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| **Joint Video Experts Team (JVET)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29**  32nd Meeting, Hannover, DE, 13–20 October 2023 | Document: JVET-AF\_notes\_d2 |

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| *Title:* | **Meeting Report of the 32nd Meeting of the Joint Video Experts Team (JVET), Hannover, DE, 13–20 October 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 thirty-second meeting during 13–20 October 2023 at the Hannover Congress Centrum (HCC) in Hannover, Germany. 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 thirteenth 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 2.16 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 CEST (UTC+2) on Friday 13 October 2023. Meeting sessions were held on all days, including the weekend days of Saturday and Sunday 14 and 15 October 2023, until the meeting was closed at approximately XXXX hours CEST on Friday 20 October 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(s) were discussed. 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 thirty-first JVET meeting in producing the following documents:

a) JVET documents

* [JVET-AE1004](https://jvet-experts.org/doc_end_user/current_document.php?id=12567) Errata report items for VVC, VSEI, HEVC, AVC, and Video CICP
* [JVET-AE1006](https://jvet-experts.org/doc_end_user/current_document.php?id=12568) New profiles, colour decriptors, and SEI messages for HEVC (draft 1), also issued as WG 5 CDAM N 226
* [JVET-AE1011](https://jvet-experts.org/doc_end_user/current_document.php?id=12569) HEVC multiview profiles supporting extended bit depth (draft 2)
* [JVET-AE1013](https://jvet-experts.org/doc_end_user/current_document.php?id=12569) Common test conditions of 3DV experiments
* [JVET-AE1016](https://jvet-experts.org/doc_end_user/current_document.php?id=12568) AVC with extensions and corrections (draft 1), also issued as WG 5 CD of AVC 11th edition N 218
* [JVET-AE2005](https://jvet-experts.org/doc_end_user/current_document.php?id=12574) New level and systems-related supplemental enhancement information for VVC (Draft 6)
* [JVET-AE2006](https://jvet-experts.org/doc_end_user/current_document.php?id=12574) Additional SEI messages for VSEI (Draft 5)
* [JVET-AE2016](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-AE2017](https://jvet-experts.org/doc_end_user/current_document.php?id=12576) Common test conditions and evaluation procedures for enhanced compression tool testing
* [JVET-AE2019](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 4
* [JVET-AD2020](https://jvet-experts.org/doc_end_user/current_document.php?id=12579) Film grain synthesis technology for video applications (Draft 5), also issued as WG 5 DTR N 222
* [JVET-AE2021](https://jvet-experts.org/doc_end_user/current_document.php?id=12578) Verification test plan for VVC multilayer coding (update 1)
* [JVET-AE2023](https://jvet-experts.org/doc_end_user/current_document.php?id=12560) Exploration experiment on neural network-based video coding (EE1)
* [JVET-AE2024](https://jvet-experts.org/doc_end_user/current_document.php?id=12562) Exploration experiment on enhanced compression beyond VVC capability (EE2)
* [JVET-AE2025](https://jvet-experts.org/doc_end_user/current_document.php?id=12580) Algorithm description of Enhanced Compression Model 10 (ECM 10)
* [JVET-AE2027](https://jvet-experts.org/doc_end_user/current_document.php?id=12582) SEI processing order SEI message in VVC (Draft 5), also issued as WG 5 preliminary WD N 229
* [JVET-AE2028](https://jvet-experts.org/doc_end_user/current_document.php?id=12583) Additional conformance bitstreams for VVC multilayer configurations
* [JVET-AE2030](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 3), also issued as WG 5 preliminary WD N 224
* [JVET-AE2031](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-AE2032](https://jvet-experts.org/doc_end_user/current_document.php?id=12584) Technologies under consideration for future extensions of VSEI (draft 1)

b) documents produced as WG 5 documents only:

* WG 5 N 217 Request for ISO/IEC 14496-10 11th edition
* WG 5 N 219 Disposition of comments received on ISO/IEC 23002-7:2022 DAM 1
* WG 5 N 220 Text of ISO/IEC FDIS 23002-7:202x Versatile supplemental enhancement infor­mation messages for coded video bitstreams (3rd edition)
* WG 5 N 222 Disposition of comments received on ISO/IEC CDTR 23002-9
* WG 5 N 225 Request for ISO/IEC 23008-2:202x/Amd.1
* WG 5 N 227 Disposition of comments received on ISO/IEC 23090-3:2022 DAM 1
* WG 5 N 228 Text of ISO/IEC FDIS 23090-3:202x Versatile video coding (3rd edition)

c) draft revised ITU-T Recommendations forwarded by JVET and Q6/16 for ITU-T Consent:

* TD169/Plen ITU-T H.265 (V9) "High efficiency video coding" (Rev.)
* TD171/Plen ITU-T H.266 (V3) "Versatile video coding" (Rev.)
* TD159/Plen ITU-T H.266.1 (V2) "Conformance specification for ITU-T H.266 versatile video coding" (Rev.)
* TD172/Plen ITU-T H.273 (V3) "Coding-independent code points for video signal type identification" (Rev.)
* TD170/Plen (A.5: TD173/Plen) ITU-T H.274 (V3) "Versatile supplemental enhancement information messages for coded video bitstreams" (Rev.)

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

* [JVET-AE1004](https://jvet-experts.org/doc_end_user/current_document.php?id=12567) Errata report items for VVC, VSEI, HEVC, AVC, and Video CICP
* [JVET-AE1006](https://jvet-experts.org/doc_end_user/current_document.php?id=12568) New profiles, colour decriptors, and SEI messages for HEVC (draft 1), also issued as WG 5 CDAM N 226
* [JVET-AE1011](https://jvet-experts.org/doc_end_user/current_document.php?id=12569) HEVC multiview profiles supporting extended bit depth (draft 2)
* [JVET-AE1013](https://jvet-experts.org/doc_end_user/current_document.php?id=12569) Common test conditions of 3DV experiments
* [JVET-AE1016](https://jvet-experts.org/doc_end_user/current_document.php?id=12568) AVC with extensions and corrections (draft 1), also issued as WG 5 CD of AVC 11th edition N 218
* [JVET-AE2005](https://jvet-experts.org/doc_end_user/current_document.php?id=12574) New level and systems-related supplemental enhancement information for VVC (Draft 6)
* [JVET-AE2006](https://jvet-experts.org/doc_end_user/current_document.php?id=12574) Additional SEI messages for VSEI (Draft 5)
* [JVET-AE2016](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-AE2017](https://jvet-experts.org/doc_end_user/current_document.php?id=12576) Common test conditions and evaluation procedures for enhanced compression tool testing
* [JVET-AE2019](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 4
* [JVET-AD2020](https://jvet-experts.org/doc_end_user/current_document.php?id=12579) Film grain synthesis technology for video applications (Draft 5), also issued as WG 5 DTR N 222
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* [JVET-AE2023](https://jvet-experts.org/doc_end_user/current_document.php?id=12560) Exploration experiment on neural network-based video coding (EE1)
* [JVET-AE2024](https://jvet-experts.org/doc_end_user/current_document.php?id=12562) Exploration experiment on enhanced compression beyond VVC capability (EE2)
* [JVET-AE2025](https://jvet-experts.org/doc_end_user/current_document.php?id=12580) Algorithm description of Enhanced Compression Model 10 (ECM 10)
* [JVET-AE2027](https://jvet-experts.org/doc_end_user/current_document.php?id=12582) SEI processing order SEI message in VVC (Draft 5), also issued as WG 5 preliminary WD N 229
* [JVET-AE2028](https://jvet-experts.org/doc_end_user/current_document.php?id=12583) Additional conformance bitstreams for VVC multilayer configurations
* [JVET-AE2030](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 3), also issued as WG 5 preliminary WD N 224
* [JVET-AE2031](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-AE2032](https://jvet-experts.org/doc_end_user/current_document.php?id=12584) Technologies under consideration for future extensions of VSEI (draft 1)

The following X documents were produced as WG 5 documents only:

* …

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, 2 Exploration Experiments (EE) were defined. The next eight JVET meetings were planned for 17 – 19 and 22 – 26 January 2024 under ISO/IEC JTC 1/‌SC 29 auspices, to be conducted as teleconference meeting; during 19 – 26 April 2024 under ITU-T SG16 auspices in Rennes, FR; 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 ISO/IEC JTC 1/‌SC 29 auspices, date and location t.b.d.; during 26 June – 4 July 2025 under ISO/IEC JTC 1/‌SC 29 auspices in Daejeon, KR; and during October 2025 under ISO/IEC JTC 1/‌SC 29 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 thirty-second meeting during 13–20 October 2023 at the Hannover Congress Centrum (HCC) in Hannover, Germany. 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 thirteenth 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, consisting of two parts, (B1) in-person attendees as recorded by a sign-in sheet circulated in meeting rooms, (B2) remote attendees 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_10_AF_Hannover/>.

## Primary goals

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

a) JVET documents

* [JVET-AE1004](https://jvet-experts.org/doc_end_user/current_document.php?id=12567) Errata report items for VVC, VSEI, HEVC, AVC, and Video CICP
* [JVET-AE1006](https://jvet-experts.org/doc_end_user/current_document.php?id=12568) New profiles, colour decriptors, and SEI messages for HEVC (draft 1), also issued as WG 5 CDAM N 226
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* [JVET-AD2020](https://jvet-experts.org/doc_end_user/current_document.php?id=12579) Film grain synthesis technology for video applications (Draft 5), also issued as WG 5 DTR N 222 (DTR to be delivered)
* [JVET-AE2021](https://jvet-experts.org/doc_end_user/current_document.php?id=12578) Verification test plan for VVC multilayer coding (update 1)
* [JVET-AE2023](https://jvet-experts.org/doc_end_user/current_document.php?id=12560) Exploration experiment on neural network-based video coding (EE1)
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* [JVET-AE2025](https://jvet-experts.org/doc_end_user/current_document.php?id=12580) Algorithm description of Enhanced Compression Model 10 (ECM 10)
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* [JVET-AE2031](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-AE2032](https://jvet-experts.org/doc_end_user/current_document.php?id=12584) Technologies under consideration for future extensions of VSEI (draft 1)

b) documents produced as WG 5 documents only:

* WG 5 N 217 Request for ISO/IEC 14496-10 11th edition
* WG 5 N 219 Disposition of comments received on ISO/IEC 23002-7:2022 DAM 1
* WG 5 N 220 Text of ISO/IEC FDIS 23002-7:202x Versatile supplemental enhancement infor­mation messages for coded video bitstreams (3rd edition) (not delivered yet)
* WG 5 N 222 Disposition of comments received on ISO/IEC CDTR 23002-9
* WG 5 N 225 Request for ISO/IEC 23008-2:202x/Amd.1
* WG 5 N 227 Disposition of comments received on ISO/IEC 23090-3:2022 DAM 1
* WG 5 N 228 Text of ISO/IEC FDIS 23090-3:202x Versatile video coding (3rd edition) (not delivered yet)

c) draft revised ITU-T Recommendations forwarded by JVET and Q6/16 for ITU-T Consent:

* TD169/Plen ITU-T H.265 (V9) "High efficiency video coding" (Rev.)
* TD171/Plen ITU-T H.266 (V3) "Versatile video coding" (Rev.)
* TD159/Plen ITU-T H.266.1 (V2) "Conformance specification for ITU-T H.266 versatile video coding" (Rev.)
* TD172/Plen ITU-T H.273 (V3) "Coding-independent code points for video signal type identification" (Rev.)
* TD170/Plen (A.5: TD173/Plen) ITU-T H.274 (V3) "Versatile supplemental enhancement information messages for coded video bitstreams" (Rev.)

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 CEST timezone (local time in Geneva), 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.
* Other parenthetical comments may be used for describing the impact or motivation of a decision. 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, 6 October 2023. Any documents uploaded after 1159 hours Paris/Geneva time on Saturday 7 October 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-AF0207 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 meeting, 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-AF0XXX (a proposal on …), uploaded 10-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-AF0XXX (a document presenting …), uploaded 10-XX,
* …

All cross-verification reports at this meeting (except for JVET-AF0074, JVET-AF0124, and JVET-AF0125) were registered late, and/or uploaded late. In the interest of brevity, these are not specifically identified here. Initial upload times for each document are recorded in Annex A of this report.

The following contribution registrations were noted that were later cancelled, withdrawn, never provided, were cross-checks of a withdrawn contribution, or were registered in error: JVET-AF0046, JVET-AF0054, JVET-AF0077, JVET-AF0078, JVET-AF0123, JVET-AF0127, JVET-AF0195, JVET-AF0196, JVET-AF0246, JVET-AF0248, JVET-AF0300.

The cross-verification reports JVET-AF0XXX, and … were still missing at the end of the meeting on Friday 20 Oct., but became available later. The following cross-verification reports were still missing three weeks after the end of the meeting: JVET-AF0XXX, and … . These were marked as withdrawn by the JVET chair, assuming their registrations had become obsolete.

“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 applied with documents JVET-AF0XXX and … , which were categorized as late in the list above, based on the time of the first reasonable document upload; this case did not happen at the current meeting, but the sentence is kept for future use.

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

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.

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.

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-AE1000, the Errata report items for VVC, VSEI, HEVC, AVC, and Video CICP JVET-AE1004, the New profiles, colour descriptors, and SEI messages for HEVC (draft 1) JVET-AE1006, the HEVC multiview profiles supporting extended bit depth (draft 2) JVET-AE1011, the Common test conditions of 3DV experiments [JVET-AE1013](https://jvet-experts.org/doc_end_user/current_document.php?id=12569), the AVC specification with extensions and corrections (draft 1) JVET-AE1016, the New level and systems-related supplemental enhancement information for VVC (Draft 6) JVET-AE2005, the Additional SEI messages for VSEI (Draft 5) JVET-AE2006, the Common test conditions and evaluation procedures for neural network-based video coding technology JVET-AE2016, the Common test conditions and evaluation procedures for enhanced compression tool testing JVET-AE2017, the Description of algorithms and software in neural network-based video coding (NNVC) version 4 JVET-AE2019, the Film grain synthesis technology for video applications (Draft 5) JVET-AE2020, the Verification test plan for VVC multilayer coding (update 1) JVET-AE2021, the Description of the EE on Neural Network-based Video Coding JVET-AE2023, the Description of the EE on Enhanced Compression beyond VVC capability JVET-AE2024, the Algorithm description of Enhanced Compression Model 10 (ECM 10) JVET-AE2025, the SEI processing order SEI message in VVC (Draft 5) JVET-AE2027, the Additional conformance bitstreams for VVC multilayer configurations JVET-AE2028, the Optimization of encoders and receiving systems for machine analysis of coded video content (Draft 3) [JVET-AE2030](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-AE2031](https://jvet-experts.org/doc_end_user/current_document.php?id=12584), and the Technologies under consideration for future extensions of VSEI (draft 1) JVET-AE2032, had been completed and were approved. In a few cases, the corresponding WG 5 N-numbered documents had not yet been uploaded, and this was requested to be done as soon as possible. The software implementations of VTM version 22.0, ECM version 10.0, and NNVC (versions 6.0 and 6.1) were also approved. The latter include modifications of loop filters confirmed by post-meeting AHG recommendations which were also approved by JVET.

Only minor editorial issues were found in the meeting report JVET-AE1000; no need to produce an update was identified (see section 2.14 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 Annexes B1 and B2 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 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 shared screen they want to see.

## 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 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 expected to be 0830-1900 CEST with coffee breaks and lunch breaks as appropriate, however some early morning or late-night sessions were anticipated to be necessary. Sessions were announced in the online JVET calendar in advance as far as possible, but it was anticipated that some activities (such as breakout sessions) could 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/PUB100011.html>.

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

These include points relating to:

* Complying with legal and statutory obligations
* Performing and acting in good faith, consistent with the purpose, policies and principles of the organization
* Behaving ethically
* Promoting and enabling all voices to be heard
* Engaging constructively in ISO and IEC activities
* Declaring actual and potential conflicts of interest and managing them appropriately
* Protecting confidential information
* Protecting ISO and IEC assets
* Avoiding and preventing any form of bribery or corruption
* Escalating and resolving disputes and upholding agreed resolutions

## 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 of June/July 2009. 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 XXXX (as of 10 July 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-AD1012 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
* **HOP**: High-complexity operating point for neural network-based filter.
* **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”)
* **LOP**: Low-complexity operating point for neural network-based filter.
* **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).
* **ONNX**: Open Neural Network Exchange – a format used to convert code from common neural network software packages into SADL code.
* **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

* MPEG-2 | H.262 (coding specification is common text)
  + ITU-T H.262 V3 was approved in 2012-02; Amd.1 was approved in 2013-03 and was not published separately; it was instead incorporated directly into the V3 text and published 2013-09
  + ISO/IEC 13818-2:2013 V3 FDIS ballot closed 2012-05-08; FDAM 1 ballot closed 2013-04-12 and was not published separately; it was instead incorporated directly into the V3 text and published 2013-10
  + Conformance testing (not joint with ITU-T)
    - ISO/IEC 13818-4:2004 V2 FDIS closed 2004-08-22, published 2004-12-12; it specifies conformance testing for Part 1 (Systems), Part 2 (Video), Part 3 (Audio), and Part 7 (AAC)
    - ISO/IEC 13818-4:2004/Amd 3:2009 Level for 1080@50p/60p conformance testing
    - Cor 1:2007, Cor 2:2009, Cor 3:2012, Cor 4:2011 may also have video relevance
  + Reference software (not joint with ITU-T)
    - ISO/IEC TR 13818-5:2005 V2 FDIS closed 2005-07-24, published 2005-10; it specifies reference software for Part 1 (Systems), Part 2 (Video), Part 3 (Audio), Part 7 (AAC) and Part 11 (IPMP)
* AVC (twin text)
  + ITU-T H.264 V14 was 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 2022-10, third draft issued at 29th meeting 2023-01, fourth draft issued at 30th meeting 2023-04, formal project requested and CD of 11th edition issued at 31st meeting 2023-07, ready for progression to DIS at the current meeting.
  + Conformance testing (twin text)
    - 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 (twin text)
    - ITU-T H.264.2 V7 Approved 2016-02-13, published 2016-05-30
    - Various amendments of ISO/IEC 14496-5:2001 have been published, 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 (twin text)
  + 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 2022-04, text submitted for DIS ballot 2022-07-10, DIS ballot closed 2023-01-10, FDIS issued 29th meeting of 2023-01, FDIS ballot opened 2023-08-06, closed 2023-10-02, pending publication
  + ITU-T H.265 V9 Consented at 31st meeting 2023-07, approved and pre-published 2023-09.
  + Preliminary draft text for YCgCo-Re and YCgCo-Ro issued at 26th meeting 2022-04, second draft including SMPTE ST 2128 issued at 28th meeting 2022-10, third draft at 29th meeting 2023-01, fourth draft at 30th meeting 2023-04, formal work item requested and CDAM1 issued 31st meeting 2023-07.
  + Conformance testing (twin text)
    - 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 (twin text)
    - 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 (twin text)
  + 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, FDIS issued 2023-07
  + ITU-T H.266 V3 Consented 2023-07, approved and pre-published 2023-09
  + Conformance testing (twin text)
    - 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, consolidated into FDIS 3rd edition issued as an output of the 29th meeting in January 2023 (awaiting ballot at the time of this meeting)
    - ITU-T H.266.1 V4 Consented 2023-07, approved and pre-published 2023-09.
  + Reference software (twin text)
    - 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 (twin text)
  + 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,[m62571](https://dms.mpeg.expert/doc_end_user/current_document.php?id=86620&id_meeting=194) FDIS 3rd edition issued 2023-07 (pending ballot)
  + ITU-T H.274 V3 Consent 2023-07, approved 2023-07, pending publication.
* CICP (twin text)
  + 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, DIS ballot closed 2023-04-06, preliminary draft text for including SMPTE ST 2128 issued at 28th meeting, incorporated into preliminary FDIS at 30th meeting 2023-04, FDIS issued 2023-07
  + ITU-T H.273 Consent 2023-07, approved 2023-09, publication waiting for publication of SMPTE ST 2128.
* Conversion and coding practices for HDR/WCG Y′CbCr 4:2:0 video with PQ transfer characteristics (twin text)
  + 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 (twin text)
  + 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 (twin text)
  + 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 (twin text)
  + 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 (twin text)
  + 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, CDTR issued at 29th meeting 2023-07, consultation period ended 2023-07-09 (ready for DTR at this meeting)
* The following freely available standards are published here in ISO/IEC:  
  <https://standards.iso.org/ittf/PubliclyAvailableStandards/index.html> as of 2023-10-09:
  + ISO/IEC 13818-4:2004 Conformance for MPEG-2
  + ISO/IEC 13818-4:2004/Amd 3:2009 Level for 1080@50p/60p conformance testing
  + ISO/IEC TR 13818-5:2005 Software simulation for MPEG-2
  + Various amendments of ISO/IEC 14496-4:2004 Conformance for AVC
  + Various amendments of ISO/IEC 14496-5:2001 Reference software for AVC
  + ISO/IEC 14496-10:2022 (Ed. 10) AVC
  + ISO/IEC 23002-7:2022 (Ed. 2) – VSEI
  + ISO/IEC 23008-2:2020 (Ed. 4) HEVC
  + ISO/IEC 23090-3:2022 (Ed. 2) VVC
  + ISO/IEC 23090-15:2022 (Ed. 1) Conformance for VVC
  + ISO/IEC 23090-16:2022 (Ed. 1) Reference software for VVC
  + ISO/IEC 23091-2:2021 (Ed. 2) Video CICP
* 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 2023-05-26 and this was still the case as of 2023-10-06. (These should be checked for previously issued requests for free availability.)
  + 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
* 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 colour type indicators for YCgCo-Re, YCgCo-Ro, and SMPTE ST 2128 (IPT-PQ-C2) and XXX are in a CD of the 11th edition issued in July 2023 (WG 5 N 218).
* HEVC 23008-2:202x (5th ed.) CDAM1 New profiles, colour descriptors, and SEI messages, with colour type indicators for YCgCo-Re, YCgCo-Ro, and SMPTE ST 2128 (IPT-PQ-C2) and XXX was issued in July 2023 (WG 5 N 226)
* 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 had not been started yet. ITU-T consent for a new edition is planned for July 2023. It was noted that the referencing of VSEI is also somewhat different in the ITU-T and ISO/IEC versions of HEVC and/or 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). However, there is currently no other need for HEVC to reference the VSEI standard. An FDIS for HEVC was issued as an output of the 29th meeting in January 2023 (and it does not reference VSEI). Its ballot began 2023-08-06 and closed 2023-10-02, and it was pending publication. A new edition of H.265 (v9) was Consented in July 2023, and approved and pre-published in September 2023 (not referencing VSEI).
* 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 of January 2023, anticipating that some alignment would be necessary with the ongoing VSEI amendment. Another preliminary FDIS was issued (WG 5 N 202) from the April meeting. The FDIS was then issued (WG 5 N 228) from the 31st meeting in July 2023. A new edition of H.266 was Consented in July 2023, approved in September 2023 and currently pending publication.
* 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 consolidated into an FDIS at the 29th meeting, but the ballot had not been started yet. ITU-T H.266.1 was Consented in July 2023 and approved and pre-published in September 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). The FDIS of a new edition of ISO/IEC 23002-7 was issued (WG 5 N 220) from the 31st meeting in July 2023 and also reached ITU-T Consent at that meeting. H.274 v3 was approved in September 2023 and currently pending publication.
* 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), and the CDTR consultation period ended 2023-07-09. A DTR ballot was issued from the 31st meeting in July 2023 and results are expected prior to the 33rd meeting in January 2024. (It was noted that a second DTR could become necessary in case of comments). The publication limit date was reportedly 2023-08-09, so action to extend that date may be needed. ITU-T approval would be anticipated in April 2024.
* Video CICP new edition draft for YCgCo-Re and YCgCo-Ro (from JVET-Z1003), an ISO/IEC 23091-2 preliminary FDIS was issued from the 30th meeting and the Summary of Voting document was available as [m62572](https://dms.mpeg.expert/doc_end_user/current_document.php?id=86621&id_meeting=194) and a draft DoC had been issued as WG 5 [N 205](https://sd.iso.org/documents/ui/#!/browse/iso/iso-iec-jtc-1/iso-iec-jtc-1-sc-29/iso-iec-jtc-1-sc-29-wg-5/library/2/Draft%20disposition%20of%20comments%20received%20on%20ISO-IEC%20DIS%2023091-2%3A202X). There was a delay in the submittal of the FDIS due to dependency on the status of SMPTE ST 2128, which was tentatively included in the preliminary FDIS, based on an NB comment. The video CICP colour type indicator for SMPTE ST 2128 had been drafted and incorporated into the preliminary FDIS issued at the 30th meeting of April 2023. It had been reported that the specification was expected to become finalized in the SMPTE meeting in March 2023, but this had not yet happened, so the production of the FDIS was delayed. ITU-T Consent for H.273 v3 proceeded at the 31st meeting of July 2023 (to prevent undue delay since SG16 does not meet very frequently) and the text was approved in September 2023, but the text was on hold pending the publication of SMPTE ST 2128.
* 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 13 October at 0900 CEST were as follows.

* Timing and organization of the meeting and online access, calendar posting of session plans
  + The initial number of documents was increased relative to the previous meeting (160->180) – parallel sessions might be necessary.
  + Scheduling of NNVC discussions – might need alignment with NNPF discussions (but no overlap with JPEG meeting this time, JPEG meets from Oct. 30)
* Plans for subsequent F2F meeting in April (Rennes), July (Sapporo), and October 2024 (??).
* The meeting logistics, agenda, working practices, policies, and document allocation considerations were reviewed.
  + Remote access to the meeting was provided using Zoom. This required discipline in the meeting room (no microphone to be switched on, podium and room microphones to be under central control). Presentations in the room are also managed via zoom – experts who present need to connect to the zoom meeting for screen sharing. Recording of the meeting notes by the session chair will also permanently be shared via zoom.
  + 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-AE1000 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 1 (summary), JVET-AE1016 is alternatively denoted as “WG 5 DIS of AVC 11th edition N 218”, which actually was issued as WG 5 CD, not DIS.
  + In section 2.1, annex B is mentioned, but information is missing that it consists of two parts, (B1) in-person attendees as recorded by ITU-T via registration and badge pickup, (B2) remote attendees as recorded by the teleconferencing tool used for the meeting.
  + In annex B2, the remote attendees are associated with the thirtieth JVET meeting, which should have been the thirty-first meeting.
* There was a somewhat decreased number of late non-cross-check documents, compared to previous meetings. In particular, all non-cross-check documents that had been registered before the deadline were also available in time.
* There were only 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 were asked not to pick a specific JVET number for regular documents – this function is reserved for AHG reports, summary reports, and output docs
* Experts were asked to always register JVET documents via the “jvet-experts.org” site, not via the MPEG dms site.
* Experts were 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:
  + Any action on a new version of VVC software as standards part – target April 2024, for inclusion of NNPF SEI, software from TRs, layered coding, bug fixes, etc.
  + 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) draft DoCR in [MDS22710](https://dms.mpeg.expert/doc_end_user/current_document.php?id=87856&id_meeting=194), and preliminary FDIS text in [MDS22711](https://dms.mpeg.expert/doc_end_user/current_document.php?id=87857&id_meeting=194)) – inclusion of ST 2128 descriptor needed clarification of the status, therefore it was not yet submitted for FDIS yet; was consented and approved in ITU-T, but cannot be published as long as ST2128 is not available. It was verbally reported that availability can be expected around 6 weeks after the meeting – therefore it was concluded to issue the FDIS in January.
  + TR on film grain synthesis technology for video applications – DTR not yet submitted for ballot in ISO, ballot results cannot be expected before the January meeting. ITU consent is targeted for April 2024, possibly second DTR by April as well.
  + Optimization of encoders and receiving systems for machine analysis of coded video content – new WD of TR to be issued
  + Preparation of subjective tests for film grain, also new content proposed – expert viewing to be planned
  + Also plan expert viewing for multi-layer verification test
  + Any action items on reference software JM/HM? Status of MV-HEVC software and test conditions (refer to resolution of a previous meeting for the latter)?
  + New edition of AVC
    - 11th ed. 14496-10 CD ballot response in [m65567](https://dms.mpeg.expert/doc_end_user/current_document.php?id=90188&id_meeting=196), DIS to be issued (no long editing period if ballot results shall return before April 2024 meeting)
    - ITU consent for new H.264 edition was targeted for April 2024
  + HEVC updates
    - CDAM includes elements that are not in the ISO 5th edition – ballot response in [m65568](https://dms.mpeg.expert/doc_end_user/current_document.php?id=90189&id_meeting=196), DAM to be issued, check/confirm registered title, possibly recommendation (no long editing period if ballot results shall return before April 2024 meeting).
    - 5th edition not published yet, ballot results in [m65579](https://dms.mpeg.expert/doc_end_user/current_document.php?id=90200&id_meeting=196). Would be important to get the IS published still in 2023, to allow for a next edition including the ongoing Amd.1 in 2024.
    - An updated H.265 edition was sent for ITU consent in the last meeting; consent for next H.265 edition was targeted for April 2024 with new elements from CDAM
  + Exploration Experiments
    - Neural network-based video coding
    - Enhanced compression beyond VVC
* Liaison communication:
  + Incoming liaison statements: JPEG [m65594](https://dms.mpeg.expert/doc_end_user/current_document.php?id=90215&id_meeting=196), 3GPP [m65645](https://dms.mpeg.expert/doc_end_user/current_document.php?id=90266&id_meeting=196).
* Joint meetings were expected with AG 5 (on Monday 16 Oct.) and possibly with other groups.
* Principles of standards development were discussed.
* Lunch: Oct. 13-15 1200-1400 in the conference center. Lunch break 1230-1330 on the first three days. Oct. 16-20 in the conference center, JVET shall use the time slot 1245-1330 to avoid congestion with other WGs.

## 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 0830-1900 CEST with coffee breaks and lunch breaks as appropriate, however some early morning or late-night sessions were anticipated to be necessary. Sessions were announced in the JVET calendar and the ITU posting system in advance as far as possible, although it was acknowledged that some activities (such as breakout sessions) might be held at short notice.

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

Coffee breaks 1030, 1530

* Fri. 13 October, 1st day
  + Morning session:
    - 0900–1000 Opening remarks, review of practices, agenda, IPR policy reminder
    - 1000–1240 Reports of AHGs 1–11, 14
  + Afternoon session:
    - 1340–1400 Reports of AHGs 12, 13
    - 1400–1900 EE2 summary report
* Sat. 14 October, 2nd day
  + Morning session:
    - 0830–1230 Review of EE1 summary report and related,
  + Afternoon session:
    - 1330–1900 Review of EE2.4 summary (RPR) EE2-related and non-EE2 (Leibniz rm., track chaired by Y. Ye)
    - 1330-1900 Review of HLS (rm. 27, track chaired by J. Ohm)
* Sun. 15 October, 3rd day
  + Morning session:
    - 0830–1230 Review of EE2-related and non-EE2 (Leibniz rm., track chaired by Y. Ye)
    - 0830–1230 Review of HLS/SEI 6.4, 6.3, 6.6ff. (rm. 27, track chaired by JRO)
  + Afternoon session:
    - 1330–1900 Review of EE2-related and non-EE2 (Leibniz rm., track chaired by Y. Ye)
    - 1330–1800 Review of HLS/SEI 6.4, 6.3, 6.6ff. (rm. 27, track chaired by JRO)
* Mon. 16 October, 4th day
  + 0900–1230 MPEG information sharing session
  + 1330–1800 Afternoon session t.b.d.
  + Joint Meetings t.b.d.
  + 1800-2200 Evening sessions possible
* Tue 17 October, 5th day
  + Morning session:
    - 0830–1245 t.b.d.
  + Afternoon session:
    - 1330–1800 t.b.d.
  + 1800-2200 Evening sessions possible
* Wed. 18 October, 6th day
  + 0900–1030 MPEG information sharing session
  + Morning session:
    - 1045–1245 t.b.d.
  + Afternoon session:
    - 1330–1900 t.b.d.
  + Social event starts 1930
* Thu. 19 October, 7th day
  + Morning session:
    - 0830–1245 t.b.d.
  + Afternoon session:
    - 1330–1800 t.b.d.
  + 1800-2200 Evening sessions possible
* Fri. 20 Oct., 8th day
  + 0830–1300 JVET wrap-up plenary:
    - Review liaison doc
    - Approval of output docs
    - Establishment of AHGs
    - Review of meeting recommendations
    - Future planning, a.o.b.
  + 1400–1600 MPEG information sharing session
  + XXXX–XXXX WG 5 approval of meeting recommendations, closing of meeting

## Contribution topic overview (update tbd)

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 (3)
  + AHG2: Text development and errata reporting (1)
  + AHG3: Test conditions (0)
  + AHG3: Software development (0)
  + AHG4: Subjective quality testing and verification testing (4)
  + AHG4: Test Material (0)
  + AHG4: Codec performance with alternative test material (2)
  + AHG5: Conformance test development (0)
  + AHG7: ECM tool assessment (1)
  + AHG8: Optimization of encoders and receiving systems for machine analysis of coded video content (2)
  + AHG10: Encoding algorithm optimization (3)
  + AHG13: Film grain synthesis (5)
  + Implementation studies (1)
  + Profile/tier/level specification (1)
  + General aspects of standards development and applications of standards (1)
* 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 (78) (section 5.2)
* AHG9: High-level syntax (HLS) proposals (section 6) with subtopics
  + SEI messages on neural-network post filter (13) (sections 6.1, 6.2, 6.3)
  + SEI messages on topics other than NNPF (30) (sections 6.4, 6.5, 6.6, 6.7, 6.8, 6.9)
  + Non-SEI HLS aspects (0) (section 6.10)
* Joint meetings, plenary discussions, BoG reports (X), 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 XXXX–XXXX on Friday 13 Oct. 2023 (chaired by JRO).

[JVET-AF0001](https://jvet-experts.org/doc_end_user/current_document.php?id=13372) JVET AHG report: Project Management (AHG1) [J.-R. Ohm (chair), G. J. Sullivan (vice chair)]

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

The number of subscribers (by the beginning of the current meeting) was 1233. Furthermore, the previous lists of joint teams (which were still kept open as archives) had the following number of subscribers:

* JCT-VC – 1159 subscribers
* JCT-3V – 682 subscribers
* JVT-experts – 2068 subscribers

1. **Goals and activity**

The work of the JVET overall had proceeded well in the interim period with 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_07_AE_Geneva/>). 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:

a) JVET documents

* The meeting report (JVET-AE1000) [Posted 2023-08-16, also submitted as WG 5 N 215]
* [JVET-AE1004](https://jvet-experts.org/doc_end_user/current_document.php?id=12567) Errata report items for VVC, VSEI, HEVC, AVC, and Video CICP [Posted 2023-07-26]
* [JVET-AE1006](https://jvet-experts.org/doc_end_user/current_document.php?id=12568) New profiles, colour decriptors, and SEI messages for HEVC (draft 1) [Posted 2023-08-21, last update 2023-09-04, also issued as WG 5 CDAM N 226]
* [JVET-AE1011](https://jvet-experts.org/doc_end_user/current_document.php?id=12569) HEVC multiview profiles supporting extended bit depth (draft 2) [Posted 2023-09-23]
* [JVET-AE1013](https://jvet-experts.org/doc_end_user/current_document.php?id=12569) Common test conditions of 3DV experiments [Posted 2023-10-12]
* [JVET-AE1016](https://jvet-experts.org/doc_end_user/current_document.php?id=12568) AVC with extensions and corrections (draft 1) [Posted 2023-08-16, also issued as WG 5 CD of AVC 11th edition N 218]
* [JVET-AE2005](https://jvet-experts.org/doc_end_user/current_document.php?id=12574) New level and systems-related supplemental enhancement information for VVC (Draft 6) [Posted 2023-08-11, last update 2023-10-03]
* [JVET-AE2006](https://jvet-experts.org/doc_end_user/current_document.php?id=12574) Additional SEI messages for VSEI (Draft 5) [Posted 2023-07-21, last update 2023-08-23]
* [JVET-AE2016](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 [Posted 2023-08-01]
* [JVET-AE2017](https://jvet-experts.org/doc_end_user/current_document.php?id=12576) Common test conditions and evaluation procedures for enhanced compression tool testing [Posted 2023-08-01]
* [JVET-AE2019](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 4 [Posted 2023-09-01, last update 2023-09-04]
* [JVET-AD2020](https://jvet-experts.org/doc_end_user/current_document.php?id=12579) Film grain synthesis technology for video applications (Draft 5) [Posted 2023-09-222, last update 2023-09-28, also to be issued as WG 5 DTR N 222]
* [JVET-AE2021](https://jvet-experts.org/doc_end_user/current_document.php?id=12578) Verification test plan for VVC multilayer coding (update 1) [Posted 2023-10-06]
* [JVET-AE2023](https://jvet-experts.org/doc_end_user/current_document.php?id=12560) Exploration experiment on neural network-based video coding (EE1) [Posted 2023-07-17, last update 2023-08-10]
* [JVET-AE2024](https://jvet-experts.org/doc_end_user/current_document.php?id=12562) Exploration experiment on enhanced compression beyond VVC capability (EE2) [Posted 2023-07-18, last update 2023-08-22]
* [JVET-AE2025](https://jvet-experts.org/doc_end_user/current_document.php?id=12580) Algorithm description of Enhanced Compression Model 10 (ECM 10) [Posted 2023-10-02]
* [JVET-AE2027](https://jvet-experts.org/doc_end_user/current_document.php?id=12582) SEI processing order SEI message in VVC (Draft 5) [Posted 2023-09-02, also issued as WG 5 preliminary WD N 229]
* [JVET-AE2028](https://jvet-experts.org/doc_end_user/current_document.php?id=12583) Additional conformance bitstreams for VVC multilayer configurations [Posted 2023-09-01]
* [JVET-AE2030](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 3) [Posted 2023-09-14, also issued as WG 5 preliminary WD N 224]
* [JVET-AE2031](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 [Posted 2023-08-11]
* [JVET-AE2032](https://jvet-experts.org/doc_end_user/current_document.php?id=12584) Technologies under consideration for future extensions of VSEI (draft 1) [Posted 2023-09-15]

b) documents produced as WG 5 documents only:

* WG 5 N 217 Request for ISO/IEC 14496-10 11th edition
* WG 5 N 219 Disposition of comments received on ISO/IEC 23002-7:2022 DAM 1
* WG 5 N 220 Text of ISO/IEC FDIS 23002-7:202x Versatile supplemental enhancement infor­mation messages for coded video bitstreams (3rd edition) (to be delivered)
* WG 5 N 222 Disposition of comments received on ISO/IEC CDTR 23002-9
* WG 5 N 225 Request for ISO/IEC 23008-2:202x/Amd.1
* WG 5 N 227 Disposition of comments received on ISO/IEC 23090-3:2022 DAM 1
* WG 5 N 228 Text of ISO/IEC FDIS 23090-3:202x Versatile video coding (3rd edition) (to be delivered)
* Liaison statement to SC 29/WG 1 (JPEG) on JPEG AI, neural network-based video coding, and SEI messages for neural network-based post filtering (WG 5 N 234)
* List of AHGs established at the 12th WG 5 meeting (WG 5 N 235)

c) draft revised ITU-T Recommendations forwarded by JVET and Q6/16 for ITU-T Consent:

TD169/Plen ITU-T H.265 (V9) "High efficiency video coding" (Rev.)

TD171/Plen ITU-T H.266 (V3) "Versatile video coding" (Rev.)

TD159/Plen ITU-T H.266.1 (V2) "Conformance specification for ITU-T H.266 versatile video coding" (Rev.)

TD172/Plen ITU-T H.273 (V3) "Coding-independent code points for video signal type identification" (Rev.)

TD170/Plen (A.5: TD173/Plen) ITU-T H.274 (V3) "Versatile supplemental enhancement information messages for coded video bitstreams" (Rev.)

It is noted that documents JVET-AC 2026 Conformance testing for VVC operation range extensions (Draft 4), and the corresponding FDIS 23090-15 as WG 5 N 185 (VVC conformance 2nd ed.) have finally been delivered as outputs from the 29th JVET (10th WG 5) meeting of January 2023.

