, -0.05%, 0.00%; 78%, 100%};

RA: {-0.01%, -0.04%, 0.05%; 80%, 84%}.

Encoder runtime is unreliable.

In the exploration, replacing division operations is not overly important. However, CCLM has the only division operations in ECM that are not executed by table lookup, and the method is coherent with those used in other places.

Revisit after confirmation by crosscheck.

[JVET-AD0273](https://jvet-experts.org/doc_end_user/current_document.php?id=12837) Crosscheck of JVET-AD0184 (Non-EE2: Removal of Division Operations) [C. Zhou (vivo)] [late]

[JVET-AD0397](https://jvet-experts.org/doc_end_user/current_document.php?id=12961) Crosscheck of JVET-AD0184 (Non-EE2: Removal of Division Operations) [J. Lainema (Nokia)] [late]

[JVET-AD0185](https://jvet-experts.org/doc_end_user/current_document.php?id=12747) Non-EE2: ISP Extension for Chroma [W. Jia, K. Zhang, Y. Wang, L. Zhang (Bytedance)]

Intra sub-partitions (ISP) divides a luma intra-predicted block vertically or horizontally into 2 or 4 sub-partitions depending on the block size. In this contribution, it is proposed to extend ISP to chroma components accordingly when dual-tree structure is applied. On top of ECM-8.0, simulation results of the proposed method are reported as below:

AI: {0.00%, -0.21%, -0.18%; 96%, 86%};

Class F: {-0.02%, -0.71%, -0.94%; 94%, 87%};

Class TGM: {-0.32%, -1.24%, -1.29%; 100%, 84%};

RA: {xxx%, xxx%, xxx%; xxx%, xxx%}.

Runtimes are unreliable.

Main benefit for class TGM, and regarding typical gains for that class, the benefit is relatively small.

No significant interest by other experts to investigate this. ISP is not a new tool, and enabling it for chroma had already been considered (and not been done) in VVC development, as benefit was too small. No action.

[JVET-AD0374](https://jvet-experts.org/doc_end_user/current_document.php?id=12938) Crosscheck of JVET-AD0185 (Non-EE2: ISP Extension for Chroma) [[H.-J. Jhu](mailto:jhuhong-jheng@kwai.com), [X. Xiu (Kwai)](mailto:xiaoyuxiu@kwai.com)] [late]

[JVET-AD0187](https://jvet-experts.org/doc_end_user/current_document.php?id=12751) Non-EE2: On large NSPT [M. Koo, J. Zhao, J. Lim, S. Kim (LGE)]

In the 29th JVET meeting, Non-Separable Primary Transform (NSPT) was incorporated into ECM-8.0, where the NSPT is applied to 4x4, 4x8/8x4, 4x16/16x4, 8x8, and 8x16/16x8 transform blocks instead of the combination of DCT-2 and LFNST. This contribution introduces additional large NSPT for Nx32/32xN (N = 4 and 8) blocks of which matrix dimensions are 36x128 (N = 4) and 48x256 (N = 8), respectively. The number of transform sets and kernels per set are not changed for the proposed large NSPT. The BD-rate changes and encoding/decoding times for AI configuration are -0.09%/-0.11%/-0.11% for Y/U/V and 102%/100%, respectively.

Why is encoding time increased?

Gain is relatively small, compared to previous NSPT adoptions, and additional larger kernels are introduced.

Kernels were trained the same way as the existing ones

Some interest was expressed in the proposal.

Investigate in EE, reduction of coding time should be studied, worst case complexity, and memory needs for the additional kernels.

[JVET-AD0204](https://jvet-experts.org/doc_end_user/current_document.php?id=12768) AHG12: Context modeling for transform coefficients for LFNST/NSPT [P. Nikitin, M. Coban, B. Ray, V. Seregin, M. Karczewicz (Qualcomm)]

This contribution proposes to modify the way how the context modelling is done for LFNST/NSPT. The proposed method uses the previous 5 coefficients in the coding order to model the contexts of sig\_coeff\_flag, coeff\_abs\_level\_greaterX\_flag, and for the derivation of Rice parameter for parsing the remainder of the coefficient, rather than using the causal 2D neighborhood for the context derivation.

The following results are provided on top of ECM-8.0:

AI: -0.06% (Y), -0.26% (U), -0.15 % (V), 100% (EncT),100% (DecT).

It was noted that in an earlier stage of HEVC, the same (or similar) context modelling had been used.

Several experts found it interesting that this gives (small) compression gain in context of ECM. Though not of prior importance, this could even be simpler to implement.

Investigate in EE.

[JVET-AD0206](https://jvet-experts.org/doc_end_user/current_document.php?id=12770) AHG12: CABAC Initialization for GDR Pictures [S. Hong, L. Wang, K. Panusopone (Nokia)]

This contribution proposes that CABAC initialization shall be invoked for GDR pictures, even though inter pictures can inherit CABAC states from previously coded inter pictures in ECM. Otherwise, decoding cannot start at GDR pictures without leaks or mismatch. The simulation results demonstrate that the proposal performs better than ECM8.0 GDR with TempCabacInit set to 0 by -0.43% for class B, -0.53% for class C, -0.82% for class D, -1.25% for class E and -3.02% for class F, respectively.

It is argued that this is rather a bug fix for the GDR part of ECM software, as ECM has the feature of inheriting CABAC context temporally, these may not be available, such that decoding would not work.

Not relevant for CTC.

Decision(SW/BF/nonCTC): Adopt JVET-AD0206

[JVET-AD0352](https://jvet-experts.org/doc_end_user/current_document.php?id=12916) Crosscheck of JVET-AD0206 (AHG 12: CABAC Initialization for GDR Pictures) [J. Enhorn (Ericsson)] [late]

[JVET-AD0214](https://jvet-experts.org/doc_end_user/current_document.php?id=12778) Non-EE2: On search region of intra template matching in ECM8.0 [X. Xiu, N. Yan, C. Ma, H.-J. Jhu, C.-W. Kuo, W. Chen, X. Wang (Kwai)]

No need for presentation – included in JVET-AD0342.

[JVET-AD0285](https://jvet-experts.org/doc_end_user/current_document.php?id=12849) Crosscheck of JVET-AD0214 (Non-EE2: On search region of intra template matching in ECM8.0) [Y. Yu (OPPO)] [late]

[JVET-AD0215](https://jvet-experts.org/doc_end_user/current_document.php?id=12779) Non-EE2: Extension of IBC-GPM [C. Ma, X. Xiu, W. Chen, H.-J. Jhu, C.-W. Kuo, N. Yan, X. Wang (Kwai)]

In ECM-8.0, IBC-GPM is applied which divides a CU into two geometry partitions based on a sample-wise combination of two prediction signals. In the current design, one of the IBC-GPM prediction signals is generated from the IBC prediction while the other is generated from the intra prediction. In this contribution, the existing IBC-GPM is further extended to allow the predictions of both partitions are generated using the IBC. The simulation results on top of ECM-8.0 are summarized as follows.

AI:

Class F : {-0.16%, -0.27%, -0.28%, 100%, 100%}, Class TGM : {-0.43%, -0.34 %, -0.31%, 99%, 99%};

RA:

Class F : {-0.17%, -0.86 %, -0.25%, 100%, 101%}, Class TGM : {-0.36%, -0.18%, -0.25%,100%, 100%};

Investigate in EE (along with JVET-AD0134 which proposes a similar approach)

[JVET-AD0372](https://jvet-experts.org/doc_end_user/current_document.php?id=12936) Crosscheck of JVET-AD0215 (Non-EE2: Extension of IBC-GPM) [Y. Wang (Bytedance)] [late]

V1 rejected – no results.

[JVET-AD0216](https://jvet-experts.org/doc_end_user/current_document.php?id=12780) Non-EE2: IBC with non-adjacent spatial candidates [C. Ma, X. Xiu, W. Chen, H.-J. Jhu, C.-W. Kuo, N. Yan, X. Wang (Kwai)]

This contribution proposes to utilize non-adjacent spatial neighbors to improve the efficiency of IBC merge and AMVP modes. Specifically, several new candidates, which are derived from non-adjacent spatial blocks, are added in-between the adjacent spatial candidates and the HBVP candidates of the candidate lists of both IBC merge and IBC AMVP. The simulation results on top of ECM-8.0 are summarized as follows:

AI:

Class F : {-0.34%, -0.35%, -0.42%, 100%, 101%}, Class TGM : {-0.42%, -0.37 %, -0.35%, 100%, 103%};

RA:

Class F : {-0.26%, -0.54 %, -0.24%, 100%, 100%}, Class TGM : {-0.31%, -0.34%, -0.41%, 99%, 101%};

Investigate in EE along with JVET-AD0231. See further notes there

[JVET-AD0344](https://jvet-experts.org/doc_end_user/current_document.php?id=12908) Crosscheck of JVET-AD0216 (Non-EE2: IBC with non-adjacent spatial candidates) [Y. Wang (Bytedance)] [late]

[JVET-AD0217](https://jvet-experts.org/doc_end_user/current_document.php?id=12781) Non-EE2: Filtered Intra Block Copy (FIBC) [H.-J. Jhu, X. Xiu, C.-W. Kuo, W. Chen, N. Yan, C. Ma, X. Wang (Kwai)]

In this proposal, filtered intra block copy (FIBC) mode is proposed where the prediction samples of the IBC are enhanced by applying a linear filter. The proposed filter consists of five spatial terms and one bias term. The filter coefficients are derived via the regression-based minimization of the difference between the template samples and their corresponding reference samples. Compared to ECM-8.0 anchors, simulation results are summarized as follows:

For class F sequences:

AI { -0.92%, -1.10%, -1.04%, 101%, 100% }, RA { -0.29%, -0.67%, -0.72%, 101%, 100% }

For TGM sequences:

AI { -0.17%, -0.19%, -0.15%, 102%, 101% }, RA { -0.15%, -0.13%, -0.18%, 101%, 100% }

JVET-AD0223 is similar. See further notes there.

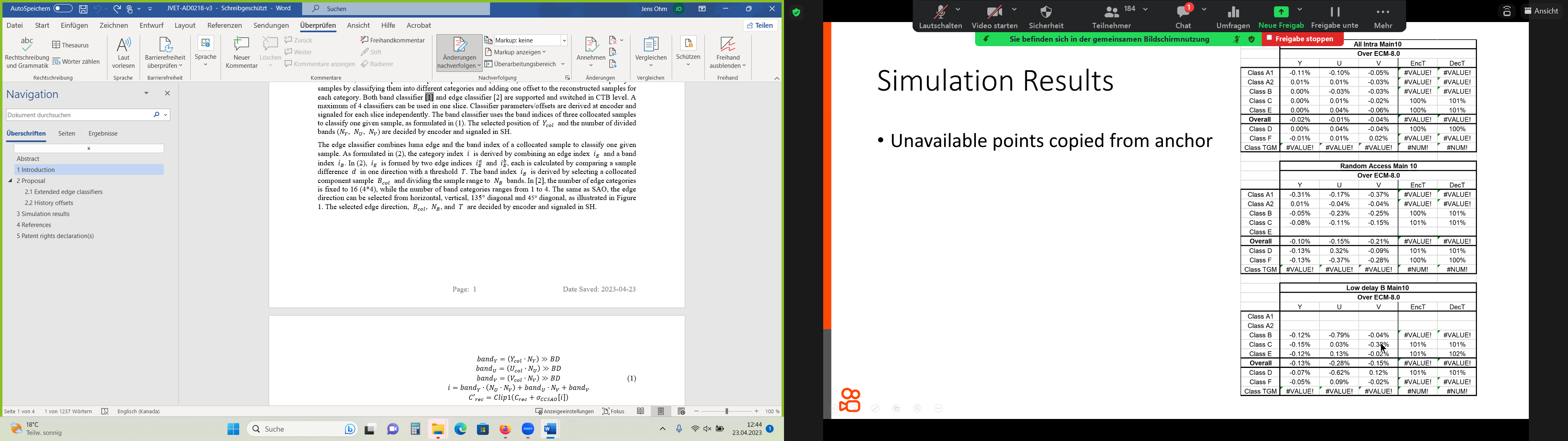
[JVET-AD0356](https://jvet-experts.org/doc_end_user/current_document.php?id=12920) Crosscheck of JVET-AD0217 (Non-EE2: Filtered Intra Block Copy (FIBC) [L. Zhang, Y. Yu (OPPO)] [late]

[JVET-AD0218](https://jvet-experts.org/doc_end_user/current_document.php?id=12782) AHG12: CCSAO with extended edge classifiers and history offsets [C.-W. Kuo, X. Xiu, W. Chen, H.-J. Jhu, N. Yan, C. Ma, X. Wang (Kwai)] [late]

Initial version rejected as “placeholder”.

In this contribution, two modifications are proposed to improve the coding efficiency of CCSAO. Firstly, the edge classifier is extended with multiple edge/band combinations and the component used for edge classification can be selected from one of all three components. Secondly, similar to the APS design in VVC, temporal historical CCSAO offsets are stored for the usage of future frames.

Compared to ECM-8.0 anchors, the BD-rate impact is summarized as below (from preliminary results shown in presentation).



Following comments were made:

Significant encoder optimization was performed – how much gain by that?

For RA, gain is inhomogeneous over different classes.

Several experts expressed interest in the proposal

Investigate in EE. Report results of different aspects of proposal separately (picture based optimization, etc.).

[JVET-AD0220](https://jvet-experts.org/doc_end_user/current_document.php?id=12784) Non-EE2: Improved fixed filters for ALF [M. Karczewicz, N. Hu, V. Seregin (Qualcomm)]

In ECM-8.0, when applying adaptive loop filter (ALF) to a sample, two fixed filters with the corresponding Laplacian-based classifiers are firstly applied to the input of ALF. The outputs of the fixed filters are then used to derive ALF output. In this contribution, fixed filters are extended to be applied to the samples before deblocking filters. In addition, classifiers of the fixed filters are extended by using the differences between the mean value and the sample values. The proposed methods achieve 0.22%, 0.31% and 0.39% luma gain with similar encoding and decoding run time, in AI, RA and LDB configurations respectively over ECM-8.0. In addition, the outputs of the first fixed filter are used as the inputs to the second fixed filter, which can achieve estimated 0.32% luma gain in AI.

The output of the filters is not fed into deblocking, it is applied to the non-deblocked samples before fceding them into ALF.