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 32nd meeting had been announced in the JVET reflector, in the JVET logistics document (<https://www.itu.int/wftp3/av-arch/jvet-site/2023_10_AF_Hannover/JVET-AF_Logistics.docx>), and in the WG 5 calling notice (N 236) and agenda (N 237) for the 13th 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 180 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 32nd meeting had been made publicly available on the ITU-hosted ftp site as <http://wftp3.itu.int/av-arch/jvet-site/2023_10_AF_Hannover/JVET-AF_notes_d0.docx>.

1. **Recommendations**

The AHG recommends its continuation.

[JVET-AF0002](https://jvet-experts.org/doc_end_user/current_document.php?id=13373) 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)]

1. **Ad hoc group activity**
   1. **Output documents produced**
      1. **JVET-AE1004 - Errata report items for VVC, VSEI, HEVC, AVC, and Video CICP**

This document contains a list of reported errata items for VVC, VSEI, HEVC, AVC, Video CICP, and the TR on usage of video signal type code points, for tracking purposes. Some of the items have been confirmed by the JVET and have been agreed to require fixing. This document also provides publication status backgrounds of these standards.

Incorporated items at the JVET-AE meeting:

* Updated the general descriptions for VVC, VSEI, HEVC, and AVC.
* Removed obsolete/resolved errata items.
* Added 16 items for the ISO text only for HEVC, identified when working on the ITU-T consent text for H.265 version 9 (edition 5).
* Added 9 items on the semantics of post-filter hint SEI message from JVET-AE0155 for both HEVC and AVC.
* Added 4 items for AVC, on semantics of the omnidirectional video SEI messages. These items were among the items for HEVC and have been resolved for HEVC.
* Added an item for AVC on use of the "should" wording for the use of the film grain characteristics SEI messages when present.
* Removed the section for codepoint usage TR as the TR part has been dropped from the title of the document a while ago.
* Added an item for HEVC regarding replacing of "Max slice segments per picture MaxSliceSegmentsPerPicture" in Table A.8 with "Max # of slice segments per picture MaxSliceSegmentsPerPicture" (reported by [Cliff Reader](mailto:cliff@reader.com) – thanks!).
  + 1. **JVET-AE1006 - New profiles, colour descriptors, and SEI messages for HEVC (draft 1)**

This document contains the draft text for changes on new profiles, colour descriptors, and SEI messages for the 5th edition of the High Efficiency Video Coding (HEVC) standard (Rec. ITU-T H.265 | ISO/IEC 23008-2). The changes include: 1) the support of four new profiles, namely the Multiview Main 10, Multiview Monochrome, Multiview Monochrome 10, and Multiview Monochrome 12 profiles; 2) the support of three additional colour type identifiers; 3) the HEVC-specific supports for some supplemental enhancement information (SEI) messages that may be included in HEVC bitstreams but are not to be specified in the HEVC specification, and 4) some technical corrections and editorial improvements to the 5th edition text of HEVC. The SEI messages are the neural network post-filter characteristics (NNPFC) SEI message, the neural-network post-filter activation (NNPFA) SEI message, and the phase indication SEI message, that are to be specified in the 3rd edition of the Versatile Supplemental Enhancement Information messages for coded video bitstreams (VSEI) standard (ITU‑T H.274 | ISO/IEC 23002-7).

Draft 1 incorporated items:

* Changes for NNPF and phase indication SEI messages (based on JVET-AE0101 as well as the latest changes to the interface text for the NNPF SEI messages agreed at the JVET-AE meeting
* JVET-AD1008 Additional colour type identifiers
* Fixes and changes for the film grain characteristics SEI message
* New multiview profiles from JVET-AE0296, plus an additional Multiview Monochrome 10 profile
* Some errata items to subclauses A.4.1, A.4.2, G.11.2.3, and H.11.2.2 reported by Cliff Reader (thanks!)
* Changes to D.1 related to referring to VSEI in HEVC
  + 1. **JVET-AE1016 – AVC with extensions and corrections (Draft 1)**

This document contains the draft text for changes of the Advanced Video Coding (AVC) standard (Rec. ITU-T H.264 | ISO/IEC 14496-10). Text modifications are provided for 1) the support of additional colour type identifiers; 2) some technical corrections and editorial improvements to the 10th edition text of AVC; and 3) the AVC-specific supports for some supplemental enhancement information (SEI) messages that may be included in AVC bitstreams but are not to be specified in the AVC specification. These SEI messages include three other SEI messages, namely the neural network post-filter characteristics SEI message, the neural-network post-processing filter activation SEI message, and the phase indication 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).

The affected sections are provided relative to the 2022 edition of ISO/IEC 14496-10, i.e. the 10th edition.

Draft 1 incorporated items:

* JVET-AD1008 Additional colour type identifiers for AVC
* JVET-AE0101 Use of neural network post filter and phase indication SEI messages for AVC
* JVET-AE1004 Errata items on AVC
* Fix for film grain synthesis equation in FGC SEI message (see notes under BoG report JVET-AE0294)
  + 1. **JVET-AE2005 - New level and systems-related supplemental enhancement information for VVC (Draft 6)**

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 four 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, and the phase indication 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 6 incorporated items:

* Fixed bug tickets [#1594](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/1594), [#1602](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/1602) and [#1606](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/1606).
* Allow multiple NNPFC and NNPFA SEI messages with different content in the same picture unit by excluding NNPFC and NNPFA SEI messages from the existing constraint in JVET-AD2005, subclause D.3.1. The NNPFA SEI message is constrained in a manner that the payload shall be identical for the same nnpfa\_target\_id value. Editors are requested to make sure the blanket constraint in VVC on constraining SEI payload content to be the same within a PU does not impose a problem for SEI messages that contain ID values. No such blanket constraint appears to exist in HEVC, and this was intentional for some SEI messages such as tone mapping information and colour remapping information SEI messages. (JVET-AE0049 item 1).
* Constrain the repeated inference to generate interpolated pictures up to the end of the bitstream only to NNPFs that perform only picture rate upsampling. (JVET-AE0049 item 2)
* Change the index range in input picture assignment for repeated inference at the end of a bitstream: it is proposed to remove "− j" from "When numInputPics is greater than 1, the following applies for each value of i in the range of j + 1 to numInputPics − j − 1, inclusive, in increasing order of i:" (JVET-AE0049 item 3, JVET-AE0142 item 1)
* In the following sentence in the NNPFC interface text, replace "inputPic" with "resampledPic": If sourceWidth is equal to CroppedWidth and sourceHeight is equal to CroppedHeight, inputPic is set to be the same as sourcePic. (JVET-AE0142 item 2)
* In the NNPFC interface text, condition the following constraint on "when pictureRateUpsamplingFlag is equal to 1", and num\_interpolated\_pics[ i − 1 ] shoud be nnpf\_interpolated\_pics[ i − 1 ]: It is a requirement of bitstream conformance that num\_interpolated\_pics[ i − 1 ] shall not be greater than 0. (JVET-AE0142 item 3)
* VVC changes corresponding to the addition of nnpfa\_no\_prev\_clvs\_flag. (JVET-AE0050 item 1)
* VVC changes corresponding to the addition of nnpfa\_no\_foll\_clvs\_flag. (JVET-AE0050 item 2)
* At the end of a bitstream, add repeated inference of NNPF for creating pictures corresponding to input pictures (regardless of the purpose indicated by nnpfc\_purpose except for picture rate upsampling) when there are multiple input pictures to which the NNPF applies, with an update to use the nnpfa\_output\_flag rather than the nnpfc\_input\_pic\_output\_flag. (JVET-AE0134 item 2)
* Add a constraint based on nnpfa\_output\_flag[ i ], as part of the process for derivation of the NNPF input pictures in the interface text, to ensure that input pictures that are not present in the bitstream do not have a corresponding NNPF output picture. (JVET-AE0070 item 2)
* Editorial changes (JVET-AE0127 attachment)
* Do not include the post-filter hint SEI message in VVC v3 due to its apparent lack of clarity. (JVET-AE0155)
  + 1. **JVET-AE2006 - Additional SEI messages for VSEI (Draft 5)**

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.

**Changes that have been integrated for VSEI v3 and JVET-AE2006:**

* Add missing value ranges for resampling syntax elements nnpfc\_pic\_width\_num\_minus1, nnpfc\_pic\_width\_denom\_minus1, nnpfc\_pic\_height\_num\_minus1, and nnpfc\_pic\_height\_denom\_minus1 to be in the range of 0 to 65535, inclusive. (JVET-AE0048 item 1)
* Add missing value ranges for nnpfc\_inp\_format\_idc and nnpfc\_out\_format\_idc to be in the range of 0 to 255, inclusive. (JVET-AE0048 item 2).
* Arrange the definitions of DeriveInputTensors(), the syntax elements related to overlap and padding type, and the definition of the InpSampleVal function so that forward references are avoided by moving the derivations of strengthControlScaledVal (Formula 87), DeriveInputTensor (Formula 88), and StoreOutputTensor (91) to a later position that immediately follows the derivation of the InpSampleVal function. (JVET-AE0048 item 3)
* Clarify that indicated or inferred values of vui\_colour\_primaries, vui\_transfer\_characteristics, vui\_matrix\_coeffs, and vui\_full\_range\_flag apply when nnpfc\_separate\_colour\_description\_present\_flag is equal to 0. Here, the possibility of inferring these syntax elements is made explicit when compared to JVET-AD2006. (JVET-AE0048 item 4)
* Signal nnpfc\_chroma\_loc\_info\_present\_flag only when nnpfc\_out\_order\_idc is not equal to 0. Infer nnpfc\_chroma\_loc\_info\_present\_flag to be equal to 0 when not present. (JVET-AE0060 item 1)
* Clarify using the approach in the following suggestion: “nnpfc\_mode\_idc equal to 0 indicates that the stuff is in the SEI message. nnpfc\_mode\_idc equal to 1 indicates the stuff is in a location identified by a URI. When nnpfc\_mode\_idc is equal to 0, the stuff is in the format specified by ISO/IEC 15938-17.” (JVET-AE0175)
* Change nnpfc\_reserved\_zero\_bit(\_a/\_b) to nnpfc\_alignment\_zero\_bit(\_a/\_b). (JVET-AE0126 item 2)
* Change the condition for the constraint on either nnpfcOutputPicWidth is not equal to CroppedWidth or nnpfcOutputPicHeight is not equal to CroppedHeight from "when nnpfc\_pic\_width\_num\_minus1, nnpfc\_pic\_width\_denom\_minus1, nnpfc\_pic\_height\_num\_minus1, and nnpfc\_pic\_height\_denom\_minus1 are present" to "when resolutionResamplingFlag is equal to 1". (JVET-AE0126 item 5)
* Move nnpfa\_target\_base\_flag to be immediately after nnpfa\_persistence\_flag, such that the persistence flag, when present, immediately follows the cancel flag. (JVET-AE0126 item 7)
* State that “All NNPFC SEI messages in a CLVS that have a particular nnpfc\_id value and nnpfc\_base\_flag equal to 1 shall have identical SEI payload content.” (or editorial equivalent) (JVET-AE0128 item 2)
* Remove ChromaFormatIdc from the constraint for when colourizationFlag shall be equal to 0. (JVET-AE0141)
* Cancel the persistence of an NNPFA SEI message with any subsequent NNPFA SEI message with the same nnpfa\_target\_id. (JVET-AE0048 item 5)
* Update the constraint related to nnpfcTargetPictures and nnpfaTargetPictures by also considering the value of nnpfa\_target\_base\_flag. (JVET-AE0189 item 3)
* Add the following constraint: When nnpfa\_target\_base\_flag in an NNPFA SEI message is equal to 0, there shall be at least one NNPFC SEI message with nnpfc\_id equal to nnpfa\_target\_id and nnpfc\_base\_flag equal to 0 that precedes the NNPFA SEI message in decoding order. (JVET-AE0189 item 2)
* Add nnpfa\_no\_prev\_clvs\_flag to the NNPFA SEI message. (JVET-AE0050 item 1)
* Add nnpfa\_no\_foll\_clvs\_flag to the NNPFA SEI message, gated by nnpfa\_persistence\_flag being equal to 1. (JVET-AE0050 item 2)
* Disallow generating NNPF output pictures between any particular pair of consecutive input pictures more than once. (JVET-AE0135 item 2)
* Add a constraint to ensure that there is at least one NNPF output picture when an NNPF is activated and applied. (JVET-AE0069)
* Specify that all NNPFC SEI messages with a particular value of nnpfc\_id within a CLVS shall have the same value of nnpfc\_purpose. (JVET-AE0142 item 4)
* Do not include the post-filter hint SEI message in VSEI v3 due to its apparent lack of clarity. (JVET-AE0155)
* Editorial changes (JVET-AE0048 item 6, JVET-AE0126 items 3, 4, 6, JVET-AE0126 attachment, and ticket #1605, JVET-AE0054)
* Use “should” for film grain synthesis and retain prior drafted language for other SEI messages. (JVET-AE0155)
* Editors are requested to make sure it is clear that activating an “update” can (and basically always would) require using information from a “base” filter in order to interpret the update. (JVET-AE0189 item 1)
* Clarify, as necessary, that an NNPFA message can activate a base with a particular ID when an update is active, which will switch the filter from the updated filter to the base filter. (JVET-AE0173)
* Add a NOTE to clarify an implied, hidden constraint on picture-rate-upsampling NNPFs with persistent activation, with expansion to consider all possible cases that have a similar implication: (JVET-AE0135 item 1)
* Editors are requested to check/clarify the existing intent that if the current picture contains an SEI message (any SEI message that uses the typical persistence scope scheme) with a cancel flag equal to 1, the current picture is not within the scope of the previous SEI message (regardless of whether the SEI message is a suffix or prefix SEI message). (JVET-AE0048 item 5)
* Text related to the remaining revisit from the BoG report JVET-AE0272 was presented on Tuesday 18 July at 1035. This is related to the issue that for frame interpolation between frames A and B only one activation shall be performed for all frames that are to be interpolated altogether. It was commented that the purpose may be difficult to understand for implementers. It was suggested to add a NOTE explaining the purpose of that constraint.
  + 1. **JVET-AE2027 - SEI processing order SEI message in VVC (draft 5)**

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.

**Changes yet to be integrated:**

none

**Changes that have been integrated:**

Updates from JVET-AE0156. Leave out the change in CVS (for further study), and add a note about the usage of wrapping.

1. **Related input contributions**

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

* [JVET-AF0045](https://jvet-experts.org/doc_end_user/current_document.php?id=13289) AHG2/AHG9: On the use of NNPF SEI messages in AVC
* [JVET-AF0063](https://jvet-experts.org/doc_end_user/current_document.php?id=13311) On MV-HEVC profiles
* [JVET-AF0064](https://jvet-experts.org/doc_end_user/current_document.php?id=13312) AHG2: Some editorial issues in AVC, HEVC, VVC, and VSEI

1. **Remaining bug tickets**

* [#1594](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/1594) Mismatch between VVC spec and VTM for sample generation in CCLM process
* [#1607](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/1607) Wrong sign (+ instead of -) in Fig 16 Flowchart for decoding a decision in the ITU text
* [#1609](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/1609) NoBackwardPredFlag derivation ambiguity
* [#1617](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/1617) Not initialized NumCtusInSlice[0] to 0.

1. **Recommendations**

The AHG recommends to:

* Approve JVET-AE1004, JVET-AE1006, JVET-AE1016, JVET-AE2005, JVET-AE2006, and JVET-AE2027 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-AF0003](https://jvet-experts.org/doc_end_user/current_document.php?id=13374) 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 22.0](https://vcgit.hhi.fraunhofer.de/jvet/VVCSoftware_VTM/-/releases/VTM-22.0) (Sept. 2023)
* [HM-18.0](https://vcgit.hhi.fraunhofer.de/jvet/HM/-/releases/HM-18.0) (Apr. 2023)
* [HM-16.21+SCM-8.8](https://vcgit.hhi.fraunhofer.de/jvet/HM/-/tags/HM-16.21+SCM-8.8) (Mar. 2020)
* [SHM 12.4](https://vcgit.hhi.fraunhofer.de/jvet/SHM/-/tags/SHM-12.4) (Jan. 2018)
* [HTM 16.3](https://vcgit.hhi.fraunhofer.de/jvet/HTM/-/tags/HTM-16.3) (Jul. 2018)
* [JM 19.1](https://vcgit.hhi.fraunhofer.de/jvet/JM/-/releases/JM-19.1) (Apr. 2023)
* [JSVM 9.19.15](https://vcgit.hhi.fraunhofer.de/jvet/jsvm/-/tags/JSVM_9_19_15)
* [JMVC 8.5](https://vcgit.hhi.fraunhofer.de/jvet/jmvc/-/tags/JMVC_8_5)
* [3DV ATM 15.0](https://vcgit.hhi.fraunhofer.de/jvet/3dv-atm/-/tags/3DV-ATM_v15.0) (no version history)
* [HDRTools 0.24](https://gitlab.com/standards/HDRTools/-/tags/v0.24) (March 2023)

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.

1. **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.

1. **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 20.1 and 20.2 were tagged on May 8, and VTM version 21.0 was tagged on Jul. 9. VTM 21.1 is expected during the 31st JVET meeting.

VTM 21.1 was tagged on July 21, 2023. Changes include:

* JVET-AD0057 item 1: Allow inclusion of NNPFC and NNPFA SEI messages in suffix SEI NAL units
* JVET-AD0054 item 3: NNPF interpolated pictures constraint
* Add encoder parameter WriteVuiHrdFromY4m
* fix RPL with inter-layer references

VTM 21.2 was tagged on July 22, 2023. Changes include:

* Remove macros from previous cycle

VTM 22.0 was tagged Sept. 24, 2023. Changes include:

* remove macro JVET\_Z0120\_SII\_SEI\_PROCESSING
* Clean up data types in ALF code
* Only one VPS can be active at any time
* JVET-AE0060: Signal nnpfc\_chroma\_loc\_info\_present\_flag only when nnpfc\_out\_order\_idc is not equal to 0
* JVET-AE0180: Add missing condition on PIC\_RECON\_WRAP buffer allocation
* JVET-AE0057: MTT split modes early termination
* JVET-AE0162: fix MS-SSIM calculation for RPR/SR
* Use PLTRunMode instead of bool for palette data
* Fix access to unitialized value in SPS
* Clean up code from JVET-AD0045 (encoder DMVR avoidance)
* Use std::vector to avoid memory deallocation/reallocation
* Port JVET-Z0150 on memory usage log
* Add TGM config files from ECM
* Remove unnecessary memory allocation for CCALF
* JVET-AE0141: Fix a bug in NNPFC SEI message for colourization
* Fix overflow condition in static\_vector
* JVET-AE0135 item2: On NNPF picture rate upsampling constraint
* JVET-AE0126: NNPF cleanup and editorial changes for VSEI include item 2, item 3, item 5, and item 7
* JVET-AE0142 item 3 and item 4: Fix two bugs including an added condition and a nnpfc\_purpose related constraint.
* JVET-AE0128 item 2: Update the constraint on when an NNPFC SEI message shall be a repetition of the first NNPFC SEI message in the CLVS
* JVET-AE0122: Fix for ppsid when both GOP based RPR and scalable coding is used
* JVET-AE0048 item 1: Add missing value ranges for nnpfc\_pic\_width\_num\_minus1,...
* JVET-AE0048 item 5: Cancel the persistence of an NNPFA SEI message with any...
* JVET\_AE0048 item 2: Add missing value ranges for nnpfc\_inp\_format\_idc and nnpfc\_out\_format\_idc
* Clean up CommonDefX86.h
* JVET-AE0049 item 2: Constrain the repeated inference to NNPFs that perform...
* JVET-AE0181: Scaling window support
* JVET-AE0189 Item 2: Check when activating NNPFA with base flag equal to 0
* JVET-AE0050 item 1: Add nnpfa\_no\_prev\_clvs\_flag to the NNPFA SEI message
* Clean up AffineGradientSearch SIMD code
* JVET-AE0049 item 3: Change the index range in input picture assignment for...
* JVET-AE0049 item 1: Update NNPF SEI identical content constraints
* JVET-AE0050 item 2: Add nnpfa\_no\_foll\_clvs\_flag to the NNPFA SEI message
* JVET-AE0134 item 2: add repeated inference of NNPF for creating pictures corresponding to input pictures at the end of a bitstream or a CLVS under some conditions
* Reduce memory for ALF covariance data

VTM 22.1 is expected to be tagged during the 32nd JVET meeting. Changes are expected to include the remaining implementations of the 31st meeting, issue fixes and code optimizations.

* 1. ***CTC Performance***

The following tables shows **VTM 20.0** performance over **HM 17.0** (not updated, results identical with previous versions).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **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).

There is no change in coding performance or run time between **VTM 22.0** and **VTM 21.1** using SDR CTC.

For the high bit depth CTCs, there is no change in coding performance or run time between VTM 22.0 and VTM 21.0 for the low QP range; however, a change in coding performance and run-time had been observed for the standard QP range (22-37), as shown in the summary tables below. The coding performance changes were attributed to an optimisation of ALF causing small floating point calculation discrepancies (ALF is turned off for the low QP range experiments).

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | | | | | | |
|  | **VTM 22.0 vs VTM21.0 for High Bit Depth, Standard QP range (JVET-AA2018)** | | | | | | | | | |
|  |  |  | **wPSNR** |  |  | **PSNR** |  |  |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | 0.17% | 0.02% | 0.00% | 0.12% | 0.23% | 0.00% | 0.08% | 0.21% | 99% | 105% |
| Class H2 |  |  |  |  |  | 0.00% | 0.00% | 0.00% | 99% | 104% |
| **Overall** | 0.17% | 0.02% | 0.00% | 0.12% | 0.23% | 0.00% | 0.04% | 0.11% | 99% | 105% |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **All Intra** | | | | | | | | | |
|  | **VTM 22.0 vs VTM21.0 for High Bit Depth, Standard QP range (JVET-AA2018)** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | 0.06% | 0.00% | 0.00% | 0.09% | 0.08% | 0.00% | 0.05% | 0.07% | 98% | 102% |
| Class H2 |  |  |  |  |  | 0.00% | 0.00% | 0.00% | 100% | 102% |
| **Overall** | 0.06% | 0.00% | 0.00% | 0.09% | 0.08% | 0.00% | 0.03% | 0.03% | 99% | 102% |

The coding performance differences had been almost eliminated in a pending merge request (!2682), as shown in the table below:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | | | | | | |
|  | **(VTM 22.0 + !2682) vs VTM21.0 for High Bit Depth, Standard QP range (JVET-AA2018)** | | | | | | | | | |
|  |  |  | **wPSNR** |  |  | **PSNR** |  |  |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | -0.01% | 0.01% | 102% | 107% |
| Class H2 |  |  |  |  |  | 0.00% | 0.00% | 0.00% | 102% | 107% |
| **Overall** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | -0.01% | 0.00% | 102% | 107% |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **All Intra** | | | | | | | | | |
|  | **(VTM 22.0 + !2682) vs VTM21.0 for High Bit Depth, Standard QP range (JVET-AA2018)** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 101% | 104% |
| Class H2 |  |  |  |  |  | 0.00% | 0.00% | 0.00% | 102% | 103% |
| **Overall** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 101% | 103% |

Results using HDR CTC show slight differences between **VTM 22.0** and **VTM 21.0**, as depicted in table below.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | | | | | | |
|  | **Over VTM21.0** | | | | | | | | | |
|  |  |  | **wPSNR** |  |  | **PSNR** |  |  |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | 0.08% | 0.02% | 0.02% | 0.25% | 0.19% | 0.01% | 0.22% | 0.20% | 101% | 101% |
| Class H2 |  |  |  |  |  | 0.00% | 0.00% | 0.00% | 101% | 101% |
| **Overall** | 0.08% | 0.02% | 0.02% | 0.25% | 0.19% | 0.00% | 0.14% | 0.13% | 101% | 101% |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **All Intra** | | | | | | | | | |
|  | **Over VTM21.0** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | 0.08% | 0.00% | 0.00% | 0.09% | 0.06% | 0.00% | 0.06% | 0.04% | 99% | 100% |
| Class H2 |  |  |  |  |  | 0.00% | 0.00% | 0.00% | 98% | 99% |
| **Overall** | 0.08% | 0.00% | 0.00% | 0.09% | 0.06% | 0.00% | 0.04% | 0.02% | 98% | 100% |

The following tables show **VTM 22.0** performance over **HM 18.0** using HDR CTC:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | | | | | | |
|  | **Over HM18.0** | | | | | | | | | |
|  |  |  | **wPSNR** |  |  | **PSNR** |  |  |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | -39.51% | -37.55% | -36.66% | -54.89% | -48.36% | -33.68% | -49.39% | -40.75% | 289% | 102% |
| Class H2 |  |  |  |  |  | -31.97% | -57.69% | -63.36% | 257% | 90% |
| **Overall** | -39.51% | -37.55% | -36.66% | -54.89% | -48.36% | -33.06% | -52.41% | -48.97% | 277% | 97% |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **All Intra** | | | | | | | | | |
|  | **Over HM18.0** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | -41.41% | -27.31% | -26.79% | -57.69% | -52.79% | -24.00% | -52.89% | -45.12% | 1506% | 117% |
| Class H2 |  |  |  |  |  | -21.76% | -47.21% | -50.57% | 1280% | 109% |
| **Overall** | -41.41% | -27.31% | -26.79% | -57.69% | -52.79% | -23.18% | -50.83% | -47.10% | 1420% | 114% |

* 1. ***Issues in VTM affecting conformance***

The following issues in VTM master branch may affect conformance:

* Missing HLS features (see sections below)
  1. ***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.

1. **HM related activities**

There had not been any further developments to HM during this meeting cycle.

The following MRs are pending [with status indicated]:

* Implement phase indication SEI message (JVET-AE0101) [waiting review]
* 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.

Otherwise the [HEVC bug tracker](https://hevc.hhi.fraunhofer.de/trac/hevc/query?status=accepted&status=assigned&status=new&status=reopened&component=HM&col=id&col=summary&col=status&col=type&col=priority&col=milestone&col=time&col=reporter&report=16&order=time) 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,
* 1 ticket for “RExt Text” (8 years old)
* 1 ticket for “SCC Text” (8 years old)
* 6 tickets for text (3-5 years old)
* 2 tickets for encoder description (3-9 years old)

Help to address these tickets would be appreciated.

1. **360Lib related activities**

The latest 360Lib software can be found at <https://vcgit.hhi.fraunhofer.de/jvet/360lib/-/tags/360Lib-13.6>

The following table is for the projection formats comparison using VTM-22.0 according to 360-degree video CTC (JVET-U2012) compared to that using VTM-21.0 (VTM-21.0 as anchor).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **End-to-end WS-PSNR** | | | **End-to-end S-PSNR-NN** | | |
|  | Y | U | V | Y | U | V |
| Class S1 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Class S2 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **Overall** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

The following table compares generalized cubemap (GCMP) coding and padded equi-rectangular projection (PERP) coding using VTM-22.0 (PERP as anchor).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **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-22.0 and HM-16.22 (HM as anchor), respectively.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **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% |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **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% |

1. **SCM related activities**

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

1. **SHM related activities**

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

1. **HTM related activities**

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

One merge request is pending:

* JVET-AE0295: MV Main 10 profile support (waiting for proponent response)

The next release will include the following changes:

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

1. **HDRTools related activities**

There had not been any further developments to HDRTools during this meeting cycle.

1. **JM, JSVM, JMVM related activities**

There had not been any further developments to JM, JSVM or JMVM during this meeting cycle.

For the previous release of JM only 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. An possible encoder/decoder mismatch was reported privately, but needs more investigation.

1. **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.

1. **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.

1. **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

JVET-AE1013 3DV test conditions

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.

1. **Guidelines for reference software development**

No further work was conducted on Guidelines for VVC and HEVC reference software development and documents JVET-AC2003 and JVET-AC1001 remain current.

1. **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.

The software coordinators expressed thanks to experts who diligently delivered implementations of HLS related software in a timely fashion.

[JVET-AF0004](https://jvet-experts.org/doc_end_user/current_document.php?id=13375) JVET AHG report: Test material and visual assessment (AHG4) [V. Baroncini, T. Suzuki, M. Wien (co-chairs), W. Husak, S. Iwamura, P. de Lagrange, S. Liu, S. Puri, A. Segall, S. Wenger (vice-chairs)]

1. **Activities**
   1. ***Verification test preparation for VVC multilayer coding***

A teleconference was organized by AG 5 and JVET AhG4 on 2023-09-20 13:00h UTC. The topic was the Verification Test preparation for VVC Multilayer Coding.

The AhG reviewed the status and progress with respect to the compression performance assessment of dual-layer coding category of the verification test. Potential issues with the current configuration and implementation of the VTM software were identified. Furthermore, the suitability of the current test sequences under consideration and the intended rate range were discussed. The provision of alternative test material, potentially including other resolutions, and further study was encouraged. The conduction of corresponding expert viewing tests at the meeting site in Hannover was solicited.

The report of the AhG meeting is available in JVET-AF0044.

* 1. ***Test sequences***

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

In the report period, test material related to the CTC for SHVC and HEVC SCC has been made available in that directory.

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

1. **Related contributions**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| [JVET number](https://jvet-experts.org/doc_end_user/current_meeting.php?id_meeting=195&type_order=&sql_type=document_number) | MPEG number | [Created](https://jvet-experts.org/doc_end_user/current_meeting.php?id_meeting=195&type_order=&sql_type=document_date_time) | First upload | [Last upload](https://jvet-experts.org/doc_end_user/current_meeting.php?id_meeting=195&type_order=&sql_type=upload_document_date_time) | [Title](https://jvet-experts.org/doc_end_user/current_meeting.php?id_meeting=195&type_order=&sql_type=title) | [Source](https://jvet-experts.org/doc_end_user/current_meeting.php?id_meeting=195&type_order=&sql_type=authors) |
| [JVET-AF0004](https://jvet-experts.org/doc_end_user/current_document.php?id=13375) | m64938 | 2023-10-06 14:09:48 |  |  | JVET AHG report: Test material and visual assessment (AHG4) | V. Baroncini, T. Suzuki, M. Wien (co-chairs), W. Husak, S. Iwamura, P. de Lagrange, S. Liu, S. Puri, A. Segall, S. Wenger |
| [JVET-AF0044](https://jvet-experts.org/doc_end_user/current_document.php?id=13288) | m64729 | 2023-09-20 14:59:44 | 2023-09-20 16:26:38 | 2023-09-20 16:26:38 | AHG4: Report on AhG meeting on verification testing for VVC multilayer coding | [M. Wien (RWTH)](mailto:wien@lfb.rwth-aachen.de) |
| [JVET-AF0047](https://jvet-experts.org/doc_end_user/current_document.php?id=13294) | m64758 | 2023-09-28 12:30:50 | 2023-10-02 08:11:08 | 2023-10-02 08:11:08 | [AHG4] ECM10.0 evaluation on V3C test content | [S. Schwarz](mailto:sebastian.schwarz@nokia.com), M. M. Hannuksela (Nokia) |
| [JVET-AF0075](https://jvet-experts.org/doc_end_user/current_document.php?id=13323) | m64859 | 2023-10-06 04:56:24 | 2023-10-06 09:00:29 | 2023-10-11 06:44:02 | Evaluation results of Low Complexity Enhancement Video Codec (LCEVC) with HM and VTM on 4K content | O. Chubach, Y.-L. Hsiao, C.-Y. Chen, C.-W. Hsu, T.-D. Chuang, Y.-W. Chen, Y.-W. Huang, S.-M. Lei (MediaTek) |
| [JVET-AF0186](https://jvet-experts.org/doc_end_user/current_document.php?id=13444) | m65031 | 2023-10-06 23:27:22 | 2023-10-06 23:56:26 | 2023-10-06 23:56:26 | AHG4: experiments related to VVC spatial scalability visual testing | [P. de Lagrange](mailto:philippe.delagrange@interdigital.com), [F. Urban (InterDigital)](mailto:fabrice.urban@interdigital.com) |
| [JVET-AF0187](https://jvet-experts.org/doc_end_user/current_document.php?id=13445) | m65032 | 2023-10-06 23:28:48 | 2023-10-06 23:33:14 | 2023-10-06 23:33:14 | Compression of Gaming Contents | Z. Lin, [K. Cai](mailto:caikangying@huawei.com), J. Sauer, Y. Zhao, E. Alshina (Huawei) |
| [JVET-AF0253](https://jvet-experts.org/doc_end_user/current_document.php?id=13516) | m65538 | 2023-10-11 10:26:29 | 2023-10-11 17:38:45 | 2023-10-11 17:38:45 | [AHG-4] On the proposed gaming sequences from InterDigital and class gaming | [S. Puri](mailto:saurabh.puri@interdigital.com), T. Poirier, C. Bonnineau, I. Marzuki, R. Utida, E. Francois (InterDigital) |
| [JVET-AF0262](https://jvet-experts.org/doc_end_user/current_document.php?id=13526) | m65563 | 2023-10-12 01:10:15 | 2023-10-12 01:20:34 | 2023-10-12 01:20:34 | New Film Grain Material based on a Ground Truth approach | D. Ugur, D. Podborski, [A. M. Tourapis (Apple Inc)](mailto:atourapis@apple.com) |
| [JVET-AF0263](https://jvet-experts.org/doc_end_user/current_document.php?id=13527) | m65564 | 2023-10-12 01:12:29 | 2023-10-12 01:20:56 | 2023-10-12 01:20:56 | Suggested process for measuring Grain Fidelity using the Ground Truth test set | [A. M. Tourapis](mailto:atourapis@apple.com), J. Kim, S. Paluri, D. Podborski (Apple Inc) |

1. **Recommendations**

The AHG recommends:

* To review and consider JVET-AF0186 in the finalization of the multi-layer VVC verification test plan.
* To consider the structure of a verification test report for multi-layer VVC taking into account the results achieved at the Geneva meeting in the content layering category of the verification test plan.
* To review and consider JVET-AE0262 and JVET-AE0263 in the development of the draft plan for subjective quality testing of FGC SEI message.
* To review document JVET-AF0075 in a joint meeting with WG 4 and AG 5.
* To collect volunteers to conduct further verification tests and subjective quality tests, including volunteers to encode.
* To continue to discuss and to update the non-finalized categories of the verification test plan and subjective quality test plan for FGS, including those which have not been addressed yet.
* To review the set of available test sequences for the verification tests as well as subjective quality tests and potentially collect more test sequences with a variety of content.
* To continue to collect new test sequences available for JVET with licensing statement.

A joint meeting with WG 4 and AG 5 has to be planned on JVET-AF0075.

[JVET-AF0005](https://jvet-experts.org/doc_end_user/current_document.php?id=13376) JVET AHG report: Conformance testing (AHG5) [I. Moccagatta (chair), F. Bossen, K. Kawamura, P. de Lagrange, T. Ikai, S. Iwamura, H.-J. Jhu, S. Paluri, K. Sühring, Y. Yu (vice chairs)]

1. **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 31st and 32nd meetings.

1. **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
  + ISO/IEC FDIS 23090-15:202x 2nd edition text output of 2023-01, preparation delayed to 2023-09
  + H.266.1 V2 forwarded by JVET and Q6/16 for ITU-T Consent: 2023-07
  + H.266.1 V2 approved 2023-09-13
  + H.266.2 V2 pre-published 2023-10-06

1. **Status on bitstream submission**

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
  + No changes in bitstream between 31st and 32nd meeting.
* 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 31st and 32nd meeting.

1. **Activities and Discussion**

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

VVC activities:

In the 2nd edition company names and emails have been removed from the packages, 2nd edition packages are available at <https://www.itu.int/wftp3/av-arch/jvet-site/bitstream_exchange/VVC2ndEd/>

VVC operation range extensions activities:

In the 2nd edition company names and emails have been removed from the packages, 2nd edition packages are available at <https://www.itu.int/wftp3/av-arch/jvet-site/bitstream_exchange/VVC2ndEd/>

VVC Multilayer activities:

Six of the 7 additional conformance bitstreams for VVC multilayer configurations in JVET-AE2028 decoded correctly using VTM-20.2 are available in <https://www.itu.int/wftp3/av-arch/jvet-site/bitstream_exchange/VVCMultilayer/under_test/VTM-20.2/>.

Volunteers to cross check these 6 conformance bitstreams for VVC multilayer configurations have been identified and cross-check is ongoing.

According to the proponents, the VVC multilayer configurations bitstream in JVET-AE0111 can be decoded by VTM-20.2 and a volunteer to cross-check the bitstream has been identified. This bitstream has been added to JVET-AE2028 and will be uploaded to <https://www.itu.int/wftp3/av-arch/jvet-site/bitstream_exchange/VVCMultilayer/under_test/VTM-20.2/> shortly.

In total currently 7 additional conformance bitstreams for VVC multilayer configurations have been generated.

HEVC Multilayer supporting extended bit depth activities:

A merge request (MR) implementing the HEVC Multiview Main 10 profiles in JVET-AA1011 has been submitted in <https://vcgit.hhi.fraunhofer.de/jvet/HTM/-/merge_requests/5>

An implementation for the other HEVC Multiview profiles in JVET-AA1011 (Multiview Monochrome, and Multiview Monochrome 10 profiles) is still in progress.

Cross-checking of the 4 HEVC Multilayer supporting extended bit depth bitstreams in AD0232 is contingent to the merging of the above MR. Review of the MR is on-going.

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.

1. **Contributions**

None.

1. **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.

1. **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-AE2028).
* Maintain and update the conformance bitstream database and contribute to report problems in JVET document 1004.
* Continue the generation, cross-checking, and documentation of the conformance streams for the HEVC multiview profiles supporting extended bit depth (JVET-AA1011).

It was requested to clarify whether additional work can be expected for defining more bitstreams in the category of VVC multi-layer, or if at some point the verified bitstreams could be submitted as an extension of VVC conformance.

[JVET-AF0006](https://jvet-experts.org/doc_end_user/current_document.php?id=13295) JVET AHG report: ECM software development (AHG6) [V. Seregin (chair), J. Chen, R. Chernyak, F. Le Léannec, K. Zhang (vice-chairs)]

(zoom connection broke down Fri 13 1100)

1. **Software development**

ECM software repository is located at <https://vcgit.hhi.fraunhofer.de/ecm/ECM>.

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-10.0:

JVET-AE0091: High-Accuracy template matching (Test 3.3e) (MR 449)

JVET-AE0174: Add non-inter TM SPS flag for tool control (MR 452)

JVET-AE0139(Test 5.2c): Improved ALF fixed filters (MR 450)

JVET-AE0059(Test3.1b): Convolutional cross-component model for inter prediction (MR 453)

JVET-AE0169 (Test 2.2c/2.3b): Bi-predictive IBC (MR 448)

JVET-AE0100 (Test 2.1b): Block vector guided CCCM (MR 455)

JVET-AE0125 (Test 4.1) Shifting Quantization Center (MR 461)

JVET-AE0150: RPR filters and thresholds for scale factors 1.1x to 1.35x (MR 468)

JVET-AE0077(Test-2.9): Extended search areas for IntraTMP mode (MR 458)

JVET-AE0094(Test 2.6c): IBC with non-adjacent spatial candidates (MR 457)

JVET-AE0086(Test-4.2): Large NSPT (MR 466)

JVET-AE0091: Iterative BDOF Part (Test 3.5) (MR 460)

JVET-AE0084(Test-2.11a): Harmonization of IBC HMVP and IBC-LIC (MR 459)

[JVET-AE0046(Test 3.2): Bi-predictive GPM](https://vcgit.hhi.fraunhofer.de/ecm/ECM/-/merge_requests/465#top) (MR 465)

[JVET-AE0159(Test 2.5c): Filtered Intra Block Copy](https://vcgit.hhi.fraunhofer.de/ecm/ECM/-/merge_requests/462) (MR 462)

JVET-AE0169: IBC MBVD list construction (Test 2.4a) (MR 469)

JVET-AE0097: Remove offset update process in CCP merge (MR 463)

JVET-AE0043 (Test 2.7): Cross-component merge mode with temporal candidates (MR 467)

JVET-AE0102: LFNST/NSPT coefficients context (Test 4.3) (MR 478)

JVET-AE0151 (Test5.1b): CCSAO with history offsets and extended edge classifiers (MR 472)

JVET-AE0278: ALF, CCALF memory reduction (lossless change) (MR 480)

JVET-AE0078: IBC-LIC extension (Test 2.10a) (MR 482)

JVET-AE0136: Fix on TM-based reordering for affine MMVD (MR 456)

JVET-AE0162: fix MS-SSIM calculation for RPR/SR (MR 475)

JVET-AE0055: Add NumSignPredOverrideByQP to LD configurations (MR 454)

Bug fixes:

Fix: memory release for JVET\_AB0155\_SGPM (MR 452)

Fixes for DebugStream tool (MRs 488, 489, 490, 502)

Fix: buffer copy for AC0119 LM chroma fusion (MR 484)

Fix condition for checking buffer overflow (MR 494)

Fix: add initialization for BIF overhead parsing and copy (MR 504)

Fix: Add checks for scaled collocated picture, inter check for GPM (MR 508)

Fix: Valgrind error in spanGeoMMVDMotionInfo (MR 514)

Fix: use picture level reconstructed buffer for SBT sub-TUs in BIF (MR 512)

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

JVET-AE0057: MTT split modes early termination (MR 474)

JVET-AE0162: fix MS-SSIM calculation for RPR/SR (MR 476)

ECM-10.0 and VTM-11ecm10.0 were tagged on August 29, 2023.