Several experts expressed interest.

Investigate in EE.

[JVET-AD0223](https://jvet-experts.org/doc_end_user/current_document.php?id=12787) Non-EE2: Filtering for IBC predicted block [B. Ray, P. Garus, M. Coban, V. Seregin, M. Karczewicz (Qualcomm)]

In ECM-8.0, IBC is enabled for screen content and in EE2-test 1.8 IBC performance in camera captured content is being studied. This contribution proposes to apply filtering on top of IBC prediction as an additional mode. The 6-tap linear filter consists of 5 spatial luma samples in the reference block and a bias term. Filter coefficients are derived for each block using the regression based the minimized MSE on samples between the reference template and current template.

The test results on top of EE2-test1.8.a are as follows:

AI(Y/U/V): -0.14%/-0.18%/-0.16%, EncT 101%, DecT 100%

RA(Y/U/V): -0.xx%/-0.xx%/-0.xx%, EncT 1xx%, DecT 1xx%

Test results combined with JVET-AD0200 on top of EE2-test 1.8a are as follows:

AI(Y/U/V): -0.21%/-0.21%/-0.18%, EncT 102%, DecT 100%

Several experts expressed interest.

Investigate in EE (along with JVET-AD0217). Also performance for camera captured captured content should be reported.

[JVET-AD0231](https://jvet-experts.org/doc_end_user/current_document.php?id=12795) Non-EE2: Non-adjacent spatial candidates for IBC [Y. Wang, K. Zhang, L. Zhang (Bytedance)]

This contribution presents to use non-adjacent spatial candidates for IBC merge candidate list construction. On top of ECM-8.0, simulation results of the proposed method are reported as below:

AI: Class F {-0.27%, -0.27%, -0.31%; 100%, 101%}, Class TGM {-0.41%, -0.36%, -0.34%; 100%, 103%};

RA: Class F{-0.24%, -0.68%, -0.32%, 100%, 100%}, Class TGM {-0.26%, -0.29%, -0.26%; 100%, 99%}.

List size is not changed (same as in JVET-AD0216)

Investigate in EE (along with JVET-AD0216). Also performance for camera captured captured content should be reported.

[JVET-AD0350](https://jvet-experts.org/doc_end_user/current_document.php?id=12914) Crosscheck of JVET-AD0231 (Non-EE2: Non-adjacent spatial candidates for IBC) [C. Ma (Kwai)] [late]

[JVET-AD0234](https://jvet-experts.org/doc_end_user/current_document.php?id=12798) Non-EE2: Extensions of Residual-based Taps in ALF and CCALF [W. Yin, K. Zhang, L. Zhang (Bytedance)]

In the current adaptive loop filter (ALF) design of ECM-8.0, residual values are stored and used in the online-trained luma filter of ALF. In this contribution, extensions of the usage of residual values for ALF and CCALF are proposed. Chroma residual values are introduced into the chroma online-trained filter of ALF and luma residual values are utilized in CCALF.

On top of ECM-8.0, simulation results of the proposed method are reported as below:

AI: %, %, %, %, %.

RA: 0.00%, -0.39%, -0.55%, 100%, 99%.

LB: %, %, %, %, %.

2 Elements: Chroma residual for chroma ALF, Luma residual for CCALF.

It was pointed out that currently chroma residual is not stored. Luma residual in CCALF would be available.

What is the benefit of the two elements? Would need to be investigated

No results for AI and LDB yet, RA Gain in chroma is not very high, compared to possible additional memory for chroma residual.

Further study recommended.

[JVET-AD0378](https://jvet-experts.org/doc_end_user/current_document.php?id=12942) Crosscheck of JVET-AD0234 (Non-EE2: Extensions of Residual-based Taps in ALF and CCALF) [I. Jumakulyyev (Qualcomm)] [late]

[JVET-AD0235](https://jvet-experts.org/doc_end_user/current_document.php?id=12799) Non-EE2: Enhanced subblock-based motion compensation [L. Zhao, K. Zhang, L. Zhang (Bytedance)]

This contribution proposes to enhance subblock-based motion compensation in three aspects. Firstly, an interweaved prediction method is presented for affine motion compensation (AMC). Secondly, Regression- based Motion Vector Field (RMVF) candidate derivation is enhanced by allowing the MVF from multiple CUs as input. Thirdly, it is proposed to determine whether to skip the OBMC operation for each boundary subblock independently. It is reported that on top of ECM-8.0, simulation results of the proposed method are as below:

RA: -0.12 % (Y), -0.07 % (U), -0.12 % (V), 106% (EncT), 98% (DecT)

LB: -0.07 % (Y), -0.03 % (U), 0.03 % (V), 113% (EncT), 98% (DecT)

Results reported are in combination with EE2-2.4, which was not adopted. Encoder runtime is significantly increased, not acceptable tradeoff for relatively low compression advantage.

No support by other experts for investigation in EE. Further study recommended. Also, comparison with pixel-based affine MC was recommended, and it was asked what the benefits of the different elements of the proposal are.

[JVET-AD0381](https://jvet-experts.org/doc_end_user/current_document.php?id=12945) Crosscheck of JVET-AD0235 (Non-EE2: Enhanced subblock-based motion compensation) [H. Huang (Qualcomm)] [late]

[JVET-AD0236](https://jvet-experts.org/doc_end_user/current_document.php?id=12800) Non-EE2: On Classification of In-Loop Filters [W. Yin, K. Zhang, L. Zhang (Bytedance)]

In this contribution, three additional rules for classification of in-loop filters are proposed, including deblocking filter-boundary strength (DBF-BS) based classification for ALF, DBF-BS based classification for SAO and variance based classification for biliteral filter (BF).

On top of ECM-8.0, simulation results of the proposed methods are reported as below:

AI: -0.01%, -0.03%, 0.04%, 100%, 100%.

RA: %, %, %, %, %.

LB: %, %, %, %, %.

For AI, gain is not interesting

Expected in RA: 0.1% luma, most gain comes from class C

What are the contributions of the three elements which could be implemented completely independent?

No support by other experts for investigation in EE. Further study recommended.

[JVET-AD0335](https://jvet-experts.org/doc_end_user/current_document.php?id=12899) Crosscheck of JVET-AD0236 (Non-EE2: On Classification of In-Loop Filters) [V. Shchukin, J. Ström (Ericsson)] [late]

[JVET-AD0239](https://jvet-experts.org/doc_end_user/current_document.php?id=12803) Non-EE2: Fixes for IntraTMP template availability [G. Verba, Z. Zhang, V. Seregin, M. Karczewicz (Qualcomm)]

In ECM-8.0, it is asserted that IntraTMP has problems in checking availability for the left template of the current block and for the reference block templates located at picture boundaries. Those two problems are fixed in the contribution and test results on top of ECM-8.0 are summarized as follows:

AI(Y/U/V): 0.00%/-0.04%/0.05%, EncT 99%, DecT 100%

RA(Y/U/V): -0.xx%/-0.xx%/-0.xx%, EncT 1xx%, DecT 1xx%

Test results on top of EE2-1.20j are summarized as follows:

AI(Y/U/V): -0.02%/-0.05%/-0.06%, EncT 99%, DecT 100%

RA(Y/U/V): -0.xx%/-0.xx%/-0.xx%, EncT 1xx%, DecT 1xx%

For the first aspect (checking availability for the left template), see notes under JVET-AD0124.

For the second aspect (L-shaped availability check also in case of left-only or above-only templates) it should be clarified with original proponents if it was intended. K. Naser to report – revisit.

[JVET-AD0387](https://jvet-experts.org/doc_end_user/current_document.php?id=12951) AHG12: Software Check for JVET-AD0239 (Non-EE2: Fixes for IntraTMP template availability) [K. Naser (InterDigital)] [late]

[JVET-AD0373](https://jvet-experts.org/doc_end_user/current_document.php?id=12937) Crosscheck of JVET-AD0239 (Non-EE2: Fixes for IntraTMP template availability) [D. Ruiz Coll (Ofinno)] [late] [miss]

[JVET-AD0251](https://jvet-experts.org/doc_end_user/current_document.php?id=12815) AhG12: Shifting Quantizer Center [M. Balcilar, K. Naser, F. Galpin, F. Le Léannec (InterDigital)] [late]

This contribution proposes a straightforward implementation of recently proposed Latent-shift algorithm on the end-to-end compression [1] to the conventional compression. This technique proposes to add some offset value which is driven by gradient of the entropy on the reconstructed transform coefficient.

The following results are obtained:

* AI: {-0.09%, -0.12%, -0.13%; 99%, 100%}.
* RA: {%, %, %; %, %}.

Gain is small, but several experts expressed interest, as it is extremely simple to implement (no change in quantization, “post processing” of dequantized output), and the gain is consistent over classes.

It was asked if there is dependency on bit depth.

Investigate in EE. It was suggested to consider checking tendency of performance in other QP ranges.

[JVET-AD0308](https://jvet-experts.org/doc_end_user/current_document.php?id=12872) Non-EE2: Extension of unified PDPC [G. Rath, T. Dumas, F. Le Léannec, K. Reuzé (InterDigital)] [late]

This contribution refines the unified PDPC in intra prediction by first introducing a combination between PDPC and gradient PDPC. Specifically, for a positive directional intra prediction mode with angular scale value greater than -2 and less than 2, a combination of PDPC and gradient PDPC is applied. In the second refinement, the secondary reference samples are computed with a 4-tap filter instead of the nearest neighbor (in PDPC) or linear interpolation (gradient PDPC). In the third refinement, for the current block, the unified PDPC is disabled if the neighbor block on the side of the secondary reference sample is not available.

It is reported that, on top of ECM-8.0, the proposed unified PDPC yields -0.04%, -0.06%, -0.08% and -0.03%, -0.12%, -0.06% in AI and RA configurations, respectively, for encoding and decoding runtimes of 101% and 101%, and 101% and 101%, respectively.

RA gains preliminary, higher in class F (0.09%)

Gain very small, and additional processing necessary depending on availability of neighbors.

No support by other experts for investigation in EE. No action.

[JVET-AD0315](https://jvet-experts.org/doc_end_user/current_document.php?id=12879) Non-EE2: Directional DC modes [K. Kim, D. Kim, J.-H. Son, J.-S. Kwak (WILUS)] [late]

This contribution proposes two additional directional DC modes (Above DC, Left DC) which generate predicted samples with a constant value based on the above and left samples, respectively. They can be used regardless of whether the current block is a square or non-square block, like the directional planar mode. Compared to ECM-8.0, the proposed methods achieve -0.03% gain in AI configurations with 105% encoder and 101% decoder run time in AI configurations of common test conditions.

AI: {-0.03%, -0.02%, 0.03%, 105%, 101%}

No attractive tradeoff, 0.03% versus 5% encoder runtime increase. Probably the additional need for signalling the modes compensates for improved prediction, such that no gain is achieved.

Further study, no action at this point.

[JVET-AD0338](https://jvet-experts.org/doc_end_user/current_document.php?id=12902) Non-EE2: On MHP weight derivation [Y. Zhang, H. Huang, V. Seregin, M. Karczewicz (Qualcomm)] [late]

This contribution reports the experiment results of template matching (TM) based MHP weight derivation. On top of ECM-8.0, the reported BDR Y/Cb/Cr are -0.03% / -0.02% / -0.04% in RA and -0.11% / 0.08% / 0.02% in LDB.

Encoder runtime increase by approx. 2%.

Gain over explicit signalling of the weights is very small, and using TM for determining the weights introduces some complexity.

Further study.

[JVET-AD0376](https://jvet-experts.org/doc_end_user/current_document.php?id=12940) Cross-check of JVET-AD0338 (Non-EE2: On MHP weight derivation) [W. Chen (Kwai)] [late] [miss]

[JVET-AD0363](https://jvet-experts.org/doc_end_user/current_document.php?id=12927) AHG12: Reduce maximum number of predicted signs for small TB sizes [Y. Chen, E. François, F. Galpin, K. Naser (InterDigital)] [late]

This contribution proposes to reduce the maximum number of signs to be predicted to 4 for small TB sizes.

It is reported that this proposal achieves averagely, on top of ECM-8.0, according to partial results, 4-5% ET and 2-3% DT running time decrease in AI CTC, 2% ET and 1% DT running time decrease in RA CTC, with negligible performance loss.

Currently in ECM-8, maximum number of signs predicted in a TB is set to 8 (set by an SPS syntax) regardless of the size of the TB. This contribution proposes to set the maximum number of predicted signs to half of that syntax value if the TB is less than 8 in either dimension.

For AI, one class F sequence (SlideShow) has 0.23% luma performance loss, otherwise, relatively small losses were observed for other seuqences. The same sequence (SlideShow) has -0.11% luma performance gain in RA.

Results are not complete for AI and RA, and no results are available for LB.

The proponent’s main motivation was to reduce encoding runtime.

No cross check is available.

No action can be taken before full results (both in terms of performance impact and in terms of runtime reduction) are provided. Further study.

### CTC for EE2/ECM (4)

Contributions in this area were discussed at 1640-1910 on Sunday 23 April 2023 (chaired by Y. Ye).

[JVET-AD0105](https://jvet-experts.org/doc_end_user/current_document.php?id=12656) Modifications of common test condition and ECM software [Y. Yasugi, T. Ikai (Sharp)]

The encoding time required for the ECM experiments increases with each version, and the time required for QP=22 is particularly long and slowing down the development. On the other hand, the decoding time of the ECM software reaches several times longer compared to that of VTM, but it is observed that unnecessary processing takes a non-trivial part. This contribution proposes two modifications to speed up the encoder and decoder: the first is to modify CTC so that the sign prediction parameter (NumSignPred) is set to a smaller value for experiments with QP=22. The second is to change the ECM software to avoid unnecessary initializations of large buffers in release builds. These changes are reported to show the following experimental results under the All-Intra condition:

Test1 (CTC change): BD-rate(Y,U,V)= 0.01%,0.01%,0.00% ET,DT=98%,98%

Test2 (ECM modification): BD-rate(Y,U,V)= 0.00%,0.00%,0.00% ET,DT=99%,94%

Test1+2(combination): BD-rate(Y,U,V)= 0.01%,0.01%,0.00% ET,DT=97%,92%

For aspect #1 on changing the CTC, it is proposed to set number of predicted signs in a TB to 4 for QP 22. Results are provided for AI and RA, and show very minor impact on coding performance. For AI, for QP=22, the average encoding time reduction and decoding time reduction were reported to be 7% and 8% respectively. For RA, for QP =22, the average encoding time reduction and decoding time reduction were reported to be 3%, and 2% respectively.

It was asked what would be the performance and runtime impact if the proposed change to set maximum number of predicted signs to 4 is applied to all QP values. This was reported to cause more significant performance loss.

It was commented that making this change results in runtime reduction for the longest simulation time (at the lowest QP point), which is welcome. It was also noted that in the current CTC, some special treatment of QP 22 is already applied with the same motivation to reduce the longest simulation time. Multiple experts expressed support for making this change.

It was commented that software change is needed for QP = 22 to enable the proposed config change. The proponent agreed to provide the required software change.

Decision (SW&CTC): adopt the first aspect in JVET-AD0105, i.e., to set NumSignPred to 4 for QP=22 in RA and AI.

Currently, no LB and LP results are available. It was commented that LB is currently the bottleneck in terms of simulation time. It was suggested to further study the impact of aspect #1 on LB and LP configurations.

For aspect #2 on memory allocation, it was asked if valgrind was used to confirm whether this would not cause memory issues (such as memory leaks, missing memory initialization, etc) in CTC and in other non-CTC conditions. This was not yet done. Proponents are encouraged to further study this aspect.

[JVET-AD0375](https://jvet-experts.org/doc_end_user/current_document.php?id=12939) Crosscheck of JVET-AD0105 (Modifications of common test condition and ECM software) [Y.-J. Chang (Qualcomm)] [late]

[JVET-AD0128](https://jvet-experts.org/doc_end_user/current_document.php?id=12679) AHG12: modified CTC proposal for low-delay configurations [F. Le Léannec, F. Galpin, K. Naser, T. Poirier, E. François (InterDigital)]

This contribution proposes to modify EE2 common test conditions, to significantly reduce the worst-case encoding runtime for LDB/LDP, together with slightly improved overall BD-rate results.

The CTC proposal consists in modifying encoder configuration as follows. The maximum MTT hierarchy depth is set to 4 in the I slice. For QP 22 of HD sequences, it is decreased from 3 to 2 for slices with temporal depth higher or equal to 2.

In LDB, the proposed modified CTC reportedly leads to 66% encoding time for the worst case (BQTerrace QP 22), 97% average encoding time relative to ECM-8.0 CTC, with -0.22% luma coding gain.

In LDP, the proposed modified CTC reportedly leads to 73% encoding time for the worst case, 100% average encoding time relative to ECM-8.0 CTC, with -0.16% luma coding gain.

The cross checker confirmed the performance results and the runtime reduction.

The proposed changes can be applied to the anchors (VTM11-ECM8) as well as the ECM itself.

It was commented that the encoding runtime impact seems to be inconsistent, where class B runtime was reduced significantly but class F runtime actually increased. This level of variation caused by the proposed change is considered undesirable.

It was commented that the proposed change to class F is applied on only one sequence, and that this type of sequence-dependent treatment is currently not done in ECM CTC. It was commented that sequence-dependent treatment could potentially result in skewed performance results on these “special” sequences in the future. This is considered undesirable.

It was commented that the proposed change would result in some increase in I slice quality but some decrease in B slice quality.

No action can be taken at this time. Further study.

[JVET-AD0268](https://jvet-experts.org/doc_end_user/current_document.php?id=12832) Crosscheck of JVET-AD0128 (Ahg12: modified CTC proposal for low-delay configurations) [M. Blestel (Xiaomi)] [late]

[JVET-AD0229](https://jvet-experts.org/doc_end_user/current_document.php?id=12793) AHG4/AHG12/AHG7: Mixed-Content Sequences for ECM CTC or Tool Assessment [X. Li (Google), Z. Deng, K. Zhang, L. Zhang (Bytedance)]

It is reported that during the development of ECM some coding tools improved camera content coding but sometimes unexpectedly hurt screen content coding (SCC). The issue is reportedly challenging for mixed content which becomes more popular in today’s video conferencing applications. In this contribution, it is proposed to include three mixed-content sequences which are used in the common test conditions for screen content coding (JVET-AC1015) into the test sets of enhancement compression tool testing (ECM CTC) or ECM tool assessment (AHG7) to better evaluate coding tools in mix-content scenario.

This contribution also appears in 4.9.

The proponent suggested that this proposed set of mixed content sequences could be considered as a separate class in the reporting template, and not be aveareged with other classes, in the same way as class F and class TGM currently.

It was asked if any problems have been identified for mixed content with ECM tools. It was commented that past problems have been identified and resolved for screen content sequences, but not directly for mixed content.

It was asked if any simulation on these sequences has been run with ECM and VTM. It was reported by the proponent that internal results on ECM exist, but not on VTM.

It was commented that currently AHG7 evaluates tool performance under CTC (in the same manner as our previous AHG13 during VVC development), and including sequences only within AHG7 but not in CTC would create a deviation from our past practice.

Some support for considering mixed content sequences was expressed.

It was suggested to add an additional mandate to AHG7 to collect simulation results on non-CTC sequences, and to report any issues identified with non-CTC sequences. This was agreed.

[JVET-AD0197](https://jvet-experts.org/doc_end_user/current_document.php?id=12761) EE2-related: Worst-Case Timing Reduction for ECM RA Simulations [M. Salehifar, Y. Wang, Y. He, K. Zhang, L. Zhang (Bytedance)]

Current ECM is drastically slower than VTM. Simulations for RA configuration takes 12 days to finish. In this contribution, it is proposed to reduce intra period from 64 to 32 for slow QP points of class A1/A2. This will lead to more parallelization and, thus allowing all RA simulations to be finished in 7 days.

Compared with ECM-8.0 in the current CTC setting, the overall BD loss is reported as:

RA: 0.10%, -0.13%, -0.14%, 101%, 101%.

The proposal includes an element that is sequence dependent, specifically, QP 27 for ParkRunning is treated differently compared to QP 27 for other sequences. This is considered undesirable.

It was commented that this proposal puts a “penalty” on high-resolution sequences.

It was commented that encoder speedup algorithms could be used to reduce encoding time (with some performance penalty).

It was commented that this could create a weird behavior of rate-distorion curves because the distance between QP points on the curve could become uneven and/or inconsistent. This could in turn affect BD-rate calculation. This is considered undesirable.

No action.

[JVET-AD0242](https://jvet-experts.org/doc_end_user/current_document.php?id=12806) On Common Test Conditions document [R. Chernyak, L.-F. Chen, X. Xu, S. Liu (Tencent)]

This document reports two missing parts in the recent Common Test Conditions (CTC) document (JVET-Y2017) as well as several minor issues and proposes to modify the document accordingly to keep maintaining well-defined environme and facilitate the comparison of the outcome of experiments. Neither of the proposed changes intend to affect the current testing methodology, so the main purpose of this document is to align the CTC document with the actual testing process. The suggested edits in the attachment were reviewed. All suggestions are editorial in nature. No changes to CTC as JVET-Y2017 are suggested in this contribution. It was delegated to the editors to review the suggested changes and take actions accordingly.

# High-level syntax (HLS) and related proposals (45)

## AHG9: SEI messages on neural-network post filter and SEI processing order (36)

Contributions in this area were discussed at XXXX–XXXX on XXday 2X April 2023 (chaired by JRO).

[JVET-AD0258](https://www.jvet-experts.org/doc_end_user/current_document.php?id=12822) AHG9: A summary of proposals on NNPF and SEI processing order SEI messages [Y.-K. Wang (Bytedance)] [late]

[JVET-AD0052](https://jvet-experts.org/doc_end_user/current_document.php?id=12599) AHG9: NNPFC SEI extension mechanism to enable usages beyond user viewing [M. M. Hannuksela, F. Cricri, H. Zhang (Nokia)]

This contribution also fits under section 4.10.

[JVET-AD0053](https://jvet-experts.org/doc_end_user/current_document.php?id=12600) AHG9: On NNPFC SEI for filtering input pictures and upsampling picture rate [M. M. Hannuksela, F. Cricri, M. Santamaria (Nokia)]

[JVET-AD0054](https://jvet-experts.org/doc_end_user/current_document.php?id=12601) AHG9: On NNPFC SEI for picture rate upsampling [M. M. Hannuksela, F. Cricri, M. Santamaria (Nokia)]

[JVET-AD0055](https://jvet-experts.org/doc_end_user/current_document.php?id=12602) AHG9: On buffering requirements for multi-picture NNPFC SEI [M. M. Hannuksela, F. Cricri (Nokia)]

[JVET-AD0056](https://jvet-experts.org/doc_end_user/current_document.php?id=12603) AHG9: Miscellaneous VSEI changes on neural-network post-filter SEI messages [M. M. Hannuksela, F. Cricri, M. Santamaria (Nokia)]

[JVET-AD0057](https://jvet-experts.org/doc_end_user/current_document.php?id=12604) AHG9: Miscellaneous VVC changes on SEI messages [M. M. Hannuksela, F. Cricri, M. Santamaria (Nokia)]

JVET-AD0057 items 1, 2, 5 and 6 belong to this category.

[JVET-AD0058](https://jvet-experts.org/doc_end_user/current_document.php?id=12605) AHG9: Approaches for region-based neural-network post-filtering [M. M. Hannuksela, F. Cricri (Nokia)]

[JVET-AD0059](https://jvet-experts.org/doc_end_user/current_document.php?id=12606) AHG9: Indicating processing order of NNPFs and SEI messages [M. M. Hannuksela, F. Cricri (Nokia)]

JVET-AD0059 item 2 overlaps with JVET-AD0061 and JVET-AD0079.

[JVET-AD0061](https://jvet-experts.org/doc_end_user/current_document.php?id=12608) AHG9: On the SEI processing order SEI message [Y. He, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-AD0079](https://jvet-experts.org/doc_end_user/current_document.php?id=12627) AHG9: On the SEI processing order SEI message [P. Yin, S. McCarthy, W. Husak, K. Konstantinides, T. Lu, F. Pu, A. Arora, T. Shao (Dolby)]

[JVET-AD0065](https://jvet-experts.org/doc_end_user/current_document.php?id=12613) AHG9: On NNPFC Auxiliary Input Information [S. Deshpande (Sharp)]

[JVET-AD0066](https://jvet-experts.org/doc_end_user/current_document.php?id=12614) AHG9: On NNPFC Description and Identification [S. Deshpande (Sharp)]

[JVET-AD0067](https://jvet-experts.org/doc_end_user/current_document.php?id=12615) AHG9: Comments on Neural-Network Post-Filter Characteristics Message [S. Deshpande (Sharp)]

[JVET-AD0078](https://jvet-experts.org/doc_end_user/current_document.php?id=12626) AHG9: On comments for the draft of VSEI [T. Chujoh, Y. Yasugi, T. Ikai (Sharp)]

JVET-AD0078 items 1 to 3 belong to this category.

[JVET-AD0087](https://jvet-experts.org/doc_end_user/current_document.php?id=12638) AHG9: On cascading of post-processing filters [Y.-K. Wang, L. Zhang, J. Xu, C. Lin, Y. Li, J. Li, K. Zhang (Bytedance)]

[JVET-AD0088](https://jvet-experts.org/doc_end_user/current_document.php?id=12639) AHG9: Overall post-processing filtering process using NNPFs [Y.-K. Wang, J. Xu, L. Zhang (Bytedance)]

[JVET-AD0089](https://jvet-experts.org/doc_end_user/current_document.php?id=12640) AHG9: NNPF activation parameters [Y.-K. Wang, Y. Li, J. Xu, C. Lin, J. Li, L. Zhang, K. Zhang (Bytedance)]

[JVET-AD0090](https://jvet-experts.org/doc_end_user/current_document.php?id=12641) AHG9: On input pictures to an NNPF [Y.-K. Wang, L. Zhang (Bytedance)]

[JVET-AD0091](https://jvet-experts.org/doc_end_user/current_document.php?id=12642) AHG9: Miscellaneous NNPF topics (set 1) [Y.-K. Wang, J. Xu, C. Lin, Y. Li, J. Li, L. Zhang, K. Zhang (Bytedance)]

[JVET-AD0093](https://jvet-experts.org/doc_end_user/current_document.php?id=12644) AHG9: Neural-network post-processing filter with downsampling capabilities [Y. Li, J. Xu, Y.-K. Wang, C. Lin, J. Li, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0094](https://jvet-experts.org/doc_end_user/current_document.php?id=12645) AHG9: On the NNPFC SEI message involving depth pictures [C. Lin, Y.-K. Wang, J. Xu, Y. Li, J. Li, K. Zhang, L. Zhang (Bytedance)]

[JVET-AD0104](https://jvet-experts.org/doc_end_user/current_document.php?id=12655) AHG9: On NNPF Overlap [A. Sidiya, S. Deshpande (Sharp)]

[JVET-AD0141](https://jvet-experts.org/doc_end_user/current_document.php?id=12692) AHG9: On discardable and non-output pictures for NNPF SEI messages [Hendry, J. Nam, H. Jang, S. Kim, J. Lim (LGE)]

[JVET-AD0143](https://jvet-experts.org/doc_end_user/current_document.php?id=12694) AHG9: On picture size for input and output pictures of NNPFC SEI message [Hendry, J. Nam, H. Jang, S. Kim, J. Lim (LGE)]

[JVET-AD0145](https://jvet-experts.org/doc_end_user/current_document.php?id=12696) AHG9: On non-consecutive input pictures for NNPFC SEI message [Hendry, J. Nam, H. Jang, S. Kim, J. Lim (LGE)]

[JVET-AD0149](https://jvet-experts.org/doc_end_user/current_document.php?id=12700) AHG9: On carriage of NNPF bitstream only in NNPFC SEI message [Hendry, J. Nam, H. Jang, S. Kim, J. Lim (LGE)]

[JVET-AD0151](https://jvet-experts.org/doc_end_user/current_document.php?id=12702) AHG9: On output picture design in NNPFC SEI message [Hendry, J. Nam, H. Jang, S. Kim, J. Lim (LGE)]

[JVET-AD0154](https://jvet-experts.org/doc_end_user/current_document.php?id=12705) AHG9: Additional purposes for the NNPFC SEI message [M. Pettersson, M. Damghanian, R. Sjöberg (Ericsson)]

[JVET-AD0159](https://jvet-experts.org/doc_end_user/current_document.php?id=12710) AHG9: Explicit identification of NNPF input pictures [R. Sjöberg, M. Pettersson, M. Damghanian (Ericsson)]

[JVET-AD0233](https://jvet-experts.org/doc_end_user/current_document.php?id=12797) AHG9: Miscellaneous NNPF topics (set 2) [J. Xu, Y.-K. Wang, C. Lin, Y. Li, J. Li, L. Zhang, K. Zhang (Bytedance)]

[JVET-AD0240](https://jvet-experts.org/doc_end_user/current_document.php?id=12804) AHG9: Support more NNPF purposes [J. Xu, Y.-K. Wang, L. Zhang, J. Li, C. Lin (Bytedance)]

[JVET-AD0370](https://jvet-experts.org/doc_end_user/current_document.php?id=12934) AHG9: Editorial improvement for signalling of NNPFC purpose [K. Sühring (HHI)] [late]

[JVET-AD0383](https://jvet-experts.org/doc_end_user/current_document.php?id=12947) AHG9: Modification to the signalling of output picture size in NNPFC SEI message [Hendry (LGE), Y.-K. Wang (Bytedance), S. Deshpande (Sharp)] [late]

[JVET-AD0384](https://jvet-experts.org/doc_end_user/current_document.php?id=12948) AHG9: On extensibility of NNPFC purpose bitmask [S. Wenger, S. Liu (Tencent)] [late]

[JVET-AD0388](https://jvet-experts.org/doc_end_user/current_document.php?id=12952) AHG9: Output flags in the NNPFA SEI message [M. M. Hannuksela, F. Cricri (Nokia), Y.-K. Wang (Bytedance)] [late]

## AHG9: SEI messages on topics other than NNPF and SEI processing order (9)

Contributions in this area were discussed at 1125–1250 and 1600-1840 on Tuesday 25 April 2023 (chaired by JRO, Y. Ye from 1810).