* 1. ***CTC Performance***

In this section, ECM test results following ECM CTC configuration descried in JVET-AE2017 are summarized.

Next tables show ECM-10.0 performance over ECM-9.1 anchor.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main 10** | | | | | |
|  | **Over ECM-9.1** | | | | | |
|  | Y | U | V | EncT | DecT | VmPeak |
| Class A1 | -0.93% | -0.63% | -1.17% | 108.3% | 102.2% | 74.2% |
| Class A2 | -1.02% | -1.59% | -1.37% | 106.5% | 100.6% | 74.2% |
| Class B | -1.06% | -1.10% | -1.31% | 106.0% | 102.1% | 70.5% |
| Class C | -0.89% | -0.66% | -0.80% | 110.1% | 103.5% | 87.7% |
| Class E | -1.06% | -1.05% | -0.98% | 105.8% | 102.1% | 79.9% |
| **Overall** | -1.00% | -1.00% | -1.13% | 107.3% | 102.2% | 76.9% |
| Class D | -0.62% | -0.79% | -0.72% | 108.0% | 99.2% | 95.1% |
| Class F | -2.56% | -2.81% | -3.05% | 106.7% | 103.7% | 80.1% |
| Class TGM | -3.21% | -3.53% | -3.50% | 104.9% | 108.7% | 71.4% |
|  |  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | | |
|  | **Over ECM-9.1** | | | | | |
|  | Y | U | V | EncT | DecT | VmPeak |
| Class A1 | -1.74% | -3.59% | -6.37% | 108.4% | 97.7% | 79.4% |
| Class A2 | -2.07% | -4.14% | -5.39% | 106.1% | 96.0% | 79.6% |
| Class B | -1.24% | -3.84% | -3.50% | 103.1% | 95.7% | 72.3% |
| Class C | -1.25% | -2.08% | -1.93% | 105.3% | 99.5% | 85.5% |
| Class E |  |  |  |  |  |  |
| **Overall** | -1.51% | -3.38% | -4.04% | 105.3% | 97.2% | 78.5% |
| Class D | -1.27% | -2.12% | -2.15% | 105.8% | 100.2% | 92.8% |
| Class F | -2.13% | -2.98% | -3.03% | 107.9% | 97.6% | 80.2% |
| Class TGM | -2.23% | -2.82% | -2.95% | 102.1% | 90.8% | 76.0% |
|  |  |  |  |  |  |  |
|  | **Low delay B Main 10** | | | | | |
|  | **Over ECM-9.1** | | | | | |
|  | Y | U | V | EncT | DecT | VmPeak |
| Class A1 |  |  |  |  |  |  |
| Class A2 |  |  |  |  |  |  |
| Class B | -0.69% | -8.86% | -7.04% | 94.0% | 98.5% | 69.8% |
| Class C | -0.97% | -3.14% | -3.09% | 106.7% | 101.6% | 86.2% |
| Class E | -0.98% | -3.47% | -3.09% | 105.8% | 98.2% | 78.5% |
| **Overall** | -0.86% | -5.61% | -4.74% | 101.0% | 99.4% | 77.1% |
| Class D | -0.87% | -4.16% | -3.75% | 105.0% | 99.7% | 94.0% |
| Class F | -1.59% | -6.03% | -7.65% | 106.9% | 95.9% | 79.7% |
| Class TGM | -1.98% | -4.41% | -5.46% | 103.8% | 94.5% | 74.6% |
|  |  |  |  |  |  |  |
|  | **Low delay P Main 10** | | | | | |
|  | **Over ECM-9.1** | | | | | |
|  | Y | U | V | EncT | DecT | VmPeak |
| Class A1 |  |  |  |  |  |  |
| Class A2 |  |  |  |  |  |  |
| Class B | -0.42% | -8.57% | -7.36% | 93.1% | 95.5% | 69.6% |
| Class C | -0.84% | -3.48% | -3.68% | 105.2% | 94.6% | 86.3% |
| Class E | -0.59% | -2.68% | -2.66% | 107.0% | 98.0% | 78.5% |
| **Overall** | -0.60% | -5.40% | -4.96% | 100.4% | 95.8% | 77.1% |
| Class D | -1.01% | -2.98% | -4.80% | 105.1% | 95.4% | 94.2% |
| Class F | -2.00% | -6.37% | -6.84% | 109.5% | 96.1% | 79.5% |
| Class TGM | -2.71% | -5.41% | -6.28% | 105.5% | 98.0% | 73.5% |

The below tables show ECM-10.0 performance comparing to VTM-11.0ecm10.0 anchor.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main 10** | | | | | |
|  | **Over VTM-11.0ecm10** | | | | | |
|  | Y | U | V | EncT | DecT | VmPeak |
| Class A1 | -10.55% | -21.81% | -29.24% | 915.8% | 439.3% | #DIV/0! |
| Class A2 | -16.68% | -28.60% | -31.54% | 916.2% | 458.0% | #DIV/0! |
| Class B | -11.02% | -26.58% | -24.82% | 826.4% | 455.0% | #DIV/0! |
| Class C | -11.07% | -16.52% | -17.06% | 898.0% | 452.7% | #DIV/0! |
| Class E | -14.59% | -24.40% | -22.89% | 804.1% | 467.8% | #DIV/0! |
| **Overall** | -12.49% | -23.52% | -24.63% | 867.2% | 454.4% | #DIV/0! |
| Class D | -9.17% | -14.38% | -14.35% | 851.0% | 445.1% | #DIV/0! |
| Class F | -26.21% | -35.26% | -35.17% | 541.1% | 452.7% | #DIV/0! |
| Class TGM | -39.28% | -47.12% | -46.45% | 457.3% | 496.2% | #DIV/0! |
|  |  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | | |
|  | **Over VTM-11.0ecm10** | | | | | |
|  | Y | U | V | EncT | DecT | VmPeak |
| Class A1 | -22.25% | -27.01% | -36.07% | 882.3% | 784.9% | #DIV/0! |
| Class A2 | -25.50% | -35.13% | -38.75% | 791.3% | 889.0% | #DIV/0! |
| Class B | -20.50% | -34.42% | -32.13% | 673.3% | 731.6% | #DIV/0! |
| Class C | -21.91% | -26.29% | -26.07% | 708.2% | 777.7% | #DIV/0! |
| Class E |  |  |  |  |  |  |
| **Overall** | -22.23% | -30.91% | -32.63% | 744.0% | 784.1% | #DIV/0! |
| Class D | -22.87% | -27.80% | -28.10% | 738.6% | 851.2% | #DIV/0! |
| Class F | -28.30% | -36.71% | -37.10% | 602.2% | 482.5% | #DIV/0! |
| Class TGM | -36.63% | -43.02% | -43.08% | 570.5% | 415.0% | #DIV/0! |
|  |  |  |  |  |  |  |
|  | **Low delay B Main 10** | | | | | |
|  | **Over VTM-11.0ecm10** | | | | | |
|  | Y | U | V | EncT | DecT | VmPeak |
| Class A1 |  |  |  |  |  |  |
| Class A2 |  |  |  |  |  |  |
| Class B | -17.55% | -38.06% | -35.34% | 589.9% | 668.2% | #DIV/0! |
| Class C | -19.29% | -28.96% | -29.31% | 648.1% | 710.0% | #DIV/0! |
| Class E | -16.12% | -28.03% | -27.57% | 642.1% | 459.1% | #DIV/0! |
| **Overall** | -17.77% | -32.52% | -31.39% | 621.7% | 620.8% | #DIV/0! |
| Class D | -21.17% | -30.48% | -30.27% | 656.7% | 758.7% | #DIV/0! |
| Class F | -24.60% | -37.20% | -36.64% | 588.5% | 498.3% | #DIV/0! |
| Class TGM | -35.27% | -43.12% | -43.29% | 560.3% | 418.2% | #DIV/0! |
|  |  |  |  |  |  |  |
|  | **Low delay P Main 10** | | | | | |
|  | **Over VTM-11.0ecm10** | | | | | |
|  | Y | U | V | EncT | DecT | VmPeak |
| Class A1 |  |  |  |  |  |  |
| Class A2 |  |  |  |  |  |  |
| Class B | -16.23% | -37.00% | -34.66% | 529.3% | 651.6% | #DIV/0! |
| Class C | -18.30% | -28.47% | -28.23% | 561.3% | 660.2% | #DIV/0! |
| Class E | -15.42% | -26.79% | -27.20% | 626.8% | 468.8% | #DIV/0! |
| **Overall** | -16.72% | -31.60% | -30.65% | 563.0% | 602.8% | #DIV/0! |
| Class D | -21.10% | -29.72% | -30.38% | 592.5% | 707.9% | #DIV/0! |
| Class F | -23.63% | -37.06% | -36.33% | 602.7% | 467.7% | #DIV/0! |
| Class TGM | -32.74% | -41.78% | -41.94% | 624.2% | 417.1% | #DIV/0! |

1. **ECM memory consumption**

ECM memory consumption (VmPeak, GiB) is provided in ECM encoder log files and is summarized in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
|  | AI | RA | LB |
| class A (A1& A2) | 9 | 20 |  |
| class B | 7 | 10 | 8 |
| class C | 5 | 6 | 5 |
| class D | 5 | 5 | 5 |
| class E | 6 |  | 6 |
| class F | 8 | 10 | 8 |
| class TGM | 8 | 12 | 11 |

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 existed memory wherever possible, rather than systematically allocating new memory, and allocate only the required amount of memory if new memory is needed.

Memory consumption was further reduced after ECM-10.0 release, for the current master branch it is reduced by ~10% to ~60% depending on configuration and resolution. It is planned to tag it as ECM-10.1.

1. **Contributions**

[JVET-AF0090](https://jvet-experts.org/doc_end_user/current_document.php?id=13337), “AHG6: Encoder memory profiling on ECM software“, Y. Yasugi, T. Ikai (Sharp), R. Chernyak, S. Liu (Tencent)

[JVET-AF0156](https://jvet-experts.org/doc_end_user/current_document.php?id=13414), “AHG6: ECM software optimizations”, F. Urban, T. Poirier, F. Le Léannec (InterDigital)

[JVET-AF0177](https://jvet-experts.org/doc_end_user/current_document.php?id=13435), “AHG6: Memory reduction for ECM encoder”, N. Hu, V. Seregin, M. Karczewicz (Qualcomm), Y. Yasugi, T. Ikai (Sharp)

[JVET-AF0201](https://jvet-experts.org/doc_end_user/current_document.php?id=13462), “AHG6: On ECM SW memory consumption”, R. Chernyak, M. Xu, S. Liu (Tencent), Y. Yasugi, T. Ikai (Sharp)

1. **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.
* Encourage people to continue working on ECM memory consumption reduction.
* Encourage people to continue working on speeding up ECM encoder to reduce the simulation time.

One expert commented that as a general practice in ECM development, the person issuing a merge request should not also do the merge. In case a SW coordinator does a merge request, another SW coordinator should do the merge.

[JVET-AF0007](https://jvet-experts.org/doc_end_user/current_document.php?id=13377) JVET AHG report: ECM tool assessment (AHG7) [X. Li (chair), L.-F. Chen, Z. Deng, J. Gan, E. François, H.-J. Jhu, X. Li, H. Wang (vice chairs)]

(zoom connection still down Fri 13 1110)

1. **Group off tests**
   1. ***Test settings and crosschecking***

The same four groups were used in this meeting cycle.

* 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

Five group-off tests were performed and crosschecked on top of ECM-10 and later versions with bug fixes. The two anchors are ECM 10.0 and VTM-11ECM10.0. The cfg files used are also attached with this report.

The testers and crosscheckers are summarized in the table below. All the tests below have been crosschecked. Note that in all the crosschecks, the special setting for LD class B QP22 (with encoder configuration parameter MaxMTTHierarchyDepthByTidOverrideByQP) was not set so that the LDB class B results are slightly different from the results in tests. As the issue was spotted too late and LDB class B QP22 are the slowest points, reruns could not be finished before the JVET-AF meeting.

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

The software versions used in the tests are summarized below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Tests | Tester | | Crosschecker | |
| Anchor | Test | Anchor | Test |
| Group 1 off | ECM-10 | ECM-10 | ECM-10 | ECM-10 |
| Group 2 off | ECM-10 (41ef8a15) | ECM-10 (41ef8a15) | ECM-10 | ECM-10 (41ef8a15) |
| Group 3 off | ECM-10 | ECM-10 | ECM-10 | ECM-10 (41ef8a15) |
| Group 4 off | ECM-10 | ECM-10 | ECM-10 | ECM-10 (41ef8a15) |
| Group 1-4 off | ECM-10 | ECM-10 (b0b4f1e9b) | ECM-10 | ECM-10 (41ef8a15) |

* 1. ***Group 1 off***

Group 1 includes inter template matching tools. The attached offgroup1.cfg was used in addition to ECM CTC settings.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | | | | |
|  | **Over ECM-10.0** | | | | | | **Over VTM-11.0ecm10.0** | | | | |
|  | Y | U | V | EncT | DecT | VmPeak | Y | U | V | EncT | DecT |
| Class A1 | 0.00% | 0.00% | 0.00% | 97.8% | 98.9% | 100.0% | -10.55% | -21.81% | -29.24% | 799.4% | 482.6% |
| Class A2 | 0.00% | 0.00% | 0.00% | 95.9% | 94.5% | 99.9% | -16.68% | -28.60% | -31.54% | 785.6% | 473.1% |
| Class B | 0.00% | 0.00% | 0.00% | 98.2% | 97.0% | 100.0% | -11.03% | -26.58% | -24.82% | 736.7% | 471.3% |
| Class C | -0.01% | -0.01% | -0.01% | 103.6% | 109.4% | 100.0% | -11.08% | -16.53% | -17.07% | 746.9% | 424.0% |
| Class E | -0.01% | -0.01% | -0.01% | 105.3% | 110.6% | 100.0% | -14.60% | -24.41% | -22.90% | 736.8% | 509.9% |
| **Overall** | -0.01% | -0.01% | -0.01% | 100.1% | 101.7% | 100.0% | -12.50% | -23.53% | -24.63% | 757.2% | 468.6% |
| Class D | -0.03% | -0.02% | -0.02% | 99.2% | 102.0% | 100.0% | -9.20% | -14.40% | -14.37% | 736.8% | 412.4% |
| Class F | -0.01% | -0.01% | -0.01% | 98.0% | 102.8% | 100.0% | -26.22% | -35.27% | -35.17% | 501.7% | 496.4% |
| Class TGM | 0.00% | 0.00% | 0.00% | 96.8% | 100.0% | 100.0% | -39.29% | -47.12% | -46.45% | 419.3% | 538.1% |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | | | | | | | |
|  | **Over ECM-10.0** | | | | | | **Over VTM-11.0ecm10.0** | | | | |
|  | Y | U | V | EncT | DecT | VmPeak | Y | U | V | EncT | DecT |
| Class A1 | 3.92% | 3.93% | 3.99% | 83.6% | 80.9% | 100.1% | -19.20% | -24.26% | -33.44% | 666.7% | 758.6% |
| Class A2 | 4.36% | 4.59% | 4.61% | 83.8% | 77.6% | 100.0% | -22.26% | -32.18% | -35.93% | 598.3% | 836.7% |
| Class B | 3.71% | 3.94% | 3.69% | 81.3% | 74.5% | 99.9% | -17.52% | -31.80% | -29.60% | 507.3% | 678.0% |
| Class C | 4.06% | 4.24% | 4.64% | 81.0% | 78.8% | 100.0% | -18.71% | -23.13% | -22.58% | 508.5% | 602.3% |
| Class E |  |  |  |  |  |  |  |  |  |  |  |
| **Overall (Ref)** | 3.98% | 4.15% | 4.18% | 82.2% | 77.5% | 100.0% | -19.12% | -28.05% | -29.76% | 554.1% | 700.7% |
| Class D | 3.31% | 3.71% | 3.47% | 78.2% | 71.4% | 100.0% | -20.26% | -25.06% | -25.54% | 540.0% | 617.7% |
| Class F | 2.94% | 2.92% | 3.11% | 89.3% | 84.3% | 99.9% | -26.11% | -34.80% | -35.07% | 506.3% | 421.7% |
| Class TGM | 3.79% | 3.79% | 3.74% | 88.3% | 86.1% | 100.0% | -34.24% | -40.83% | -40.93% | 504.3% | 467.3% |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | **Low delay B Main10** | | | | | | | | | | |
|  | **Over ECM-10.0** | | | | | | **Over VTM-11.0ecm10.0** | | | | |
|  | Y | U | V | EncT | DecT | VmPeak | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |  |  |  |  |  |  |
| Class A2 |  |  |  |  |  |  |  |  |  |  |  |
| Class B | 4.59% | 5.35% | 4.80% | 79.3% | 70.6% | 100.0% | -13.75% | -34.87% | -32.35% | 405.0% | 535.0% |
| Class C | 4.70% | 4.76% | 5.20% | 72.1% | 58.4% | 100.0% | -15.47% | -25.61% | -25.62% | 407.9% | 439.6% |
| Class E | 4.50% | 5.53% | 5.32% | 79.7% | 75.8% | 100.0% | -12.34% | -24.14% | -23.82% | 467.4% | 398.5% |
| **Overall (Ref)** | 4.60% | 5.20% | 5.06% | 76.9% | 67.5% | 100.0% | -13.97% | -29.10% | -27.98% | 420.8% | 465.5% |
| Class D | 4.13% | 4.64% | 4.25% | 72.8% | 60.7% | 100.0% | -17.89% | -27.18% | -27.32% | 468.6% | 513.5% |
| Class F | 4.24% | 3.47% | 4.11% | 82.1% | 72.8% | 100.0% | -21.33% | -34.99% | -34.06% | 470.0% | 412.4% |
| Class TGM | 5.78% | 5.60% | 5.50% | 91.3% | 85.5% | 100.6% | -31.51% | -39.83% | -40.05% | 469.8% | 374.6% |

* 1. ***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 attached offgroup2.cfg was used in addition to ECM CTC settings.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | | | | |
|  | **Over ECM-10 (41ef8a15)** | | | | | | **Over VTM-11ecm10** | | | | |
|  | Y | U | V | EncT | DecT | VmPeak | Y | U | V | EncT | DecT |
| Class A1 | 0.39% | 0.80% | 0.64% | 91.5% | 96.5% | 99.8% | -10.19% | -21.21% | -28.74% | 788.0% | 445.3% |
| Class A2 | 0.55% | 0.75% | 0.77% | 89.0% | 95.8% | 99.9% | -16.22% | -28.07% | -31.02% | 764.8% | 443.9% |
| Class B | 0.48% | 0.72% | 0.70% | 87.7% | 94.8% | 99.9% | -10.59% | -26.02% | -24.27% | 692.3% | 442.3% |
| Class C | 0.34% | 0.51% | 0.68% | 85.3% | 91.8% | 99.9% | -10.76% | -16.11% | -16.49% | 700.8% | 397.2% |
| Class E | 0.72% | 0.98% | 0.93% | 87.9% | 94.5% | 99.9% | -13.96% | -23.65% | -22.15% | 660.2% | 456.0% |
| **Overall** | 0.49% | 0.74% | 0.73% | 88.0% | 94.5% | 99.9% | -12.06% | -22.96% | -24.06% | 715.5% | 434.8% |
| Class D | 0.31% | 0.42% | 0.49% | 85.4% | 89.2% | 99.9% | -8.89% | -14.01% | -13.92% | 713.2% | 407.2% |
| Class F | 3.58% | 3.71% | 3.97% | 89.5% | 95.7% | 99.9% | -23.78% | -33.16% | -32.92% | 486.0% | 464.9% |
| Class TGM | 0.87% | 0.91% | 0.94% | 89.1% | 100.3% | 99.9% | -38.74% | -46.64% | -45.95% | 416.6% | 535.0% |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | | | | | | | |
|  | **Over ECM-10 (41ef8a15)** | | | | | | **Over VTM-11ecm10** | | | | |
|  | Y | U | V | EncT | DecT | VmPeak | Y | U | V | EncT | DecT |
| Class A1 | 2.37% | 0.74% | 1.65% | 91.2% | 98.4% | 99.9% | -20.39% | -26.36% | -34.98% | 776.8% | 861.1% |
| Class A2 | 1.68% | 0.94% | 1.39% | 90.1% | 99.7% | 100.2% | -24.23% | -34.48% | -37.87% | 669.6% | 996.2% |
| Class B | 1.65% | 1.11% | 1.29% | 89.6% | 96.9% | 99.7% | -19.18% | -33.64% | -31.27% | 607.6% | 832.9% |
| Class C | 1.25% | 0.97% | 0.53% | 87.7% | 95.2% | 99.9% | -20.95% | -25.63% | -25.72% | 627.8% | 872.8% |
| Class E |  |  |  |  |  |  |  |  |  |  |  |
| **Overall (Ref)** | 1.70% | 0.96% | 1.18% | 89.5% | 97.3% | 99.9% | -20.90% | -30.21% | -31.85% | 656.4% | 879.9% |
| Class D | 0.68% | -0.03% | 0.11% | 86.3% | 95.2% | 99.9% | -22.32% | -27.76% | -28.00% | 666.9% | 961.1% |
| Class F | 3.73% | 3.60% | 3.45% | 88.9% | 95.8% | 100.0% | -25.71% | -34.60% | -35.11% | 566.3% | 524.4% |
| Class TGM | 1.92% | 1.93% | 2.02% | 90.0% | 100.3% | 100.0% | -35.38% | -41.89% | -41.89% | 549.7% | 508.2% |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | **Low delay B Main10** | | | | | | | | | | |
|  | **Over ECM-10 (41ef8a15)** | | | | | | **Over VTM-11ecm10** | | | | |
|  | Y | U | V | EncT | DecT | VmPeak | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |  |  |  |  |  |  |
| Class A2 |  |  |  |  |  |  |  |  |  |  |  |
| Class B | 1.90% | 0.53% | 0.59% | 84.8% | 97.2% | 99.9% | -15.97% | -37.26% | -34.59% | 501.8% | 783.5% |
| Class C | 1.58% | 0.81% | 1.11% | 84.6% | 93.3% | 99.9% | -18.09% | -28.43% | -28.57% | 539.4% | 750.0% |
| Class E | 1.16% | 0.97% | 0.14% | 87.4% | 96.7% | 99.9% | -15.13% | -27.23% | -27.12% | 571.3% | 537.9% |
| **Overall (Ref)** | 1.61% | 0.73% | 0.65% | 85.4% | 95.8% | 99.9% | -16.46% | -31.81% | -30.72% | 531.0% | 702.9% |
| Class D | 0.77% | 0.41% | 0.60% | 84.0% | 93.9% | 99.9% | -20.52% | -30.29% | -30.09% | 580.6% | 933.4% |
| Class F | 3.38% | 1.85% | 1.52% | 88.6% | 96.3% | 99.8% | -22.07% | -35.99% | -35.72% | 544.4% | 557.4% |
| Class TGM | 2.01% | 2.04% | 2.34% | 90.5% | 102.1% | 100.2% | -33.94% | -42.10% | -42.06% | 513.2% | 496.1% |

* 1. ***Group 3 off***

Group 3 includes intra and IBC template matching (with search) related tools. The attached offgroup3.cfg was used in addition to ECM CTC settings.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | | | | |
|  | **Over ECM-10** | | | | | | **Over VTM-11ecm10** | | | | |
|  | Y | U | V | EncT | DecT | VmPeak | Y | U | V | EncT | DecT |
| Class A1 | 1.00% | 2.85% | 4.29% | 80.0% | 88.8% | 99.9% | -9.65% | -19.75% | -26.36% | 715.7% | 360.7% |
| Class A2 | 1.84% | 4.41% | 4.43% | 80.8% | 79.3% | 99.9% | -15.12% | -25.67% | -28.71% | 712.3% | 329.9% |
| Class B | 1.86% | 3.90% | 3.87% | 78.5% | 74.8% | 100.0% | -9.39% | -23.94% | -22.06% | 647.7% | 317.1% |
| Class C | 1.66% | 2.10% | 2.25% | 78.5% | 74.1% | 100.0% | -9.62% | -14.84% | -15.26% | 662.7% | 290.4% |
| Class E | 2.94% | 3.78% | 3.52% | 78.6% | 75.1% | 100.0% | -12.08% | -21.63% | -20.20% | 625.2% | 320.3% |
| **Overall** | 1.85% | 3.39% | 3.62% | 79.1% | 77.6% | 100.0% | -10.89% | -21.12% | -22.06% | 668.6% | 320.3% |
| Class D | 1.22% | 1.81% | 1.79% | 80.2% | 73.4% | 100.0% | -8.06% | -12.83% | -12.83% | 677.0% | 298.7% |
| Class F | 4.36% | 5.57% | 5.66% | 78.7% | 69.8% | 100.0% | -23.11% | -31.86% | -31.72% | 464.5% | 302.0% |
| Class TGM | 8.63% | 10.60% | 10.93% | 82.1% | 59.9% | 99.9% | -34.14% | -41.63% | -40.72% | 414.4% | 287.3% |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | | | | | | | |
|  | **Over ECM-10** | | | | | | **Over VTM-11ecm10** | | | | |
|  | Y | U | V | EncT | DecT | VmPeak | Y | U | V | EncT | DecT |
| Class A1 | 0.96% | 2.00% | 5.80% | 95.1% | 99.0% | 100.2% | -21.50% | -25.59% | -32.98% | 813.1% | 702.3% |
| Class A2 | 1.10% | 3.01% | 3.27% | 95.7% | 100.1% | 99.6% | -24.68% | -33.27% | -36.81% | 739.3% | 828.6% |
| Class B | 1.00% | 3.61% | 3.47% | 94.5% | 98.4% | 99.9% | -19.70% | -32.07% | -29.80% | 645.0% | 684.2% |
| Class C | 0.80% | 1.16% | 1.19% | 94.4% | 99.0% | 100.0% | -21.28% | -25.40% | -25.17% | 663.9% | 707.8% |
| Class E |  |  |  |  |  |  |  |  |  |  |  |
| **Overall (Ref)** | 0.96% | 2.51% | 3.29% | 94.8% | 99.1% | 99.9% | -21.48% | -29.24% | -30.60% | 699.6% | 721.1% |
| Class D | 0.68% | 1.56% | 1.85% | 95.2% | 98.4% | 100.0% | -22.34% | -26.62% | -26.73% | 711.7% | 728.1% |
| Class F | 2.80% | 3.63% | 3.81% | 92.3% | 99.5% | 100.2% | -26.43% | -34.60% | -34.82% | 589.0% | 412.3% |
| Class TGM | 5.50% | 7.34% | 7.70% | 93.9% | 98.0% | 100.0% | -33.15% | -38.85% | -38.74% | 585.9% | 381.1% |

* 1. ***Group 4 off***

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

The attached offgroup4.cfg was used in addition to ECM CTC settings.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | | | | |
|  | **Over ECM-10** | | | | | | **Over VTM-11ecm10** | | | | |
|  | Y | U | V | EncT | DecT | VmPeak | Y | U | V | EncT | DecT |
| Class A1 | 1.60% | 5.59% | 7.45% | 86.9% | 94.4% | 99.9% | -9.12% | -17.75% | -24.20% | 752.4% | 416.8% |
| Class A2 | 2.48% | 6.17% | 7.18% | 83.7% | 96.3% | 99.9% | -14.70% | -24.44% | -26.94% | 702.7% | 429.4% |
| Class B | 1.01% | 6.50% | 5.30% | 87.5% | 96.9% | 100.0% | -10.14% | -22.27% | -21.13% | 691.2% | 442.6% |
| Class C | 0.89% | 2.91% | 2.83% | 84.5% | 95.8% | 100.0% | -10.29% | -14.24% | -14.84% | 689.1% | 416.4% |
| Class E | 1.16% | 6.61% | 3.92% | 87.6% | 98.0% | 100.0% | -13.60% | -19.81% | -20.08% | 666.8% | 463.0% |
| **Overall** | 1.35% | 5.51% | 5.19% | 86.1% | 96.3% | 100.0% | -11.34% | -19.68% | -21.04% | 698.3% | 433.4% |
| Class D | 0.87% | 2.53% | 2.34% | 85.6% | 96.9% | 100.0% | -8.38% | -12.27% | -12.38% | 696.3% | 433.3% |
| Class F | 1.21% | 4.10% | 4.28% | 92.3% | 97.1% | 100.0% | -25.33% | -32.83% | -32.59% | 477.0% | 458.9% |
| Class TGM | 2.27% | 3.84% | 3.76% | 91.4% | 96.2% | 100.0% | -37.97% | -45.22% | -44.56% | 415.0% | 500.0% |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | | | | | | | |
|  | **Over ECM-10** | | | | | | **Over VTM-11ecm10** | | | | |
|  | Y | U | V | EncT | DecT | VmPeak | Y | U | V | EncT | DecT |
| Class A1 | 1.18% | 2.92% | 5.22% | 91.1% | 98.9% | 100.5% | -21.33% | -24.98% | -33.17% | 779.5% | 786.8% |
| Class A2 | 1.08% | 3.53% | 4.33% | 94.2% | 99.8% | 99.8% | -24.69% | -32.95% | -36.23% | 709.2% | 913.4% |
| Class B | 0.52% | 6.08% | 4.97% | 93.5% | 100.0% | 100.1% | -20.08% | -30.65% | -28.98% | 623.8% | 788.6% |
| Class C | 0.41% | 1.88% | 1.76% | 94.0% | 99.8% | 100.0% | -21.60% | -24.89% | -24.75% | 644.2% | 828.5% |
| Class E |  |  |  |  |  |  |  |  |  |  |  |
| **Overall (Ref)** | 0.73% | 3.82% | 4.04% | 93.3% | 99.7% | 100.1% | -21.66% | -28.44% | -30.14% | 674.9% | 822.5% |
| Class D | 0.37% | 1.81% | 2.11% | 95.0% | 100.2% | 100.0% | -22.58% | -26.52% | -26.61% | 691.3% | 889.2% |
| Class F | 0.94% | 3.23% | 3.45% | 95.8% | 98.4% | 99.9% | -27.69% | -34.90% | -35.15% | 594.3% | 493.7% |
| Class TGM | 0.68% | 1.56% | 1.34% | 94.6% | 99.3% | 100.0% | -36.23% | -42.17% | -42.36% | 576.2% | 455.0% |

* 1. ***Group 1-4 off***

In this test, all the tools in the group 1-4 are switched off. The attached offgroup1-4.cfg was used in addition to ECM CTC settings.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | | | | |
|  | **Over ECM-10** | | | | | | **Over VTM-11ecm10** | | | | |
|  | Y | U | V | EncT | DecT | VmPeak | Y | U | V | EncT | DecT |
| Class A1 | 3.24% | 9.59% | 13.34% | 61.0% | 76.1% | 99.7% | -7.63% | -14.77% | -20.19% | 546.8% | 316.3% |
| Class A2 | 5.22% | 12.08% | 12.57% | 57.6% | 68.7% | 99.7% | -12.36% | -20.41% | -23.37% | 507.5% | 297.0% |
| Class B | 3.67% | 11.44% | 10.20% | 56.4% | 63.4% | 99.9% | -7.78% | -18.82% | -17.57% | 455.0% | 281.3% |
| Class C | 3.23% | 5.74% | 5.93% | 54.4% | 56.8% | 99.9% | -8.23% | -11.93% | -12.29% | 453.5% | 250.0% |
| Class E | 5.56% | 11.56% | 8.76% | 57.6% | 64.5% | 99.9% | -9.84% | -16.07% | -16.33% | 461.4% | 294.5% |
| **Overall** | 4.07% | 9.99% | 9.93% | 57.1% | 64.8% | 99.8% | -8.96% | -16.42% | -17.59% | 478.5% | 284.1% |
| Class D | 2.76% | 4.96% | 4.94% | 55.1% | 54.7% | 99.9% | -6.66% | -10.17% | -10.14% | 465.3% | 242.1% |
| Class F | 10.53% | 15.32% | 15.80% | 64.0% | 61.5% | 99.9% | -18.81% | -26.29% | -25.77% | 367.0% | 277.9% |
| Class TGM | 14.28% | 18.07% | 18.81% | 64.7% | 56.0% | 99.9% | -30.83% | -37.82% | -36.67% | 315.8% | 267.9% |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | | | | | | | |
|  | **Over ECM-10** | | | | | | **Over VTM-11ecm10** | | | | |
|  | Y | U | V | EncT | DecT | VmPeak | Y | U | V | EncT | DecT |
| Class A1 | 9.01% | 10.53% | 18.25% | 65.8% | 80.5% | 99.8% | -15.22% | -19.48% | -25.41% | 564.9% | 579.9% |
| Class A2 | 8.71% | 12.98% | 14.22% | 65.7% | 77.3% | 99.6% | -18.99% | -26.94% | -30.19% | 499.4% | 641.7% |
| Class B | 7.23% | 14.79% | 13.93% | 63.7% | 73.7% | 99.8% | -14.70% | -24.88% | -22.86% | 434.1% | 532.6% |
| Class C | 6.73% | 8.54% | 8.96% | 60.7% | 65.9% | 99.9% | -16.60% | -19.91% | -19.32% | 433.5% | 499.6% |
| Class E |  |  |  |  |  |  |  |  |  |  |  |
| **Overall (Ref)** | 7.75% | 11.91% | 13.53% | 63.7% | 73.5% | 99.8% | -16.17% | -22.89% | -23.89% | 470.4% | 552.8% |
| Class D | 5.26% | 7.62% | 8.28% | 61.7% | 64.5% | 99.9% | -18.72% | -22.17% | -21.99% | 462.6% | 530.5% |
| Class F | 11.45% | 14.38% | 14.99% | 69.5% | 76.9% | 99.8% | -20.36% | -28.13% | -28.20% | 443.8% | 344.8% |
| Class TGM | 13.48% | 16.18% | 16.41% | 72.2% | 77.4% | 99.9% | -28.09% | -33.82% | -33.78% | 453.6% | 318.9% |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | **Low delay B Main10** | | | | | | | | | | |
|  | **Over ECM-10** | | | | | | **Over VTM-11ecm10** | | | | |
|  | Y | U | V | EncT | DecT | VmPeak | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |  |  |  |  |  |  |
| Class A2 |  |  |  |  |  |  |  |  |  |  |  |
| Class B | 7.07% | 9.46% | 9.24% | 56.8% | 64.8% | 100.0% | -11.69% | -32.34% | -29.54% | 337.7% | 424.7% |
| Class C | 6.74% | 7.49% | 8.02% | 54.4% | 53.9% | 99.9% | -13.83% | -23.70% | -23.63% | 346.6% | 369.5% |
| Class E | 6.48% | 14.60% | 11.45% | 66.3% | 75.6% | 99.9% | -10.66% | -17.94% | -19.36% | 435.9% | 334.0% |
| **Overall (Ref)** | 6.81% | 10.09% | 9.39% | 58.2% | 63.4% | 99.9% | -12.14% | -25.86% | -25.03% | 363.1% | 381.8% |
| Class D | 5.19% | 6.89% | 7.08% | 57.3% | 54.4% | 99.9% | -17.01% | -25.62% | -25.22% | 390.5% | 429.3% |
| Class F | 10.40% | 11.81% | 11.19% | 66.3% | 71.0% | 99.9% | -16.84% | -29.98% | -29.78% | 412.1% | 322.5% |
| Class TGM | 13.46% | 14.95% | 15.60% | 72.1% | 72.4% | 99.4% | -26.57% | -34.63% | -34.56% | 425.6% | 276.2% |

* 1. ***Summary***

The tool-off results on top of the recent ECM versions are summarized below. Note that SCC results are not included.

1. **Issues**
   1. ***Resolved issues***

* Software issues #51, #54 with tool off tests was resolved
  1. ***Open issues***
* #53, decoding mismatch was observed when AMVR is off
* The variation of runtime over VTM11ECM9 is relatively large, for which the version of compiler matters
* Different software versions were used in AHG7 tests, which leads to slightly different results between testing and crosschecking.
* It was commented that it is not consistent to set LDB class B QP22 setting for ECM-10 anchor without also setting it for VTM11-ECM10 anchor. JVET-AF0165 is related to this issue.

1. **Input contributions**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| [JVET-AF0165](https://jvet-experts.org/doc_end_user/current_document.php?id=13423) | m64994 | 2023-10-06 18:23:08 | 2023-10-06 19:45:18 | 2023-10-06 19:45:18 | Ahg7/Ahg12: On VTM-11ecm anchor low-delay test conditions | [F. Le Léannec](mailto:fabrice.leleannec@interdigital.com), S. Puri, E. François, K. Naser (InterDigital) |

1. **Recommendations**

* Continue and improve tool assessment
* Resolve identified software issues related to the tool assessment
* Review all the input contributions

[JVET-AF0008](https://jvet-experts.org/doc_end_user/current_document.php?id=13379) 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)]

1. **Activities**

The AHG used the main JVET reflector, jvet@lists.rwth-aachen.de, for email discussion. There was a kick-off email sent to the reflector with announcement of CTC document upload. Offline discussions were conducted among co-chairs, editors and interested experts for technical report preparation, common test conditions and anchor generation, etc. There are seven input contriubtions related to AHG 8 mandates submitted to this meeting. They are listed in Section 3.

* 1. ***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-AE2031. 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.

Following the decision made in the last meeting, the CTC includes two anchors, generated by VTM12 and VTM20 software, respectively. Hence, two reporting templates in Excel format are enclosed in the document package for reporting VTM12 and VTM20 based restuls, respectively. This output document package JVET-AE2031 was uploaded on 2023-08-11 to JVET document management system and is also available at <https://vcgit.hhi.fraunhofer.de/jvet-ahg-ofm>/ofm-ctc.

* 1. ***Technical Report***

The draft 3 of the technical report (TR) has been prepared and uploaded as JVET-AE2030 based on discussions and decisions in the last (31st) JVET meeting on 2023-09-14. Descriptions about

* Denoising filter (JVET-AE0081)
* NNPF and post-filter hint SEI message (JVET-AE0099)

were included in the TR, together with some text improvements.

* 1. ***Git Management***

AHG 8 related software and documents can be found at <https://vcgit.hhi.fraunhofer.de/jvet-ahg-ofm>. This repository contains two projects, one (<https://vcgit.hhi.fraunhofer.de/jvet-ahg-ofm/ofm-ctc>) containing instrucitons and information for conducting experiements and evaluation, such as evaluation scripts, machine task networks, CTC and reporting template with anchor results, while the other (<https://vcgit.hhi.fraunhofer.de/jvet-ahg-ofm/vtm-ofm>) containing implementation examples. Three software implementation examples are hosted in separate branches:

* 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
* JVET-AE0143: a spatial resampling algorithm and an exemplar software implementation

1. **Input contributions**

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

|  |  |  |
| --- | --- | --- |
| **Report** | | |
| JVET-AF0008 | 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-AF0060 | AHG8: An exemplar software implementation for temporal resampling for VCM | [S. Wang](mailto:shurun.wsr@alibaba-inc.com), [J. Chen](mailto:jiechen.cj@alibaba-inc.com), [Y. Ye (Alibaba)](mailto:yan.ye@alibaba-inc.com), [S. Wang (CityU)](mailto:shiqwang@cityu.edu.hk) |
| JVET-AF0157 | AHG8: A temporal resampling algorithm | D. Ding, X. Zhao, Z. Liu, S. Liu (Tencent) |
| JVET-AF0068 | AHG8/AHG9: Signalling of encoder preprocessing information | [W. Jia](mailto:wei.jia@bytedance.com), [Y. Li](mailto:yue.li@bytedance.com), [Y.-K. Wang](mailto:yekui.wang@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com) |
| JVET-AF0138 | AHG8/AHG9: Truncated bit depth support SEI messages | [D. Ding](mailto:ddding@global.tencent.com), [X. Zhao](mailto:xinzzhao@global.tencent.com), [S. Liu](mailto:shanl@global.tencent.com), [G. Teniou](mailto:teniou@global.tencent.com), [S. Wenger (Tencent)](mailto:swenger@global.tencent.com) |
| JVET-AF0147 | AHG8/AHG9: On Picture Modality Type | [J. Gao](mailto:jingying.gao@sg.panasonic.com), [H.-B. Teo](mailto:hanboon.teo@sg.panasonic.com), C.-S. Lim, [K. Abe (Panasonic)](mailto:abe.kiyo@jp.panasonic.com) |
| **Crosscheck** | | |
| JVET-AE0241 | Cross-check of JVET-AF0157 (AHG8: A temporal resampling algorithm) | C. Hollmann (Ericsson) |

1. **Recommendations**

The AHG recommends to:

* Review all input contributions.
* Discuss and refine test conditions, evalution and reporting procedures.
* 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.
* Discuss TR development and finalization schedule.

Revisit: Discuss about potential timelines for the TR. It was commented that the topic has such a broad range of applications that it might be impossible to cover all of them. A first version could very well be a subset of those. Newly proposed SEI messages could not be included.

[JVET-AF0009](https://jvet-experts.org/doc_end_user/current_document.php?id=13380) 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 42 contributions are identified relating to the mandates of AHG9. Some contributions also relate to the work of AHG8.

The number of contributions relating to each AHG9 mandate is as follows (some contributions relate to more than one mandate):

* 10 contributions relate to the mandate to study the SEI messages in VSEI, VVC, HEVC, and AVC.
  + 8 contributions relate to SEI processing order SEI message aspects other than post-processing filter (PPF) grouping
  + 2 contributions relate to SEI messages related to film grain synthesis
* 24 contributions relate to the mandate to discuss the document for the TuC for future extensions of VSEI.
  + 3 contributions relate to the general direction of grouping of PPFs, including NNPFs
  + 9 contributions relate to detailed aspects of NNPF grouping
  + 6 contributions relate to the source picture timing information SEI message
  + 4 contributions relate to the encoder optimization information SEI message
  + 2 contributions relate to the object mask information SEI message
* 2 contributions relate to the mandate to collect software and showcase information for SEI messages;
* 13 contributions relate to the mandate to identify potential needs for additional SEI messages.
  + 4 contributions relate to SEI messages related to generative video
  + 9 contributions relate to other SEI messages
* 1 contribution relates to the mandate to study the alignments of the same SEI messages in different standards.

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

* 1. ***Study*** ***the SEI messages in VSEI, VVC, HEVC and AVC***
     1. **AHG9: SEI processing order SEI message aspects other than PPF grouping (8)**

[JVET-AF0049](https://jvet-experts.org/doc_end_user/current_document.php?id=13297) AHG9: On the SEI processing order SEI message [M. M. Hannuksela (Nokia)]

[JVET-AF0061](https://jvet-experts.org/doc_end_user/current_document.php?id=13309) AHG9: On grouping of post-processing filters [Y.-K. Wang, W. Jia, J. Xu, L. Zhang (Bytedance)]

JVET-AF0061 also relates to the mandate to discuss the TuC for future extensions of VSEI.

[JVET-AF0062](https://jvet-experts.org/doc_end_user/current_document.php?id=13310) AHG9: Some syntax and semantics changes for the SEI processing order SEI message [Y.-K. Wang (Bytedance)]

[JVET-AF0065](https://jvet-experts.org/doc_end_user/current_document.php?id=13313) AHG9: On the SEI processing order SEI message (Part 1) [L. Chen, O. Chubach, Y.-W. Huang, S. Lei (MediaTek)]

[JVET-AF0067](https://jvet-experts.org/doc_end_user/current_document.php?id=13315) AHG9: On the SEI processing order SEI message (Part 2) [L. Chen, O. Chubach, Y.-W. Huang, S. Lei (MediaTek)]

[JVET-AF0070](https://jvet-experts.org/doc_end_user/current_document.php?id=13318) AHG9: On the SEI processing order SEI message [T. Chujoh, Y. Yasugi, T. Ikai (Sharp)]

[JVET-AF0174](https://jvet-experts.org/doc_end_user/current_document.php?id=13432) AHG9: On the SEI processing order SEI message and NNPF groups [Y. Sanchez, C. Hellge, T. Schierl (Fraunhofer HHI)]

JVET-AF0061 also relates to the mandate to discuss the TuC for future extensions of VSEI.

[JVET-AF0189](https://jvet-experts.org/doc_end_user/current_document.php?id=13449) AHG9: Proposed modifications of the draft SEI processing order SEI message in VVC [G. J. Sullivan, S. McCarthy, P. Yin (Dolby Labs)]

* + 1. **AHG9: SEI messages related to film grain synthesis (2)**

[JVET-AF0142](https://jvet-experts.org/doc_end_user/current_document.php?id=13400) [AHG9] Local Film Grain Synthesis using Annotated Regions SEI [G. Teniou, S. Wenger (Tencent)]

JVET-AF0142 also relates to the mandate to identify potential needs for additional SEI messages.

[JVET-AF0144](https://jvet-experts.org/doc_end_user/current_document.php?id=13402) [AHG9] Adaptive Film grain synthesis using Alpha Channel Information SEI message [G. Teniou, S. Wenger (Tencent)]

JVET-AF0144 also relates to the mandate to identify potential needs for additional SEI messages.

* 1. ***Discuss the document for the TuC for future extensions of VSEI***
     1. **AHG9: General direction of grouping of post-processing filters (PPFs), including NNPFs (3)**

[JVET-AF0050](https://jvet-experts.org/doc_end_user/current_document.php?id=13298) AHG9: On NNPF groups [M. M. Hannuksela, F. Cricri (Nokia)]

[JVET-AF0061](https://jvet-experts.org/doc_end_user/current_document.php?id=13309) AHG9: On grouping of post-processing filters [Y.-K. Wang, W. Jia, J. Xu, L. Zhang (Bytedance)]

JVET-AF0061 also relates to the mandate to study SEI messages in VSEI, VVC, HEVC and AVC.

[JVET-AF0174](https://jvet-experts.org/doc_end_user/current_document.php?id=13432) AHG9: On the SEI processing order SEI message and NNPF groups [Y. Sanchez, C. Hellge, T. Schierl (Fraunhofer HHI)]

JVET-AF0174 also relates to the mandate to study SEI messages in VSEI, VVC, HEVC and AVC.

* + 1. **AHG9: Detailed aspects of NNPF grouping (9)**

[JVET-AF0050](https://jvet-experts.org/doc_end_user/current_document.php?id=13298) AHG9: On NNPF groups [M. M. Hannuksela, F. Cricri (Nokia)]

[JVET-AF0051](https://jvet-experts.org/doc_end_user/current_document.php?id=13299) AHG9: Signalling the gain provided by NNPFs and NNPF groups [M. M. Hannuksela, F. Cricri, A. Hallapuro (Nokia)]

[JVET-AF0067](https://jvet-experts.org/doc_end_user/current_document.php?id=13315) AHG9: On the SEI processing order SEI message (Part 2) [L. Chen, O. Chubach, Y.-W. Huang, S. Lei (MediaTek)]

JVET-AF0067 also relates to the mandate to study SEI messages in VSEI, VVC, HEVC and AVC.

[JVET-AF0091](https://jvet-experts.org/doc_end_user/current_document.php?id=13338) [AHG9] On design for signalling purpose information for NNPFGC [[Hendry](mailto:dr.hendry@lge.com), J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0092](https://jvet-experts.org/doc_end_user/current_document.php?id=13339) [AHG9] On the output pictures from NNPFGC with parallel grouping type [[Hendry](mailto:dr.hendry@lge.com), J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0093](https://jvet-experts.org/doc_end_user/current_document.php?id=13340) [AHG9] On intermediary output picture(s) from activation of an NNPFGC [[Hendry](mailto:dr.hendry@lge.com), J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0094](https://jvet-experts.org/doc_end_user/current_document.php?id=13341) [AHG9] On activation of an NNPFGC that contains another NNPFGC [[Hendry](mailto:dr.hendry@lge.com), J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0095](https://jvet-experts.org/doc_end_user/current_document.php?id=13342) [AHG9] On order of output pictures when skipped candidate input pictures are present in NNPFGA [Hendry, J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0096](https://jvet-experts.org/doc_end_user/current_document.php?id=13343) [AHG9] On miscellaneous aspects of NNPFGC and NNPFGA [Hendry, J. Nam, S. Kim, J. Lim (LGE)]

* + 1. **AHG9:** **Source picture timing information SEI message aspects (6)**

[JVET-AF0055](https://jvet-experts.org/doc_end_user/current_document.php?id=13303) AHG9: On Source Picture Timing Information (SPTI) SEI message [[J. Samuelsson-Allendes](mailto:samuelssonj@sharplabs.com), S. Deshpande (Sharp)]

[JVET-AF0069](https://jvet-experts.org/doc_end_user/current_document.php?id=13317) AHG9: On source picture timing information SEI message [S. McCarthy, G. J. Sullivan, P. Yin (Dolby)]

[JVET-AF0097](https://jvet-experts.org/doc_end_user/current_document.php?id=13344) [AHG9] On description of picture 0 in source picture timing information SEI message [Hendry, J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0098](https://jvet-experts.org/doc_end_user/current_document.php?id=13345) [AHG9] On temporal reversal feature in source picture timing information SEI message [Hendry, J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0099](https://jvet-experts.org/doc_end_user/current_document.php?id=13346) [AHG9] On signaling of source picture interval scale factor and sublayer synthesized flag in source picture timing information SEI message [Hendry, J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0100](https://jvet-experts.org/doc_end_user/current_document.php?id=13347) [AHG9] On miscellaneous aspects of source picture timing information SEI message [Hendry, J. Nam, S. Kim, J. Lim (LGE)]

* + 1. **AHG9: Encoder optimization information SEI message aspects (4)**

[JVET-AF0052](https://jvet-experts.org/doc_end_user/current_document.php?id=13300)AHG9: Proposed updates on the encoder optimization information SEI message **[**M. M. Hannuksela, F. Cricri (Nokia)]

[JVET-AF0068](https://jvet-experts.org/doc_end_user/current_document.php?id=13316) AHG8/AHG9: Signalling of encoder preprocessing information [W. Jia, Y. Li, Y.-K. Wang, K. Zhang, L. Zhang (Bytedance)]

[JVET-AF0105](https://jvet-experts.org/doc_end_user/current_document.php?id=13352) AHG9: On color vision deficiency optimization type for encoder optimization info SEI message [C. Kim, Hendry, D. Gwak, J. Lim, S. Kim (LGE)]

[JVET-AF0107](https://jvet-experts.org/doc_end_user/current_document.php?id=13354) AHG9: On miscellaneous aspects for encoder optimization info SEI message [C. Kim, Hendry, D. Gwak, J. Lim, S. Kim (LGE)]

* + 1. **AHG9: Object mask information SEI message aspects (2)**

[JVET-AF0087](https://jvet-experts.org/doc_end_user/current_document.php?id=13335) AHG9: Experimental results of object mask auxiliary picture coding [Z. Zhang, [J. Chen](mailto:jiechen.cj@alibaba-inc.com), Y. Ye, S. Wang (Alibaba)]

[JVET-AF0088](https://jvet-experts.org/doc_end_user/current_document.php?id=13336) AHG9: Software implementation and further fixes of the object mask information SEI message [J. Chen, Z. Zhang, Y. Ye, S. Wang (Alibaba)]

JVET-AF0088 also relates to the mandate to collect software and showcase information for SEI messages.

* 1. ***Collect software and showcase information for SEI messages***

[JVET-AF0088](https://jvet-experts.org/doc_end_user/current_document.php?id=13336) AHG9: Software implementation and further fixes of the object mask information SEI message [J. Chen, Z. Zhang, Y. Ye, S. Wang (Alibaba)]

JVET-AF0088 also relates to the mandate to discuss the TuC for future extensions of VSEI

[JVET-AF0167](https://jvet-experts.org/doc_end_user/current_document.php?id=13425) AHG9: On the Proposed Multiplane Image Information SEI Message [T. Lu, P. Yin, S. Oh, S. McCarthy, W. Husak, G. J. Sullivan (Dolby)]

JVET-AF00167 also relates to the mandate to identify potential needs for additional SEI messages.

* 1. ***Identify potential needs for additional SEI messages***
     1. **AHG9: SEI messages related to generative video (4)**

[JVET-AF0048](https://jvet-experts.org/doc_end_user/current_document.php?id=13296) A Study on Decoder Interoperability of Generative Face Video Compression [B. Chen, S. Yin, J. Chen, Y. Ye (Alibaba), S. Wang (CityU HK)]

[JVET-AF0145](https://jvet-experts.org/doc_end_user/current_document.php?id=13403) AHG9: SEI message for text for generative AI [A. Hinds, S. Wenger (Tencent)]

[JVET-AF0146](https://jvet-experts.org/doc_end_user/current_document.php?id=13404) AHG9: On Face Motion Information for Generative Face Video [H.-B. Teo, J.-Y Thong, K. Jayashree, C.-S. Lim, K. Abe (Panasonic)]

[JVET-AF0234](https://jvet-experts.org/doc_end_user/current_document.php?id=13497) AHG9: Common text for proposed generative face video SEI message [B. Chen, S. Yin, J. Chen, Y. Ye (Alibaba), S. Wang (CityU HK), S. McCarthy, P. Yin, G.-M. Su, A. K. Choudrhury, W. Husak, G.J. Sullivan (Dolby)]

* + 1. **AHG9: Other SEI messages (9)**

[JVET-AF0138](https://jvet-experts.org/doc_end_user/current_document.php?id=13396) AHG8/AHG9: Truncated bit depth support SEI messages [D. Ding, X. Zhao, S. Liu, G. Teniou, S. Wenger (Tencent)]

[JVET-AF0140](https://jvet-experts.org/doc_end_user/current_document.php?id=13398) [AHG9] Inter Picture Dependency SEI message [G. Teniou, S. Wenger, S. Liu (Tencent)]

[JVET-AF0141](https://jvet-experts.org/doc_end_user/current_document.php?id=13399) AHG9: SEI messages for common image metadata formats [A. Hinds, S. Wenger (Tencent)]

[JVET-AF0142](https://jvet-experts.org/doc_end_user/current_document.php?id=13400) [AHG9] Local Film Grain Synthesis using Annotated Regions SEI [G. Teniou, S. Wenger (Tencent)]

JVET-AF0142 also relates to the mandate to study SEI messages in VSEI, VVC, HEVC and AVC.

[JVET-AF0144](https://jvet-experts.org/doc_end_user/current_document.php?id=13402) [AHG9] Adaptive Film grain synthesis using Alpha Channel Information SEI message [G. Teniou, S. Wenger (Tencent)]

JVET-AF0144 also relates to the mandate to study SEI messages in VSEI, VVC, HEVC and AVC.

[JVET-AF0147](https://jvet-experts.org/doc_end_user/current_document.php?id=13405) AHG8/AHG9: On Picture Modality Type [J. Gao, H.-B. Teo, C.-S. Lim, K. Abe (Panasonic)]

[JVET-AF0148](https://jvet-experts.org/doc_end_user/current_document.php?id=13406) [AHG9] Large SEI message signalling [G. Teniou, S. Wenger (Tencent)]

[JVET-AF0149](https://jvet-experts.org/doc_end_user/current_document.php?id=13407) [AHG9] Application-required SEI NAL Units [G. Teniou, S. Wenger (Tencent)]

[JVET-AF0167](https://jvet-experts.org/doc_end_user/current_document.php?id=13425) AHG9: On the Proposed Multiplane Image Information SEI Message [T. Lu, P. Yin, S. Oh, S. McCarthy, W. Husak, G. J. Sullivan (Dolby)]

JVET-AF00167 also relates to the mandate to collect software and showcase information for SEI messages.

* 1. ***Study the alignments of the same SEI messages in different standards***

[JVET-AF0045](https://jvet-experts.org/doc_end_user/current_document.php?id=13289) AHG2/AHG9: On the use of NNPF SEI messages in AVC [M. M. Hannuksela (Nokia)]

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.

Topics that could possibly be discussed in BoG: 6.1-6.4, 6.6-6.8

[JVET-AF0010](https://jvet-experts.org/doc_end_user/current_document.php?id=13381) JVET AHG report: Encoding algorithm optimization (AHG10) [P. de Lagrange, A. Duenas, R. Sjöberg, A. Tourapis (AHG chairs)]

1. **Related contributions**

A total of 5 contributions, not including cross-checks, are identified relating to AHG10, and summarized in the following sections.

* 1. ***DMVR encoder control***
     1. **JVET-AF0057 – EE2-3.5: DMVR with robust MV derivation**

Though this contribution in an EE2 test, it contains an encoder-only aspect (test 3.5b), maxing out the RD cost of coding modes where DMVR is likely to create annoying artefacts. The BD-rate impact can be up to around 2% for high QPs (the normative solution seems to have both much less BD-rate impact and better subjective quality).

* 1. ***Adaptive resolution***
     1. **JVET-AF0058 – AHG12: GOP-based RPR encoder control for ECM**

This contribution proposes to port the GOP-base RPR encoder control feature available in the VTM to ECM. The gains seem to be reduced by more than half, but are still significant (around 1.5%; more than 3% in class A). It is said that subjective quality is also improved.

* 1. ***Local QP optimization***
     1. **JVET-AF0089 - AhG10: Lagrange multiplier and QP adaptation at CTU-level for VVC**

This contribution proposes a method that tries to give more quality weight to local areas that are likely to be reused in other picture (through temporal prediction). It does so by estimating a “distortion propagation factor” with a fast 1st inter pass. BD-Rate of around -4% is reported for LD and -0.25% for RA.

This is probably related to the “block importance mapping” feature present since VTM-16.0 (but not enable that default), that makes use of MCTF-derived metrics, and gives around -2% BD-rate for both RA and LD.

* 1. ***Fast methods***
     1. **JVET-AF0111 – AHG10: MTT split modes early termination**

This contribution further studies an early termination method that reduces encoding runtime for ECM and VTM (JVET-AE0057, adopted in ECM CTC, and VTM but not in CTC), by skipping MTT splits when the no-split cost of 64x64 CU is above a threshold. Other bit depths and larger QP range are tested, and some threshold adjustments are made. Encoding times of -3% to -4% are reported, with a BD-rate difference in the range of +0.02% to +0.06%, the tradeoff being improved compared to JVET-AE0057 for high QP values.

* 1. ***Lamba optimization***
     1. **JVET-AF0122 - AhG10: Lagrange multiplier optimization for chroma ALF and CCALF**

As in JVET-AD0136 and JVET-AE0123, 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 signaling, and also encourage combined signaling (resulting in more chroma filter diversity). Chroma gains are reported.

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-AF0011](https://jvet-experts.org/doc_end_user/current_document.php?id=13382) JVET AHG report: Neural network-based video coding (AHG11) [E. Alshina, F. Galpin, S. Liu, A. Segall (co chairs), J. Li, R.-L. Liao, D. Rusanovskyy, T. Shao, M. Wien, P. Wu (vice chairs)]

1. **Activities**

The AHG used the main JVET reflector, jvet@lists.rwth-aachen.de, for email. Nine emails were exchanged on the reflector related to the AHG mandates.

* 1. ***Common Test Conditions***
     1. **Document**

The AHG released revised common test conditions as decided at the 31st meeting, including the following changes:

* Define the software anchor to be either NNVC-6.0 or the latest version of NNVC.
* Section 2 (Editorial): Change “a set” to “the set”.
* Section 3.3 (Editorial): Clarify how decoder runtime should be calculated when parallel processing is used. Specifically, clarify that the decoding run-time can be calculated in the same way as what’s defined for PSNR and MS-SSIM. That is, it can be calculated by either concatenated the bit-streams and performing a single decode or summing up the parallel decoding runtimes across segments.
* Other editorial improvements.
  + 1. **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>.

* 1. ***EE Coordination***

The AHG finalized, conducted, and discussed the EE on NN based video coding. A summary report for the EE is available at this meeting as:

|  |  |  |
| --- | --- | --- |
| JVET-AF0023 | 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) |

* 1. ***Teleconferences***

The AHG conducted a joint teleconference with AHG14 and EE1 during the interim period. The teleconference was held on August 9, 2023. In this teleconference the progress of High Operation Point (HOP) NN-based filter training was discussed. Authors of JVET-AE0191 presented results of the third (last) stage training. Final results were reported in JVET-AF0041.

Low Operation Point (LOP) unified filter training status was also discussed.

On August 30, 2023, a second joint teleconference with AHG 14 was held to discuss further LOP training status. The training process and test results for each stage of training and inference testing are reported in JVET-AF0043.The meeting minutes are reported in JVET-AF0042. :

* 1. ***Performance Evaluation***

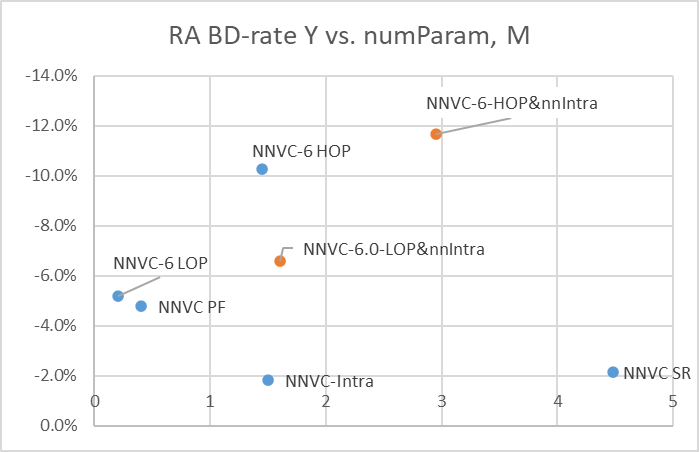
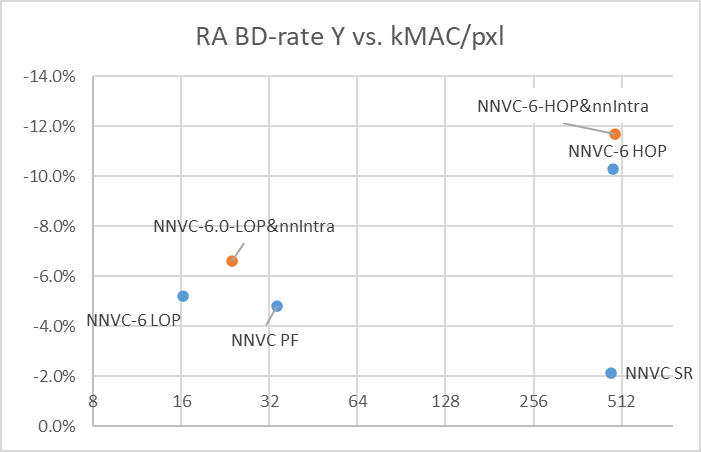
The performance of the NNVC-6.0 anchor compared to VTM anchor is reported below. By default, NN-Intra and Low Operation Point (LOP.1) filter are enabled in NNVC-6.0.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |  |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |  |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU | PSNR Overlap |
| Class A1 | -7.2% | -4.9% | -6.0% | -8.7% | -4.1% | -5.1% | 134% | 7667% | 96% |
| Class A2 | -6.6% | -5.8% | -5.1% | -6.5% | -4.1% | -2.9% | 130% | 7183% | 97% |
| Class B | -6.3% | -8.2% | -7.5% | -6.0% | -6.1% | -5.2% | 132% | 7834% | 98% |
| Class C | -6.6% | -10.5% | -9.6% | -6.3% | -7.9% | -5.6% | 132% | 7422% | 98% |
| Class E |  |  |  |  |  |  |  |  |  |
| **Overall** | **-6.6%** | **-7.7%** | **-7.3%** | **-6.7%** | **-5.8%** | **-4.8%** | **132%** | **7557%** | **97%** |
| Class D | -7.6% | -9.4% | -9.7% | -5.8% | -6.8% | -5.9% | 129% | 8193% | 98% |
| Class F | -3.1% | -5.9% | -4.9% | -3.0% | -4.8% | -3.5% | 148% | 9739% | 99% |
| Class H |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **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 | PSNR Overlap |
| Class A1 |  |  |  |  |  |  |  |  |  |
| Class A2 |  |  |  |  |  |  |  |  |  |
| Class B | -4.8% | -8.1% | -7.8% | -5.1% | -6.2% | -6.6% | 134% | 6812% | 99% |
| Class C | -5.2% | -11.1% | -9.0% | -5.6% | -10.7% | -4.0% | 126% | 6233% | 99% |
| Class E | -4.9% | -4.1% | -5.2% | -5.6% | -2.2% | -3.4% | 162% | 9877% | 98% |
| **Overall** | **-5.0%** | **-8.1%** | **-7.6%** | **-5.4%** | **-6.7%** | **-4.9%** | **138%** | **7257%** | **99%** |
| Class D | -6.5% | -10.8% | -9.8% | -5.8% | -9.5% | -6.8% | 125% | 6400% | 98% |
| Class F | -2.0% | -4.9% | -4.5% | -2.3% | -3.1% | -4.1% | 148% | 8941% | 99% |
| Class H |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **All Intra Main10** | | | | | | | |  |
|  | **BD-rate Over NNVC-4.0** | | | | | | | |  |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU | PSNR Overlap |
| Class A1 | -8.5% | -7.2% | -8.7% | -10.0% | -8.0% | -7.5% | 210% | 5134% | 97% |
| Class A2 | -6.6% | -8.0% | -7.9% | -6.9% | -6.4% | -5.4% | 204% | 4416% | 98% |
| Class B | -7.0% | -8.6% | -8.7% | -7.0% | -7.6% | -7.0% | 203% | 4493% | 98% |
| Class C | -7.3% | -9.8% | -9.9% | -7.6% | -8.4% | -7.6% | 190% | 3770% | 98% |
| Class E | -10.3% | -9.0% | -8.8% | -10.1% | -7.5% | -6.4% | 199% | 5149% | 96% |
| **Overall** | **-7.8%** | **-8.6%** | **-8.9%** | **-8.2%** | **-7.6%** | **-6.9%** | **201%** | **4507%** | **97%** |
| Class D | -7.6% | -8.1% | -9.3% | -7.2% | -6.8% | -7.6% | 180% | 3760% | 98% |
| Class F | -4.6% | -6.0% | -5.6% | -4.2% | -4.8% | -4.4% | 155% | 3961% | 98% |
| Class H |  |  |  |  |  |  |  |  |  |

Compression performance of other tools available in NNVC depending on two complexity metrics (kMAC/pxl and total member for parameters) is shown on plots below. Performance of tools under study in EE1 can be found in EE1 report.

Major trends in EE1 tests are

* complexity reduction of High Operation point (HOP) NN-filter, there is good chance to reduce complexity from 477 kMAC/pxl to lower than 400 kMAC/pxl almost w/o performance drop.
* More studies on training parameters, filter usage policy etc. from past filterset are studied in HOP/LOP.
* Performance improvement of Low Operation point (LOP) NN-filter, jointly trained new LOP provides 0.2% Luma gain and 4% Chroma gain over existing in NNVC-6 LOP filter, maintaining almost the same kMAC/pxl;
* Complexity reduction for NN-Intra, studied in EE1 version of NN-Intra reduces complexity from 7.8 KMAC/pxl to 4.8 kMAC/pxl;
* Content adaptation mechanisms of NN-filter are mostly useful in LDB configuration;
* NN-Inter studied in EE1 shows decoder run time increment comparable with other NNVC tools.

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1. **Input contributions**

There are 35 input contributions related to the AHG mandates. The list of input contributions is provided below.

* 1. ***EE and Related Input Contributions***

|  |  |  |
| --- | --- | --- |
| **Reporting** | | |
| [JVET-AF0023](file:////Users/shanl/Documents/contribution/jvet31ae/current_document.php%3fid=13091) | 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 Technology** | | |
| [JVET-AF0043](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13287) | AhG11/EE1: Status of the joint EE1-0 (LOP.2) training | [D. Rusanovskyy](mailto:dmytror@qti.qualcomm.com), [Y. Li (Qualcomm)](mailto:yli30@qti.qualcomm.com), [T. Shao](mailto:Tong.Shao@dolby.com), [P. Yin, S. McCarthy (Dolby)](mailto:pyin@dolby.com), [J. N. Shingala](mailto:jay.shingala@ittiam.com), [A. Shyam](mailto:ajayshyam@ittiam.com), [A. Suneja](mailto:ajat.suneja@ittiam.com), [S. P. Badya (Ittiam)](mailto:siddarth.badya@ittiam.com), [J. Li](mailto:lijunru@bytedance.com), [Y. Li](mailto:yue.li@bytedance.com), [C. Lin](mailto:linchaoyi.cy@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com), [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-AF0056](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13304) | EE1-1.2.2: Content-adaptive LOP filter | [R. Yang](mailto:ruiying.yang@nokia.com), [M. Santamaria](mailto:maria.santamaria_gomez@nokia.com), [F. Cricri](mailto:francesco.cricri@nokia.com), [H. Zhang](mailto:honglei.1.zhang@nokia.com), [J. Lainema](mailto:jani.lainema@nokia.com), [M. M. Hannuksela](mailto:miska.hannuksela@nokia.com), [A. Hallapuro (Nokia)](mailto:antti.hallapuro@nokia.com) |
| [JVET-AF0071](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13319) | EE1-related: Further complexity reduction on the joint EE1-0 (LOP.2) unified filter | [T. Shao](mailto:tong.shao@dolby.com), [P. Yin](mailto:pyin@dolby.com), S. McCarthy (Dolby), [J. N. Shingala](mailto:jay.shingala@ittiam.com), [A. Shyam](mailto:ajayshyam@ittiam.com), A. Suneja, S. P. Badya (Ittiam) |
| [JVET-AF0085](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13333) | EE1-1.2.1: On residual adjustments for NNLF | [Z. Dai](mailto:daizhenyu@oppo.com), [Y. Yu](mailto:yue.yu@oppo.com), [H. Yu](mailto:v-yuhaoping@oppo.com), [D. Wang (OPPO)](mailto:wangdong7@oppo.com) |
| [JVET-AF0086](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13334) | EE1-1.2.6: On flipping of input and output of model in NNVC HOP filter | [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) |
| [JVET-AF0102](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13349) | EE1-1.1.2 Complexity-performance tradeoff of decomposition | [D. Rusanovskyy](mailto:dmytror@qti.qualcomm.com), [Y. Li](mailto:yli30@qti.qualcomm.com), [M. Karczewicz (Qualcomm)](mailto:martak@qti.qualcomm.com) |
| [JVET-AF0103](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13350) | EE1-1.1.3 Study on input feature set optimization | [D. Rusanovskyy](mailto:dmytror@qti.qualcomm.com), [Y. Li](mailto:yli30@qti.qualcomm.com), [M. Karczewicz (Qualcomm)](mailto:martak@qti.qualcomm.com) |
| [JVET-AF0139](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13397) | EE1-3.1: Neural network-based intra prediction with reduced complexity | [T. Dumas](mailto:thierry.dumas@interdigital.com), F. Galpin, P. Bordes (InterDigital) |
| [JVET-AF0153](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13411) | EE1-1.1.1: Optimization for complexity-performance trade-off of HOP network | [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-AF0154](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13412) | EE1-1.2.3: Input and output rotation of model for NNVC in-loop filter | [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-AF0181](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13439) | EE1-1.1.4.a: Simplified feature extraction for HOP | [Y. Li](mailto:yue.li@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com) |
| [JVET-AF0182](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13440) | EE1-1.1.4.b: Group convolution for HOP | [Y. Li](mailto:yue.li@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com) |
| [JVET-AF0183](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13441) | EE1-1.1.4.c/d: Separate models for HOP | [Y. Li](mailto:yue.li@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com) |
| [JVET-AF0192](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13453) | EE1-1.1.5: Combination test of EE1-1.1.1 and EE1-1.1.2 | [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), [D. Rusanovskyy](mailto:dmytror@qti.qualcomm.com), [Y. Li](mailto:yli30@qti.qualcomm.com), [M. Karczewicz (Qualcomm)](mailto:martak@qti.qualcomm.com) |
| [JVET-AF0205](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13466) | EE1-1.2.4: An improved inference design of NN-based loop-filters at high operation point | [J. Li](mailto:lijunru@bytedance.com), [Y. Li](mailto:yue.li@Bytedance.com), [C. Lin](mailto:linchaoyi.cy@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com) |
| [JVET-AF0208](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13471) | EE1-2.1: Deep Reference Frame Generation for Inter Prediction Enhancement | [W. Bao](mailto:baoweijie@whu.edu.cn), [X. Chen](mailto:cinched@whu.edu.cn), [J. Jia](mailto:jiajh2021@whu.edu.cn), [Y. Zhang](mailto:yuantongzhang@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) |
| Cross Checks | | |
| [JVET-AF0119](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13366) | Crosscheck of JVET-AF0056 (EE1-1.2.2: Content-adaptive LOP filter) | [J. N. Shingala](mailto:jay.shingala@ittiam.com), [A. Shyam](mailto:ajayshyam@ittiam.com), [S. P. Badya (Ittiam)](mailto:siddarth.badya@ittiam.com) |
| [JVET-AF0216](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13479) | Crosscheck of JVET-AF0056 (EE1-1.2.2: Content-adaptive LOP filter) | [Z. Dai (OPPO)](mailto:daizhenyu@oppo.com) |
| [JVET-AF0217](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13480) | Crosscheck of JVET-AF0139 (EE1-3.1: neural network-based intra prediction with reduced complexity) | [Z. Dai (OPPO)](mailto:daizhenyu@oppo.com) |
| [JVET-AF0254](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13517) | Cross-check of JVET-AF0085 (EE1-1.2.1: on residual adjustments of NNLF) | [T. Dumas (Interdigital)](mailto:thierry.dumas@interdigital.com) |
| [JVET-AF0257](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13520) | Crosscheck of JVET-AF0154 (EE1-1.2.3: Input and output rotation of model for NNVC in-loop filter)) | [D. Liu (Ericsson)](mailto:du.liu@ericsson.com) |
| [JVET-AF0258](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13521) | Crosscheck of JVET-AF0103 (EE1-1.1.3 Study on input feature set optimization) | F. Galpin (InterDigital) |
| [JVET-AF0260](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13523) | Crosscheck of JVET-AF0183 (EE1-1.1.4.c/d: Separate models for HOP) | F. Galpin (InterDigital) |

* 1. ***Non-EE Input Contributions***

|  |  |  |
| --- | --- | --- |
| **Reporting** | | |
| [JVET-AF0011](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13382) | JVET AHG report: Neural network-based video coding (AHG11) | E. Alshina, F. Galpin, S. Liu, A. Segall (co chairs), J. Li, R.-L. Liao, D. Rusanovskyy, T. Shao, M. Wien, P. Wu (vice chairs) |
| [JVET-AF0041](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13285) | AhG11: HOP full results | [F. Galpin (InterDigital)](mailto:franck.galpin@interdigital.com), D. Rusanovskyy, Y. Li (Qualcomm), Y. Li, J. Li (ByteDance), L. Wang, R. Chang (Tencent), Z. Xie (OPPO), E. Alshina (Huawei) |
| [JVET-AF0042](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13286) | AhG11/AhG14 teleconference | [E. Alshina](mailto:elena.alshina@huawei.com), [F. Galpin](mailto:franck.galpin@interdigital.com) |
| Proposal | | |
| [JVET-AF0143](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13401) | AHG11: Unified CNN super resolution for resampling-based video coding | [C. Lin](mailto:linchaoyi.cy@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-AF0150](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13408) | AhG11: on HOP batch size | [F. Galpin](mailto:franck.galpin@interdigital.com), T. Dumas, P. Bordes (InterDigital) |
| [JVET-AF0155](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13413) | AhG11: on HOP luma/chroma balance | [F. Galpin](mailto:franck.galpin@interdigital.com), T. Dumas, P. Bordes (InterDigital) |
| [JVET-AF0158](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13416) | AHG11: HOP In-loop filter with transformer blocks | [Y. Li](mailto:yli30@qti.qualcomm.com), [D. Rusanovskyy](mailto:dmytror@qti.qualcomm.com), [T. Ryder](mailto:tryder@qti.qualcomm.com), [S. Eadie](mailto:seadie@qti.qualcomm.com), [M. Karczewicz (Qualcomm)](mailto:martak@qti.qualcomm.com) |
| [JVET-AF0180](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13438) | AHG11: HOP training adjustment to improve luma/chroma coding gain balance | [D. Rusanovskyy](mailto:dmytror@qti.qualcomm.com), [Y. Li](mailto:yli30@qti.qualcomm.com), [M. Karczewicz (Qualcomm)](mailto:martak@qti.qualcomm.com) |
| [JVET-AF0193](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13454) | AHG11: Decoder complexity optimization for NNVC in-loop filter | [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-AF0206](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13467) | AHG11: Complexity reduction of NN-based loop-filters | [J. Li](mailto:lijunru@bytedance.com), [Y. Li](mailto:yue.li@Bytedance.com), [C. Lin](mailto:linchaoyi.cy@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com) |
| Cross Checks | | |
| [JVET-AF0256](file:///C:\Users\e00443164\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\8LUVY5N7\current_document.php%3fid=13519) | Crosscheck of JVET-AF0193 (AHG11: Decoder complexity optimization for NNVC in-loop filter) | [D. Liu (Ericsson)](mailto:du.liu@ericsson) |

1. **Recommendations**

The AHG recommends:

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

It was suggested to also look into more combinations of tools, such as LF and inter pred., super resolution, in the upcoming EE.