[JVET-AD0051](https://jvet-experts.org/doc_end_user/current_document.php?id=12598) AHG9: Common SEI Message of Generative Face Video [B. Chen, J. Chen, Y. Ye (Alibaba), S. Wang (CityU)]

At the 29th JVET meeting, JVET-AC0088 proposed a generative face video SEI message to allow VVC-coded pictures to be used as source images to enable ultra low rate face video compression. In this updated proposal, we expand the proposed generative face video SEI message to include different facial representations, such as 2D keypoints, 2D landmarks, 3D keypoints, facial semantics and other formats. We demonstrate the effectiveness of the proposed SEI message in its capability to reconstruct high-quality talking face video at ultra-low bitrate. We also provide further information on rate allocation between VVC-coded pictures and SEI messasges and model complexity of a few typical generative systems. The proposed generative face video SEI message can be applicable to video conferencing, live entertainment and face animation applications.

The additional brought in this contribution is helpful for understanding the benefit and potential of face generation algorithms.

It was asked what the amount of interoperability is that this SEI message would provide? More precisely, would it still have benefit if not *exactly* one of the mentioned end-to-end algorithms with perfectly matching encoder and decoder would be used.

It appears necessary to provide more information what operation a decoding device should perform (if possible). For example, what is a decoder expected to do with the keypoints, and how is the texture from the base picture combined with the keypoints to produce the output?

From the current proposal, it appears that it is expected to have an aligned pair of encoder and decoder. A question would be if this would require to signal which encoder has produced the bitstream.

This is generally asserted to be a very interesting direction with high potential e.g. for extreme compression of facial videos, but further study appears necessary how it fits into the general concept of SEI messages which typically don’t describe a detailed decoding process.

[JVET-AD0057](https://jvet-experts.org/doc_end_user/current_document.php?id=12604) AHG9: Miscellaneous VVC changes on SEI messages [M. M. Hannuksela, F. Cricri, M. Santamaria (Nokia)]

JVET-AD0057 items 3 and 4 belong to this category.

This input document proposes the following items for the VVC text related to the neural-network post-filter characteristics (NNPFC), neural-network post-filter activation (NNPFA), and other SEI messages:

1. It is proposed to allow NNPFC and NNPFA SEI messages within the suffix SEI NAL unit syntax.
2. It is proposed to disallow post-filter hint, NNPFC, and NNPFA SEI messages present in both a prefix SEI NAL unit and a suffix SEI NAL unit in the same picture unit.
3. VclAssociatedSeiList consists of the payloadType values of the SEI messages that, when non-scalable-nested, infer constraints on the NAL unit header of the SEI NAL unit on the basis of the NAL unit header of the associated VCL NAL unit. It is proposed to add the payloadType value of the green metadata SEI message in VclAssociatedSeiList
4. PicUnitRepConSeiList consists of the payloadType values of the SEI messages that are subject to the restriction on 4 repetitions per picture unit (PU). It is proposed to add the payloadType values of post-filter hint, green metadata, scalability dimension information, NNPFC, NNPFA, and phase indication SEI messages in PicUnitRepConSeiList.
5. Related to the use of the NNPFC SEI message, it is proposed to reinforce the decision on JVET-AC0074, i.e., limit the special treatment of temporal interleaving frame packing arrangement to picture rate upsampling only rather than for any multi-picture-input NNPF.
6. Related to the use of the NNPFC SEI message, it is proposed to specify that any multi-picture-input NNPF can only be used when all input pictures have the same dimensions after applying super resolution post-filter applicable to the input pictures, if any.

Decision: Agreed on items 3 and 4 (for other items, see BoG report JVET-AD0362)

[JVET-AD0060](https://jvet-experts.org/doc_end_user/current_document.php?id=12607) AHG8/AHG9: Indications related to suboptimal user viewing [M. M. Hannuksela, F. Cricri, H. Zhang (Nokia)]

This contribution also fits under section 4.10.

The contribution reviews some earlier contributions on preprocessing and encoding methods targeted at machine analysis and concludes that spatial and temporal quality fluctuations resulting from such methods may result into decoded video that looks subjectively unpleasant. To avoid accidental displaying of video that is not intended for user viewing, such as machine-targeted bitstreams, the following items are proposed in this input document:

1. A VUI indication to indicate that there shall not be any annotated regions SEI messages with ar\_not\_optimized\_for\_viewing\_flag equal to 1 or suboptimal user viewing SEI messages present. The following options for the VUI indication are proposed, from which the proponent prefers option 3:
   1. Overloading vui\_non\_packed\_constraint\_flag.
   2. Overlading vui\_non\_projected\_constraint\_flag.
   3. Adding vui\_suboptimal\_user\_viewing\_constraint\_flag.
2. A suboptimal user viewing indication SEI message, as proposed earlier in JVET-AC0077, which indicates that the video resulting by decoding the current CLVS is not optimized for user viewing and may therefore look incoherent.

It is proposed to add the proposed items to a VSEI amendment working draft.

It was commented that re-using one of the existing flags would be that legacy decoders might be warned that something is wrong with the video.

It was commented that annotated regions (which is included as one case that might be suboptimal for viewing) could actually have application where the non-annotated part could be viewable. It should not be forbidden to be present when the flag is zero.

It was asked why an SEI message (which does not have any syntax as it is proposed) is needed at all. It was answered that this allows to indicate certain sublayers being not viewable

It was commented that it might never happen that a stream optimized for machine consumption appears in a domain where videos are intended to be viewable, such as broadcast or streaming. Also in the domain of machine consumption a human operator might want to have a look at the video.

It was asked if the purpose could also be fulfilled by some mechanism at the systems layer.

See also further notes under JVET-AD0137.

Further study recommended.

Further discussion in joint meeting with WG 4.

[JVET-AD0078](https://jvet-experts.org/doc_end_user/current_document.php?id=12626) AHG9: On comments for the draft of VSEI [T. Chujoh, Y. Yasugi, T. Ikai (Sharp)]

JVET-AD0078 items 4 and 5 belong to this category.

This contribution reports two editorial problems and three technical problems in JVET-AC2032, the latest draft of the versatile supplemental enhancement information messages for coded video bitstreams (VSEI) standard (Rec. ITU-T H.274 | ISO/IEC 23002-7) and proposes solutions. One technical suggestion regarding Neural-network post-filter characteristics SEI is that when only chroma samples are processed, the integer variable, strengthControlScaledVal, should be derived from the chroma variable, inpTensorBitDepthC. The others technical suggestions are about Post-filter hint SEI. The equation to derive the syntax elements filter\_hint\_value should be improved because the normalization value may be too large, and the pixel out of the picture may be indicated. The latter problems concern not only VSEI but also HEVC

Item 4: There is a technical problem in the equation (95) of subsection 8.30.4. The value of normalization, (28+bitDepth-1)2 in the following equation (95) may not be correct.

Item 5: There is a technical problem in the equation (95) of subsection 8.30.4. The decoded signal s’ indexes may indicate out of the picture.

Item 4: Comparing to the original proposal (which was intended for 8 bit), the normalization value should be 1. The suggested correction formula was mentally crosschecked for the cases of 10 bit and 12 bit:

* In 10-bit case, two 10-bit numbers are multiplied, which gives a 20-bit number, to be normalized by 16 to provide a 16-bit number filter\_hint\_value
* In 10-bit case, two 12-bit numbers are multiplied, which gives a 24-bit number, to be normalized by 256 to provide a 16-bit number filter\_hint\_value
* etc.

The same problem is existing in AVC and HEVC

Item 5: Due to the fact that offset\_x/offset\_y are only half of the maximum of cx/cy, respectively, samples outside of the reconstructed picture would be addressed in the formula. Even though the formula comes in a note and is not normative, this is confusing. The proposed solution of clipping to the picture width/height resolves the problem.

Decision: It is agreed that items 4 and 5 shall be resolved by the solutions proposed in JVET-AD0078. This fix should be included in VSEI v3, and in a new version of JVET-AD1004. Furthermore, it should be implemented in the HEVC FDIS 5th edition. As the FDIS had not yet been submitted for ballot, it was agreed later to leave it to the discretion of editors to make this change.

[JVET-AD0121](https://jvet-experts.org/doc_end_user/current_document.php?id=12672) AHG9: Attenuation Map Information SEI for reducing energy consumption of displays [O. Le Meur, C. H. Demarty, F. Aumont, E. François, L. Blonde, E. Reinhard (InterDigital)]

Following up on JVET-AC0122, this contribution reports a comparison of the proposal to use an Attenuation Map to reduce the energy consumption of images while displayed, with a linear scaling and an implementation of a clipping as described in informative annex B of Green metadata specification. Two different techniques to build attenuation maps are reported and compared. The comparison is reported in terms of objective quality metrics. It is asserted that the use of attenuation maps as built by the two compared techniques provides higher objective quality metrics than the approach described in Green metadata specification, and comparable PSNR values and higher SSIM values than linear scaling.

This contribution also states that the use of Attenuation Maps to reduce the energy consumption of images while displayed is consistent across different screen types and options.

Following the recommendations from JVET 29th meeting, this contribution also provides a technical solution to carry the attenuation map by reusing auxiliary pictures of type AUX\_ALPHA. It is reported that auxiliary pictures of type AUX\_ALPHA with only luma component are currently supported, limiting the use of Attenuation Map to one single component.

**Finally, it is reported that the new metadata for Attenuation Maps will be proposed to be defined in an amendment of the Green metadata specification.**

No action necessary in JVET

Question was asked if this really requires an SEI message, or if this could not also be done in a content-adaptive way at the display.

[JVET-AD0137](https://jvet-experts.org/doc_end_user/current_document.php?id=12688) [AHG8] SEI for encoder optimization information [C. Kim, Hendry, D. Gwak, J. Lim (LGE)]

This contribution also fits under section 4.10.

At the last meeting, AHG8 provided a description of optimization techniques for video encoders and receiving systems. However, a method for identifying optimization has not been described. This contribution proposes the SEI message to indicate whether encoding optimization is applied and what optimization methods is used.

Different from JVET-AD0060, this proposal contains a list of “optimization methods” which let the decoding device know which manipulations have been applied, e.g. temporal or spatial subsampling, ROI preprocessing, etc. It could be combined with any of the VUI signalling approaches of JVET-AD0060 (perhaps leaving out the annotated regions, as region emphasis is included here.

It was commented that the list of “optimization methods” should appear in the SEI message itself rather than pointing to the TR.

It was commented that starting the SEI with the cancellation flag may be undesirable. Mechanisms of cancelling should be implemented similar to other SEI messages.

It was commented that the SEI message may require more study; in terms of extensibility, it has a similar problem as the SEI messages for purpose signalling.

It was commented that a flag would be desirable indicating that the video is not intended for human viewing (similar to annotated regions SEI).

Further study recommended.

Further discussion in joint meeting with WG 4.

[JVET-AD0161](https://jvet-experts.org/doc_end_user/current_document.php?id=12712) AHG9: Alternative Output Timing Hint SEI [H.-B. Teo, J. Gao, C.-S. Lim, K. Abe (Panasonic)]

This contribution is a further follow-up proposal on JVET-AC0141. This contribution proposes an Alternative Output Timing Hint SEI message for VSEI. In the case if the video bitstream contains slow-motion scenes, this SEI can indicate the actual motion speed of the content at captured time. Two aspects are included. In the first aspect, a time scale factor is introduced. This time scale factor is used to calculate the alternative output time using the DPB output time. In the second aspect, recommended level\_idc for every temporal sublayer is added. These recommended level\_idc values are to inform the decoder the minimum level that is needed to decode each temporal sublayer using the alternative output time. The proposal suggests to adopt either aspect 1, or aspect 1 and aspect 2 into VSEI specification.

For aspect 2, it was asked if it is a requirement that the sublayer level to be identical with the one present in the bitstream. The proponent suggests that these do not have to be identical, and could be slightly different.

It was asked how to ensure HRD functions correctly if there is no conformance test of the additional operations enabled by the proposed SEI. The proponent suggests that this could be accomplished by using a scale factor carried in the proposed SEI. However, several experts expressed reservation that using this scaling factor could replace the conformance test.

The next version of VSEI spec is yet to start. There is no urgency to adopt new SEI messages at this time.

Further study recommended.

[JVET-AD0175](https://jvet-experts.org/doc_end_user/current_document.php?id=12726) AHG8/AHG9: On object mask auxiliary picture and object mask information SEI message for VSEI and HEVC [J. Chen, S. Wang, Y. Ye (Alibaba)]

This contribution also fits under section 4.10.