[JVET-AF0012](https://jvet-experts.org/doc_end_user/current_document.php?id=13383) 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, Y. Yu (vice-chairs)]

1. **Activities**

The Common Test Conditions were updated (JVET-AE2017). The peak memory usage has been added to the reporting template. The primary activity of the AHG was the “Exploration experiment on enhanced compression beyond VVC capability” (JVET-AE2024). The combined improvements of the ECM-10.0 over VTM-11.0ecm10.0 anchorfor AI, RA and LB configurations are:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | All Intra Main10 | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 | -10.55% | -21.81% | -29.24% | 915.8% | 439.3% |
| Class A2 | -16.68% | -28.60% | -31.54% | 916.2% | 458.0% |
| Class B | -11.02% | -26.58% | -24.82% | 826.4% | 455.0% |
| Class C | -11.07% | -16.52% | -17.06% | 898.0% | 452.7% |
| Class E | -14.59% | -24.40% | -22.89% | 804.1% | 467.8% |
| Overall | **-12.49%** | **-23.52%** | **-24.63%** | **867.2%** | **454.4%** |
| Class D | -9.17% | -14.38% | -14.35% | 851.0% | 445.1% |
| Class F | -26.21% | -35.26% | -35.17% | 541.1% | 452.7% |
| Class TGM | -39.28% | -47.12% | -46.45% | 457.3% | 496.2% |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Random Access Main 10 | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 | -22.25% | -27.01% | -36.07% | 882.3% | 784.9% |
| Class A2 | -25.50% | -35.13% | -38.75% | 791.3% | 889.0% |
| Class B | -20.50% | -34.42% | -32.13% | 673.3% | 731.6% |
| Class C | -21.91% | -26.29% | -26.07% | 708.2% | 777.7% |
| Class E |  |  |  |  |  |
| Overall | **-22.23%** | **-30.91%** | **-32.63%** | **744.0%** | **784.1%** |
| Class D | -22.87% | -27.80% | -28.10% | 738.6% | 851.2% |
| Class F | -28.30% | -36.71% | -37.10% | 602.2% | 482.5% |
| Class TGM | -36.63% | -43.02% | -43.08% | 570.5% | 415.0% |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Low Delay B Main 10 | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -17.55% | -38.06% | -35.34% | 589.9% | 668.2% |
| Class C | -19.29% | -28.96% | -29.31% | 648.1% | 710.0% |
| Class E | -16.12% | -28.03% | -27.57% | 642.1% | 459.1% |
| Overall | **-17.77%** | **-32.52%** | **-31.39%** | **621.7%** | **620.8%** |
| Class D | -21.17% | -30.48% | -30.27% | 656.7% | 758.7% |
| Class F | -24.60% | -37.20% | -36.64% | 588.5% | 498.3% |
| Class TGM | -35.27% | -43.12% | -43.29% | 560.3% | 418.2% |

The rate reduction for natural sequences over VTM in RA configuration for {Y, U, V} increased from ECM-9.0’s {-21.03%, -28.42%, -29.93%} to ECM-10.0’s {-22.23%, -30.91%, -32.63%}. For SCC sequences (class TGM) the rate reduction for RA configuration increased from ECM-9.0’s {-35.17%, -41.66%, -41.35%} to ECM-10.0’s {-36.63%, -43.02%, -43.08%}.

1. **Contributions**

In addition to 24 EE2 contributions, 48 (comparing to 52 last meeting) EE2-related and AHG12-related contributions were received. There are also 7 contributions to AHG6 and AHG10 which address ECM encoder performance. The EE2-related and AHG12-related contributions can be subdivided as follows:

* 1. **Intra *(7)***

JVET-AF0059, "AHG12: Fix to interpolation filter for intra prediction", K. Andersson (Ericsson)

JVET-AF0083, "Non-EE2: Enhancements on CCP merge for chroma intra coding", H. Huang, Y. Yu, H. Yu, D. Wang (OPPO), Z. Deng, K. Zhang, L. Zhang (Bytedance)

JVET-AF0106, "EE2-related: Non-adjacent spatial candidates for DIMD merge", J. Huo, J. Fan, Z. Zhang, Y. Ma, F. Yang (Xidian Univ.), M. Li (OPPO)

JVET-AF0114, "AHG12: Local-Boosting on Cross-Component Merge Mode", H. Qin, K. Ding, Z. Xu (TCL)

JVET-AF0176, "Non-EE2: Decoder Derived Cross-Component Prediction", Y.-J. Chang, P.-H. Lin, V. Seregin, J.-L. Lin, M. Karczewicz (Qualcomm)

JVET-AF0199, "Non-EE2: Bilateral Filtering for Intra Prediction", W. Yin, K. Zhang, Y. Wang, L. Zhang (Bytedance)

JVET-AF0246, "AHG12: Harmonization of intra prediction mode derivation from neighboring blocks", D. Kim, K. Kim, J.-H. Son, J. -S. Kwak (WILUS)

* 1. **IntraTMP *and IntraBC (15)***

JVET-AF0053, "EE2-related: Test 2.5a and TIMD fusion improvement", P. Andrivon, M. Blestel (Ofinno), K. Naser, F. Le Léannec, P. Bordes, F. Galpin, A. Robert (InterDigital)

JVET-AF0072, "AHG12: FIBC flag inherits IntraTMP-FLM flag", M.-H. Jia, Y. Gao, Y. -X. Bai, S.-W. Xie, P. Wu, C. Huang (ZTE)

JVET-AF0084, "Non-EE2: Update on IBC-LIC Model Merge mode", L. Zhang, Y. Yu, H. Yu, D. Wang (OPPO)

JVET-AF0115, "Non-EE2: IBC with a further upward-extended reference area for screen content", Y. Kidani, H. Kato, K. Kawamura (KDDI)

JVET-AF0116, "Non-EE2: slope adjustment for IBC LIC", C. Ma, X. Xiu, W. Chen, H.-H.Jhu, C.-W. Kuo, N. Yan, X. Wang (Kwai)

JVET-AF0117, "Non-EE2: extensions of IBC GPM", C. Ma, X. Xiu, W. Chen, H.-H.Jhu, C.-W. Kuo, N. Yan, X. Wang (Kwai)

JVET-AF0129, "Non-EE2: Auto relocated block vector prediction", N. Zhang, K. Zhang, L. Zhang (Bytedance)

JVET-AF0132, "Non-EE2: Optimization of TIMD blending mode", C. Zhou, Z. Lv (vivo)

JVET-AF0137, "AHG12: IntraTMP with Merge Candidates", K. Naser, F. Le Léannec, A. Robert, F. Galpin (InterDigital)

JVET-AF0161, "AHG12: Harmonized IBC/ITMP search area with adaptive sampling", D. Ruiz Coll, B. Chen, (Ofinno), K. Naser, P. Bordes, F. Le Léannec, F. Galpin, (InterDigital)

JVET-AF0162, "AHG12: Fixes to template matching", J. Chen, R.-L. Liao, X. Li, Y. Ye (Alibaba)

JVET-AF0166, "Non-EE2: Intra TMP fusion probing", J.-L. Lin, P.-H. Lin, Y.-J. Chang, Z. Zhang, V. Seregin, M. Karczewicz (Qualcomm)

JVET-AF0184, "Non-EE2: Search range optimization for Intra TMP", G. Verba, Z. Zhang, V. Seregin, M. Karczewicz (Qualcomm)

JVET-AF0226, "AHG12: SGPM with IntraTMP and IBC", K. Naser, F. Le Léannec, P. Bordes, Y. Chen (InterDigital)

JVET-AF0248, "Non-EE2: TIMD fusion optimization", P. Andrivon, M. Blestel (Ofinno), C. Zhou, Zhuoyi Lv (vivo)

* 1. **Inter *(12)***

JVET-AF0113, "Non-EE2: Modifications of affine merge candidates", K. Kim, D. Kim, J.-H. Son, J.-S. Kwak (WILUS)

JVET-AF0118, "Non-EE2: Regression-based GPM blending", P. Bordes, F. Galpin, K. Naser, F. Urban, K. Reuze, F. Le Leannec, E. Francois (InterDigital)

JVET-AF0121, "AHG12: Adjusting out-of-boundary prediction samples", P. Astola, J. Lainema (Nokia)

JVET-AF0134, "AHG12: AMVP with SbTMVP mode", R.-L. Liao, J. Chen, Y. Ye, X. Li (Alibaba)

JVET-AF0135, "AHG12: Additional SbTMVP candidates", R.-L. Liao, J. Chen, Y. Ye, X. Li (Alibaba)

JVET-AF0160, "Non-EE2: On DMVR Extensions", M. Salehifar, Y. He, K. Zhang, L. Zhang (Bytedance)

JVET-AF0168, "Non-EE2: Geometric partitioning mode with affine prediction", K. Zhang, Z. Deng, L. Zhang (Bytedance)

JVET-AF0170, "Non-EE2: CIIP with subblock-based motion compensation", L. Zhao, K. Zhang, L. Zhang (Bytedance)

JVET-AF0171, "Non-EE2: Sample distance-based weighting for CIIP", J. Zhao, S. Kim (LGE)

JVET-AF0191, "Non-EE2: Enhancements on local illumination compensation", X. Xiu, C. Ma, N. Yan, H.-J. Jhu, C.-. Kuo, W. Chen, X. Wang (Kwai)

JVET-AF0194, "Non-EE2: On LIC flag in merge mode", Y. Zhang, V. Seregin, H. Wang, Z. Zhang, C.-C. Chen, H. Huang, M. Karczewicz (Qualcomm)

JVET-AF0200, "Non-EE2: Extension of local illumination compensation", Y. Wang, K. Zhang, Y. He, H. Liu, L. Zhang (Bytedance)

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

JVET-AF0169, "Non-EE2: Adaptive clipping with signaled lower and upper bounds", K. Cui, Z. Zhang, H. Huang, V. Seregin, M. Karczewicz (Qualcomm)

JVET-AF0178, "Non-EE2: Applying fixed filters to output of the Gaussian filter", N. Hu, M. Karczewicz, V. Seregin (Qualcomm)

JVET-AF0179, "Non-EE2: Fixed filter for Chroma ALF", N. Hu, M. Karczewicz, H. Wang, V. Seregin (Qualcomm)

JVET-AF0198, "Non-EE2: Coefficient Precision Adjustment for ALF", W. Yin, K. Zhang, L. Zhang (Bytedance)

* 1. **Transform *(2)***

JVET-AF0082, "Non-EE2: On LFNST/NSPT for inter coding", F. Wang, J. Gan, Y. Yue, H. Yu, D. Wang (OPPO)

JVET-AF0104, "Non-EE2: Direct Decoder-side Intra Mode Derivation for IntraTMP blocks", J. Huo, N. Qiu, Y. Ma, F. Yang (Xidian Univ.), Ming Li (OPPO)

* 1. ***Coefficients and Entropy Coding (4)***

JVET-AF0151, "EE2 related: CABAC parameters retraining", F. Galpin, F. Lo Bianco, C. Salmon-Legagneur, K. Naser (InterDigital)

JVET-AF0164, "AHG12: CABAC inter/intra model switch", F. Lo Bianco, F. Galpin, C. Salmon-Legagneur (InterDigital)

JVET-AF0185, "Non-EE2: Transform Coefficient Coding", P. Nikitin, M. Karczewicz, M. Coban, V. Seregin (Qualcomm)

JVET-AF0202, "EE2 related: CABAC context initialization retraining and slice type based window offsets", V. Seregin, M. Karczewicz (Qualcomm)

* 1. **Other *(4)***

JVET-AF0058, "AHG12: GOP-based RPR encoder control for ECM", K. Andersson, J. Ström, R. Yu, W. Ahmad, P. Wennersten (Ericsson)

JVET-AF0101, "AHG12: ECM software cleanup for decoder side intra predictions acceleration", Z. Fan, Y. Yasugi, T. Ikai (Sharp)

JVET-AF0165, "Ahg12: On VTM-11ecm anchor low-delay test conditions", F. Le Léannec, S. Puri, E. François, K. Naser (InterDigital)

JVET-AF0187, "Compression of Gaming Contents", Z. Lin, K. Cai, J. Sauer, Y. Zhao, E. Alshina (Huawei)

1. **Recommendations**

The AHG recommends to:

* To review all the related contributions.

[JVET-AF0013](https://jvet-experts.org/doc_end_user/current_document.php?id=13384) JVET AHG report: Film grain technologies (AHG13) [W. Husak, P. de Lagrange (co-chairs), A. Duenas, D. Grois, Y. He, X. Meng, M. Radosavljević, A. Segall, A. Tourapis, W. Zhang (vice-chairs)]

1. **Discussion**

For this AHG period, there were three major topics of conversation. ISO/IEC 23002-9 DTR was edited to reflect the National Body (NB) comments received in the CDTR period and style recommendations from SC29. The group also discussed content containing film grain for development, demonstrations, and testing of systems and processes. The final topic discussed was profiling and conformance for film grain synthesis.

There was substantial editing required to resolve the CDTR comments. Most were changes due to editorial comments. There were also some comments that required more detailed technical text additions. Other comments suggested reorganizing parts of the document for flow and appearance. Finally, SC29 advised redrawing the graphics to separate the text from the graphics for editing and translation for other languages.

An extensive amount of time was spent on content. Apple created a dataset using both content captured by Apple and content that is publicly available. The dataset is comprised of 20 sequences with 27 variants and is stored as 16-bit TIFFs yielding approximately 50TB. The dataset includes files that are considered “ground truth” files that are nominally noise free. A collection of representative still images was circulated for feedback and critique. Apple intends to distribute some or all of the content set in the future. Five other companies are looking at providing content.

Another major topic of discussion was profiling and conformance. The group felt profiling was out-of-scope for this AHG period however, the group recognized that conformance was worth exploring. This is because the group discussed conformance in the past and it was recognized that ISO/IEC/ITU could perform a valuable service by describing how an organization could approach conformance. This is not meant to exclude ISO/IEC/ITU as a conformance entity, just that at present, a common method (or methods) for film grain conformance could be explored and documented for other entities that may create conformance test plans and streams.

In the past, AHG13 discussed hard conformance, no conformance, and soft conformance. Due to a number of issues, soft conformance seems comfortable for discussion. The group enumerated several potential sources for inspiration when considering soft conformance including:

1. AOM’s philosophy for film grain conformance
2. Conformance for VPCC and/or V3C
3. Conformance for HDR – SL-HDR(x)

Most of the discussion was centered on AOM’s philosophy with comparable practices being used in V3C/VPCC and SL-HDR(x) for similar reasons. AOM offers two types of conformance methods: 1) hard conformance where a decoder can produce a bit-exact representation of the film grain, and 2) soft conformance that allows implementers to modify their video display path but still produces a “similar” film grain look with a variety of video processing pipelines. What is considered as “similar” is defined by distributors and not AOM.

There was also a discussion about a future version of the report that may contain an annex or even a section describing how a group could create a conformance program. In this way, application SDOs (or even SC29 groups) could have guidelines and tools for developing programs that could be consistent.

1. **Related contributions**

Eight contributions related to AHG13 were identified as of 10/10/2023.

* The one contribution was the AHG report:
  + JVET-AE0013 JVET AHG report: Film grain technologies (AHG13)
* Seven other contributions were added at the time of the report drafting:
  + JVET-AF0142 Local Film Grain Synthesis using Annotated Regions SEI
  + JVET-AF0144 Adaptive Film grain synthesis using Alpha Channel Information SEI message
  + JVET-AF0209 Frequency domain Film Grain Objective Metrics
  + JVET-AF0210 Exploration on the Capability of Frequency-Based Film Grain Synthesis
  + JVET-AF0262 New Film Grain Material based on a Ground Truth approach
  + JVET-AF0263 Suggested process for measuring Grain Fidelity using the Ground Truth test set
  + JVET-AF0274 film grain tuning tool
  1. **Contributions**

There were seven contributions uploaded other than the AHG report.

* + 1. **JVET-AF0142 Local Film Grain Synthesis using Annotated Regions SEI**

Film Grain Synthesis (aka FGS) is a tool aimed at maintaining the original film grain while preserving the encoding efficiency due to its random nature and complexity. While being used to maintain the artistic intent or to mitigate visual artefacts, film grain is not necessarily applicable to the entire picture. This contribution proposes to address the film grain synthesis applied locally on the picture by using the annotated regions as a mask.

The film grain characteristics SEI message has been defined in the VSEI specification to synthetize the grain of the content without encoding it. Today, it lacks the identification of the regions where it is only applicable in the image.

The proposed approach intends to define the labels "FGS-E" and "FGS-D" for FGS enabled and FGS disabled respectively. When one of these labels is identified in the list of labels from the Annotated Regions SEI message, the application of the film grain synthesis is limited to each object with the same label.

* + 1. **JVET-AF0144 Adaptive Film grain synthesis using Alpha Channel Information SEI message**

Film Grain Synthesis (aka FGS) is a tool aimed at maintaining the original film grain while preserving the encoding efficiency due to its random nature and complexity. While being used to maintain the artistic intent or to mitigate visual artefacts, film grain is not seen relevant for the entire sequence or even within an image. This contribution proposes to address the film grain synthesis applied locally on a per image basis by using the auxiliary data as a mask.

The film grain characteristics SEI message has been defined to synthetize the grain of the content without encoding it. Today, it lacks the spatial adaptation to the image.

The VSEI specification also specifies the Alpha Channel Information (ACI) SEI messages that defines how to combine the auxiliary data with the output image for alpha blending.

The ACI SEI message has 2 defined modes in alpha\_channel\_use\_idc: mode 0: multiplicative and mode 1: non multiplicative. A 3rd mode (mode 3, since mode 2 is set to "unspecified") can be defined as the multiplicative use of the auxiliary data with the corresponding simulated film grain, defined by the Film Grain characteristics SEI message.

While interpreting the film grain characteristics SEI message, if the ACI SEI message is also present for the same picture with alpha\_channel\_use\_idc equal to 3, then the associated auxiliary picture is used as a weighting factor of the film grain values.

* + 1. **JVET-AF0209 Frequency domain Film Grain Objective Metrics**

In this proposal, we propose a subband based film grain assessment method (SFGA), which shows promising results. SFGA, designed as a full-reference film grain quality assessment tool, initially transforms both reference and test images from the spatial domain to the frequency domain. It then selects several sub-bands within the frequency domain, compares their sub-band noise power spectra, and subsequently combines the sub-band results. The PLCC and SROCC between the proposed metric and MOS are both larger than 0.75, outperforming existing metrics like NSS (Natural Scene Statistics), FFT (Fast Fourier Transform), PSNR, and SSIM. This metric not only enhances our understanding of film grain technology, but also provides a valuable tool for fine-tuning film grain parameters in the modeling and synthesis process.

* + 1. **JVET-AF0210 Exploration on the Capability of Frequency-Based Film Grain Synthesis**

The state-of-the-art film grain synthesis framework cannot meet the needs of high-quality film grain synthesis. This deficiency may primarily stem from limitations in the denoiser, film grain modelling, or film grain synthesis. To isolate the denoiser's impact, we captured clean images and introduced film grain using Davinci Resolve. Then we evaluated the subjective results of film grain modelling and synthesis. We can see that for finer-grained film grain it is challenging for the frequency model to generate film grain effectively. For coarser-grained film grain, the AR model faces difficulties in generating film grain effectively. To further confirm the bottleneck of the film grain framework, we explored the capability of frequency-based film grain synthesis by generating 16470 film grain models and evaluating the 16470 synthesis results. Experimental results show that,

1. In most cases, we can find a suitable film grain model for film grain synthesis, which means the capability of film grain SEI message and synthesis is sufficient.
2. In the current film grain synthesis framework, the film grain modeling highly constraints the performance of film grain synthesis.
3. The proposed metric SFGA in JVET-AF0209 can help to fine-tune the film grain models.
   * 1. **JVET-AF0262 New Film Grain Material based on a Ground Truth approach**

This contribution presents the film grain content material that was generated using the ground truth method discussed in contributions JVET-AD0369 and JVET-AE0250. The material consists of either newly captured content or scenes taken from the OpenMovie project “Tears of Steel”. A total of 26 noise variants is created for each scene selected, with the noise variants exhibiting different noise characteristics. The proponents of the material suggest that the group study, and if desired use, such content in its different activities.

* + 1. **JVET-AF0263 Suggested process for measuring Grain Fidelity using the Ground Truth test set**

This contribution presents a suggested framework/method of how to potentially measure film grain fidelity using the Ground Truth test-set presented in contribution JVET-AF0262 for the evaluation of proposals and technologies relating to film grain analysis or synthesis. The idea is based on techniques that have already been provided to the group, e.g. in contributions JVET‑X0048 and JVET­‑X0103, for performing film grain analysis in the context of estimating film grain parameters using the Film Grain characteristics SEI message. The framework only provides suggestions of measuring the fidelity of noise and not of the final content with the added noise. No actual implementation is provided.

* + 1. **JVET-AF0274 film grain tuning tool**

This contribution describes a new tool to graphically display and edit an FGC SEI configuration file, available in the JVET gitlab (in “JVET AHG Film Grain Technologies” group).

As announced during the 30th JVET meeting, a group called “JVET AHG Film Grain Technologies” has been created on gitlab (https://vcgit.hhi.fraunhofer.de/jvet-ahg-fgt). This group contains software developments related to film grain that are either independent or not yet merged into reference software.

A recent addition is “FGC SEI designer”, a graphical interactive tool to edit an FCG SEI config file, that can be useful when automatic estimation is either not practical or needs to be refined. It can also be used to export a graphical representation of film grain parameters, for use e.g. in a document.

As it is implemented as a single python script, and supposed to be connected to a film grain synthesizer, it was just added to the “VFGS” software repository (https://vcgit.hhi.fraunhofer.de/jvet-ahg-fgt/vfgs), rather than creating a new repository. External dependencies are matplotlib and numpy.

The tool is also available from InterDigital github (https://github.com/InterDigitalInc/VersatileFilmGrain), which is in fact its primary source.

1. **Recommendations**

The AHG recommends:

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

It was commented that the definition of “soft conformance” is still rather vague.

[JVET-AF0014](https://jvet-experts.org/doc_end_user/current_document.php?id=13385) JVET AHG report: NNVC software development (AHG14) [F. Galpin (chair), Y. Li, Y. Li, J. Shingala, L. Wang, Z. Xie (vice 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-6.0 anchor at <https://vcgit.hhi.fraunhofer.de/jvet-ahg-nnvc/VVCSoftware_VTM> is used for NNVC performance evaluation.

* 1. ***Software changes***

Several commits were merged in the NNVC repository.

The following changes were integrated:

* HOP related
  + JVET-AE0191 HOP models
  + JVET-AE0289 HOP stage 3 training process
  + JVET-AE0291 HOP stage 3 dataset
  + JVET-AE0214 SADL v6
  + clarify documentation
  + naive quantization script
* fixes:
  + training hyper-parameters
  + 3 issues related to residual scaling in HOP (available in NNVC-6.1)
  + avoid log overwrite when resuming training
  + port JVET-AE0180 (memory reduction)
  + correct resume training hyper-parameters reloading
* cleaning:
  + remove dead code
  + remove dead features
  1. ***Software version***

NNVC-6.1 was tagged September 25th, 2023 (fix)

NNVC-6.0 was tagged September 6th, 2023.

NNVC-5.1 was tagged July 19th, 2023.

NNVC-5.0 was tagged May 11th, 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. **Comparison *to VTM***
     1. ***Comparison* to previous version - NNVC-5.0 vs NNVC-6.0 VTM mode**

NNVC-6.0 in VTM mode performance are the same as the ones in NNVC-5.0 VTM (only changes are memory consumption).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over nnvc5.0\_VTM-anchor** | | | | | | | |
|  | 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% | 99% | 99% |
| Class A2 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 99% |
| Class B | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 98% |
| Class C | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 98% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 98% |
| Class D | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 98% |
| Class F | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 98% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B Main10** | | | | | | | |
|  | **BD-rate Over nnvc5.0\_VTM-anchor** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 |  |  |  |  |  |  |  |  |
| Class A2 |  |  |  |  |  |  |  |  |
| Class B | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 99% |
| Class C | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 100% |
| Class E | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 100% |
| **Overall** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 100% |
| Class D | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 98% |
| Class F | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 97% | 98% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | |
|  | **BD-rate Over nnvc5.0\_VTM-anchor** | | | | | | | |
|  | 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% | 99% | 100% |
| Class A2 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 100% |
| Class B | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 100% | 99% |
| Class C | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 98% |
| Class E | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 100% |
| **Overall** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 99% | 99% |
| Class D | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 100% | 97% |
| Class F | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 98% | 96% |

* + 1. **NNVC-6.0 VTM mode vs NNVC-6.0 anchor**

The NNVC-6.0 anchor includes LC filter and Intra Prediction tools activated. Results are the same as for NNVC-5.0 anchor (results are copied here for reference)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over nnvc4.0\_VTM-anchor** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -7.23% | -4.86% | -6.00% | -8.72% | -4.05% | -5.06% | 134% | 7667% |
| Class A2 | -6.56% | -5.78% | -5.09% | -6.53% | -4.14% | -2.90% | 130% | 7183% |
| Class B | -6.29% | -8.19% | -7.53% | -5.97% | -6.06% | -5.18% | 132% | 7834% |
| Class C | -6.62% | -10.53% | -9.55% | -6.26% | -7.91% | -5.58% | 132% | 7422% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -6.62% | -7.66% | -7.28% | -6.71% | -5.77% | -4.81% | 132% | 7557% |
| Class D | -7.57% | -9.45% | -9.68% | -5.76% | -6.81% | -5.94% | 129% | 8193% |
| Class F | -3.07% | -5.88% | -4.94% | -3.05% | -4.76% | -3.54% | 148% | 9739% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B Main10** | | | | | | | |
|  | **BD-rate Over nnvc4.0\_VTM-anchor** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 |  |  |  |  |  |  |  |  |
| Class A2 |  |  |  |  |  |  |  |  |
| Class B | -4.85% | -8.13% | -7.84% | -5.15% | -6.16% | -6.65% | 134% | 6812% |
| Class C | -5.24% | -11.13% | -9.00% | -5.61% | -10.74% | -4.02% | 126% | 6233% |
| Class E | -4.88% | -4.09% | -5.17% | -5.64% | -2.18% | -3.36% | 162% | 9877% |
| **Overall** | -4.98% | -8.12% | -7.56% | -5.42% | -6.69% | -4.95% | 138% | 7257% |
| Class D | -6.54% | -10.76% | -9.77% | -5.75% | -9.48% | -6.83% | 125% | 6400% |
| Class F | -2.05% | -4.88% | -4.46% | -2.29% | -3.08% | -4.12% | 148% | 8941% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | |
|  | **BD-rate Over nnvc4.0\_VTM-anchor** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -8.46% | -7.23% | -8.67% | -10.00% | -8.00% | -7.50% | 210% | 5134% |
| Class A2 | -6.61% | -8.04% | -7.94% | -6.90% | -6.44% | -5.44% | 204% | 4416% |
| Class B | -7.03% | -8.58% | -8.71% | -7.04% | -7.61% | -6.99% | 203% | 4493% |
| Class C | -7.34% | -9.76% | -9.92% | -7.61% | -8.38% | -7.64% | 190% | 3770% |
| Class E | -10.29% | -9.04% | -8.85% | -10.14% | -7.52% | -6.38% | 199% | 5149% |
| **Overall** | -7.81% | -8.60% | -8.87% | -8.16% | -7.64% | -6.86% | 201% | 4507% |
| Class D | -7.57% | -8.11% | -9.33% | -7.16% | -6.81% | -7.56% | 180% | 3760% |
| Class F | -4.55% | -5.97% | -5.65% | -4.24% | -4.75% | -4.38% | 155% | 3961% |

* + 1. **NNVC-6.0 VTM mode vs NNVC-6.0 VTM mode + HOP (HOP only)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over nnvc6.0\_VTM-anchor** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -10.52% | -20.62% | -25.85% | -11.91% | -22.85% | -27.10% | 176% | 49507% |
| Class A2 | -10.79% | -23.75% | -22.70% | -10.55% | -23.08% | -19.47% | 169% | 47472% |
| Class B | -9.65% | -25.88% | -24.33% | -9.17% | -25.28% | -24.84% | 171% | 49184% |
| Class C | -10.49% | -27.44% | -27.39% | -9.82% | -24.33% | -25.44% | 150% | 44716% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -10.27% | -24.82% | -25.12% | -10.17% | -24.10% | -24.38% | 166% | 47674% |
| Class D | -11.88% | -26.75% | -27.45% | -9.11% | -24.06% | -23.76% | 145% | 41584% |
| Class F | -5.81% | -18.45% | -17.28% | -6.60% | -19.43% | -18.41% | 218% | 18932% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B Main10** | | | | | | | |
|  | **BD-rate Over nnvc6.0\_VTM-anchor** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 |  |  |  |  |  |  |  |  |
| Class A2 |  |  |  |  |  |  |  |  |
| Class B | -9.46% | -20.43% | -14.83% | -9.63% | -21.13% | -17.32% | 166% | 48578% |
| Class C | -10.61% | -25.51% | -22.61% | -10.89% | -25.00% | -21.30% | 148% | 44637% |
| Class E | -11.79% | -15.78% | -6.88% | -12.19% | -16.97% | -7.79% | 266% | 54934% |
| **Overall** | -10.43% | -20.96% | -15.43% | -10.69% | -21.38% | -16.27% | 180% | 48701% |
| Class D | -11.81% | -23.44% | -16.11% | -10.59% | -23.09% | -14.53% | 141% | 41240% |
| Class F | -6.98% | -19.22% | -14.15% | -8.44% | -20.83% | -20.68% | 219% | 23962% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | |
|  | **BD-rate Over nnvc6.0\_VTM-anchor** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -7.20% | -18.27% | -22.13% | -8.54% | -20.42% | -23.39% | 180% | 34113% |
| Class A2 | -7.09% | -20.09% | -18.85% | -7.96% | -19.89% | -16.46% | 142% | 28458% |
| Class B | -6.98% | -19.22% | -19.78% | -7.01% | -20.82% | -21.74% | 134% | 26660% |
| Class C | -8.08% | -18.41% | -21.09% | -7.96% | -20.09% | -22.71% | 118% | 18245% |
| Class E | -10.45% | -20.65% | -21.76% | -10.85% | -20.11% | -23.27% | 140% | 29315% |
| **Overall** | -7.86% | -19.27% | -20.64% | -8.27% | -20.32% | -21.60% | 139% | 26224% |
| Class D | -7.92% | -17.77% | -21.44% | -7.11% | -21.03% | -22.49% | 114% | 16314% |
| Class F | -5.27% | -15.78% | -15.91% | -5.35% | -17.94% | -18.72% | 120% | 21783% |

* + 1. **NNVC-6.0 VTM mode vs NNVC-6.0 + HOP**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |  |
|  | **BD-rate Over NNVC-6.0 VTM** | | | | | | | |  |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU | DecT GPU |
| Class A1 | -12.25% | -21.90% | -26.99% | -13.64% | -23.87% | -28.04% | 192% | 49788% | #DIV/0! |
| Class A2 | -11.87% | -24.22% | -23.45% | -11.67% | -23.33% | -20.04% | 183% | 47404% | #DIV/0! |
| Class B | -11.02% | -26.65% | -25.11% | -10.45% | -25.97% | -24.94% | 187% | 49058% | #DIV/0! |
| Class C | -11.78% | -28.42% | -28.35% | -11.11% | -25.13% | -25.96% | 166% | 44554% | #DIV/0! |
| Class E |  |  |  |  |  |  |  |  |  |
| **Overall** | -11.64% | -25.69% | -26.02% | -11.51% | -24.80% | -24.85% | 181% | 47628% | #DIV/0! |
| Class D | -12.99% | -27.60% | -28.21% | -10.31% | -24.82% | -24.56% | 159% | 41349% | #DIV/0! |
| Class F | -6.64% | -18.95% | -17.80% | -7.35% | -19.89% | -18.68% | 234% | 18908% | #DIV/0! |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B Main10** | | | | | | | | | | | | | | | |
|  | **BD-rate Over NNVC-6.0 VTM** | | | | | | | | | | | | | | | |
|  | 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 | -9.87% | -20.94% | | -15.27% | | -10.13% | | -21.91% | | -18.18% | | 174% | | | 48596% | |
| Class C | -10.84% | -25.68% | | -22.82% | | -11.11% | | -25.25% | | -21.39% | | 153% | | | 44563% | |
| Class E | -11.89% | -16.58% | | -6.94% | | -12.09% | | -17.05% | | -7.82% | | 269% | | | 54898% | |
| **Overall** | -10.70% | -21.43% | | -15.70% | | -10.94% | | -21.81% | | -16.66% | | 186% | | | 48674% | |
| Class D | -11.97% | -23.63% | | -15.96% | | -10.74% | | -22.83% | | -13.85% | | 147% | | | 41272% | |
| Class F | -7.11% | -19.37% | | -14.40% | | -8.62% | | -21.48% | | -21.24% | | 225% | | | 23976% | |
|  | **All Intra Main10** | | | | | | | | | | | | | | |
|  | **BD-rate Over NNVC-6.0 VTM** | | | | | | | | | | | | | | |
|  | Y-PSNR | | U-PSNR | | V-PSNR | | Y-MSIM | | U-MSIM | | V-MSIM | | EncT | DecT CPU | |
| Class A1 | -10.80% | | -21.61% | | -25.21% | | -12.42% | | -24.08% | | -26.37% | | 257% | 34651% | |
| Class A2 | -9.50% | | -22.21% | | -20.70% | | -10.28% | | -22.04% | | -18.20% | | 221% | 29092% | |
| Class B | -9.67% | | -21.93% | | -22.37% | | -9.68% | | -23.46% | | -23.99% | | 211% | 27305% | |
| Class C | -10.66% | | -21.34% | | -23.99% | | -10.48% | | -22.56% | | -25.23% | | 187% | 18934% | |
| Class E | -14.31% | | -24.62% | | -25.51% | | -14.72% | | -23.78% | | -26.51% | | 212% | 29758% | |
| **Overall** | -10.82% | | -22.24% | | -23.45% | | -11.25% | | -23.18% | | -24.12% | | 214% | 26851% | |
| Class D | -10.32% | | -20.91% | | -24.43% | | -9.53% | | -23.50% | | -25.27% | | 176% | 17077% | |
| Class F | -7.18% | | -17.41% | | -17.55% | | -7.14% | | -19.12% | | -20.80% | | 161% | 22168% | |

* 1. **Comparison *to NNVC-6.0 anchor***
     1. ***NNVC*-6.0 anchor vs NNVC-6.0 HOP**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over NNVC-6.0 anchor** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -5.41% | -17.63% | -22.03% | -5.35% | -20.16% | -23.98% | 145% | 679% |
| Class A2 | -5.71% | -19.22% | -19.10% | -5.49% | -19.70% | -17.46% | 142% | 695% |
| Class B | -5.06% | -19.76% | -18.79% | -4.75% | -21.02% | -20.82% | 141% | 640% |
| Class C | -5.52% | -19.47% | -20.33% | -5.15% | -18.40% | -21.14% | 128% | 637% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -5.38% | -19.15% | -19.91% | -5.12% | -19.88% | -20.86% | 138% | 658% |
| Class D | -5.84% | -19.48% | -19.97% | -4.76% | -18.71% | -19.54% | 129% | 567% |
| Class F | -3.74% | -13.98% | -13.51% | -4.46% | -16.07% | -15.83% | 158% | 207% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B Main10** | | | | | | | |
|  | **BD-rate Over NNVC-6.0 anchor** | | | | | | | |
|  | 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 | -5.29% | -13.80% | -7.93% | -5.25% | -16.62% | -12.00% | 128% | 606% |
| Class C | -5.91% | -16.15% | -15.00% | -5.80% | -16.41% | -18.24% | 120% | 617% |
| Class E | -7.28% | -12.89% | -2.29% | -6.77% | -15.05% | -5.00% | 163% | 434% |
| **Overall** | -5.99% | -14.36% | -8.88% | -5.81% | -16.16% | -12.33% | 133% | 561% |
| Class D | -5.79% | -14.12% | -6.95% | -5.27% | -14.49% | -7.18% | 117% | 556% |
| Class F | -5.19% | -15.13% | -10.53% | -6.60% | -18.51% | -17.78% | 149% | 209% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | |
|  | **BD-rate Over NNVC-6.0 anchor** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -2.58% | -15.45% | -18.02% | -2.61% | -17.91% | -20.40% | 119% | 592% |
| Class A2 | -3.12% | -15.30% | -13.68% | -3.64% | -16.63% | -13.39% | 106% | 602% |
| Class B | -2.88% | -14.39% | -14.82% | -2.83% | -17.15% | -18.16% | 102% | 540% |
| Class C | -3.63% | -12.62% | -15.24% | -3.12% | -15.61% | -18.81% | 96% | 464% |
| Class E | -4.52% | -16.74% | -18.11% | -5.00% | -17.14% | -21.34% | 105% | 529% |
| **Overall** | -3.31% | -14.72% | -15.81% | -3.35% | -16.85% | -18.41% | 104% | 538% |
| Class D | -2.98% | -13.49% | -16.04% | -2.54% | -17.60% | -18.62% | 94% | 393% |
| Class F | -2.82% | -12.02% | -12.45% | -2.94% | -14.92% | -16.77% | 100% | 495% |

* 1. ***Comparison to NNVC-6.0 HOP***
     1. **NNVC-6.0 anchor NNVC-6.1 HOP**

A bug fix was performed on top of NNVC 6.0 and tagged 6.1. It only affects the HOP results. Please note that timing is not reliable.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | | | | |
|  | **BD-rate Over NNVC-6.0 VTM** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -0.08% | -0.57% | -0.40% | 0.01% | -0.42% | -0.17% | 140% | 153% |
| Class A2 | -0.04% | -0.15% | 0.07% | -0.08% | -0.08% | 0.02% | 139% | #NUM! |
| Class B | -0.05% | 0.00% | -0.53% | -0.14% | -0.36% | -0.62% | 142% | 159% |
| Class C | 0.03% | -0.24% | -0.32% | 0.02% | -0.29% | -0.42% | 143% | 170% |
| Class E |  |  |  |  |  |  |  |  |
| **Overall** | -0.03% | -0.21% | -0.33% | -0.06% | -0.30% | -0.35% | 141% | #NUM! |
| Class D | 0.08% | -0.33% | -0.45% | 0.12% | -0.26% | -0.22% | 141% | 170% |
| Class F | -0.16% | -0.71% | -0.50% | 0.17% | -0.48% | -0.44% | 143% | 175% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Low delay B Main10** | | | | | | | |
|  | **BD-rate Over NNVC-6.0 VTM** | | | | | | | |
|  | 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 | 0.03% | -0.38% | -3.75% | 0.13% | -0.96% | -3.75% | 138% | #NUM! |
| Class C | -0.01% | -0.17% | -0.89% | 0.03% | -0.11% | -1.18% | 139% | 166% |
| Class E | 0.06% | -0.82% | -0.70% | -0.07% | -0.61% | -0.61% | 145% | 150% |
| **Overall** | 0.03% | -0.42% | -2.04% | 0.05% | -0.59% | -2.11% | 140% | #NUM! |
| Class D | -0.06% | -2.23% | -2.57% | 0.13% | -3.51% | -2.84% | 138% | 170% |
| Class F | -0.07% | -0.06% | -0.74% | 0.06% | -0.56% | -1.02% | 143% | #NUM! |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra Main10** | | | | | | | |
|  | **BD-rate Over NNVC-6.0 VTM** | | | | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | Y-MSIM | U-MSIM | V-MSIM | EncT | DecT CPU |
| Class A1 | -0.14% | -0.17% | 0.75% | -0.16% | 0.02% | 0.52% | 144% | 147% |
| Class A2 | -0.02% | -0.13% | -0.04% | -0.04% | 0.19% | -0.07% | 143% | 146% |
| Class B | -0.06% | 0.04% | -0.09% | -0.07% | -0.04% | -0.18% | 141% | 149% |
| Class C | -0.09% | -0.92% | -0.90% | -0.12% | -0.82% | -0.86% | 140% | 163% |
| Class E | -0.14% | 0.78% | 0.56% | -0.08% | 0.56% | 0.37% | 142% | 152% |
| **Overall** | -0.09% | -0.11% | -0.01% | -0.09% | -0.07% | -0.10% | 142% | 152% |
| Class D | -0.05% | -0.12% | -0.31% | 0.01% | -0.11% | -0.58% | 137% | 166% |
| Class F | -0.23% | -0.47% | 1.12% | -0.08% | -0.72% | 1.86% | 131% | 165% |

* 1. ***Other tools***

Other results remain the same as tools were not changed.

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

The following points were discussed:

* Final training strategy for HOP model: final training and models were decided.
* Some aspects of encoder optimization (eg RDO models) are not yet aligned with HOP model.

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-6.0 software
* P: the results are the ones from previous NNVC 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
* N: no cross-check available

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Tools | Configuration | Tested | Xcheck |
| NNVC-6.0 VTM mode | none | encoder\_xxx\_vtm.cfg | Y | Y |
| NNVC 6.0 Anchor/EE1 | Intra Pred + LC filterset | encoder\_xxx\_nnvc.cfg | Y | Y |
| NNVC-6.0. HOP | Intra Pred + HOP | encoder\_xxx\_nnvc.cfg + nn-based/HOP.cfg | Y |  |
| HOP only | HOP | encoder\_xxx\_vtm.cfg + nn-based/HOP.cfg | Y |  |
| set0 | Loop filter set #0 | encoder\_xxx\_vtm.cfg + nn-based/NnlfOption\_1.cfg | P | Y |
| set1 | Loop filter set #1 | encoder\_xxx\_vtm.cfg + nn-based/NnlfOption\_2.cfg | P | Y |
| Intra | Intra prediction | nn-based/encoder\_xxx\_nnvc.cfg | P | Y |
| set0+intra | Loop filter set #0+ Intra prediction | nn-based/encoder\_xxx\_nnvc.cfg + nn-based/NnlfOption\_1.cfg | P | Y |
| set1+intra | Loop filter set #1+ Intra prediction | nn-based/encoder\_xxx\_nnvc.cfg + nn-based/NnlfOption\_2.cfg | P | Y |
| set0+rdo+intra | Loop filter set #0 + Rdo + Intra prediction | nn-based/encoder\_xxx\_nnvc.cfg + nn-based/NnlfOption\_1.cfg + --EncNnlfOpt=1 | P | 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 | P | Y |
| Sr | Super-resolution | encoder\_xxx\_vtm.cfg + nn-based/nnsr.cfg + nn-based/nnsr\_classAx.cfg | P | 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 | P | 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 | P | P |
| Intra+pf | Intra prediction + adaptive post-filter | nn-based/encoder\_xxx\_nnvc.cfg + nn-based/nnpf\_int16.cfg | P | N |

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.

It was commented that at some point it might again be useful to test combinations of ECM and NNVC tools.

# Project development (23)

## AHG1: Deployment and advertisement of standards (3)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0020](https://jvet-experts.org/doc_end_user/current_document.php?id=13447) Deployment status of the HEVC standard [G. J. Sullivan (SC 29 chair & VCEG rapporteur)]

[JVET-AF0021](https://jvet-experts.org/doc_end_user/current_document.php?id=13448) Deployment status of the VVC standard [G. J. Sullivan (SC 29 chair & VCEG rapporteur)]

[JVET-AF0175](https://jvet-experts.org/doc_end_user/current_document.php?id=13433) MC-IF VVC technical guidelines [L. Litwic (Ericsson), S. McCarthy (Dolby), S. Wenger, J. Ridge (Nokia), B. Bross (Fraunhofer HHI), D. Rusanovskyy (Qualcomm), A. Stein (InterDigital), J. Outters (Ateme), T. Suzuki (Sony), Y.-J. Chiu (Intel), J. Lemotheux (Orange)]

## AHG2: Text development and errata reporting (1+2)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0045](https://jvet-experts.org/doc_end_user/current_document.php?id=13289) AHG2/AHG9: On the use of NNPF SEI messages in AVC [M. M. Hannuksela (Nokia)]

See section 6.3

[JVET-AF0063](https://jvet-experts.org/doc_end_user/current_document.php?id=13311) On MV-HEVC profiles [Y.-K. Wang, H. Liu, L. Zhang, S. Jiao, C. Hu, J. Cui, G. Xu (Bytedance)]

See section 4.14

[JVET-AF0064](https://jvet-experts.org/doc_end_user/current_document.php?id=13312) AHG2: Editor commentary on some editorial issues [Y.-K. Wang, G. J. Sullivan (Editors)]

## AHG3: Test conditions (0)

This section is kept as a template for future use.

## AHG3: Software development (0)

This section is kept as a template for future use.

## AHG4: Subjective quality testing and verification testing (4)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by JRO and MW, joint meeting with AG 5).

[JVET-AF0044](https://jvet-experts.org/doc_end_user/current_document.php?id=13288) AHG4: Report on AhG meeting on verification testing for VVC multilayer coding [M. Wien]

[JVET-AF0075](https://jvet-experts.org/doc_end_user/current_document.php?id=13323) Evaluation results of Low Complexity Enhancement Video Codec (LCEVC) with HM and VTM on 4K content [O. Chubach, Y.-L. Hsiao, C.-Y. Chen, C.-W. Hsu, T.-D. Chuang, Y.-W. Chen, Y.-W. Huang, S.-M. Lei (MediaTek)]

[JVET-AF0224](https://jvet-experts.org/doc_end_user/current_document.php?id=13487) Crosscheck of JVET-AF0075 (Evaluation results of LCEVC) [C. Lehmann (HHI)] [late] [miss]

[JVET-AF0228](https://jvet-experts.org/doc_end_user/current_document.php?id=13491) Crosscheck of JVET-AF0075 (Evaluation results of Low Complexity Enhancement Video Codec with HM and VTM on 4K content) [P. Chen, M. Zhou, W. Wan (Broadcom)] [late]

[JVET-AF0277](https://jvet-experts.org/doc_end_user/current_document.php?id=13541) Crosscheck of JVET-AF0075 (Evaluation results of Low Complexity Enhancement Video Codec (LCEVC) with HM and VTM on 4K content) [V. Seregin (Qualcomm)] [late]

[JVET-AF0292](https://jvet-experts.org/doc_end_user/current_document.php?id=13556) Considerations on LCEVC performances in relation to input document JVET-AF0075/m65560 [S. Ferrara, X. Ciccarelli (V-Nova)] [late]

[JVET-AF0186](https://jvet-experts.org/doc_end_user/current_document.php?id=13444) AHG4: experiments related to VVC spatial scalability visual testing [P. de Lagrange, F. Urban (InterDigital)]

## AHG4: Test material (0+2)

This section is kept as a template for future use.

[JVET-AF0253](https://jvet-experts.org/doc_end_user/current_document.php?id=13516) [AHG-7] On the proposed gaming sequences from InterDigital and class gaming [S. Puri, T. Poirier, C. Bonnineau, I. Marzuki, R. Utida, E. Francois (InterDigital)] [late] [miss]

See section 4.9

[JVET-AF0262](https://jvet-experts.org/doc_end_user/current_document.php?id=13526) New Film Grain Material based on a Ground Truth approach [D. Ugur, D. Podborski, A. M. Tourapis (Apple Inc)] [late]

See section 4.12

## Codec performance with alternative test materials (2)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0047](https://jvet-experts.org/doc_end_user/current_document.php?id=13294) [AHG4] ECM10.0 evaluation on V3C test content [S. Schwarz, M.M. Hannuksela (Nokia)]

[JVET-AF0187](https://jvet-experts.org/doc_end_user/current_document.php?id=13445) Compression of Gaming Contents [Z. Lin, K. Cai, J. Sauer, Y. Zhao, E. Alshina (Huawei)]

## AHG5: Conformance test development (0)

This section is kept as a template for future use.

## AHG7: ECM tool assessment (1+1)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0165](https://jvet-experts.org/doc_end_user/current_document.php?id=13423) Ahg7/Ahg12: On VTM-11ecm anchor low-delay test conditions [F. Le Léannec, S. Puri, E. François, K. Naser (InterDigital)]

See section 5.2.5

[JVET-AF0253](https://jvet-experts.org/doc_end_user/current_document.php?id=13516) [AHG-7] On the proposed gaming sequences from InterDigital and class gaming [S. Puri, T. Poirier, C. Bonnineau, I. Marzuki, R. Utida, E. Francois (InterDigital)] [late] [miss]

## AHG8: Optimization of encoders and receiving systems for machine analysis of coded video content (2+3)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

### Non-SEI contributions (2)

[JVET-AF0060](https://jvet-experts.org/doc_end_user/current_document.php?id=13308) AHG8: An exemplar software implementation for temporal resampling for VCM [S. Wang, J. Chen, Y. Ye (Alibaba), S. Wang (CityU)]

[JVET-AF0157](https://jvet-experts.org/doc_end_user/current_document.php?id=13415) AHG8: A temporal resampling algorithm [D. Ding, X. Zhao, Z. Liu, S. Liu (Tencent)]

[JVET-AF0241](https://jvet-experts.org/doc_end_user/current_document.php?id=13504) Cross-check of JVET-AF0157 (AHG8: A temporal resampling algorithm) [C. Hollmann (Ericsson)] [late] [miss]

### Contributions related to SEI messages (see section 6.2) (3)

[JVET-AF0068](https://jvet-experts.org/doc_end_user/current_document.php?id=13316) AHG8/AHG9: Signalling of encoder preprocessing information [W. Jia, Y. Li, Y.-K. Wang, K. Zhang, L. Zhang (Bytedance)]

[JVET-AF0138](https://jvet-experts.org/doc_end_user/current_document.php?id=13396) AHG8/AHG9: Truncated bit depth support SEI messages [D. Ding, X. Zhao, S. Liu, G. Teniou, S. Wenger (Tencent)]

[JVET-AF0147](https://jvet-experts.org/doc_end_user/current_document.php?id=13405) AHG8/AHG9: On Picture Modality Type [J. Gao, H.-B. Teo, C.-S. Lim, K. Abe (Panasonic)]

## AHG10: Encoding algorithm optimization (3)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0089](https://jvet-experts.org/doc_end_user/current_document.php?id=13293) AhG10: Lagrange multiplier and QP adaptation at CTU-level for VVC [H. Guo, C. Zhu, L. Luo, J. Chen (UESTC), Y. Huo, Y. Liu (Transsion)]

[JVET-AF0111](https://jvet-experts.org/doc_end_user/current_document.php?id=13358) AHG10 MTT split modes early termination [W. Ahmad, P. Wennersten, K. Andersson (Ericsson)]

[JVET-AF0247](https://jvet-experts.org/doc_end_user/current_document.php?id=13510) Cross-check of JVET-AF0111 (AHG10: MTT split modes early termination) [T. Dumas (Interdigital)] [late] [miss]

[JVET-AF0122](https://jvet-experts.org/doc_end_user/current_document.php?id=13291) AhG10: Lagrange multiplier optimization for chroma ALF and CCALF [S.-W. Xie, Y. Gao, M.-H. Jia, Y.-X. Bai, C. Huang, P. Wu (ZTE)]

## AHG13: Film grain synthesis (5+2)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0142](https://jvet-experts.org/doc_end_user/current_document.php?id=13400) [AHG9] Local Film Grain Synthesis using Annotated Regions SEI [G. Teniou, S. Wenger (Tencent)]

See section 6.3

[JVET-AF0144](https://jvet-experts.org/doc_end_user/current_document.php?id=13402) [AHG9] Adaptive Film grain synthesis using Alpha Channel Information SEI message [G. Teniou, S. Wenger (Tencent)]

See section 6.3

[JVET-AF0209](https://jvet-experts.org/doc_end_user/current_document.php?id=13472) AHG13: Frequency domain Film Grain Objective Metrics X. Meng, W. Zhang, S. Labrozzi (Disney Streaming) [late] [miss]

[JVET-AF0210](https://jvet-experts.org/doc_end_user/current_document.php?id=13473) AHG13: Exploration on the Capability of Frequency-Based Film Grain Synthesis X. Meng, W. Zhang, S. Labrozzi (Disney Streaming) [late] [miss]

[JVET-AF0262](https://jvet-experts.org/doc_end_user/current_document.php?id=13526) New Film Grain Material based on a Ground Truth approach [D. Ugur, D. Podborski, A. M. Tourapis (Apple Inc)] [late]

[JVET-AF0263](https://jvet-experts.org/doc_end_user/current_document.php?id=13527) Suggested process for measuring Grain Fidelity using the Ground Truth test set [A. M. Tourapis, J. Kim, S. Paluri, D. Podborski (Apple Inc)] [late]

[JVET-AF0274](https://jvet-experts.org/doc_end_user/current_document.php?id=13538) AHG13/AHG3: film grain tuning tool [P. de Lagrange (InterDigital)] [late]

## Implementation studies (1)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0211](https://jvet-experts.org/doc_end_user/current_document.php?id=13474) Latest update on Ali266: performance and deployment S. Fang, Z. Huang, S. Xu, L. Yu, J. Chen, R.-L. Liao, Y. Ye (Alibaba), X. Zhai, Y. Jia, D. Fan, Y. Zhang, C. Dou, X. Fu, F. Hu, R. Li (Youku) [late] [miss]

## Profile/tier/level specification (1)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0063](https://jvet-experts.org/doc_end_user/current_document.php?id=13311) On MV-HEVC profiles [Y.-K. Wang, H. Liu, L. Zhang, S. Jiao, C. Hu, J. Cui, G. Xu (Bytedance)]

## General aspects of standards development and applications of standards (1)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0022](https://jvet-experts.org/doc_end_user/current_document.php?id=13450) Summary of time spans for NB comment availability [G. J. Sullivan (SC 29 chair)]

# Low-level tool technology proposals (114)

## AHG11/AHG14: Neural network-based video coding (28+2)

### Summary, BoG reports, and information documents (2)

Contributions in this area were discussed at 0840–1125 on Saturday 14 Oct. 2023 (chaired by JRO).

[JVET-AF0023](https://jvet-experts.org/doc_end_user/current_document.php?id=13469) 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]

This report summarizes the activities of the Exploration Experiment 1 (EE1) performed between the JVET-AE and JVET-AF meetings to evaluate Neural Network-based Video Coding (NNVC) technologies, analyze their performance, evaluate their complexity aspects, and clarify training procedure. Two teleconferences have been conducted during this meeting circle.

This round of EE1 tests included:

1. EE1-0.x: Unified LOP (based on [JVET-AE0281](https://jvet-experts.org/doc_end_user/current_document.php?id=13244))
2. EE1-1.1.x category: architectural changes for HOP (based on [JVET-AE0160](https://jvet-experts.org/doc_end_user/current_document.php?id=13123) , [JVET-AE0164](https://jvet-experts.org/doc_end_user/current_document.php?id=13127)).
3. EE1-1.2.x category: filter usage aspects (based on [JVET-AE0072](https://jvet-experts.org/doc_end_user/current_document.php?id=13020), [JVET-AE0093](https://jvet-experts.org/doc_end_user/current_document.php?id=13041), [JVET-AE0161](https://jvet-experts.org/doc_end_user/current_document.php?id=13124), [JVET-AE0238](https://jvet-experts.org/doc_end_user/current_document.php?id=13201)).
4. EE1-2.x NN-Inter (based on [JVET-AE0112](https://jvet-experts.org/doc_end_user/current_document.php?id=13060) investigating complexity reduction possibilities).
5. EE1-3.x NN-Intra (based on [JVET-AE0144](https://jvet-experts.org/doc_end_user/current_document.php?id=13060), awaiting training cross-check).

All tests in EE1 were advised to use NNVC-6.0 as code base (unless it is not possible). The anchor for EE1 test is the default configuration of NNVC-6.0 as defined by AhG11/AhG14 (NN-intra and low complexity NN-filter enabled by default) in JVET-AE2016. Anchor performance and reference point for HOP NN-filters will be provided by AhG14.

Tests targeting to LOP replacement in NNVC (EE1-0) should report results vs NNVC-6.0 default configuration (LOP-1 filter and NN-Intra are enabled by default). Tests targeting improvement of HOP (EE1-1 category) should report results in comparison to NNVC-6.0 with HOP-1 (instead LOP-1) and NN-Intra enabled. HOP-1 architecture and reproducible training procedure description can be found in JVET-AE2019 and [readme.md](https://vcgit.hhi.fraunhofer.de/jvet-ahg-nnvc/VVCSoftware_VTM/-/blob/VTM-11.0_nnvc/training/training_scripts/NN_Filtering_HOP/readme.md).

NNVC has two NN-filters, so can be configures for Low Operation Point (LOP) and High Operation Point (HOP), in both NN-Intra is enabled. Performance of those two configurations relatively to VTM is summarized in Table 1. Run time is not always very reliable and accurate, but can give group extra information about complexity, so run time was added to the tables.

Table 1 Two configuration of NNVC tested vs VTM, NN-Intra enabled in both.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Test | Doc# | # Par M | kMAC /pxl | Random Access cfg. | | | | | All Intra cfg. | | | | |
| Y | U | V | Enc | Dec | Y | U | V | Enc | Dec |
| LOP | [JVET-AE0014](https://jvet-experts.org/doc_end_user/current_document.php?id=13090) | 0.2+1.3 | 17+8 | **-6.6%** | -7.7% | -7.3% | 1.3 | 76 | **-7.8%** | -8.6% | -8.9% | 2.0 | 45 |
| HOP | [JVET-AE0014](https://jvet-experts.org/doc_end_user/current_document.php?id=13090) | 1.5+1.3 | 477+8 | **-11.6%** | -25.7% | -26.0% | 1.8 | 476 | **-10.8%** | -22.2% | -23.4% | 2.1 | 269 |

By default in NNVC-6.0 NN-Intra and Low Operation Point (LOP) NN-filter are enabled. Proposals tested against NNVC-6.0 are listed in Table 2.

Table 2 Proposals tested against NNVC default configuration (LOP and NN-Intra are enabled)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Test | Doc# | # Par M | kMAC /pxl | Random Access cfg. | | | | | All Intra cfg. | | | | | |
| Y | U | V | Enc. | Dec. | Y | U | V | Enc. | Dec. |
| NNVC-6-LOP | [JVET-AE0014](https://jvet-experts.org/doc_end_user/current_document.php?id=13090) | 0.2 | 17 | **0.0%** | 0.0% | 0.0% | 100% | 100% | **0.0%** | 0.0% | 0.0% | 100% | 100% |
| Targeting replacement of LOP filter in NNVC | | | | | | | | | | | | | | |
| EE1-0 | [JVET-AF0043](https://jvet-experts.org/doc_end_user/current_document.php?id=13287) | 0.05 | 17 | **-0.3%** | -4.3% | -4.3% | 96% | 114% | **-0.2%** | -4.6% | -4.6% | 97% | 119% |
| Content adaptation with overfitting at encoder side | | | | | | | | | | | | | | |
| EE1-1.2.2 | [JVET-AF0056](https://jvet-experts.org/doc_end_user/current_document.php?id=13304) | 0.2 | 17 | **-1.2%** | -6.4% | -5.5% | 99% | 105% |  |  |  |  |  |
| NN-Inter (performance on top of LOP & NN-Intra) | | | | | | | | | | | | | | |
| EE1-2.1 | [JVET-AF0208](https://jvet-experts.org/doc_end_user/current_document.php?id=13471) | 3.8 | 504 | **-2.3%** | -4.2% | -3.8% | 133% | 1204% |  |  |  |  |  |
| Targeting replacement of NN-Intra filter in NNVC | | | | | | | | | | | | | | |
| EE1-3.1 | [JVET-AF0139](https://jvet-experts.org/doc_end_user/current_document.php?id=13397) | 1.3 | 4.8 | **0.2%** | 0.1% | 0.2% | 99% | 99% | **0.5%** | 0.6% | 0.7% | 95% | 94% |

Majority of EE1 tests are focusing on improvement of High Operation Point (HOP) complexity-performance trade-off. The natural anchor for those tests is NNVC-6.0 with HOP and NN-Intra enabled. Test results relatively to this anchor are summarized in Table 3.

Table 3 Proposals tested against NNVC- high configuration (HOP and NN-Intra are enabled)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Test | Doc# | #Par M | kMAC /pxl | Random Access cfg. | | | | | All Intra cfg. | | | | |
| Y | U | V | Enc. | Dec. | Y | U | V | Enc. | Dec. |
| NNVC-6-HOP | [JVET-AF0014](https://jvet-experts.org/doc_end_user/current_document.php?id=13385) | 1.45 | 477 | **0.0%** | 0.0% | 0.0% | 100% | 100% | **0.0%** | 0.0% | 0.0% | 100% | 100% |
| Group convolutions in BBB (Back Bone Block) | | | | | | | | | | | | | |
| EE1-1.1.1-t1 | [JVET-AF0153](https://jvet-experts.org/doc_end_user/current_document.php?id=13411) | 1.28 | 422 | **0.3%** | 2.0% | 1.5% |  |  | **0.1%** | 1.1% | 1.0% |  |  |
| EE1-1.1.4b1 | [JVET-AF0182](https://jvet-experts.org/doc_end_user/current_document.php?id=13440) | 1.23 | 406 | **0.3%** | 2.7% | 1.0% | 120% | 155% | **0.1%** | 0.7% | 0.7% | 111% | 157% |
| EE1-1.1.4b2 | [JVET-AF0182](https://jvet-experts.org/doc_end_user/current_document.php?id=13440) | 1.27 | 419 | **0.3%** | 1.1% | 1.2% | 124% | 172% | **0.2%** | 0.9% | 0.9% | 112% | 175% |
| EE1-1.1.4b3 | [JVET-AF0182](https://jvet-experts.org/doc_end_user/current_document.php?id=13440) | 1.05 | 349 | **0.6%** | 2.6% | 2.4% | 135% | 204% | **0.3%** | 1.3% | 1.1% | 118% | 210% |
| Number of channels reduction in BBB (Back Bone Block) | | | | | | | | | | | | | |
| EE1-1.1.2b | [JVET-AF0102](https://jvet-experts.org/doc_end_user/current_document.php?id=13349) | 1.3 | 426 | **0.1%** | 1.0% | 0.4% | 82% | 71% | **0.1%** | 0.2% | 0.4% | 83% | 66% |
| EE1-1.1.1-t2 | [JVET-AF0153](https://jvet-experts.org/doc_end_user/current_document.php?id=13411) | 1.35 | 442 | **0.3%** | 1.3% | 0.9% |  |  | **0.2%** | 0.8% | 1.1% |  |  |
| EE1-1.1.5 | [JVET-AF0192](https://jvet-experts.org/doc_end_user/current_document.php?id=13453) | 1.2 | 392 | **0.4%** | 1.7% | 1.2% | 72% | 56% | **0.2%** | 1.0% | 0.8% | 77% | 53% |
| “head” block simplifications | | | | | | | | | | | | | |
| EE1-1.1.4a | [JVET-AF0181](https://jvet-experts.org/doc_end_user/current_document.php?id=13439) | 1.45 | 457 | **0.2%** | 0.9% | 0.5% | 95% | 86% | **0.1%** | 0.2% | 0.4% | 98% | 89% |
| EE1-1.1.3 | [JVET-AF0103](https://jvet-experts.org/doc_end_user/current_document.php?id=13350) | 1.45 | 472 | **0.0%** | 1.0% | 0.3% | 98% | 96% | **0.1%** | 0.3% | 0.3% | 95% | 92% |
| Separation of NN-filters for Luma and Chroma | | | | | | | | | | | | | |
| EE1-1.1.4c | [JVET-AF0183](https://jvet-experts.org/doc_end_user/current_document.php?id=13441) | 1.42 | 473 | **-0.3%** | 1.5% | 1.9% | 129% | 202% | **-0.4%** | 0.3% | 0.5% | 112% | 206% |
| EE1-1.1.4d | [JVET-AF0183](https://jvet-experts.org/doc_end_user/current_document.php?id=13441) | 1.23 | 390 | **0.0%** | 1.8% | 2.0% | 137% | 221% | **-0.2%** | -0.1% | 0.2% | 116% | 232% |
| Filter usage aspects (also applicable to LOP) | | | | | | | | | | | | | |
| EE1-1.2.1 | [JVET-AF0085](https://jvet-experts.org/doc_end_user/current_document.php?id=13333) | 1.45 | 477 | **0.0%** | -0.2% | -0.5% | 100% | 101% | **0.0%** | -0.1% | 0.0% | 100% | 99% |
| EE1-1.2.3 | [JVET-AF0154](https://jvet-experts.org/doc_end_user/current_document.php?id=13412) | 1.45 | 477 | **-0.1%** | -0.6% | -0.8% | 97% | 99% |  |  |  |  |  |
| EE1-1.2.4 | [JVET-AF0205](https://jvet-experts.org/doc_end_user/current_document.php?id=13466) | 1.45 | 477 | **0.0%** | -0.1% | -0.1% | 100% | 99% | **0.0%** | -0.1% | -0.1% | 100% | 100% |
| EE1-1.2.6 | [JVET-AF0086](https://jvet-experts.org/doc_end_user/current_document.php?id=13334) | 1.45 | 477 | **-0.1%** | -0.5% | -0.7% | 98% | 99% |  |  |  |  |  |

Some proponents managed to complete LDB test, results are summarized in Table 4.

Table 4 Proposals tested against NNVC- high configuration (HOP and NN-Intra are enabled) in LDB configuration.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Test | Doc# | #Par M | kMAC /pxl | Low Delay-B cfg. | | | | |
| **Y** | U | V | Enc. | Dec. |
| NNVC-6-HOP | [JVET-AF0014](https://jvet-experts.org/doc_end_user/current_document.php?id=13385) | 1.45 | 477 | **0.0%** | 0.0% | 0.0% | 100% | 100% |
| EE1-1.1.1-t1 | [JVET-AF0153](https://jvet-experts.org/doc_end_user/current_document.php?id=13411) | 1.28 | 422 | **0.2%** | -0.1% | -6.2% |  |  |
| EE1-1.1.4b1 | [JVET-AF0182](https://jvet-experts.org/doc_end_user/current_document.php?id=13440) | 1.23 | 406 | **0.2%** | 0.0% | -5.8% | 121% | 157% |
| EE1-1.1.4b2 | [JVET-AF0182](https://jvet-experts.org/doc_end_user/current_document.php?id=13440) | 1.27 | 419 | **0.2%** | -0.4% | -7.4% | 127% | 174% |
| EE1-1.1.1-t2 | [JVET-AF0153](https://jvet-experts.org/doc_end_user/current_document.php?id=13411) | 1.35 | 442 | **0.1%** | -0.5% | -8.2% |  |  |
| EE1-1.1.5 | [JVET-AF0192](https://jvet-experts.org/doc_end_user/current_document.php?id=13453) | 1.2 | 392 | **0.3%** | -0.8% | -7.2% |  |  |
| EE1-1.1.4a | [JVET-AF0181](https://jvet-experts.org/doc_end_user/current_document.php?id=13439) | 1.45 | 457 | 0.3% | -1.6% | -8.4% | 94% | 85% |
| EE1-1.2.1 | [JVET-AF0085](https://jvet-experts.org/doc_end_user/current_document.php?id=13333) | 1.45 | 477 | **-0.3%** | -1.8% | -4.9% | 100% | 105% |
| EE1-1.2.3 | [JVET-AF0154](https://jvet-experts.org/doc_end_user/current_document.php?id=13412) | 1.45 | 477 | **-0.4%** | -2.6% | -2.2% | 98% | 100% |
| EE1-1.2.6 | [JVET-AF0086](https://jvet-experts.org/doc_end_user/current_document.php?id=13334) | 1.45 | 477 | **-0.4%** | -2.1% | -1.4% | 98% | 101% |

Observations of those test results are as follows:

* Reduction of kMAC/pxl not necessarily leads to reduction of encoding/decoding run-time (often causes opposite effect).
* Strangely almost all proposals tested in LDB cfg demonstrated significant gain in PSNR-V. Likely this indicates some problem with NNVC-HOP training or usage.

Observations on tests:

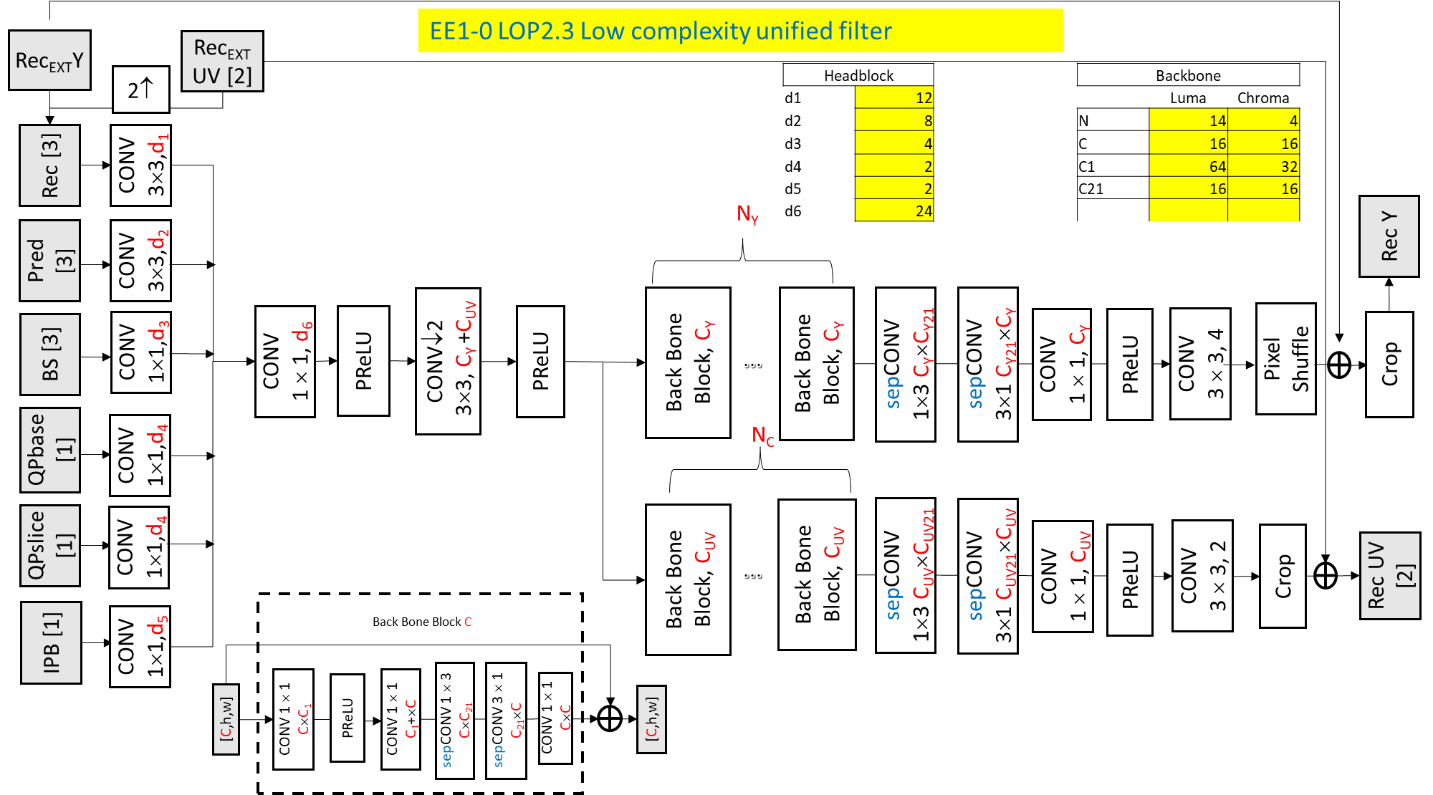
* Majority of proposed HOP NN-filter simplifications do not contradict to each other, potentially can be used together (the only exception is group convolution size, group should choose between group size 2 or 4).
* Among filter usage aspects (flipping, rotating, residual adjustment…) noticeable (0.3-0.4%) gain is observed in LDB cfg.

Mode details about EE1 tests can be found in presentation attached to this contribution.

**Tests description and results**

***EE1-0 tests 0.1 to 0.4***

Input contribution: [JVET-AF0043](https://jvet-experts.org/doc_end_user/current_document.php?id=13287) **AhG11/EE1: Status of the joint EE1-0 (LOP.2) training** [D. Rusanovskyy](mailto:dmytror@qti.qualcomm.com)**,**[Y. Li (Qualcomm)](mailto:yli30@qti.qualcomm.com)**,**[T. Shao](mailto:Tong.Shao@dolby.com)**,**[P. Yin (Dolby)](mailto:pyin@dolby.com)**,**[J. N. Shingala](mailto:jay.shingala@ittiam.com)**,**[A. Shyam](mailto:ajayshyam@ittiam.com)**,**[A. Suneja](mailto:ajat.suneja@ittiam.com)**,**[S. P. Badya (Ittiam)](mailto:siddarth.badya@ittiam.com)**,**[J. Li](mailto:lijunru@bytedance.com)**,**[Y. Li](mailto:yue.li@bytedance.com)**,**[C. Lin](mailto:linchaoyi.cy@bytedance.com)**,**[K. Zhang](mailto:zhangkai.video@bytedance.com)**,**[L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com)**,**[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)



*Figure* *1 Proposed unified architecture for LOP EE1 test*

Training and inference cross-checked since training was conducting by multiple parties: Qualcomm, Ittiam, Dolby (no separate documents needed).

After Stage 3 training, selected LOP 2.3 candidate model demonstrated BD-rate change of: {-4.7%, -9.8, -10.1%} and {-5.3%, -10.9%,-10.4%} vs VTM for AI and RA configurations, respectively.

Comparing to NNVC anchor (NN-Intra ON), LOP2.3 with enabled NN-Intra demonstrated BD-rate change of {-0.2%, -4.6%, -4.6%} and {-0.3%,-4.3%,-4.3%} for AI and RA, respectively. In this test, filter LOP2.3 utilizes a single model with 0.05M parameters, whereas the Anchor uses 4 models, total size of 0.2M.

Additional bd-rate gain of {-0.0%, -0.5%, -0.2%} and {-0.0%,-1.3%,-0.3%} for AI and RA, respectively, is reported in the sub-test EE1-0.4, targeting improved filter usage (interface).Aspects of common interest:

* finding in training strategy,
* layer quantization

Recommendation: to be presented in details as strong candidate for adoption and source of useful information.

***EE1-1.1.1***

Input contribution: [JVET-AF0153](https://jvet-experts.org/doc_end_user/current_document.php?id=13411) EE1-1.1.1: Optimization for complexity-performance trade-off of HOP network [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)

A diagram of a computer

Description automatically generated

Filter architecture: HOP-based

Training strategy: HOP

Training conducted: Tencent

Cross-check: Inference and training cross-check of test 1 are conducted, cross-checker: OPPO ([JVET-AF0266](https://jvet-experts.org/doc_end_user/current_document.php?id=13530)).

Notes: This test includes subtests targeting to optimize the complexity-performance trade-off of residual block structures and network architecture. The improved residual blocks (HOP residual block with depth-wise separable convolution and HOP residual block with group convolution) and split architecture from JVET-AE0160 are to be tested. This test may include the subtests by combining the elements from JVET-AE0160 and the subtests planned in test EE1-1.5 from JVET-AD2023.

***EE1-1.1.2***

Input contribution: [JVET-AF0102](https://jvet-experts.org/doc_end_user/current_document.php?id=13349) EE1-1.1.2 Complexity-performance tradeoff of decomposition [D. Rusanovskyy](mailto:dmytror@qti.qualcomm.com)**,**[Y. Li](mailto:yli30@qti.qualcomm.com)**,**[M. Karczewicz (Qualcomm)](mailto:martak@qti.qualcomm.com)

A screenshot of a computer

Description automatically generated A screenshot of a computer

Description automatically generated

Filter architecture: HOP-based.

Training strategy: HOP

Training conducted: Qualcomm

Cross-check: Inference and training supposed to be cross-checked by Byetedance, cross-check is missed.

This test targets to optimize the complexity-performance trade-off of the convolution decomposition and residual block structures. Reduced rank decomposition and decomposition order alternation of JVET-AE0164 to be tested. The test will include sub-tests with across architecture complexity-performance optimization.

***EE1-1.1.3***

Input contribution: [JVET-AF0103](https://jvet-experts.org/doc_end_user/current_document.php?id=13350) **EE1-1.1.3 Study on input feature set optimization,**[Y. Li](mailto:yli30@qti.qualcomm.com)**,**[M. Karczewicz (Qualcomm)](mailto:martak@qti.qualcomm.com)

A diagram of a block diagram

Description automatically generated

Filter architecture: HOP-based

Training strategy: HOP

Training conducted: Qualcomm

Cross-check: Training cross-checked by InterDigital ([JVET-AF0258](https://jvet-experts.org/doc_end_user/current_document.php?id=13521))

This test targets to optimize input feature set extraction, along methods of EE1-1.3.2 (JVET-AD0205). In particular, the headblock design optimization toward improving performance-complexity trade-off and hardware friendliness.

***EE1-1.1.4***

Input contribution(s):

[JVET-AF0181](https://jvet-experts.org/doc_end_user/current_document.php?id=13439) **EE1-1.1.4.a: Simplified feature extraction for HOP** [Y. Li](mailto:yue.li@bytedance.com)**,**[K. Zhang](mailto:zhangkai.video@bytedance.com)**,**[L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com)

[JVET-AF0182](https://jvet-experts.org/doc_end_user/current_document.php?id=13440) **EE1-1.1.4.b: Group convolution for HOP** [Y. Li](mailto:yue.li@bytedance.com)**,**[K. Zhang](mailto:zhangkai.video@bytedance.com)**,**[L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com)

[JVET-AF0183](https://jvet-experts.org/doc_end_user/current_document.php?id=13441) **EE1-1.1.4.c/d: Separate models for HOP** [Y. Li](mailto:yue.li@bytedance.com)**,**[K. Zhang](mailto:zhangkai.video@bytedance.com)**,**[L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com)

A diagram of a flowchart

Description automatically generatedA diagram of a system

Description automatically generated

Filter architecture: HOP-based.

Training strategy: HOP

Training conducted: Bytedance

This test was planned to include sub-tests targeting at optimizing the complexity-performance trade-off of the HOP model, e.g. separate models for luma and chroma (as described in EE1-1.1 in JVET-AD2023), network architecture optimization (as described in EE1-1.4 in JVET-AD2023), along methods in JVET-AD0106, JVET-AD0237.

Cross-check:

* 1.1.4.c/d: Separate luma/chroma model: InterDigital ([JVET-AF0260](https://jvet-experts.org/doc_end_user/current_document.php?id=13523))
* 1.1.4.a/b: Reduced complexity headblock and group convolution usage: Qualcomm ([JVET-AF0282 and JVET-AF0283)](https://jvet-experts.org/doc_end_user/current_document.php?id=13523)

***EE1-1.1.5: Combination of EE1-1.1.1 and EE1-1.1.2***

Input contribution: [JVET-AF0192](https://jvet-experts.org/doc_end_user/current_document.php?id=13453) **EE1-1.1.5: Combination test of EE1-1.1.1 and EE1-1.1.2** [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)**,**[D. Rusanovskyy](mailto:dmytror@qti.qualcomm.com)**,**[Y. Li](mailto:yli30@qti.qualcomm.com)**,**[M. Karczewicz (Qualcomm)](mailto:martak@qti.qualcomm.com)

A diagram of a block diagram

Description automatically generated

Filter architecture: HOP-based.

Training strategy: HOP

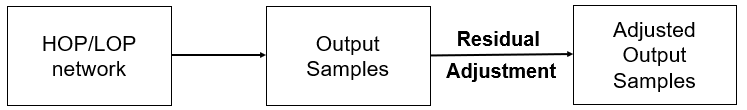
Training conducted: Qualcomm and Tencent

Cross-check: Inference and training cross-check are planned, cross-checker: OPPO ([JVET-AF0267](https://jvet-experts.org/doc_end_user/current_document.php?id=13531)).

This test study a direct combination of tests EE1-1.1.1 and EE1-1.1.2. Group convolution of EE1-1.1.1 to be introduced in the multi-scale branch of the Backbone Blocks (T1/T2) with a reduced rank decomposition of EE1-1.1.2 being used in the main branch of the T1/T2.

***EE1-1.2.1***

Input contribution: [JVET-AF0085](https://jvet-experts.org/doc_end_user/current_document.php?id=13333) EE1-1.2.1: On residual adjustments for NNLF [Z. Dai](mailto:daizhenyu@oppo.com), [Y. Yu](mailto:yue.yu@oppo.com), [H. Yu](mailto:v-yuhaoping@oppo.com), [D. Wang (OPPO)](mailto:wangdong7@oppo.com)



Filter architecture: HOP and LOP

Tester: OPPO

Cross-check of test: Inference cross-check is conducted, cross-checker: InterDigital([JVET-AF0254](https://jvet-experts.org/doc_end_user/current_document.php?id=13517)).

Notes: This test evaluates the residual offset adjustment and combination with chroma order adjustment on top of HOP/LOP. A frame level two-step residual adjustment method is proposed to adjust the output of the NNLF in the inference stage. Firstly, 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}. Secondly, the residual is decremented by the average residual value which is derived by computing the average of the residual for all pixels in each CTU. 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.