In this contribution, it is proposed to add a new type of auxiliary picture to represent the object mask for the detected or tracked object within the compressed video bit-stream in VSEI and HEVC. To support the proposed object mask auxiliary picture, the associated SEI message called the object mask information (OMI) SEI message is also proposed to VSEI and HEVC.

The proposal is to encode the aux picture in 10 bits, and use the value as index for the corresponding object (max. 1024). There could be multiple auxiliary pictures.

It was asked if lossless coding is necessary, and which could be data rates?

What would be typical uase cases of having 1024 different objects?

Could the auxiliary pictures be downsampled?

Could the auxiliary picture also apply to a cropped part? It was commented that the cropping window cannot be used for this purpose, as this is intended for display.

Further study recommended along these questions.

[JVET-AD0386](https://jvet-experts.org/doc_end_user/current_document.php?id=12950) AHG9: Common text for the SEI processing order SEI message [M. M. Hannuksela (Nokia), Y. He (Qualcomm), S. McCarthy (Dolby)] [late]

Was already reviewed in BoG, and agreed upon (see list of recommendations under JVET-AD0362)

## Non-SEI HLS aspects (0)

Section kept as a template for future use.

# Plenary meetings, joint meetings, BoG reports, and liaison communications

## JVET plenaries

No intermediate plenaries were held, as document review and decisions were made in single-track mode at this meeting (with some BoG activity as noted). Further detail on scheduling is recorded in section 2.13.

Communication and coordination items were discussed on Monday April 24 at 1430

* Joint meetings:
  + With AG 5 on visual testing: Tuesday 25 April 0900 (1 hr.)
  + With WG 4 on VCM: Thursday 27 April 0900 (1 hr.)
* Session planning (participants were encouraged to see the posted online calendar)
* Agreed to issue preliminary FDIS on VSEI v3 instead FDIS, and draft DoCR (to be produced during meeting)
* Potentially issue preliminary FDIS on VSEI v3 instead FDIS, and draft DoCR (to be produced during meeting) – some clarification about SMPTE ST 2128 timeline needed
* Clarify if new version of VVC preliminary FDIS is needed (likely not)
* Liaison from JPEG – to be presented Thu. 1000 in AG 3

General plenary wrap-up discussions are recorded under sections 8, 9, and 10.

## Information sharing meetings

Information sharing sessions with other WGs and AGs of the MPEG community were held on Monday 24 April 0900–1130, Wednesday 26 April 0900–1000, and Friday 28 April 1400–XXXX. The status of the work in the MPEG WGs and AGs was reviewed at these information sharing sessions.

## Joint meetings with MPEG AG/WG X on XXXX

## BoGs (2)

The following break-out groups were established at this meeting to conduct discussion and develop recommendations on particular subjects

[JVET-AD0362](https://jvet-experts.org/doc_end_user/current_document.php?id=12926) BoG report on NNPF and SEI processing order SEI messages [Y.-K. Wang, M. M. Hannuksela, S. Deshpande (BoG coordinators)]

See section X for notes on this BoG report.

Was presented Tuesday 25 Apr. 1000-1110

This document contains the report of the BoG on neural-network post-processing filter (NNPF) and SEI processing order SEI messages. Following the summary provided in JVET-AD0208, the BoG met on

* Friday 21 April 2023 at 1400-1900, discussing proposal items in the proposal categories 1), 2), and 4).
* Saturday 22 April 2023 at 0900-1300 and 1400-2000, discussing proposal items in the proposal categories 5) to 9), 11) to 14), and 16).
* Sunday 23 April 2023 at 0900-1240 and 1340-2000, discussing proposal items in the proposal categories 3), 10), 15), and 17) to 19), as well as some revisits.
* Monday 24 April 2023 at 1610-1920, discussing remaining revisits and item 5)g.

The BoG recommended the following actions:

* Action on item 1)a.ii: Plan, in v4 (of VSEI and VVC), to update the SEI processing order SEI message to include NNPFs, without clearly specifying the behavior of multiple NNPFs activated for the same picture in v3 except for the special case of spatial resolution upsampling followed by picture rate upsampling.
* Action on item 1)c: To endorse that it is desirable to support all of the following NNPF related capabilities in v4 (of VSEI and VVC):
  + Multiple activated NNPFs (with the same or different purposes) for a picture in an alternative manner (choose to apply none, filter a only, or filter b only)
  + Multiple activated NNPFs (with the same or different purposes) for a picture in a cascading+alternative manner (choose to apply none, filter a only, filter b only, or both filter a and b in a cascaded manner in the indicated order)
  + Multiple activated NNPFs for a picture while the reciever may process the bitstream multiple time to generate multiple different results (for each time, to choose to apply none, filter a only, or filter b only)
  + Multiple activated NNPF cascades in an alternative manner (choose to apply none, both filter a and b in a cascaded manner in the indicated order, or both filter c and d in a cascaded manner in the indicated order)
* Action on item 1)d: Extend the latest SEI processing order SEI message to enable signalling of prefix information for any type of SEI messages.
* Action on item 2)b.ii: To allow input pictures to an NNPF activated for any current picture to come from an earlier CLVS than the CLVS containing the current picture, and for the derivation of which pictures are used as in the input pictures, instead of using picture order count values, plain language phrases like "the previous picture in output order" and "the n-th previous picture in output order" are used.
* Action on item 2)b.i.1: Add an indication nnpfc\_absent\_input\_pic\_zero\_flag in the NNPFC SEI message that indicates how pictures that would not originate from the bitstream are expected to be replaced in the input tensor. nnpfc\_absent\_input\_pic\_zero\_flag equal to 1 indicates that the NNPF expects an input picture that is not present in the bitstream to be represented sample arrays with sample values equal to 0. nnpfc\_absent\_input\_pic\_flag equal to 1 indicates that the NNPF expects an input picture that is not present in the bitstream to be represented by the closest input picture in output order within the bitstream.
* Action on item 2)b.i.2: Add a constraint that NNPF shall not be activated so that it creates an interpolated picture before the first picture in the bitstream in output order.
* Action on item 2)d: At the end of a bitstream, repeated inference of NNPF for creating interpolated pictures: When an NNPF is active until the end of the bitstream, the NNPF is applied up to but excluding a set of input pictures that would cause creation of any interpolated picture after the last picture of the bitstream in output order.
* Action on item 2)e.i: Limit the special treatment of temporal interleaving frame packing arrangement to picture rate upsampling only rather than for any multi-picture-input NNPF.
* Action on item 2)f with the change of "the CLVS" to "the bitstream": Fix an asserted bug in the derivation of input pictures for the case when there are multiple input pictures for an NNPF activated for currCodedPic and currCodedPic is associated with a frame packing arrangement SEI message with fp\_arrangement\_type equal to 5, taking into account that there can be multiple pictures preceding an input picture in output order.
* Action on item 2)g: Specify that any multi-picture-input NNPF can only be used when all input pictures have the same dimensions after applying super resolution post-filter applicable to the input pictures, if any, using text provided in JVET-AD0057 item 6.
* Action on item 3)a.i: Add nnpfa\_output\_flag[ i ] syntax elements in the NNPFA SEI message for controlling which NNPF-generated pictures that correspond to input pictures are output by the NNPF process, and impose both of the following constraints:
  + For a particular NNPF, disallow it to output a picture multiple times for any particular output order or output time instance.
  + For all NNPFs activated for at least one picture in a bitstream, disallow the NNPFs (when alternative, only one is used) to output a picture multiple times for any particular output order or output time instance.
* Action on items 3)c, 3)d, and 3)e.i: Specify a general post-processing filtering process using NNPFs, wherein the input to the process is a bitstream BitstreamToFilter, and the output of the process is a list of NNPF output pictures. Then clearly specify the above constraints (as part of the recommended action on item 3)a.i) in the context of the general post-processing filtering process.  
  Revisit after text review
* Action on items 3)f, 3)f.i.1, and 3)f.i.2: Include nnpfc\_input\_pic\_output\_flag[ i ] in the NNPFC SEI message when nnpfc\_num\_input\_pics\_minus1 is greater than 0 regardless of the nnpfc\_purpose value, move the flag to be immediately after nnpfc\_num\_input\_pics\_minus1, and skip signalling of the flag when nnpfc\_num\_input\_pics\_minus1 is equal to 0. Require at least one of the flags to be equal to 1 when there are multiple of them and picture rate upsampling is not indicated.
* Action on item 3)f.ii: Delegate to the editor to decide to either specify an inference rule for nnpfc\_input\_pic\_output\_flag[ i ] or directly consider the possible absence in the equations for derivation of the number of output pictures.
* Action on item 4)a: Add the following constraints: It is a requirement of bitstream conformance that the value of nnpfc\_pic\_width\_in\_luma\_samples % outSubWidthC shall be equal to 0. It is a requirement of bitstream conformance that the value of nnpfc\_pic\_height\_in\_luma\_samples % outSubHeightC shall be equal to 0.
* Action on item 4)b: For spatial resolution upsampling, signal the scaling ratios instead of the NNPF output picture width and height.
* Action on item 4)f: Specify that the width of the NNPF output picture shall be in the range of CroppedWidth to CroppedWidth \* 16, inclusive (instead of CroppedWidth to CroppedWidth \* 16 − 1, inclusive), and the width of the NNPF output picture shall be in the range of CroppedHeight to CroppedHeight \* 16, inclusive (instead of CroppedHeight to CroppedHeight \* 16 − 1, inclusive).
* Action on item 4)h: Add a constraint on NNPF input tensor and output tensor bit depth values to avoid changing in opposite directions from input to output (e.g., luma bit depth getting bigger while chroma bit depth getting smaller).
* Action on item 5)e: Add a metadata extension mechanism in the NNPFC SEI message, to allow new metadata syntax elements to be added in the NNPFC SEI message in future VSEI amendments or editions, and require parsers of v3 of VSEI to skip and ignore such additional metadata syntax elements.
* Action on item 6)a.i: Move nnpfc\_base\_flag next to nnpfc\_id in the NNPFC SEI message syntax.
* Action on item 6)b: Make changes to avoid a repetition of an NNPFC SEI message affecting the persistence of an NNPF update.
* Action on item 6)c: Fix the incorrect inference of upsampled resolution, colour primaries, transfer characteristics, and matrix coefficients syntax elements when nnpfc\_property\_present\_flag is equal to 0
* Action on item 6)e: Enable the activation of the base NNPF with a particular nnpfc\_id value after an NNPF update for the same nnpfc\_id is available.
* Action on item 6)g: In the VVC text, disallow the NNPFA SEI message from associated with a non-output picture and disallow any input pictures being a non-output picture.
* Action on item 6)h: Change the persistence scope of the NNPFC SEI message to "The CLVS containing the SEI message".
* Action on items 8)a and 8)a.i: Move nnpfc\_inp\_order\_idc and nnpfc\_out\_order\_idc before the bit depth syntax elements, and gate the bit depth syntax elements so that the luma bit depth is present only when the input or output tensor contains luma, and the chroma bit depth is present only when the input or output tensor contains chroma. And update the related constraints on the values of nnpfc\_out\_tensor\_luma\_bitdepth\_minus8 and nnpfc\_out\_tensor\_chroma\_bitdepth\_minus8 accordingly.
* Action on item 8)b: Add syntax conditions such that nnpfc\_luma\_padding\_val is present only when the input tensor contains a luma sample array, and nnpfc\_cb\_padding\_val and nnpfc\_cr\_padding\_val are present only when the input tensor contains chroma sample arrays.
* Action on item 8)c: Signal nnpfc\_auxiliary\_inp\_idc before nnpfc\_inp\_order\_idc, as the semantics of nnpfc\_inp\_order\_idc syntax element use nnpfc\_auxiliary\_inp\_idc.
* Action on item 9)a: Add the following constraint: When nnpfc\_purpose & 0x02 is not equal to 0, nnpfc\_inp\_order\_idc shall not be equal to 0.
* Action on item 9)b: Remove "(from the 4:0:0 chroma format to the 4:2:0, 4:2:2, or 4:4:4 chroma format)" in the table describing the NNPF purposes, such that colourization can be applied even when the cropped decoded pictures are of the 4:0:0 chroma format.
* Action on item 9)c: Add a constraint that disallows nnpfc\_inp\_order\_idc indicating that the input tensor has chroma component when ChromaFormatIdc is equal to 0.
* Action on item 9)d: Make the following change (additions indicated with underline): When nnpfc\_purpose & 0x02 is not equal to 0, nnpfc\_out\_order\_idc shall not be equal to 0 or 3.
* Action on item 9)e: Add a constraint such that when the purpose indicates colorization, there shall be chroma output by the NNPF.
* Action on item 10)a: Move nnpfc\_separate\_colour\_description\_present\_flag, nnpfc\_colour\_primaries, nnpfc\_transfer\_characteristics, and nnpfc\_matrix\_coeffs to be after nnpfc\_out\_order\_idc. Include the nnpfc\_matrix\_coeffs syntax element in the syntax under the constraint that nnpfc\_out\_format\_idc is equal to 1 (indicating integer sample values in the output tensor). For the semantics of nnpfc\_matrix\_coeffs, replicate the semantics of vui\_matrix\_coeffs with reference to the chroma format, chroma bit depth, and luma bit depth of the output tensor.
* Action on item 10)b: Include a syntax element nnpfc\_full\_range\_flag in the NNPFC message when nnpfc\_separate\_colour\_description\_present\_flag is equal to 1 and when nnpfc\_out\_format\_idc is equal to 1.
* Action on item 10)c: Add a syntax element indicting the location of chroma samples, and the presence of the syntax element is controlled by a new presence flag. Add a constraint to require the value of the new presence flag to be equal to 0 when nnpfc\_output\_color\_format\_idc is not equal to 1.
* Action on item 11)a: Change the definition of the function InpSampleVal( ) to take the component index (0 for luma, 1 for Cb, 2 for Cr) as an additional input argument. For nnpfc\_padding\_type equal to 4, change the function InpSampleVal to return the fixed luma, Cb, or Cr padding value corresponding to the component index given as input argument. For each invocation of the function InpSampleVal, add the component index among the input arguments.
* Action on item 12)a: Remove the following constraints on nnpfa\_target\_id values, which were asserted to be enforced by other constraints and are therefore asserted to be redundant: Values of nnpfa\_target\_id from 256 to 511, inclusive, and from 231 to 232 − 2, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders conforming to this edition of this document encountering an NNPFA SEI message with nnpfa\_target\_id in the range of 256 to 511, inclusive, or in the range of 231 to 232 − 2, inclusive, shall ignore the SEI message.
* Action on item 13)a: Allow inclusion of NNPFC and NNPFA SEI messages in suffix SEI NAL units.
* Action on item 13)b: Disallow the post-filter hint SEI message to be present in both a prefix SEI NAL unit and a suffix SEI NAL unit in the same picture unit.
* Action on item 14)a: Specify an array of filtering strength control variables for multiple input pictures (as StrengthControlVal[ idx ] values for the input pictures with index idx in the range of 0 to numInputPics − 1, inclusive), and derive an array scaled strengthControlScaledVal[ i ] values for multiple input pictures and use them to derive the input tensors.
* Action on item 14)c: Make changes to Equation (83) such that when nnpfc\_inp\_order\_idc is equal to 1 (i.e., only chroma is present in the input tensor), the variable strengthControlScaledVal is derived from the variable inpTensorBitDepthC (instead of from inpTensorBitDepthY).
* Action on item 14)d: Set StrengthControlVal equal to ( SliceQpY + QpBdOffset ) ÷ ( 63 + QpBdOffset), instead of SliceQpY ÷ 63, where SliceQpY is that of the first slice of currCodedPic.
* Action on item 15)a: Extend the current resolution upsampling to be resolution resampling such that both resolution upsampling and resolution downsampling capabilities are supported.
* Action on item 16)a.ii: Clarify that the output from the PostProcessingFilter (i.e. outputTensor) does not include overlap regions.
* Action on item 17)a: Update the specification of the value range of nnpfc\_padding\_type to take into account that the values in the range 5 to 15, inclusive, are reserved.
* Action on item 17)b: Add missing value ranges of ue(v)-coded syntax elements nnpfc\_luma\_padding\_val, nnpfc\_cb\_padding\_val, and nnpfc\_cr\_padding\_val, with the lower limit being 0 and the upper limit being two power of the corresponding bit depth values of the cropped output pictures minus 1.
* Action on items 18)a and 18)b (editorial): Fix typos by changing all instances of "nnpfc\_parameter\_parameter\_type\_idc" to "nnpfc\_parameter\_type\_idc" and changing "4:2:4 format" to "4:4:4 format".
* Action on item 18)c (editorial): Restructure the semantics of nnpfc\_purpose including table 20 with the definition of the nnpfc\_purpose.
* Action on item 18)d (editorial): Avoid repeatedly using "&" operations in many places, e.g., by deriving and using variables, e.g., spatialResolutionResamplingIncludedFlag.

All action items listed above (except one revisit) were agreed/decision by JVET plenary.

Some of the action items relate to the NNFPA SEI, and therefore require changes in the VVC amendment / FDIS

It was pointed out that the specification of VVC wrt suffix SEI deviates from HEVC:

* No user data (according to experts, this might have been forgotten when v1 was created)
* post filter hint (new, already in newest prelim. FDIS)
* NNPFA and NNPFC (new)

It was agreed to include all of those.

[JVET-AD0380](https://jvet-experts.org/doc_end_user/current_document.php?id=12944) BoG report on NN-filter design unification [E. Alshina, F. Galpin]

See section X for notes on this BoG report.

Initial version of the report was presented Mon. 1510 in JVET plenary

* Use weighted BD rate – has problems in interpretation, and may not be urgent
* Exact specification of “high complexity” filter needs another BoG meeting (planned Tue morning), filter will then be implemented after the meeting
* It was confirmed that training crosscheck shall also be mandatory for encoder-only elements of NNVC
* Decision: Adopt JVET-AD0156 (16 kMAC/pxl) to NNVC-5.0 (quanztization aspect to be aligned with other filters in NNVC) as “low-complexity” operation point
* The recommendations from the BoG report about EE-related documents were confirmed. To be integrated into meeting notes 5.1.3 as decisions

A follow-up was presented Tue. 1400 in JVET plenary

* The recommded architecture concept for the “high” filter was presented
* Open question that could not be agreed: Should a joint model be used for luma and chroma, or separate models; also in case of separate models, the unfiltered luma would be input to the chroma model
* Separate models are of bigger total size (also more kMAC/pxl), advantage that they can be controlled separately, and they could be better parallelized in training and inference (however, as the chroma model is significantly smaller, this effect may be limited
* It was argued that single model might have better performance, but this is not known for the architecture

It was decided to go for the single model at this stage (as one of them has been selected), but test it against the separate models in EE, and by the next meeting make the final decision, treating both as if they were candidates for selection in first place.

* The recommendations from the new version of the BoG report about EE-related documents were confirmed. To be integrated into meeting notes 5.1.3 as decisions

## Liaison communications (1)

[m63436](https://dms.mpeg.expert/doc_end_user/current_document.php?id=87485&id_meeting=194) Liaison statement from SC 29/WG 1 to WG 5 on JPEG AI [WG 1 via SC 29 Secretariat]

A draft needs to be presented in the AG 3 meeting Thursday 10:00 (E. Alshina)

A reply was drafted by JVET as WG 5 N XXXX. This was reviewed in session X

# Project planning

## Software timeline

ECM8 software (including all adoptions) was planned to be available 3 weeks after the meeting.

The NNVC 4.0 codebase software was planned to be available 4 weeks after the meeting.

VTM20.0 software was planned to be available on 2022-02-17. (Note that further updates may be released later)

Updates on top of HM17.0 software were not planned, but might be released after merging pending requests, as appropriate.

## Core experiment and exploration experiment planning

An EE on neural network-based video coding was established, as recorded in output document JVET-AC2023.

An EE on enhanced compression technology beyond VVC capability using techniques other than neural-network technology was also established, as recorded in output document JVET-AC2024.

Initial versions of these documents were presented and approved in the first plenary session on Friday 20 January.

## 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/VTM 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

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 that those rules which had been set up or refined during the 12th JVET meeting should be observed. In particular, for some CEs of some previous meetings, results were available late, and some changes in the experimental setup had not been sufficiently 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 a draft standard by the next meeting or in the near future.
* “Exploration experiments” (EEs) are also coordinated experiments. These are conducted on technology which is not foreseen to become part of a draft standard in the near future. The investigating methodology for assessment of such technology can also be an important part of an EE. (Further general rules for EEs, as far as deviating from the CE rules below, should be discussed in a future meeting. For the current meeting, procedures as described in the EE description document are deemed to be sufficient.)
* 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 that 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 as described below).
* 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 mandatory to report encoder optimizations made for the benefit of a tool, and if an equivalent optimization could be applied on the anchor, a comparison against the improved anchor shall be provided.
* A new proposal can be included in a CE based on group decision, regardless if an independent party has already performed a cross-check in the meeting when it was first proposed.

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 for SDR video are described in the prior output document JVET-T2010.

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”, “enhanced”, 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.

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. A second account exists for VCEG members with account information available in the TIES informal ftp area (IFA) system at:

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

Some agreements relating to CE activities were established as follows:

* Only qualified JVET members can participate in a CE.
* Participation in a CE is possible without a commitment of submitting an input document to the next meeting. Participation is requested by contacting the CE coordinator.
* All software, results, and documents produced in the CE should be announced and made available to JVET in a timely manner.
* A JVET CE reflector will be established and announced on the main JVET reflector. Discussion of logistics arrangements, exchange of data, minor refinement of the test plans, and preparation of documents shall be conducted on the JVET CE reflector, with subject lines prefixed by “[CEx: ]”, where “x” is the number of the CE. All substantial communications about a CE other than such details shall take place on main JVET reflector. In the case that large amounts of data are to be distributed, it is recommended to send a link to the data rather than the data itself, or upload the data as an input contribution to the next meeting.

General timeline for CEs

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 be marked as “withdrawn”.

T2 = Test model software release + 2 weeks: 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 minus 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 contribution 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 straightforward 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, JVET would like to see comprehensive cross-checking done, with analysis of whether the description matches the software, and a recommendation of the value of the tool and 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 into a standard or test model.

Availability of specification text is important to have a detailed understanding of the technology and also to judge what its impact on the complexity of the specification will be. There must also be sufficient time to study this in detail. CE contributions without sufficiently mature draft specification text in the CE input document should not be considered for adoption.

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.

# 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)).

Review of AHG plans was conducted during the plenary on Friday 28 April 2023 at XXXX.

|  |  |  |
| --- | --- | --- |
| **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 AHG and experiment studies. * Report on project status to JVET reflector. * Provide a report to the next meeting on project coordination status. * Supervise processing and delivery of output documents | J.-R. Ohm (chair), G. J. Sullivan (vice-chair) | N |
| **Draft text and test model algorithm description editing (AHG2)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Produce and finalize draft text outputs of the meeting (JVET-AC1008, JVET-AC2002, JVET-AC2005, JVET-AC2027, and JVET-AC2032). * Collect reports of errata for the VVC, VSEI, HEVC, AVC, CICP, the codepoint usage TR specification and the published HDR-related technical reports and produce the JVET-AC1004 errata output collection. * Coordinate with the test model software development AhG to address issues relating to mismatches between software and text. * Collect and consider errata reports on the texts. | B. Bross, C. Rosewarne (co-chairs), F. Bossen, A. Browne, S. Kim, S. Liu, J.‑R. Ohm, G. J. Sullivan, A. Tourapis, Y.-K. Wang, Y. Ye (vice-chairs) | N |
| **Test model software development (AHG3)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Coordinate development of test models (VTM, HM, SCM, SHM, HTM, MFC, MFCD, JM, JSVM, JMVM, 3DV-ATM, 360Lib, and HDRTools) software and associated configuration files. * Produce documentation of software usage for distribution with the software. * Enable software support for recently standardized additional SEI messages. * Discuss and make recommendations on the software development process. * Propose improvements to the guideline documents for developments of the test model software. * Perform comparative tests of test model behaviour using common test conditions, including HDR, high bit depth and high bit rate. * Suggest configuration files for additional testing of tools. * Investigate how to minimize the number of separate codebases maintained for group reference software. * 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. * Prepare drafts of merged and updated CTC documents for HM and VTM, as applicable. | F. Bossen, X. Li, K. Sühring (co-chairs), E. François, Y. He, K. Sharman, V. Seregin, A. Tourapis (vice‑chairs) | N |
| **Test material and visual assessment (AHG4)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Consider plans for additional verification testing of VVC capability, particularly target establishing a test plan for VVC scalability features by the next meeting. * Maintain the video sequence test material database for testing the VVC and HEVC standards and potential future extensions, as well as exploration activities. * Study coding performance and characteristics of available and proposed video test material. * Identify and recommend appropriate test material for testing the VVC standard and potential future extensions, as well as exploration activities. * Identify and characterize missing types of video material, solicit contributions, collect, and make available a variety of video sequence test material, in coordination with other AHGs, as appropriate. * Maintain and update the directory structure for the test sequence repository, as necessary. * Collect information about test sequences that have been made available by other organizations. * Prepare and conduct remote expert viewing for purposes of subjective quality evaluation. * Coordinate with AG 5 in studying and developing further methods of subjective quality evaluation, e.g. based on crowd sourcing. * Prepare availability of viewing equipment and facilities arrangements for future meetings. | V. Baroncini, T. Suzuki, M. Wien (co-chairs), S. Liu, S. Puri, A. Segall, P. Topiwala, S. Wenger, J. Xu, Y. Ye (vice-chairs) | Y (tel., 2 weeks notice) |
| **Conformance testing (AHG5)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Produce and finalize the draft conformance testing for operation range extensions JVET-AC2026 and the additional conformance bitstreams for VVC multilayer configurations JVET-AC2028, and investigate the need for future improvements of conformance testing specifications. * Study the requirements of VVC, HEVC, and AVC conformance testing to ensure interoperability. * Maintain and update the conformance bitstream database, and contribute to report problems, and suggest actions to resolve these. * Study additional testing methodologies to fulfil the needs for VVC conformance testing. | D. Rusanovskyy, I. Moccagatta (co-chairs), F. Bossen, K. Kawamura, T. Ikai, H.-J. Jhu, K. Sühring, Y. Yu (vice-chairs) | N |
| **ECM software development (AHG6)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Coordinate development of the ECM software and associated configuration files. * Produce documentation of software usage for distribution with the software. * Prepare and deliver ECM-8.0 software version and the reference configuration encodings according to the ECMcommon test conditions. * Investigate encoder speedup and other encoder software optimization. * Coordinate with ECM algorithm description editors to identify any mismatches between software and text, make further updates and cleanups to the software as appropriate. | V. Seregin (chair), J. Chen, F. Le Léannec, K. Zhang (vice-chairs) | Y (tel., 2 weeks notice) |
| **ECM tool assessment (AHG7)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Discuss JVET-AC0354, and prepare an updated document as input to the next meeting on the methodology of tool assessment, tool grouping and a list of tools in each group to be tested. * Investigate missing tool controls in ECM, and suggest appropriate modifications to software in coordination with AHG6. * Prepare configuration files and generate bitstreams and results of tool-on/tool-off testing. * Prepare reporting of tool assessment results. | X. Li (chair), L.-F. Chen, Z. Deng, J. Gan, E. François, H.-J. Jhu, R.-L. Liao, H. Wang (vice-chairs) | Y (tel., 2 weeks notice) |
| **Optimization of encoders and receiving systems for machine analysis of coded video content (AHG8)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Solicit and study non-normative encoder and receiving systems technologies that enhance performance of machine analysis tasks on coded video content. * Identify and collect test materials that are suitable to be used by JVET for machine analysis tasks. * Develop common test conditions and generate anchors. * Develop an evaluation framework, including evaluation procedures and methodologies. * Coordinate software development, and investigate the possibility of migrating the software basis to newest VTM version. * Coordinate experiments on optimization of encoders and receiving systems for machine analysis of coded video content. * Maintain the software implementations example algorithms in the repository, including sufficient documentation in terms of operation and performance. * Evaluate proposed technologies and their suitability for machine analysis applications. * Prepare a draft technical report on optimization of encoders and receiving systems for machine analysis of coded video content. * Coordinate with WG 4 VCM AHG on common interests and activities such as common test conditions, test and training materials, and on studying characteristics and requirements of targeted machine analysis tasks, etc. | C. Hollmann, S. Liu, S. Wang, M. Zhou (AHG chairs) | N |
| **SEI message studies (AHG9)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study the SEI messages in VSEI, VVC, HEVC and AVC. * Collect software and showcase information for SEI messages, including encoder and decoder implementations and bitstreams for demonstration and testing. * Identify potential needs for additional SEI messages, including the study of SEI messages defined in HEVC and AVC for potential use in the VVC context. * Coordinate with AHG8 and WG 4 to study mechanisms for signalling metadata in the context of machine analysis of coded video content. * Coordinate with AHG3 for software support of SEI messages. | S. McCarthy, Y.-K. Wang (co-chairs), T. Chujoh, S. Deshpande, C. Fogg, Hendry, P. de Lagrange, G. J. Sullivan, A. Tourapis, S. Wenger (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 tool adaptation and configuration, and perceptually optimized adaptive quantization for encoder optimization. * Study the impact of non-normative techniques of preprocessing for the benefit of encoder optimization. * Study encoding techniques of optimization for objective quality metrics and their relationship to subjective quality. * Study optimized encoding for reference picture resampling and scalability modes in VTM. * Study optimized encoding and tool combinations for low latency and low complexity. * Consider neural network-based encoding optimization technologies for video coding standards. * Investigate other methods of improving objective and/or subjective quality, including adaptive coding structures and multi-pass encoding. * Study methods of rate control and rate-distortion optimization and their impact on performance, subjective and objective quality. * Study the potential of defining default or alternate software configuration settings and test conditions optimized for either subjective quality, or higher objective quality, and coordinate such efforts with AHG3 and AHG6. * Study the effect of varying configuration parameters depending on temporal layer, such as those related to deblocking, partitioning, chroma QP. | P. de Lagrange, A. Duenas, R. Sjöberg, A. Tourapis (AHG chairs) | N |
| **Neural network-based video coding (AHG11)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Evaluate and quantify the performance improvement potential of NN-based video coding technologies compared to existing video coding standards such as VVC, including both individual coding tools and novel architectures. * Discuss potential refinements of the test conditions for NN-based video coding in JVET-AB2016. Generate and distribute anchor encoding, and develop supporting software as needed. * Study the impact of training (including the impact of loss functions) on the performance of candidate technologies, and identify suitable material for testing and training. * Analyse complexity characteristics, perform complexity analysis, and develop complexity reductions of candidate technology. * Finalize and discuss the EE on neural network-based video coding. * Coordinate with other relevant groups, including SC29/AG5 on the evaluation and assessment of visual quality, and AHG12 on the interaction with ECM coding tools. If possible, prepare encodings with combinations of tools included in the NNVC software for visual quality assessment at the next meeting. * Coordinate with AHG14 on items related to NNVC software development, and study the potential for unification of filter sets #0 and #1. | E. Alshina, S. Liu, A. Segall (co‑chairs), F. Galpin, J. Li, R.-L. Liao, D. Rusanovskyy, T. Shao, M. Wien, P. Wu (vice‑chairs) | Y (tel., 2 weeks notice) |
| **Enhanced compression beyond VVC capability (AHG12)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Solicit and study non-neural-network video coding tools with enhanced compression capabilities beyond VVC. * Discuss and propose refinements to the ECM8 algorithm description JVET-AC2025. * Coordinate with AHG7 to study the performance and complexity tradeoff of these video coding tools. * Coordinate with AHG6 on ECM software development. * Support AHG6 in generating anchors according to the test conditions in JVET-Y2017. * Analyse the results of exploration experiments described in JVET-AC2024 in coordination with the EE coordinators. * Coordinate with AHG11 to study the interaction with neural network-based coding tools. | M. Karczewicz, Y. Ye, L. Zhang (co-chairs), B. Bross, R. Chernyak, X. Li, K. Naser, H. Yang (vice-chairs) | Y (tel., 2 weeks notice) |
| **Film grain technologies (AHG13)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study the benefits and characteristics of film grain technologies, including autoregressive and frequency-filtering technologies. * Produce and finalize the JVET-AC2020 draft of the Technical Report on Film grain synthesis technology for video applications and suggest future improvements as necessary. * Study alternative film grain models and their associated documentation. * Coordinate with AHG4 on soliciting additional test materials as needed for further investigations on film grain technologies. * Study preprocessing and encoder technologies for determining values for FGC (Film Grain Characteristics) SEI message syntax elements. * Identify potential need for additional film grain technology and signalling, if needed. * Coordinate development of film grain technology software and configuration files. * Coordinate with AG 5 on finalizing the draft plan for subjective quality testing of the FGC SEI message JVET-AC2022, and conduct preparations for such testing. * Coordinate with AHG3 for software support of the FGC SEI message. | W. Husak, M. Radosavljević, W. Wan (co-chairs), D. Grois, Y. He, P. de Lagrange, A. Segall, A. Tourapis, W. Zhang (vice-chairs) | Y (tel., 2 weeks notice) |
| **NNVC software development (AHG14)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Coordinate development of the NNVC software and associated configuration files. * Prepare and deliver NNVC-4.0 software version and the reference configuration encodings according to the NNVC common test conditions JVET-AB2016. Prepare and release anchor data for all configurations of the software. * Study and maintain the SADL (Small Adhoc Deep-Learning Library). Identify gaps in functionality and develop improvements as needed. * Coordinate with NNVC algorithm and software description (JVET-AC2019) editors to identify any mismatches between software and description document, suggest further updates to the description document as appropriate. * Investigate combinations of tools included in the NNVC software and coordinate with AHG11 on defining default settings of such combinations. * Develop software guidelines for NNVC and SADL. * Coordinate with AHG11 on items related to NNVC activities. | S. Eadie, F. Galpin, Y. Li, L. Wang, Z. Xie (AHG chairs) |  |