***EE1-1.2.2 Content-adaptive LOP filter***

Input contribution: [JVET-AF0056](https://jvet-experts.org/doc_end_user/current_document.php?id=13304) **EE1-1.2.2: Content-adaptive LOP filter** [R. Yang](mailto:ruiying.yang@nokia.com), [M. Santamaria](mailto:maria.santamaria_gomez@nokia.com), [F. Cricri](mailto:francesco.cricri@nokia.com), [H. Zhang](mailto:honglei.1.zhang@nokia.com), [J. Lainema](mailto:jani.lainema@nokia.com), [M. M. Hannuksela](mailto:miska.hannuksela@nokia.com), [A. Hallapuro (Nokia)](mailto:antti.hallapuro@nokia.com)

3x3 conv 3x3x10xM

Leaky ReLu

3x3 conv 3x3xKxL

1x1 conv 1x1xMxM

Leaky ReLu

3x3 conv 3x3xKxK

1x1 conv 1x1xMxK

1x1 conv 1x1xKxM

Leaky ReLu

3x3 conv 3x3xKxK

1x1 conv 1x1xMxK

BS info

Qstep

Yx4+U+V 72x72x10

NxN

1x1 conv 1x1xKxM

Leaky ReLu

3x3 conv 3x3xKxK

1x1 conv 1x1xMxK

Y’x4+U’+V‘ 64x64x6

N’xN’

***n*** Hidden Layers

1x1 conv 1x1xKxR

3x1 Sep conv 3x1xRxR

3x1xRxR

1x1 conv 1x1xRxK

1x3 Sep conv 1x3xRxR

CP decomposition

Layers approximated with CP decomposition

Separable Convolution layers

1x1 conv 1x1xMxR

1x1 conv 1x1xRxM

Filter architecture: NNVC 5.0 LOP with multiplier terms

Training strategy: no re-training, but the filter is overfitted on each test sequence, see JVET-AE0093.

Cross-check of overfitting: cross-checkers: OPPO([JVET-AF0216](https://jvet-experts.org/doc_end_user/current_document.php?id=13479)) & Ittiam([JVET-AF0119](https://jvet-experts.org/doc_end_user/current_document.php?id=13366))

Notes: Study content-adaptation on top of NNVC 5.0 LOP filter & signaling mechanism for the adaptation parameters.

***EE1-1.2.3***

Input contribution: [JVET-AF0154](https://jvet-experts.org/doc_end_user/current_document.php?id=13412) **EE1-1.2.3: Input and output rotation of model for NNVC in-loop filter**

[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)

A close-up of a white card

Description automatically generated

Filter architecture: HOP and LOP

Tester: Tencent

Cross-check of test: Inference cross-check is conducted, cross-checker: Ericsson([JVET-AF0257](https://jvet-experts.org/doc_end_user/current_document.php?id=13520)).

Notes: Rotation operations are applied to the inputs and outputs of NNVC HOP/LOP network to further improve the coding performance. All the input samples including reconstructed samples, prediction samples, BS, BaseQP, SliceQP and IPB are rotated and then fed into network to perform the inference. After that, the output of network is rotated back to restore the original order of filtered samples.

***EE1-1.2.4***

Input contribution: [JVET-AF0205](https://jvet-experts.org/doc_end_user/current_document.php?id=13466) EE1-1.2.4: An improved inference design of NN-based loop-filters at high operation point [J. Li](mailto:lijunru@bytedance.com), [Y. Li](mailto:yue.li@Bytedance.com), [C. Lin](mailto:linchaoyi.cy@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com)

Filter architecture: HOP-based.

Cross-check: Inference cross-check are planned, cross-checker TBA

Notes: This EE test study the unified filter usage of HOP and LOP, along methods in JVET-AE0238.

***EE1-1.2.6***

Input contribution: [JVET-AF0086](https://jvet-experts.org/doc_end_user/current_document.php?id=13334) **EE1-1.2.6: On flipping of input and output of model in NNVC HOP filter** [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)



Filter architecture: HOP

Tester: OPPO

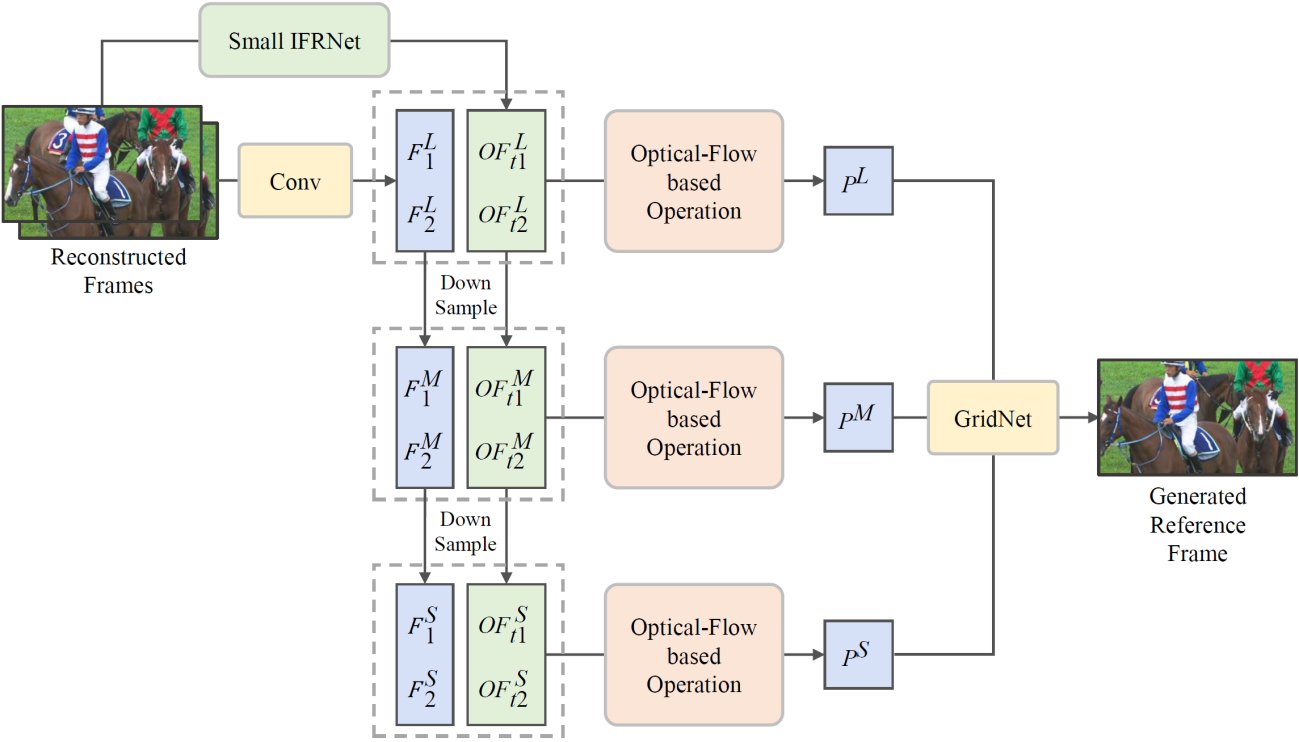
Cross-check of test: Inference cross-check is conducted, cross-checker: Tencent [JVET-AF0272](https://jvet-experts.org/doc_end_user/current_document.php?id=13536).

Notes: Flipping operations are applied to the inputs and outputs of NNVC HOP network to further improve the coding performance. All the input samples including reconstructed samples, prediction samples, BS, BaseQP, SliceQP and IPB are flipped horizontally or vertically, then fed into network to perform the inference. After inference, the output of network is flipped back to restore the original order of filtered samples.

***EE1-2.1***

Input contribution: [JVET-AF0208](https://jvet-experts.org/doc_end_user/current_document.php?id=13471) **EE1-2.1: Deep Reference Frame Generation for Inter Prediction Enhancemen** [W. Bao](mailto:baoweijie@whu.edu.cn)**,**[X. Chen](mailto:cinched@whu.edu.cn)**,**[J. Jia](mailto:jiajh2021@whu.edu.cn)**,**[Y. Zhang](mailto:yuantongzhang@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)

Filter architecture: Figure 2 illustrates the network architecture of the inter frame generation network, which is based on the model described in JVET-AE0112.



*The network architecture of the inter frame generation method*

Training strategy:The model can be trained using compressed BVI and TVD datasets or other datasets that can be used for NNVC standardization.The pictures in the dataset are compressed by VTM, with QP value randomly selected from 22, 27, 32, 37, and 42. The loss function is L1 loss, which is minimized using the Adam optimizer. A pre-trained small IFRNet network is used as our flow estimator, with a learning rate set at . The other parts of the network trained at a learning rate of . The training epochs are set to 200.

Training conducted: Wuhan University, Tencent.

Notes: This test aims to accelerate the float inference and implement integer inference. This test will analyze the compression performance of this method with LOP filter enabled, while also exploring the potential for reducing complexity.

Inference cross-check was conducted, cross-checker: OPPO ([JVET-AF0268](https://jvet-experts.org/doc_end_user/current_document.php?id=13532)).

Cross-checker(s) comments: Results match.

***EE1-3.1***

Input contribution: [JVET-AF0139](https://jvet-experts.org/doc_end_user/current_document.php?id=13397) EE1-3.1: Neural network-based intra prediction with reduced complexity [T. Dumas](mailto:thierry.dumas@interdigital.com), F. Galpin, P. Bordes (InterDigital)

NN-Intra is enabled by default in NNVC-5.0 Design of NN-Intra is show in Figure 10.

Note that all the mentioned layers are fully-connected. No convolutional layers exist in the presented neural networks. Changes compared to NN-Intra in common SW base (NNVC0) are summarized in the table below. The percentage of non-zero weights in the layer returning becomes 10% for the neural network predicting blocks of size , and 50% for the other six neural networks.

Computational complexity is different for different block sizes, the worst case is 4.8 kMAC/pixel (7.8 in NNVC). Total number of parameters is 1.3 M (1.5 in NNVC).

In AI, full test results show ~0.2% BD-rate performance degradation compared to NN-intra in NNVC-5.0. In RA, partial test results (full test results will be available by start of the meeting) show ~0.1% (RA) BD-rate performance degradation compared to NN-intra in NNVC-5.0.

Diagram

Description automatically generated

*Prediction of the current block from its context of reference samples via the neural network , parametrized by , belonging to the neural network-based intra prediction mode. Here, and The dimensions of the context of reference samples, “preprocessing”, “postprocessing”, , , are explained in NNVC description document.*

*Table 2 architecture policy for each neural network in common SW base NNVC and proposed solution (EE1-6).*

|  |  |  |
| --- | --- | --- |
| **architecture** | **NN-Intra in common SW base** | **Proposal** |
| Number of hidden layers | For 16x16, 3.  For the other six neural networks, 2. | Same. |
| Number of neurons per hidden layer | 1216. | For 4x4, 8x4, and 16x16, 1216 for the last hidden layer, and 640 for the other hidden layers.  For the other four neural networks, 1216. |
| Biases | For all layers. | Only for the layer returning and the layer returning and . |

Training cross-check was conducted by Qualcomm (JVET-AF0281) and OPPO ([JVET-AF0217](https://jvet-experts.org/doc_end_user/current_document.php?id=13480))

Cross-checker(s) comments:

***Recommendations***:

* Present JVET-AF0043 (EE1-0) in details and adopt proposed LOP design to NNVC-7
* Agree on Next HOP design, combining elements from different proponents and train HOP jointly during next meeting period (BoG is needed)
* Adopt (EE1-3.1) and so reduce computational complexity of NN-Intra in NNVC

Remarks from presentation in JVET:

For EE1-1.1.4c/d (separate filters luma chroma), some uma gain, but chroma has losses 1.5%..2%, and the decoder run time more than doubles relative to NNVC HOP (may be an implementation issue? Group convolution in SADL?), encoder run time also increases. Other variants such as 1.1.2/1.1.5 have reductions in run time.

The loss in chroma may be an issue of training, or due to the fact that luma-to-chroma benefit is lost. Chroma has higher gain in NNVC HOP anyway, and balance is more difficult to control in single model.

New unified LOP architecture from LOP (EE1-0.x) also has separate branches for luma/chroma output, but giving gain for chroma relative to old LOP.

From comments of experts in the discussion, some more preference could be found for separation of luma and chroma filters, due to higher flexibility, better control in achieving luma/chroma balance, faster (parallel) training. On the other hand, it was argued that a single model is better to understand.

At the current meeting, there is anyway no candidate to change the HOP filter into separate models, as training crosscheck would still need to be performed for proposals available.

EE1-1.2.4 has slight improvement of HOP by modification at inference (boundary processing), but crosscheck not finished. Potential candidate – revisit in BoG.

EE1-1.2.2 (content adaptive LOP): It was suggested to provide the option of sending filter parameters once per RA period (rather than once per sequence as done currently)

EE1-2.1 (deep reference frame generation): Only inference cross-checked so far – training cross-check to be conducted towards next EE, also combination with HOP filter (gain is shown over NNVC6.0 which has LOP and intra pred. in it). Training was done based on NNVC5 reference picture output (which should be similar to NNVC6).

EE1-3.1 (reduced complexity intra pred.): None of the two cross-checks was finished yet. The training consists of 4 stages, and the script may not be simple to understand, according to cross-checkers. In case that training cross-check cannot be finished before the meeting ends, a conditional adoption might be possible, similar as had been intended by the last meeting.

It was also reported verbally by proponents that by an extended training the performance of the reduced-complexity intra prediction couldbe improved (no loss relative to current version).

It was also commented that at the current stage of exploration, there is no urgency of including lower complexity intra pred.

BoG (E. Alshina, F. Galpin) on assessment of HOP proposals, starting from Monday.

Status of EE proposals:

* Suggest potential adoptions for HOP in NNVC7 (likely only EE1-1.2.4)
* Identify promising approaches for which a training crosscheck should be performed in the next EE
* Identify promising new proposals on HOP for next EE
* Discuss aspects of luma/chroma balance, and aspects of single filter vs. separate luma/chroma filters.

[JVET-AF0042](https://jvet-experts.org/doc_end_user/current_document.php?id=13286) AhG11/AhG14 teleconference [E. Alshina, F. Galpin]

### EE1 contributions: Neural network-based video coding (16)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0041](https://jvet-experts.org/doc_end_user/current_document.php?id=13285) AhG11: HOP full results [F. Galpin (InterDigital), D. Rusanovskyy, Y. Li (Qualcomm), Y. Li, J. Li (Bytedance), L. Wang, R. Chang (Tencent), Z. Xie (Oppo), E. Alshina (Huawei)]

[JVET-AF0043](https://jvet-experts.org/doc_end_user/current_document.php?id=13287) AhG11/EE1: Status of the joint EE1-0 (LOP.2) training [D. Rusanovskyy, Y. Li (Qualcomm), J. N. Shingala, A. Shyam, A. Suneja, S. P. Badya (Ittiam), T. Shao, P. Yin (Dolby)]

A Unified Filter Architecture for the Low-performance Operation Point (LOP) was proposed in JVET-AE0281 to meet LOP complexity constraints (LOP.2), following HOP based training process. This contribution reports on the progress of LOP.2 joint training and presents full set of LOP2.0, LOP2.3 results. Information presented in this document was partly presented during the AhG11/14 Telcos on 08/09/2023 and 08/30/2023.

After Stage 3 training, selected LOP 2.3 candidate model demonstrated BD-rate change of: {-4.7%, -9.8, -10.1%} and {-5.3%, -10.9%,-10.4%} vs VTM for AI and RA configurations, respectively. Comparing to NNVC anchor (NN-Intra ON), LOP2.3 with enabled NN-Intra demonstrated BD-rate change of {-0.2%, -4.6%, -4.6%} and {-0.3%,-4.3%,-4.3%} for AI and RA, respectively. In this test, filter LOP2.3 utilizes a single model with 0.05M parameters, whereas the Anchor uses 4 models, total size of 0.2M.

Additional bd-rate gain of {-0.0%, -0.5%, -0.2%} and {-0.0%,-1.3%,-0.3%} for AI and RA, respectively, is reported in the sub-test EE1-0.4, targeting improved filter usage (interface).

It is suggested to adopt filter of EE1-0 into NNVC common software and enable it by default for LOP. It is also suggested to make training strategy defined for EE1-0 a part of NNVC SW. Some aspects of LOP model training, such as training batch size, complexity-performance trade-off optimization and fast Stage 3 training can be further studied in EE1.

Was presented in JVET Saturday 14 Oct., 1125

It was asked if a better luma/chroma balance could be achieved (currently, higher gain in chroma). According to proponents likely yes, pointing to some contributions on this topic.

It is noted that the boundary padding (similar to EE1-1.2.4 for HOP) is already part of the package. It was asked if zero padding (instead of boundary sample values padding) might have subjective impact?

Influence of parameters such as batch size, learning rate? Some of these are selected different than for HOP.

Decision: Adopt JVET-AF0043 LOP 2.3 architecture, and inference interface. This will become part of NNVC7.0 anchor. Configuration files for training shall also become part of NNVC7.0.

Further study in EE: Fast stage 3 training as proposed in JVET-AF0043, influence of parameters such as batch size, learning rate, improved luma/chroma balance (bits from C to L), continuation of previous subtest EE1-0.2.

[JVET-AF0056](https://jvet-experts.org/doc_end_user/current_document.php?id=13304) EE1-1.2.2: Content-adaptive LOP filter [R. Yang, M. Santamaria, F. Cricri, H. Zhang, J. Lainema, M. M. Hannuksela, A. Hallapuro (Nokia)]

Continue EE, see under JVET-AF0023

[JVET-AF0119](https://jvet-experts.org/doc_end_user/current_document.php?id=13366) Crosscheck of JVET-AF0056 (EE1-1.2.2: Content-adaptive LOP filter) [J. N. Shingala, A. Shyam, S. P. Badya (Ittiam)] [late] [miss]

[JVET-AF0216](https://jvet-experts.org/doc_end_user/current_document.php?id=13479) Crosscheck of JVET-AF0056 (EE1-1.2.2: Content-adaptive LOP filter) [Z. Dai (OPPO)] [late] [miss]

[JVET-AF0085](https://jvet-experts.org/doc_end_user/current_document.php?id=13333) EE1-1.2.1: On residual adjustments for NNLF [Z. Dai, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AF0254](https://jvet-experts.org/doc_end_user/current_document.php?id=13517) Cross-check of JVET-AF0085 (EE1-1.2.1: on residual adjustments of NNLF) [T. Dumas (Interdigital)] [late]

[JVET-AF0086](https://jvet-experts.org/doc_end_user/current_document.php?id=13334) EE1-1.2.6: On flipping of input and output of model in NNVC HOP filter [Z. Xie, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AF0272](https://jvet-experts.org/doc_end_user/current_document.php?id=13536) Crosscheck of JVET-AF0086 (EE1-1.2.6: On flipping of input and output of model in NNVC HOP filter) [R. Chang (Tencent)] [late] [miss]

[JVET-AF0102](https://jvet-experts.org/doc_end_user/current_document.php?id=13349) EE1-1.1.2 Complexity-performance tradeoff of decomposition [D. Rusanovskyy, Y. Li, M. Karczewicz (Qualcomm)]

[JVET-AF0285](https://jvet-experts.org/doc_end_user/current_document.php?id=13549) Crosscheck of JVET-AF0102 (EE1-1.1.2 Complexity-performance trade off of decomposition) [Y. Li (Bytedance)] [late] [miss]

[JVET-AF0103](https://jvet-experts.org/doc_end_user/current_document.php?id=13350) EE1-1.1.3 Study on input feature set optimization [D. Rusanovskyy, Y. Li, M. Karczewicz (Qualcomm)]

[JVET-AF0258](https://jvet-experts.org/doc_end_user/current_document.php?id=13521) Crosscheck of JVET-AF0103 (EE1-1.1.3 Study on input feature set optimization) [F. Galpin (InterDigital)] [late] [miss]

[JVET-AF0139](https://jvet-experts.org/doc_end_user/current_document.php?id=13397) EE1-3.1: neural network-based intra prediction with reduced complexity [T. Dumas, F. Galpin, P. Bordes (InterDigital)]

[JVET-AF0217](https://jvet-experts.org/doc_end_user/current_document.php?id=13480) Crosscheck of JVET-AF0139 (EE1-3.1: neural network-based intra prediction with reduced complexity) [Z. Dai (OPPO)] [late] [miss]

[JVET-AF0281](https://jvet-experts.org/doc_end_user/current_document.php?id=13545) Crosscheck of JVET-AF0139 (EE1-3.1: neural network-based intra prediction with reduced complexity) [P. Garus, D. Rusanovskyy (Qualcomm)] [late] [miss]

[JVET-AF0153](https://jvet-experts.org/doc_end_user/current_document.php?id=13411) EE1-1.1.1: Optimization for complexity-performance trade-off of HOP network [R. Chang, L. Wang, X. Xu, S. Liu (Tencent)]

[JVET-AF0266](https://jvet-experts.org/doc_end_user/current_document.php?id=13530) Crosscheck of JVET-AF0153 (EE1-1.1.1: Optimization for complexity-performance trade-off of HOP network) test1 [Z. Xie (OPPO)] [late] [miss]

[JVET-AF0154](https://jvet-experts.org/doc_end_user/current_document.php?id=13412) EE1-1.2.3: Input and output rotation of model for NNVC in-loop filter [R. Chang, L. Wang, X. Xu, S. Liu (Tencent)]

[JVET-AF0257](https://jvet-experts.org/doc_end_user/current_document.php?id=13520) Crosscheck of JVET-AF0154 (EE1-1.2.3: Input and output rotation of model for NNVC in-loop filter) [D. Liu (Ericsson)] [late] [miss]

[JVET-AF0181](https://jvet-experts.org/doc_end_user/current_document.php?id=13439) EE1-1.1.4.a: Simplified feature extraction for HOP [Y. Li, K. Zhang, L. Zhang (Bytedance)]

[JVET-AF0282](https://jvet-experts.org/doc_end_user/current_document.php?id=13546) Crosscheck of JVET-AF0181 (EE1-1.1.4.a: Simplified feature extraction for HOP) [D. Rusanovskyy (Qualcomm)] [late] [miss]

[JVET-AF0182](https://jvet-experts.org/doc_end_user/current_document.php?id=13440) EE1-1.1.4.b: Group convolution for HOP [Y. Li, K. Zhang, L. Zhang (Bytedance)]

[JVET-AF0283](https://jvet-experts.org/doc_end_user/current_document.php?id=13547) Crosscheck of JVET-AF0182 (EE1-1.1.4.b: Group convolution for HOP) [D. Rusanovskyy (Qualcomm)] [late] [miss]

[JVET-AF0183](https://jvet-experts.org/doc_end_user/current_document.php?id=13441) EE1-1.1.4.c/d: Separate models for HOP [Y. Li, K. Zhang, L. Zhang (Bytedance)]

[JVET-AF0260](https://jvet-experts.org/doc_end_user/current_document.php?id=13523) Crosscheck of JVET-AF0183 (EE1-1.1.4.c/d: Separate models for HOP) [F. Galpin (InterDigital)] [late] [miss]

[JVET-AF0192](https://jvet-experts.org/doc_end_user/current_document.php?id=13453) EE1-1.1.5: Combination test of EE1-1.1.1 and EE1-1.1.2 [R. Chang, L. Wang, X. Xu, S. Liu (Tencent), D. Rusanovskyy, Y. Li, M. Karczewicz (Qualcomm)]

[JVET-AF0267](https://jvet-experts.org/doc_end_user/current_document.php?id=13531) Crosscheck of JVET-AF0192 (EE1-1.1.5: Combination test of EE1-1.1.1 and EE1-1.1.2) [Z. Xie (OPPO)] [late] [miss]

[JVET-AF0205](https://jvet-experts.org/doc_end_user/current_document.php?id=13466) EE1-1.2.4: An improved inference design of NN-based loop-filters at high operation point [J. Li, Y. Li, C. Lin, K. Zhang, L. Zhang (Bytedance)]

[JVET-AF0294](https://jvet-experts.org/doc_end_user/current_document.php?id=13558) Crosscheck of JVET-AF0205 (EE1-1.2.4: An improved inference design of NN-based loop-filters at high operation point) [T. Shao (Dolby)] [late] [miss]

[JVET-AF0208](https://jvet-experts.org/doc_end_user/current_document.php?id=13471) EE1-2.1: Deep Reference Frame Generation for Inter Prediction Enhancement W. Bao, X. Chen, J. Jia, Y. Zhang, Z. Chen (Wuhan Univ.), Z. Liu, X. Xu, S. Liu (Tencent) [late]

[JVET-AF0268](https://jvet-experts.org/doc_end_user/current_document.php?id=13532) Crosscheck of JVET-AF0208 (EE1-2.1: Deep Reference Frame Generation for Inter Prediction Enhancement) [Z. Xie (OPPO)] [late] [miss]

### EE1 related contributions: Neural network-based video coding (1)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0071](https://jvet-experts.org/doc_end_user/current_document.php?id=13319) EE1-related: Further complexity reduction on the joint EE1-0 (LOP.2) unified filter [[T. Shao](mailto:tong.shao@dolby.com), [P. Yin](mailto:pyin@dolby.com), S. McCarthy (Dolby), [J. N. Shingala](mailto:jay.shingala@ittiam.com), [A. Shyam](mailto:ajayshyam@ittiam.com), A. Suneja, S. P. Badya (Ittiam)]

TBP

[JVET-AF0284](https://jvet-experts.org/doc_end_user/current_document.php?id=13548) Crosscheck of JVET-AF0071 (EE1-related: Further complexity reduction on the joint EE1-0 (LOP.2) unified filter) [Y. Li, D. Rusanovskyy (Qualcomm)] [late] [miss]

### Improvements of NNVC software beyond EE1 (11)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0143](https://jvet-experts.org/doc_end_user/current_document.php?id=13401) AHG11: Unified CNN super resolution for resampling-based video coding [C. Lin, Y. Li, J. Li, K. Zhang, L. Zhang (Bytedance)]

[JVET-AF0150](https://jvet-experts.org/doc_end_user/current_document.php?id=13408) AhG11: on HOP batch size [F. Galpin, T. Dumas, P. Bordes (InterDigital)]

[JVET-AF0152](https://jvet-experts.org/doc_end_user/current_document.php?id=13410) AhG14: SADL update [F. Galpin, T. Dumas, P. Bordes, E. Francois (InterDigital)]

[JVET-AF0155](https://jvet-experts.org/doc_end_user/current_document.php?id=13413) AhG11: on HOP luma/chroma balance [F. Galpin, T. Dumas, P. Bordes (InterDigital)]

[JVET-AF0158](https://jvet-experts.org/doc_end_user/current_document.php?id=13416) AHG11: HOP In-loop filter with transformer blocks [Y. Li, D. Rusanovskyy, T. Ryder, S. Eadie, M. Karczewicz (Qualcomm)]

[JVET-AF0172](https://jvet-experts.org/doc_end_user/current_document.php?id=13430) AHG14: Cleanup on scale flag signalling for HOP [Y. Li, K. Zhang, L. Zhang (Bytedance)]

[JVET-AF0259](https://jvet-experts.org/doc_end_user/current_document.php?id=13522) Crosscheck of JVET-AF0172 (AHG14: Cleanup on scale flag signalling for HOP) [F. Galpin (InterDigital)] [late] [miss]

[JVET-AF0180](https://jvet-experts.org/doc_end_user/current_document.php?id=13438) AHG11: HOP training adjustment to improve luma/chroma coding gain balance [D. Rusanovskyy, Y. Li, M. Karczewicz (Qualcomm)]

[JVET-AF0193](https://jvet-experts.org/doc_end_user/current_document.php?id=13454) AHG11: Decoder complexity optimization for NNVC in-loop filter [R. Chang, L. Wang, X. Xu, S. Liu (Tencent)]

[JVET-AF0256](https://jvet-experts.org/doc_end_user/current_document.php?id=13519) Crosscheck of JVET-AF0193 (AHG11: Decoder complexity optimization for NNVC in-loop filter) [D. Liu (Ericsson)] [late] [miss]

[JVET-AF0278](https://jvet-experts.org/doc_end_user/current_document.php?id=13542) Cross-check of JVET-AF0193 (AHG11: Decoder complexity optimization for NNVC in-loop filter) [M. Santamaria (Nokia)] [late] [miss]

[JVET-AF0206](https://jvet-experts.org/doc_end_user/current_document.php?id=13467) AHG11: Complexity reduction of NN-based loop-filters [J. Li, Y. Li, C. Lin, K. Zhang, L. Zhang (Bytedance)]

[JVET-AF0236](https://jvet-experts.org/doc_end_user/current_document.php?id=13499) AHG14: The extension of SADL library [W. Bao, Y. Cai, Y. Zhang, Z. Chen (Wuhan Univ.)] [late]

[JVET-AF0296](https://jvet-experts.org/doc_end_user/current_document.php?id=13560) AhG11: on HOP learning rate [F. Galpin, T. Dumas, P. Bordes (InterDigital)] [late]

### Other aspects of neural network-based video coding (0)

Section kept as a template for future use.

## AHG6/AHG12: Enhanced compression beyond VVC capability (78+1)

### Summary and BoG reports (1)

Contributions in this area were discussed at 1400–1915 on Friday 13 Oct. 2023 (chaired by JRO) except otherwise noted.

[JVET-AF0024](https://jvet-experts.org/doc_end_user/current_document.php?id=13470) 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]

This document provides a summary report of Exploration Experiment on Enhanced Compression beyond VVC capability. The tests are categorized as partitioning, intra prediction, inter prediction, transform and coefficient coding, and in-loop filtering.

The software basis for this EE is ECM-10.0, released at <https://vcgit.hhi.fraunhofer.de/ecm/ECM/-/tags/ECM-10.0>. ECM-10.0 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-ae-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-ae-ee2/simulation-results> if cross-check reports are not submitted as they are optional for EE tests.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Tests** | **Tester** | **Cross-checker** |
| **1 Partitioning** | | | |
| 1.1a | Non-square quadtree partitioning | LGE  Y. Ahn  [JVET-AF0108](https://jvet-experts.org/doc_end_user/current_document.php?id=13355) | InterDigital  R. Utida |
| 1.1b | ECM with maximum MTT depth increments | LGE  Y. Ahn  [JVET-AF0108](https://jvet-experts.org/doc_end_user/current_document.php?id=13355) | InterDigital  R. Utida |
| **2 Intra prediction** | | | |
| 2.1a | DIMD merge | Nokia  S. Blasi  [JVET-AF0120](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0120-v1.zip) | Ofinno  P. Andrivon  [JVET-AF0124](https://jvet-experts.org/doc_end_user/current_document.php?id=13369) |
| 2.1b | DIMD merge with reduced storage | Nokia  S. Blasi  [JVET-AF0120](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0120-v1.zip) | Ofinno  P. Andrivon  [JVET-AF0124](https://jvet-experts.org/doc_end_user/current_document.php?id=13369) |
| 2.2a | DIMD with filtered template | vivo  C. Zhou  [JVET-AF0131](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0131-v1.zip) | Alibaba  J. Chen |
| 2.2b | DIMD with filtered template (without modification of gradient operators) | vivo  C. Zhou  [JVET-AF0131](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0131-v1.zip) | Alibaba  J. Chen |
| 2.3a | Test 2.1a + Test 2.2a | Nokia  S. Blasi  vivo  C. Zhou  [JVET-AF0126](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0126-v1.zip) | Bytedance  W. Yin  [JVET-AF0204](https://jvet-experts.org/doc_end_user/current_document.php?id=13465) |
| 2.3b | Test 2.1a + Test 2.2b | Nokia  S. Blasi  vivo  C. Zhou  [JVET-AF0126](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0126-v1.zip) | Bytedance  W. Yin  [JVET-AF0204](https://jvet-experts.org/doc_end_user/current_document.php?id=13465) |
| 2.3c | Test 2.1b + Test 2.2a | Nokia  S. Blasi  vivo  C. Zhou  [JVET-AF0126](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0126-v1.zip) | InterDigital  K. Naser |
| 2.3d | Test 2.1b + Test 2.2b | Nokia  S. Blasi  vivo  C. Zhou  [JVET-AF0126](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0126-v1.zip) | InterDigital  K. Naser |
| 2.4 | IntraCIIP as additional mode of IntraTMP | InterDigital  K. Naser  [JVET-AF0130](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0130-v1.zip) | OPPO  F. Wang  [JVET-AF0214](https://jvet-experts.org/doc_end_user/current_document.php?id=13477) |
| 2.5a | TIMD with IntraTMP/IBC | InterDigital  K. Naser  [JVET-AF0136](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0136-v1.zip) | Ofinno  P. Andrivon  [JVET-AF0125](https://jvet-experts.org/doc_end_user/current_document.php?id=13370) |
| 2.5b | Test 2.5a + Test 2.4 | InterDigital  K. Naser  [JVET-AF0136](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0136-v1.zip) | OPPO  F. Wang  [JVET-AF0215](https://jvet-experts.org/doc_end_user/current_document.php?id=13478)  Nokia  S. Blasi  [JVET-AF0243](https://jvet-experts.org/doc_end_user/current_document.php?id=13506) |
| 2.6a | Fractional-pel intraTMP BVs are stored in block vector buffer | OPPO  Y. Yu  Qualcomm  P.-H. Lin  [JVET-AF0079](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0079-v1.zip) | ETRI  W. Lim  [JVET-AF0227](https://jvet-experts.org/doc_end_user/current_document.php?id=13490) |
| 2.6b | IntraTMP BVs are stored for HMVP | OPPO  Y. Yu  Qualcomm  P.-H. Lin  [JVET-AF0079](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0079-v1.zip) | ETRI  W. Lim  [JVET-AF0227](https://jvet-experts.org/doc_end_user/current_document.php?id=13490) |
| 2.6c | Test 2.6a + Test 2.6b | OPPO  Y. Yu  Qualcomm  P.-H. Lin  [JVET-AF0079](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0079-v1.zip) | ETRI  W. Lim  [JVET-AF0227](https://jvet-experts.org/doc_end_user/current_document.php?id=13490) |
| 2.7 | Extrapolation filter-based intra prediction mode | OPPO  L. Xu  [JVET-AF0080](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0080-v1.zip) | Kwai  H. -J. Jhu  [JVET-AF0230](https://jvet-experts.org/doc_end_user/current_document.php?id=13493)  Alibaba  X. Li  [JVET-AF0221](https://jvet-experts.org/doc_end_user/current_document.php?id=13484) |
| 2.8 | DBV signalling modification | OPPO  L. Xu  [JVET-AF0081](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0081-v1.zip) | Qualcomm  H. Huang  JVET-AF0219 |
| 2.9a | Enable DBV in single tree under CTC | Qualcomm  H. Huang  [JVET-AF0066](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0066-v1.zip) | OPPO  L. Xu  [JVET-AF0076](https://jvet-experts.org/doc_end_user/current_document.php?id=13324) |
| 2.9b | Enable DBV in single tree when DualITree is set to 0 | Qualcomm  H. Huang  [JVET-AF0066](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0066-v1.zip) | OPPO  L. Xu  [JVET-AF0076](https://jvet-experts.org/doc_end_user/current_document.php?id=13324) |
| 2.10 | Combination test of Test 2.8 and Test 2.9 | Qualcomm  H. Huang  OPPO  L. Xu  [JVET-AF0207](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0207-v1.zip) | VIVO  C. Zhou |
| 2.11a | Test 2.1b + Test 2.5b | InterDigital  K. Naser  Nokia  S. Blasi  vivo  C. Zhou  [JVET-AF0229](https://jvet-experts.org/doc_end_user/current_document.php?id=13492) | Xiaomi  R.G. Youvalari  M. Abdoli  [JVET-AF0244](https://jvet-experts.org/doc_end_user/current_document.php?id=13507) |
| 2.11b | Test 2.2b + Test 2.5b | InterDigital  K. Naser  Nokia  S. Blasi  vivo  C. Zhou  [JVET-AF0229](https://jvet-experts.org/doc_end_user/current_document.php?id=13492) | Xiaomi  R.G. Youvalari  [JVET-AF0244](https://jvet-experts.org/doc_end_user/current_document.php?id=13507) |
| 2.11c | Test 2.3c + Test 2.5b | InterDigital  K. Naser  Nokia  S. Blasi  vivo  C. Zhou  [JVET-AF0229](https://jvet-experts.org/doc_end_user/current_document.php?id=13492) | Xiaomi  R.G. Youvalari  [JVET-AF0244](https://jvet-experts.org/doc_end_user/current_document.php?id=13507) |
| 2.11d | Test 2.3d + Test 2.5b | InterDigital  K. Naser  Nokia  S. Blasi  vivo  C. Zhou  [JVET-AF0229](https://jvet-experts.org/doc_end_user/current_document.php?id=13492) | Xiaomi  R.G. Youvalari  [JVET-AF0244](https://jvet-experts.org/doc_end_user/current_document.php?id=13507) |
| **3** **Inter prediction** | | | |
| 3.1a | CCP merge mode for chroma inter coding | MediaTek  M.-S. Chiang  Bytedance  Z. Deng  [JVET-AF0073](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0073-v1.zip) | InterDigital K. Naser  JVET-AF0240 |
| 3.1b | CCP merge mode for chroma inter coding without the additional second type of shifted temporal candidates | MediaTek  M.-S. Chiang  Bytedance  Z. Deng  [JVET-AF0073](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0073-v1.zip) | Qualcomm  Y.-J. Chang  JVET-AF0233 |
| 3.2 | LIC flag derivation of merge candidates with template costs | Bytedance  N. Zhang  [JVET-AF0128](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0128-v1.zip) | OPPO  Z. Xie |
| ~~3.3a~~ | ~~Multi-model CCRM~~ | ~~Bytedance~~  ~~Z. Deng~~ |  |
| 3.3b | CCP merge mode with the derived candidates with 4 derived candidates | Bytedance  Z. Deng  MediaTek  M.-S. Chiang  [JVET-AF0073](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0073-v1.zip) | vivo  Z. Lv  JVET-AF0242 |
| 3.1d | Test 3.1a + Test 3.3b (with 1 derived candidate for low-delay pictures) | MediaTek  M.-S. Chiang  Bytedance  Z. Deng  [JVET-AF0073](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0073-v1.zip) | OPPO  F. Wang  [JVET-AF0213](https://jvet-experts.org/doc_end_user/current_document.php?id=13476)  vivo  Z. Lv  JVET-AF0242 |
| 3.4a | TM-based subblock motion refinement | Bytedance  L. Zhao  [JVET-AF0163](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0163-v1.zip) | OPPO  Z. Xie  JVET-AF0270 |
| 3.4b | Interweaved affine prediction | Bytedance  L. Zhao  [JVET-AF0163](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0163-v1.zip) | OPPO  Z. Xie  JVET-AF0270 |
| 3.4c | RMVF candidate derivation with multiple CUs | Bytedance  L. Zhao  [JVET-AF0163](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0163-v1.zip) | OPPO  Z. Xie  JVET-AF0270 |
| 3.4d | Test 3.4a + Test 3.4b + Test 3.4c | Bytedance  L. Zhao  [JVET-AF0163](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0163-v1.zip) | OPPO  Z. Xie  JVET-AF0270 |
| 3.5a | DMVR with robust MV derivation | Ericsson  K. Andersson  [JVET-AF0057](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0057-v1.zip) |  |
| 3.5b | DMVREncSelect from VTM (encoder only) | Ericsson  K. Andersson  [JVET-AF0057](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0057-v1.zip) |  |
| 3.5a\* | Test 3.5a with QP 40, 43, 47, and 50 | Ericsson  K. Andersson  [JVET-AF0057](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0057-v1.zip) |  |
| 3.5b\* | Test 3.5b with QP 40, 43, 47, and 50 | Ericsson  K. Andersson  [JVET-AF0057](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0057-v1.zip) |  |
| 3.6a | Affine subblock BDOF refinement | Qualcomm  Z. Zhang  [JVET-AF0159](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0159-v1.zip) | Kwai  X. Xiu |
| 3.6b | AMVP-merge mode for affine | Qualcomm  Z. Zhang  [JVET-AF0159](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0159-v1.zip) | Kwai  X. Xiu |
| 3.6c | Test 3.6a + Test 3.6b | Qualcomm  Z. Zhang  [JVET-AF0159](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0159-v1.zip) | Kwai  X. Xiu |
| **4 Reference picture resampling** | | | |
| 4.1a | Enabling template-based reordering for scaled reference pictures | Kwai  X. Xiu  [JVET-AF0190](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0190-v1.zip) | Qualcomm  Z. Zhang |
| 4.1b | Test 4.1a + Enabling LIC for scaled reference pictures | Kwai  X. Xiu  [JVET-AF0190](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0190-v1.zip) | Qualcomm  Z. Zhang |
| 4.2a | Filtering applied after motion compensation, the post-processing upsampling is not changed | RWTH Aachen Univ.  T. Claßen  [JVET-AF0173](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0173-v1.zip) |  |
| 4.2b | Test 4.2a + perform the filtering after reconstruction | RWTH Aachen Univ.  T. Claßen  [JVET-AF0173](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0173-v1.zip) |  |
| **5 In-loop filtering** | | | |
| 5.1a | Dynamic TU scale factor for BIF with LUTs interpolation | Ericsson  V. Shchukin  [JVET-AF0112](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0112-v1.zip) | Bytedance  W. Yin  [JVET-AF0203](https://jvet-experts.org/doc_end_user/current_document.php?id=13464) |
| 5.1b | Dynamic TU scale factor for BIF | Ericsson  V. Shchukin  [JVET-AF0112](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0112-v1.zip) | Bytedance  W. Yin  [JVET-AF0203](https://jvet-experts.org/doc_end_user/current_document.php?id=13464) |
| 5.2a | Luma-residual tap in chroma-ALF | Bytedance  W. Yin  [JVET-AF0197](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0197-v1.zip) | Ericsson  V. Shchukin  [JVET-AF0225](https://jvet-experts.org/doc_end_user/current_document.php?id=13488) |
| 5.2b | Test 5.2a + Luma-residual tap in CCALF | Bytedance  W. Yin  [JVET-AF0197](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0197-v1.zip) | Ericsson  V. Shchukin  [JVET-AF0225](https://jvet-experts.org/doc_end_user/current_document.php?id=13488) |
| **6 Entropy coding** | | | |
| 6.1a | Spatial CABAC tuning | Nokia  J. Lainema  [JVET-AF0109](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0109-v1.zip) | Qualcomm  P. Nikitin, I. Jumakulyyev  [JVET-AF0188](https://jvet-experts.org/doc_end_user/current_document.php?id=13446) |
| 6.1b | Spatial CABAC tuning with reduced memory/latency | Nokia  J. Lainema  [JVET-AF0109](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0109-v1.zip) | Qualcomm  P. Nikitin, I. Jumakulyyev  [JVET-AF0188](https://jvet-experts.org/doc_end_user/current_document.php?id=13446) |
| 6.2 | Retrain I-slices context model parameters | Alibaba  R.-L. Liao  [JVET-AF0133](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0133-v1.zip) | InterDigital K. Naser  JVET-AF0239 |
| 6.3 | Test 6.2 + Test 6.1 | Nokia  J. Lainema  Alibaba  R.-L. Liao  [JVET-AF0110](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0110-v1.zip) | Kwai  X. Xiu  JVET-AF0232 |

***Test 1 - Partitioning***

**Test 1.1:** Non-square quadtree partitioning **(**[**JVET-AF0108**](https://jvet-experts.org/doc_end_user/current_document.php?id=13355)**)**

In this test, the existed restriction that any non-square block cannot be split with quadtree is removed for 2NxN and Nx2N blocks, where N is greater or equal to 8. The minimum block size depends on picture size and configuration, and the maximum block sizes can be decided according to the maximum block sizes for binary or ternary tree partitioning. Under the common test conditions, the largest block sizes for the non-square quadtree partitioning are 128×64 or 64×128 for Class A/B and 64×32 or 32×64 for other classes.