It was confirmed that the rules which can be found in document ISO/IEC JTC 1/‌SC 29/‌AG 2 [N 046](https://www.mpegstandards.org/wp-content/uploads/2022/01/ISO-IECJTC1-SC29-AG2_N0046_AhG.pdf) “Ad hoc group rules for MPEG AGs and WGs” (available at <https://www.mpegstandards.org/adhoc/>), are consistent with the operation mode of JVET AHGs. It is pointed out that JVET does not maintain separate AHG reflectors, such that any JVET member is implicitly a member of any AHG. This shall be mentioned in the related WG Recommendations. The list above was also issued as a separate WG 5 document (ISO/IEC JTC 1/‌SC 29/‌WG 5 N XXX) in order to make it easy to reference.

# 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 a WG 5 output document, a separate version under the WG 5 document header should be generated. This version should be sent to GJS and JRO for upload.

The list of JVET ad hoc groups was also issued as a WG 5 output document WG 5 N XXX, as noted in section 9.

[JVET-AC1000](https://jvet-experts.org/doc_end_user/current_document.php?id=12565) Meeting Report of the 30th JVET Meeting [J.-R. Ohm] [WG 5 N XXX] (2023-05-26)

Initial versions of the meeting notes (d0 … d9) were made available on a daily basis during the meeting.

[JVET-AC1001](https://jvet-experts.org/doc_end_user/current_document.php?id=12566) Guidelines for HM-based software development [K. Sühring, F. Bossen, X. Li (software coordinators)] (2023-02-03)

Developed from JVET-AC0204

Remains valid – not updated: [JVET-Y1002](https://jvet-experts.org/doc_end_user/current_document.php?id=11463) High Efficiency Video Coding (HEVC) Test Model 16 (HM 16) Encoder Description Update 16 [C. Rosewarne (primary editor), K. Sharman, R. Sjöberg, G. J. Sullivan (co-editors)] [WG 5 [N 103](https://dms.mpeg.expert/doc_end_user/current_document.php?id=82085&id_meeting=189)]

Remains valid – not updated: [JVET-Z1003](https://jvet-experts.org/doc_end_user/current_document.php?id=11705) Coding-independent code points for video signal type identification (Draft 1 of 3rd edition) [WG 5 DIS N 162] [G. J. Sullivan, A. Tourapis]

[JVET-AC1004](https://jvet-experts.org/doc_end_user/current_document.php?id=12567) Errata report items for VVC, VSEI, HEVC, AVC, and Video CICP [Y.-K. Wang, B. Bross, I. Moccagatta, C. Rosewarne, G. J. Sullivan] (2023-03-17, near next meeting)

New aspects included the issues pointed out in JVET-AC0311 and JVET-AC0346.

Remains valid – not updated: [JVET-Z1005](https://jvet-experts.org/doc_end_user/current_document.php?id=11707) New levels for HEVC (Draft 3) [T. Suzuki, A. Tourapis, Y.-K. Wang]

The content of this document will be included in a new edition of HEVC. For additional corrigenda items included, see documents JVET-AB1004, as well as notes under JVET-AC0311 and JVET-AC0346. A DoCR on ISO/IEC DIS23008-2 was submitted as WG 5 N178 (reviewed during session 24), and the FDIS was submitted as WG 5 N 179.

(JVET-Z1005 can be removed after publication of the new edition of ISO/IEC 23008-2.)

No output: JVET-Axx1006

Remains valid – not updated: [JCTVC-V1007](http://phenix.it-sudparis.eu/jct/doc_end_user/current_document.php?id=10312) SHVC Test Model 11 (SHM 11) Introduction and Encoder Description [G. Barroux, J. Boyce, J. Chen, M. M. Hannuksela, Y. Ye] [WG 11 N 15778]

[JVET-AC1008](https://jvet-experts.org/doc_end_user/current_document.php?id=12568) Additional colour type identifiers for AVC, HEVC and Video CICP (Draft 3) [G. J. Sullivan, W. Husak, A. Tourapis] [WG 5 Preliminary WD N186] (2023-02-24)

Modified from JVET-AB1008 in response to JVET-AC0352.

[JCTVC-AC1009](https://jvet-experts.org/doc_end_user/current_document.php?id=12569) Common test conditions for SHVC [K. Sühring] (2023-02-17)

This requires an update, as the previous version referred to an outdated location of test sequences.

Remains valid – not updated [JCTVC-O1010](http://phenix.it-sudparis.eu/jct/doc_end_user/current_document.php?id=8511) Guidelines for Conformance Testing Bitstream Preparation [T. Suzuki, W. Wan]

Remains valid – not updated: [JVET-AA1011](https://jvet-experts.org/doc_end_user/current_document.php?id=11944) HEVC multiview profiles supporting extended bit depth (draft 1) [A. Tourapis, W. Husak] [WG 5 preliminary WD N 143] (2022-08-26)

Proponents of the new profiles reported that they are currently developing software and conformance bitstreams.

Remains valid – not updated: JVET-[AB1012](https://jvet-experts.org/doc_end_user/current_document.php?id=12213) Overview of IT systems used in JVET [J.-R. Ohm, I. Moccagatta, K. Sühring, M. Wien]

Remains valid – not updated: [JCT3V-G1003](http://phenix.int-evry.fr/jct3v/doc_end_user/current_document.php?id=1884) 3D-AVC Test Model 9 [ D. Rusanovskyy, F. C. Chen, L. Zhang, T. Suzuki ] [WG 11 N 14239]

Remains valid – not updated: [JCT3V-K1003](http://phenix.int-evry.fr/jct3v/doc_end_user/current_document.php?id=2499) Test Model 11 of 3D-HEVC and MV-HEVC [Y. Chen, G. Tech, K. Wegner, S. Yea] [WG 11 N 15141]

[JVET-AC1013](https://jvet-experts.org/doc_end_user/current_document.php?id=12570) Common test conditions of 3DV experiments [K. Sühring] (2023-02-17)

This requires an update, as the previous version referred to an outdated location of test sequences.

Remains valid – not updated [JCTVC-V1014](http://phenix.it-sudparis.eu/jct/doc_end_user/current_document.php?id=10316) Screen Content Coding Test Model 7 Encoder Description (SCM 7) [R. Joshi, J. Xu, R. Cohen, S. Liu, Y. Ye] [WG 11 N 16049]

[JCTVC-AC1015](https://jvet-experts.org/doc_end_user/current_document.php?id=12571) Common test conditions for SCM-based screen content coding [K. Sühring] (2023-02-17)

This requires an update, as the previous version referred to an outdated location of test sequences.

No output: JVET-Axx1016 through JVET-Axx1099

Remains valid – not updated [JVET-AA1100](https://jvet-experts.org/doc_end_user/current_document.php?id=11944) Common Test Conditions for HM Video Coding Experiments [K. Sühring, K. Sharman]

This specifies only the CTC for non-4:2:0 colour formats. The corresponding document for VVC is JVET-T2013, with no unification yet.

**No output: JVET-Axx2001**

[JVET-AC2002](https://jvet-experts.org/doc_end_user/current_document.php?id=12572) Algorithm description for Versatile Video Coding and Test Model 19 (VTM 19) [A. Browne, Y. Ye, S. Kim] [WG 5 N 183] (2023-04-14, near next meeting)

Updates from JVET-AC0096 (description of RPR switching control).

It is noted that the list above may not be complete; if some adoption is missing that is recorded somewhere else in the meeting notes it shall also be considered included.

[JVET-AC2003](https://jvet-experts.org/doc_end_user/current_document.php?id=12573) Guidelines for VTM-based software development [F. Bossen, X. Li, K. Sühring] (2023-02-03)

Developed from JVET-AC0166.

Remains valid – not updated: [JVET-T2004](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=10542) Algorithm descriptions of projection format conversion and video quality metrics in 360Lib (Version 12) [Y. Ye, J. Boyce]

[JVET-AD2005](https://jvet-experts.org/doc_end_user/current_document.php?id=12574) New level and systems-related supplemental enhancement information for VVC (Draft 4) [E. François, B. Bross, M. M. Hannuksela, A. Tourapis, Y.-K. Wang] (2023-03-31)

New version, changes to NNPFA according to JVET-AD0362, and editorial change from JVET-AD0077.

JVET-AC2005 is an update of JVET-AA2005 (previously submitted as WG 5 DAM 1 N 145). For elements included, see documents JVET-AB1004, as well as notes under JVET-AC0311 and JVET-AC0346.

The content of this document was included in a new edition of VVC. A draft DoCR on ISO/IEC 23090-3/DAM1 was submitted as WG 5 N180 (reviewed during session 24), and the preliminary FDIS text was submitted as WG 5 N 181.

Remains valid – not updated: [JVET-AB2006](https://jvet-experts.org/doc_end_user/current_document.php?id=12215) Additional SEI messages for VSEI (Draft 3) [S. McCarthy, T. Chujoh, M. M. Hannuksela, G. J. Sullivan, Y.-K. Wang] [WG 5 DAM N 158]

No output: [JVET-Axx2007](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=9679)

New output: NNVC guidelines

Remains valid – not updated: [JVET-X2008](https://jvet-experts.org/doc_end_user/current_document.php?id=11228) Conformance testing for versatile video coding (Draft 7) [J. Boyce, F. Bossen, K. Kawamura, I. Moccagatta, W. Wan]

Remains valid – not updated: [JVET-Y2009](https://jvet-experts.org/doc_end_user/current_document.php?id=11470) Reference software for versatile video coding (Draft 3) [F. Bossen, K. Sühring, X. Li]

Remains valid – not updated [JVET-AB2010](https://jvet-experts.org/doc_end_user/current_document.php?id=12216) VTM and HM common test conditions and software reference configurations for SDR 4:2:0 10 bit video [F. Bossen, X. Li, V. Seregin, K. Sharman, K. Sühring]

[JVET-AC2011](https://jvet-experts.org/doc_end_user/current_document.php?id=12575) VTM and HM common test conditions and evaluation procedures for HDR/WCG video [A. Segall, E. François, W. Husak, S. Iwamura, D. Rusanovskyy] (2023-02-03)

Remains valid – not updated: [JVET-U2012](https://jvet-experts.org/doc_end_user/current_document.php?id=10681) JVET common test conditions and evaluation procedures for 360° video [Y. He, J. Boyce, K. Choi, J.-L. Lin]

Remains valid – not updated: [JVET-T2013](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=10546) VTM common test conditions and software reference configurations for non-4:2:0 colour formats [Y.-H. Chao, Y.-C. Sun, J. Xu, X. Xu]

Remains valid – not updated: [JVET-Q2014](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=9683) JVET common test conditions and software reference configurations for lossless, near lossless, and mixed lossy/lossless coding [T.-C. Ma, A. Nalci, T. Nguyen]

Remains valid – not updated: [JVET-Q2015](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=9684) JVET functionality confirmation test conditions for reference picture resampling [J. Luo, V. Seregin]

[JVET-AC2016](https://jvet-experts.org/doc_end_user/current_document.php?id=12576) Common test conditions and evaluation procedures for neural network-based video coding technology [E. Alshina, R.-L. Liao, S. Liu, A. Segall] (2023-02-03)

Template has an error to be fixed.

Remains valid – not updated: [JVET-Y2017](https://jvet-experts.org/doc_end_user/current_document.php?id=11473) Common test conditions and evaluation procedures for enhanced compression tool testing [M. Karczewicz and Y. Ye]

Remains valid – not updated: [JVET-AA2018](https://jvet-experts.org/doc_end_user/current_document.php?id=11949) Common test conditions for high bit depth and high bit rate video coding [A. Browne, T. Ikai, D. Rusanovskyy, X. Xiu, Y. Yu]

[JVET-AC2019](https://jvet-experts.org/doc_end_user/current_document.php?id=12563) Description of algorithms and software in neural network-based video coding (NNVC) version 2 [Y. Li, H. Wang, L. Wang, F. Galpin, J. Ström] [WG 5 N 188] (2023-03-10)

New elements from notes elsewhere in this report:

* Decision: Adopt JVET-AC0194 method 1.1-2
* Decision: Adopt JVET-AC0196 into NNVC 4.0 (EE1-2.2)
* Decision: Adopt JVET-AC0055
* Decision: Adopt JVET-AC0116
* Decision: Adopt JVET-AC0310, but make 1.5.3 the default configuration, and allow disabling 1.7.1 component. Further, the method shall be changed to use the actual reference frame (not the unfiltered decoded frame)
* Decision: Adopt JVET-AC0328, but disable the RDO network in the encoder by default (unless such an approach is generally enabled for both filter sets #0 and #1)

It is noted that the list above may not be complete; if some adoption is missing that is recorded somewhere else in the meeting notes it shall also be considered included.

[JVET-AC2020](https://jvet-experts.org/doc_end_user/current_document.php?id=12577) Film grain synthesis technology for video applications (Draft 4) [D. Grois, Y. He, W. Husak, P. de Lagrange, A. Norkin, M. Radosavljević, A. Tourapis, W. Wan] [WG 5 CDTR N 176] (2023-03-31)

Developed from JVET-AC0151.

[JVET-AC2021](https://jvet-experts.org/doc_end_user/current_document.php?id=12578) Draft verification test plan for VVC multilayer coding [S. Iwamura, P. de Lagrange, M. Wien] (2023-03-03)

See notes under section 4.4 for updates.

[JVET-AC2022](https://jvet-experts.org/doc_end_user/current_document.php?id=12579) Draft plan for subjective quality testing of FGC SEI message [P. de Lagrange, W. Husak, M. Radosavljević, M. Wien] (2023-03-03)

See notes under section 4.4 for updates.

[JVET-AC2023](https://jvet-experts.org/doc_end_user/current_document.php?id=12560) Exploration experiment on neural network-based video coding (EE1) [E. Alshina, F. Galpin, Y. Li, D. Rusanovskyy, M. Santamaria, J. Ström, L. Wang, Z. Xie] [WG 5 N 187] (2023-02-03)

An initial draft of this document was reviewed and approved at 1515-1535 on Friday 20 January.

Categories are enhancement loop filters and inter coding.

[JVET-AC2024](https://jvet-experts.org/doc_end_user/current_document.php?id=12562) Exploration experiment on enhanced compression beyond VVC capability (EE2) [V. Seregin, J. Chen, R. Chernyak, K. Naser, J. Ström, F. Wang, M. Winken, X. Xiu, K. Zhang] [WG 5 N 189] (2023-03-17)

An initial draft of this document was reviewed and approved at 1535-1550 on Friday 20 January.

Categories are intra prediction, inter prediction, screen content coding, in-loop filters, and GDR.

It was suggested moving test 1.2 after 1.7 to better group the CCCM related proposals.

The number of tests in the intra category is rather large, and will require significant time for review at the next meeting. Proponents are asked to consider withdrawing those tests where they find that the benefit is insignificant.

[JVET-AC2025](https://jvet-experts.org/doc_end_user/current_document.php?id=12580) Algorithm description of Enhanced Compression Model 8 (ECM 8) [M. Coban, F. Le Léannec, R.-L. Liao, K. Naser, J. Ström, L. Zhang] [WG 5 N 190] (2023-03-24)

New elements from notes elsewhere in this report:

* Decision: Adopt JVET-AC0105 (test 1.2)
* Decision: Adopt JVET-AC0119 (test 1.6)
* Decision: Adopt JVET-AC0098 (test 1.8)
* Decision: Adopt JVET-AC0094 (test 1.10)
* Decision: Adopt JVET-AC0054 (test 1.12a)
* Decision: Adopt JVET-AC0147 (test 1.13)
* Decision: Adopt JVET-AC0144 (test 2.2)
* Decision: Adopt JVET-AC0158 (test 2.5a) with the following modification: It was agreed to adopt a solution with pixel-based affine as in test 2.5a (not using pixel based affine whenever OBMC is used in the given block), but without the modification of OBMC flag signalling
* Decision: Adopt JVET-AC0185 test 2.7a
* Decision: Adopt JVET-AC0113 (version 3.5a)
* Decision: Adopt JVET-AC0112 test 3.6d
* Decision: Adopt JVET-AC0115 test 4.1a
* Decision: Adopt JVET-AC0130 (test 4.2b)
* Decision: Adopt JVET-AC0162 (5.1b)
* Decision: Adopt JVET-AC0053
* Decision: Adopt JVET-AC0189 (in CTC, set the PPS flag to 1 for class F and class TGM)

It is noted that the list above may not be complete; if some adoption is missing that is recorded somewhere else in the meeting notes it shall also be considered included.

[JVET-AC2026](https://jvet-experts.org/doc_end_user/current_document.php?id=12581) Conformance testing for VVC operation range extensions (Draft 4) [D. Rusanovskyy, T. Hashimoto, H.-J. Jhu, I. Moccagatta, Y. Yu] (2023-04-14)

JVET-AC2026 is an update of JVET-Y2026 (previously submitted as WG 5 DAM [N 110](https://dms.mpeg.expert/doc_end_user/current_document.php?id=81998&id_meeting=189)).

The content of this document was included in a new edition of VVC conformance. A DoCR on ISO/IEC 23090-15/DAM1 was submitted as WG 5 N184 (reviewed during session 24), and the FDIS text was submitted as WG 5 N 185.

[JVET-AC2027](https://jvet-experts.org/doc_end_user/current_document.php?id=12582) SEI processing order SEI message in VVC (draft 3) [S. McCarthy, M. M. Hannuksela, Y.-K. Wang] [WG 5 preliminary WD 3 N 182] (2023-03-31)

Updated from JVET-AC0058.

[JVET-AD2028](https://jvet-experts.org/doc_end_user/current_document.php?id=12583) Additional conformance bitstreams for VVC multilayer configurations [S. Iwamura, I. Moccagatta] (2023-04-14)

Include new streams from JVET-AD0101.

Remains valid – not updated: [JVET-AB2029](https://jvet-experts.org/doc_end_user/current_document.php?id=12225) Visual quality comparison of ECM/VTM encoding [V. Baroncini, J.-R. Ohm, M. Wien] [AG 5 N75]

[JVET-AD2030](https://jvet-experts.org/doc_end_user/current_document.php?id=12564) Optimization of encoders and receiving systems for machine analysis of coded video content (draft 1) [J. Chen, C. Hollmann, S. Liu] [WG 5 N177)] (2023-03-31)

From JVET-AD0042, plus annex about example algorithms from JVET-AD0047 and JVET-AD0135.

[JVET-AD2031](https://jvet-experts.org/doc_end_user/current_document.php?id=12584) Common test conditions for optimization of encoders and receiving systems for machine analysis of coded video content [S. Liu, C. Hollmann] (2023-02-17)

New Excel template from JVET-AD0043, potentially new anchor settings from JVET-AD0122, and potentially the new sequences from JVET-AD0181,

[JVET-AC2032](https://jvet-experts.org/doc_end_user/current_document.php?id=12585) Improvements under consideration for neural network post filter SEI messages [S. McCarthy, S. Deshpande, M. M. Hannuksela, Hendry, G. J. Sullivan, Y.-K. Wang] [WG 5 N175] (2023-03-03)

For elements included, see the notes on the BoG report JVET-AC0324 in section 6.1.

# Future meeting plans, expressions of thanks, and closing of the meeting

Future meeting plans were established according to the following guidelines (assuming face-to-face meetings):

* Meeting under ITU-T SG16 auspices when it meets (ordinarily starting meetings on the Wednesday of the first week and closing it on the Wednesday of the second week of the SG16 meeting – a total of 8 meeting days), and
* Otherwise meeting under ISO/IEC JTC 1/‌SC 29 auspices when its MPEG WGs meet (ordinarily starting meetings on the Friday prior to the main week of such meetings and closing it on the same day as other MPEG WGs – a total of 8 meeting days).

In cases where an exceptionally high workload is expected for a meeting, an earlier starting date may be defined. In cases of online meetings, no sessions should be held on weekend days, such that meetings would typically start two days earlier.

Some specific future meeting plans (to be confirmed) were established as follows:

* During Tue. 11 – Wed. 19 July 2023, 31st meeting under ITU-T SG16 auspices in Geneva, CH
* During Fri. 13 – Fri. 20 October 2023, 32nd meeting under ISO/IEC JTC 1/‌SC 29 auspices in Hannover, DE.
* During Wed. 17 – Fri. 19 and Mon. 22 – Fri. 26 January 2024, 33rd meeting under ISO/IEC JTC 1/‌SC 29 auspices, to be held as teleconference meeting.
* During April 2024, 34th meeting under ITU-T SG16 auspices, date and location t.b.d.
* During Fri. 12 – Fri. 19 July 2024, 35th meeting under ISO/IEC JTC 1/‌SC 29 auspices in Sapporo, JP
* During October 2024, 36th meeting under ISO/IEC JTC 1/‌SC 29 auspices, date and location t.b.d.
* During January 2025, 37th meeting under ITU-T SG16 auspices, date and location t.b.d.
* During April 2025, 38th meeting under ISO/IEC JTC 1/‌SC 29 auspices, date and location t.b.d.
* During Fri. 11 – Fri. 18 July 2025, 39th meeting under ISO/IEC JTC 1/‌SC 29 auspices in Daejeon, KR
* During October 2025, 40th meeting under ITU-T SG16 auspices, date and location t.b.d.

The agreed document deadline for the 31st JVET meeting was planned to be Tuesday 4 July 2023.

It was suggested that it would be interesting to perform subjective quality investigation with the elements adopted to NNVC software in a future meeting (provided that close enough rate/quality matching with VTM anchor is achieved).

The following companies were thanked for preparing new bitstreams to be included in the second edition of VVC conformance specification: Alibaba, InterDigital, KDDI, Kwai, OPPO, Qualcomm, Sharp, Sony.

Marius Preda was thanked for his support in maintaining the document site jvet-experts.org, as well as the document sites of JCT-VC and JCT-3V. Institut Mines-Télécom is thanked for hosting the sites.

The 30th JVET meeting was closed at approximately XXXX hours on Friday 28 April 2023.

# Annex A to JVET report: List of documents

# Annex B1 to JVET report: List of meeting participants attending in person

The participants who were personally present at the meeting site of the thirtieth meeting of the JVET, according to an attendance sheet circulated during the JVET meeting sessions (approximately XXX people in total), were as follows:

# Annex B2 to JVET report: List of meeting participants attending remotely

The remote participants of the thirtieth meeting of the JVET, according to the participation records from the Zoom teleconferencing tool used for the meeting sessions (approximately XXX people in total, not including those who had attended the meeting in person at least part-time (see annex B1), and not including those who attended only the joint sessions with other groups), were as follows:

# Annex C to JVET report: Recommendations of the 11th meeting of ISO/IEC JTC 1/SC 29/WG 5 MPEG Joint Video Coding Team(s) with ITU-T SG 16

**ISO/IEC JTC 1/SC 29/WG 5 N XXX**