Fast encoding algorithm is applied in the test, which is related to constraints of partitioning depths considering that non-square quadtree depth is included in MTT depths, and non-square quadtree partitioning is allowed only once in MTT depths under the common test configurations. The second fast encoding algorithm is an early termination method based on CBF of the previous coding block split with BT or TT in rate-distortion optimization process. The third fast encoding algorithm is an early termination method based on RD-cost comparison between NO\_SPLIT and BT/TT blocks in RDO process.

Test 1.1a: Non-square quadtree with fast encoding algorithms

Test 1.1b: ECM-10.0 with maximum MTT depth plus 1



Tradeoff with encoding time is far from attractive.

It was reported by cross-checkers that similar benefit can be achieved by an encoder-only change (related contribution JVET-AF0280).

Minimum block size is 8x4/4x8 for luma.

Further study recommended – no action at this meeting.

***Test 2 - Intra prediction***

**Test 2.1: DIMD merge (**[**JVET-AF0120**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0120-v1.zip)**)**

In this method, a merged Histogram of Gradient (HoG) is introduced which includes HoG of neighboring blocks coded with DIMD or DIMD merge modes. When a single DIMD or DIMD Merge neighbouring block is available, then its histogram of gradients is used to form the merged HoG for the current block. If more than one DIMD or DIMD Merge neighbouring blocks are available, the corresponding histograms are combined by means of amplitude averaging to derive the merged HoG. Up to maximum 13 neighbor CUs around the current block are considered.

Finally, the merged HoG is used to compute intra-prediction modes and weights, as in conventional DIMD. The directional modes and their weights corresponding to the five highest amplitudes in the merged HoG are selected, and the corresponding predictors are blended as in conventional DIMD.

Test 2.1a: DIMD Merge.

Test 2.1b: DIMD Merge with reduced storage. Neighbour HoGs are combined by averaging the five highest amplitudes from their respective histograms. Only the five highest amplitudes are stored for a DIMD CU.

Worst case memory analysis is performed, considering that a picture is fully partitioned into 4x4 luma blocks and all blocks are encoded using DIMD.

|  |  |  |  |
| --- | --- | --- | --- |
| Class | Number of CUs | Test 2.1a memory  [Bytes] | Test 2.1b memory  [Bytes] |
| A1/A2 | 960 | 515632 | 38480 |
| B/F | 480 | 258352 | 19280 |
| C | 208 | 112560 | 8400 |
| D | 104 | 56816 | 4240 |
| E | 320 | 172592 | 12880 |

It is asserted that in CTC All Intra, the actual memory requirements measured correspond to a 1.1% increase for Test 2.1a, and a 0.2% increase for Test 2.1b.

In CTC Random Access, the actual memory requirements measured correspond to a 0.8% increase for Test 2.1a, and a 0.2% increase for Test 2.1b

**Test 2.2: DIMD with filtered template (**[**JVET-AF0131**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0131-v1.zip)**)**

In the test, a DIMD mode with filtered template is introduced, where the template is filtered using 3x3 filter before deriving HoG.

The 3x3 filter operator is used to filter the template as follows.

In Test 2.2a, the following 3x2 and 2x3 gradient operators are used for the gradient histogram derivation of the left and top templates respectively.

and

and

In Test 2.2b, the following 3x3 Sobel gradient operators are used, which is the same as in ECM, while using unfiltered samples for gradient computation at positions where filtered samples are unavailable.

and

**Test 2.3: Combination of DIMD related tests (**[**JVET-AF0126**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0126-v1.zip)**)**

Test 2.3a: Test 2.1a + Test 2.2a

Test 2.3b: Test 2.1a + Test 2.2b

Test 2.3c: Test 2.1b + Test 2.2a

Test 2.3d: Test 2.1b + Test 2.2b

**Test 2.4: IntraCIIP as additional mode of IntraTMP (**[**JVET-AF0130**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0130-v1.zip)**)**

In this new intra prediction mode, a regular intra prediction derived by TIMD is blended with IntraTMP prediction using the existing CIIP blending of ECM-10.0 as shown in the next figure.

CIIP Blending

Regular Intra Prediction

IntraTMP prediction

TIMD process

IntraTMP process

Intra mode

Block vectors

A flag is signalled to indicate this mode as a submode of IntraTMP, and IntraCIIP is only allowed when IntraTMP fusion, IntraTMP filtering and IntraTMP subpel are not applied.

**Test 2.5: TIMD with IntraTMP/IBC (**[**JVET-AF0136**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0136-v1.zip)**)**

In the test, block vectors from neighboring blocks, which are coded by IntraTMP or IBC, are used to compute predictor candidates for TIMD cost evaluation. In TIMD mode selection process, based on template SATD cost, additional predictors obtained using block vectors from both spatial and non-adjacent neighbors are utilized. The modified TIMD process can therefore result in combining regular and IntraTMP/IBC predictions or combining two different IntraTMP/IBC predictions.

Test 2.5a: TIMD with IntraTMP/IBC.

Test 2.5b: Test 2.5a + Test 2.4

**Test 2.6: IntraTMP block vector storing (**[**JVET-AF0079**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0079-v1.zip)**)**

In ECM, IntraTMP BVs are stored for the purpose of coding future IBC blocks in integer pel resolution, even though some of the IntraTMP BVs may have a quarter-pel resolution. In addition, IntraTMP BV is not stored for HMVP. Contrary to IBC that if the current block is coded in IBC mode, the IBC BV is always stored in a quarter-pel resolution and IBC BV is also stored for HMVP.

In this test, IntraTMP BV is stored in a quarter-pel resolution, and quarter-pel IntraTMP BV is also stored for HMVP for coding future blocks.

Test 2.6a: Fractional-pel IntraTMP BVs are stored in block vector buffer.

Test 2.6b: IntraTMP BVs are stored for HMVP.

Test 2.6c: Test 2.6a + Test 2.6b.

**Test 2.7: Extrapolation filter-based intra prediction mode (**[**JVET-AF0080**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0080-v1.zip)**)**

The extrapolation filter-based intra prediction mode consists of three steps:

1. The extrapolation filter coefficients are derived from a neighboring reconstructed area of the current block or filter shape and coefficients are inherited from a previous block coded with this mode. For the latter, a mode flag is signaled, and candidate list is constructed using spatial and non-adjacent blocks coded with this mode, initial list of 12 candidates is reduced to 6 after reordering based on SAD cost measured on the L-shape template of size 1. An index is further signalled to identify a candidate from the list.
2. The extrapolation process generates predicted signals from the top-left to bottom-right corner within the current block.
3. An intra prediction angle is derived by analyzing the gradient of the predicted block, and then the corresponding intra mode is used to select MTS, NSPT, and LFNST kernels for transform.

The mode is restricted to blocks with sizes not greater than 32x32 and luma component only.

Three filer shapes are used in this method, a choice of reconstructed area and filter shape shown in the next figure is signalled.

A black and white grid

Description automatically generated

A black screen with white squares

Description automatically generated

The selected filter shape moves in the selected reconstructed area with a one-sample step either horizontally or vertically to collect input samples and output samples, then the filter coefficients are derived using CCCM solver.

The merge mode is also introduced, where the filter shape and the filter coefficients are inherited from the previous decoded blocks that are coded with the tested extrapolation filter-based intra prediction mode or the merge mode based on this mode. In the merge mode, the positions and inclusion order of the spatial adjacent, temporal, non-adjacent, shifted temporal, and history candidates are the same as those defined in ECM-10.0 for the CCP merge prediction candidates. In addition, the merge candidates are reordered by comparing the SAD cost on an L-shape template with column width and row height equal to 1. In the SAD calculation, predictions of the template area by the mode filters are generated only from reconstructed (neighbouring and template) samples, allowing the filters to be applied in parallel rather than sequentially.

In the current block, the recursive predictor is derived from the top-left to the bottom-right position by a diagonal prediction order as shown in the next figure, where the predicted results of the previous diagonal are used.

A diagram of a graph

Description automatically generated

The predicted samples are calculated as follows,

where is the predicted value at (x, y) in the current block, is the coefficient of the selected filter, the index of the coefficients is from 0 to 14, is a reconstructed or a predicted value used for the current position’s prediction, and are the position offsets to the current position along x and y directions, respectively.

**Test 2.8: DBV signalling modification (**[**JVET-AF0081**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0081-v1.zip)**)**

In this test, the signalling of chroma DM mode and DBV mode is changed. When one of the five corresponding luma positions is coded with either IntraTMP or IBC and DBV mode flag is not true, DM flag is skipped, the binarization of chroma prediction mode for this case is shown in the next table.

|  |  |  |
| --- | --- | --- |
| **intra\_chroma\_pred\_mode** | **bin string** | **chroma intra mode** |
| 0 | 11100 | list[0] |
| 1 | 11101 | list[1] |
| 2 | 11110 | list[2] |
| 3 | 11111 | list[3] |
| 4 | 110 | DIMD chroma |
| 5 | 10 | DM |
| 65 | 0 | DBV |

**Test 2.9: Enable DBV in single tree (**[**JVET-AF0066**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0066-v1.zip)**)**

In this test, the constraint on DBV flag not being used for single tree case is removed.

Test 2.9a: Enable DBV in single tree under CTC.

Test 2.9b: Enable DBV in single tree when DualITree is set to 0. Single tree is enabled for the anchor and the test.

**Test 2.10: Combination test of Test 2.8 and Test 2.9 (**[**JVET-AF0207**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0207-v1.zip)**)**

Test 2.10: Test 2.8 + Test 2.9a

**Test 2.11: Combination test of Tests 2.1, 2.2, 2.3, 2.4, and 2.5 (**[**JVET-AF0229**](https://jvet-experts.org/doc_end_user/current_document.php?id=13492)**)**

Test 2.11a: Test 2.1b + Test 2.5b

Test 2.11b: Test 2.2b + Test 2.5b

Test 2.11c: Test 2.3c + Test 2.5b

Test 2.11d: Test 2.3d + Test 2.5b

Results (AI/RA)



2.1-2.5 and combination 2.11 (2.11d is the best, combining 4 different elements) is giving only close to 0.2% luma gain, but increases processing needs both at encoder and decoder (also reflected in run times) – no attractive tradeoff.2.6x is targeting unification of the BV storage between IntraTMP and IBC (IBC already using fractional pel). Though such a design polishing is not overly important in the exploration, it also gives a very small coding gain for screen content. Support for 2.6c was expressed by several experts. Decision: Adopt JVET-AF0079 test 2.6c.

2.7 has higher gain than original proposal. The proponents explain that an EIP merge mode was added. Concern is raised that this is new element proposal that was not originally planned in the EE. Furthermore, the previous proposal (test 2.8 from JVET-AE0024) had an encoder run time increase of 2.5% with 0.16% gain, and it had been requested to reduce the run time. In the new 2.7, the run time has further increased to 3% by adding the new element. Though the gain was also increased to 0.24%, this was not the original intent given by the EE definition. Further study in the next EE, to reduce the encoder run time of both the previous proposal and the extension with the new merge mode. It was also commented that the RA performance looks more attractive with the added element.

The signalling modification from 2.8 does not have significant benefit (even less in the combination 2.10 (2.8/ 2.9), enabling DBV for single tree). Test 2.9, enabling DBV with single tree (in CTC only relevant for RA) is asserted to be straightforward, likely simpler than for dual tree where it is already enabled).

Decision: Adopt JVET-AF0066, test 2.9a.

***Test 3 - Inter prediction***

**Test 3.1/3.3: CCP merge mode for chroma inter coding (**[**JVET-AF0073**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0073-v1.zip)**)**

In CCP merge mode, cross-component model parameters of the current chroma block can be inherited from a selected candidate in the CCP merge list comprising spatial adjacent, spatial non-adjacent, history-based, and default candidates. For P- and B- slices, temporal, shifted temporal, and InterCCCM candidates are further added.

In the tests, CCP merge is extended to inter coded blocks, and this mode is indicated by a flag. If applied, a CCP model is implicitly selected from a CCP merge list. The final prediction of the current chroma inter block is formed by combining the motion-compensation predicted signals and the cross-component predicted signals derived using the selected CCP model. The weights for combining predictions are fixed as (wCCP, winter) = (3/4, 1/4).

CCP merge list construction

In addition to the existing candidates of CCP merge mode, the CCP merge list includes a second type of shifted temporal candidates and the CCP models in the list can be inherited from intra and inter blocks. After constructing the CCP merge list, the candidate with the lowest template cost is implicitly selected.

Shifted temporal candidates

While positions of the first type shifted temporal candidates are derived based on neighboring motion vectors, the positions of the second type are derived based on the current motion vector. As depicted in the next figure, the position of the collocated block and the positions of C0i and C1i, 1 ≤ i ≤ 10, are shifted by a motion vector from the current block, where C0i and C1i are the positions of the temporal candidates.

A screenshot of a game

Description automatically generated

Inheritance of CCP models from inter blocks

CCP models can also be inherited from inter blocks, in addition to models from intra blocks coded in CCLM, MMLM, CCCM, GLM, chroma fusion, and CCP merge modes. For each inter block, a CCP model is stored after the block is coded in inter CCP merge mode or InterCCCM, or retrieved from a reference position located by the motion vector of the inter block following the rules of intra prediction mode propagation.

Derived candidates

A CCP model can also be derived based on the neighboring reconstructed samples of the current block without accessing the luma reconstructed samples of the current block. When any of the derived CCCM/CCLM model parameters of Cb and Cr is non-zero, such derived candidate is inserted at the beginning of the CCP merge list. At most 4 derived candidates, including single-model CCCM, multi-model CCCM, single-model CCLM, and multi-model CCLM, are inserted to the CCP merge list for an inter CCP merge mode.

Test 3.1b: The CCP merge list consists of all candidates in CCP merge mode for intra (i.e. spatial adjacent, temporal, spatial non-adjacent, history-based, shifted temporal, and default candidates) and no additional candidates are included.

Test 3.1a: Test 3.1b with the second type of shifted temporal candidates.

Test 3.3b: Test 3.1b (without temporal and shifted temporal candidates) with at most 4 derived candidates.

Test 3.1d: Test 3.1a + Test 3.3b with at most 1 derived candidate added in the front of the CCP merge list for low-delay pictures.

**Test 3.2: LIC flag derivation for merge candidates with template costs (**[**JVET-AF0128**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0128-v1.zip)**)**

In ECM, the LIC flag is inherited for a merge candidate. In the test, the LIC flag is derived for a merge candidate based on template costs by comparing two template costs: a SAD-based template cost, denoted as C0, and a Mean Removal SAD (MRSAD)-based template cost, denoted as C1. The LIC flag is set to be false, if C0 <= C1 and is set to be true, if C0 > C1.

To favor the inherited LIC flag, C0 is multiplied by *α* if the inherited LIC flag is false while C1 is multiplied by *α* if the inherited LIC flag is true, where *α* < 1.

**Test 3.4: Enhanced subblock-based motion compensation (**[**JVET-AF0163**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0163-v1.zip)**)**

Three methods are tested for subblock-based motion compensation enhancement.

TM-based subblock motion refinement

CPMVs of uni-predicted affine merge candidates and the motion shift of SbTMVP candidates are refined using TM. For a uni-predicted affine merge candidate, a same MV offset is assigned to all the CPMVs, 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. For a SbTMVP candidate, the initial motion shift is refined with TM, and then the refined motion shift will be utilized to derive subblock temporal motion information.

Interweaved affine prediction

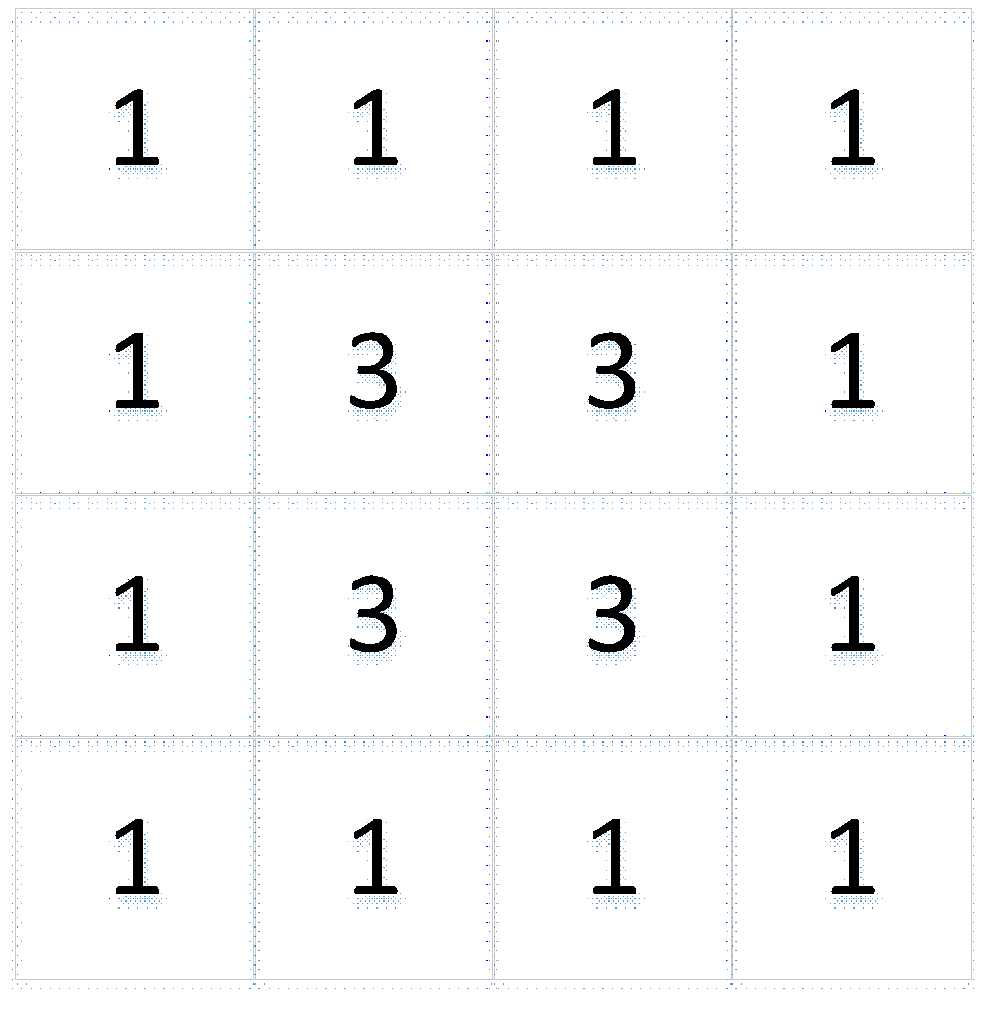
With the interweaved prediction, a coding block is divided into subblocks with two different dividing patterns. The first dividing pattern (i.e., pattern 0) is the same as that in ECM, while the second dividing pattern also divides the coding block into 4×4 subblocks but with a 2×2 offset as pattern 1 shown in the next figure.



Then the two auxiliary predictions are generated by affine motion compensation with the two dividing patterns. The final prediction is calculated as a weighted sum of the two auxiliary predictions.



As shown in next figure, weights are positions dependent, an auxiliary prediction sample located at the center of a subblock is associated with a weighting value 3, while an auxiliary prediction sample located at the boundary of a subblock is associated with a weighting value 1.



The subblocks associated with two dividing patterns are respectively refined by PROF unless the width or height is smaller than 4. Besides, subblock boundary deblocking/OBMC for affine mode is disabled.

RMVF candidate derivation with multiple CUs

Additional RMVF affine candidates are derived by taking the motion vector field of multiple CUs as regression input. In the test, two previously affine-coded CUs are simultaneously used to generate a RMVF candidate. The additional RMVF candidates are reordered together with other RMVF candidates through ARMC.

Test 3.4a: TM-based subblock motion refinement.

Test 3.4b: Interweaved affine prediction.

Test 3.4c: RMVF candidate derivation with multiple CUs.

Test 3.4d: Test 3.4a + Test 3.4b + Test 3.4c.

**Test 3.5: DMVR with robust MV derivation (**[**JVET-AF0057**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0057-v1.zip)**)**

It is asserted that multi-pass DMVR can sometimes produce dislocated subblocks due to use of unreliable motion vectors which leads to subjective artifacts. Two approaches (normative and encoder only) are tested.

Normative approach

Select motion vector that minimize distortion based on both subblock boundary distortion and subblock matching distortion when there is a risk to have unreliable motion vectors based on checks on spatial activity, subblock motion vector differences and boundary differences. The method consists of following steps:

1. Check spatial activity for the reference subblocks centered at the block motion vector. If it is determined that the spatial activity is lower than a threshold go to step 2.

2. Each candidate motion vector for the subblock is compared with a neighboring subblock’s motion vectors across a subblock boundary (if there exists). If the absolute difference between the candidate motion vector and the neighboring subblock’s motion vector for one component is greater than a threshold go to step 3.

3. A boundary check which is based on neighboring samples is made for the top respectively the left subblock boundary. If the boundary check indicates that there not is a true edge along the top subblock boundary or the left subblock boundary continue to step 4.

4. Determine subblock boundary distortion across left and/or top subblock boundary. For any subblock boundary distortion which is greater than a threshold, add the subblock boundary distortion to the block matching distortion and go to step 5.

5. Select motion vectors that minimize the total distortion.

Encoder only

In the encoder only solution the RD cost is set to a maximum value when at least one subblock of a coding unit has unreliable motion vector based on steps 1 to 4 as in the normative method following steps without adding the boundary distortion to the selection criteria. Furthermore, the RD cost is not punished for the highest temporal layer and the method is only used for QP equal to or above 33 to reduce BDR impact and still maintain subjective quality.

Test 3.5a: DMVR with robust MV derivation

Test 3.5b: DMVREncSelect from VTM (encoder only)

Test 3.5a\*: DMVR with robust MV derivation with QP 40, 43, 47, and 50

Test 3.5b\*: DMVREncSelect from VTM (encoder only) with QP 40, 43, 47, and 50

**Test 3.6: Affine subblock BDOF refinement (**[**JVET-AF0159**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0159-v1.zip)**)**

In ECM, BDOF refinement is not applied to subblocks in affine and SbTMVP modes, and AMVP-Merge mode is also not used with subblocks.

In the test, when BDOF condition is satisfied, BDOF subblock MV refinement and sample adjustment is applied to an affine or SbTMVP coded block with subblock MC.

An affine coded block, e.g. affine regular merge mode, affine BM merge mode, affine AMVP mode, derives MVs for each 4×4 subblock from the affine model. The BDOF process starts with the 4×4 subblocks grouping with identical MVs. The first iteration of BDOF MV refinement is processed in 8x8 subblock grid as in ECM-10.0. When the grouped subblock size is less than 256, the second iteration of BDOF MV refinement is processed in 4×4 subblock grid, and otherwise in 8×8 subblock grid. When the grouped subblock size is 4xN or Nx4, the first iteration of BDOF MV refinement is bypassed.

The BDOF enabling condition is the same as ECM-10.0, e.g., two reference pictures have equal POC distance to the current picture, and equal weight prediction.

AMVP-Merge mode applied to affine blocks is also tested. Like the AMVP-Merge mode in ECM-10.0, it signals reference picture list index, reference index and MVP index to indicate the AMVP predictor. A flag is signalled to indicate AMVP-Merge mode followed by affine mode flag if block size is equal or greater than 8×8 and the current picture is not a low-delay picture.

Test 3.6a: Affine subblock BDOF refinement.

Test 3.6b: AMVP-merge mode for affine.

Test 3.6c: Test 3.6a + Test 3.6b.

Results (RA/LB)

Tests 3.1/3.3: Benefit to be expected for chroma. The methods are somewhat different in selection of candidates. Test 3.1d appears most attractive, though mainly for LB.

It was commented that the gain in chroma was significantly decreased, probably due to the recent adoption of CCRM. However, also the encoder had been significantly higher (several percents), and it had been requested to be reduced, which was achieved.

It was asked what the term “low delay picture” means. It was answered that all pictures in the RPL have a POC that is before the current picture. In the case, no derived candidate is put into the list (which explains that 3.1d has no additional gain over 3.1a in RA case).

Support by non-proponents (including some of the cross-checkers).

Decision: Adopt JVET-AF0073 test 3.1d.

Test 3.2 is asserted to provide reasonable tradeoff, straightforward implementation.

Decision: Adopt JVET-AF0128 test 3.2

Tests 3.4: Most benefit seems to come from 3.4a, whereas 3.4b/c do not provide much standalone. Also in combination, the additional benefit is small. Some support was expressed by independent experts.

Decision: Adopt JVET-AF0163 Test 3.4a

Test 3.5: The purpose is avoiding visual artifacts caused by DMVR which had been observed in the context of VTM verification tests (in VTM, that had to be resolved by an encoder modification). The higher QP were tested, because more artifacts would appear in that case. It was commented by proponents that deblocking cannot resolve the problem of edge discontinuity.

It was asked if parallel processing of subblocks was still possible with the normative solution? To some extent yes in terms of the MV search, but the decision has to be done sequentially based on neighbour SB samples.

At this point of exploration, it is not urgent to go for a normative solution on this aspects. In case of a standardization, the normative solution is probably the best way to go (but eben better solutions might be possible than the one investigated in test 3.5a).

Decision (SW): Adopt JVET-AF0057 test 3.5b. Not enabled in CTC, but when visual testing with ECM is performed, it should be enabled.

Test 3.6a has a good tradeoff and is straightforward (applying BDOF for affine SBs). Compared to that, the additional benefit of test 3.6b is rather small. The increase in encoding runtime in the combination is likely caused by the fact that BDOF has then also to be executed in the affine merge mode check.

It was commented that no padding is performed in ECM, therefore combination of BDOF with affine should be straightforward.

Decision: Adopt JVET-AF0159 Test 3.6a.

***Test 4 - RPR***

This section was discussed 1340 to 1410 on Saturday 14 Oct, 2023, chaired by Y. Ye.

In RPR tests, two PSNR calculations are used:

* PSNR1: it is measured on the decoded picture size by calculating MSE for each picture, accumulating MSEs for all pictures and calculating average PSNR from the accumulated MSE.
* PSNR2: it is measured after upsampling of the decoded picture if the decoded picture size is in smaller resolution, the existed ECM interpolation filters are used for the upsampling.

**Test 4.1: Enabling template-based reordering and LIC for scaled reference pictures ([JVET-AF0190](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0190-v1.zip))**

In the tests, TM based tools are enabled for RPR.

In Test 4.1a, the template-based inter reordering tools, including ARMC, MMVD/affine MMVD reordering, template-based BCW derivation, reference picture list reordering and MVD sign and magnitude-suffix prediction, are enabled for scaled reference pictures in the RPR.

In Test 4.1b, on top of Test 4.1a LIC is additionally enabled when any of reference pictures is in different resolution comparing to the current picture.

Test 4.1 performance (RA/LB)



It was asked why the impact on encoding/decoding time is so small due to the enabling of TM and/or LIC tools. One expert commented that this is because only 5% of the pictures are impacted by the proposal.

Multiple experts including the cross checker commented that the proposed changes are straightforward, and code change is relatively small, whereas the performance vs. complexity tradeoff is very favorable.

Comparing 4.1a and 4.1b, the latter adds LIC tool on top of TM tool in the case of RPR. Multiple experts commented that 4.1b provided more favorable gain vs complexity.

Decision: Adopt JVET-AF0190 test 4.1b.

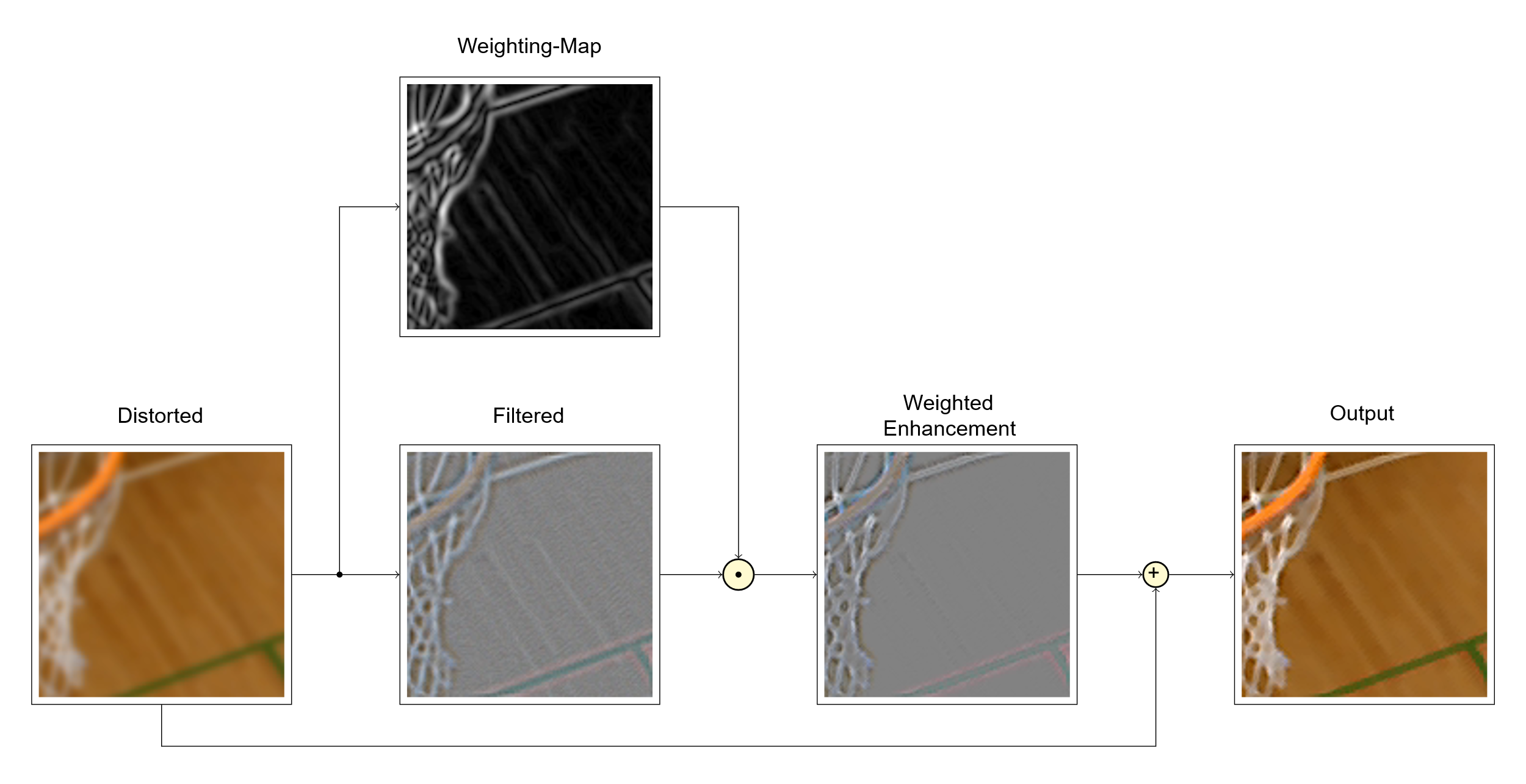
**Test 4.2: Weighted edge enhancement filtering ([JVET-AF0173](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0173-v1.zip))**

Additional processing step, adaptive locally weighted filter, is added after the upsampling.

The inputs are the decoded, upscaled picture or block and the side information which is encoded in an adaption parameter set in the bitstream. First, the filter parameters are decoded. This includes information regarding the weighting map function, filter shape, luma and chroma flags, and filter coefficients.

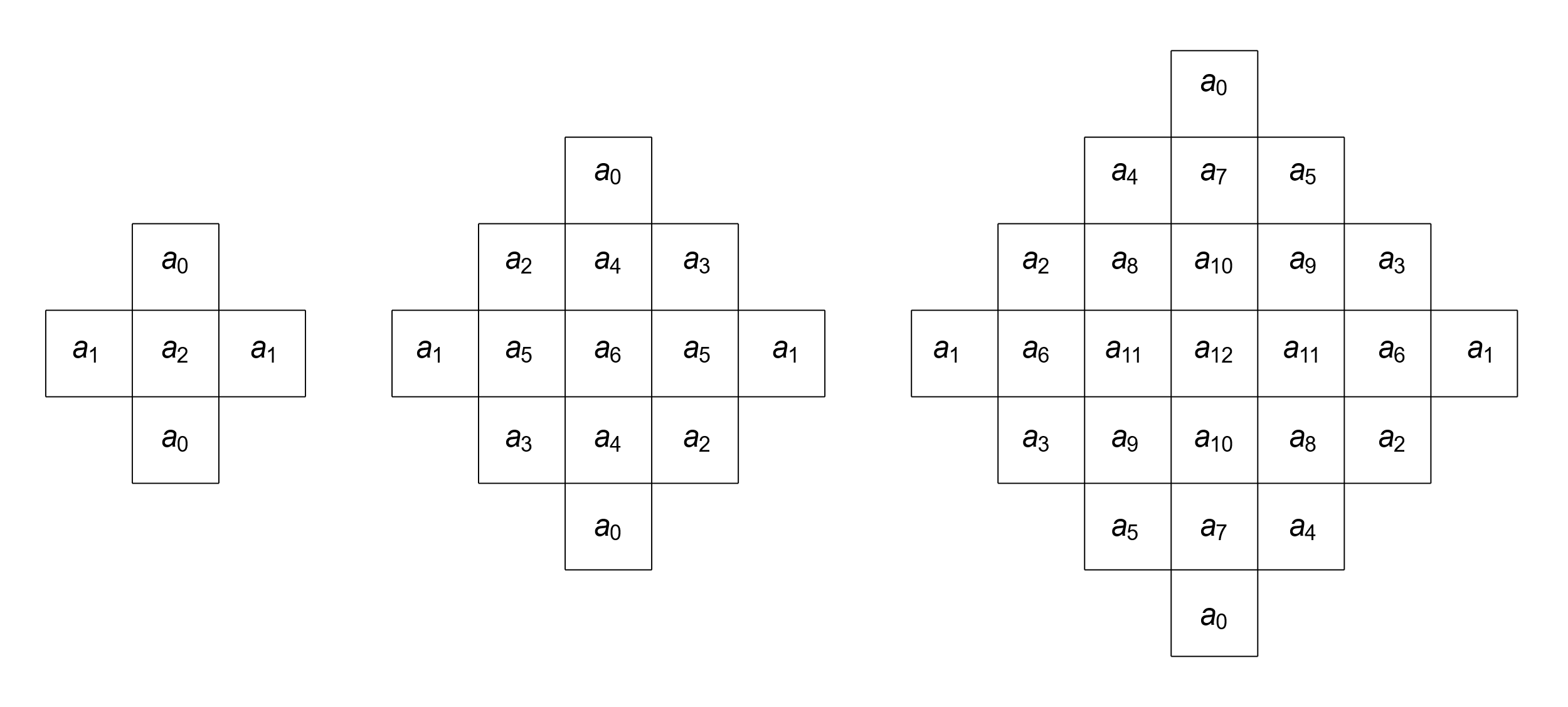
Next, the weighting map function is applied to obtain the local weighting map, which is computed such that the strength of the filter is increased at the location of edges and decreased, or set to zero, in parts of the picture with small local gradient.

Then, the filter is applied to the upscaled picture or block to generate a filtered map. The filtered map is multiplied by the local weighting and added to the upsampled picture as illustrated in next figure.



Filter coefficients are derived by minimizing the difference between the upsampled *s* and original *g* (non-donwsampled) signals.

The filters have an adaptive shape following the available shapes shown in the next figure and filter symmetries of ALF. The shape is signaled for each picture in the adaption parameter set.



In Test 4.2a, the adaptive locally weighted filtering is applied to inter prediction only but not the upscaled output for PSNR calculation.

In Test 4.2b, the filtering is also applied after reconstruction which affects PSNR calculation.

Results are not complete, available PSNR2 results for LDB are as follows: RPR 1.5x, test 4.2a

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Class C | 0.00% | 0.00% | 0.01% | 131% | 117% |
| Class E | -0.02% | 0.05% | -0.02% | 126% | 114% |

RPR2x, test 4.2a

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Class C | -0.02% | -0.05% | -0.02% | 129% | 117% |
| Class E | 0.00% | 0.00% | 0.00% | 129% | 116% |

RPR1.5x, test 4.2b

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Class C | -3.12% | -0.42% | -0.43% | 132% | 151% |
| Class E | -6.21% | 0.29% | 0.89% | 129% | 143% |

RPR2x, test 4.2b

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Class C | -4.03% | -0.69% | -0.70% | 135% | 148% |
| Class E | -12.58% | -1.11% | 0.65% | 134% | 152% |

It was commented that currently the normative aspect in 4.2a is not showing much gain, but the non-normative post processing filter in 4.2b on top of 4.2a is showing more significant coding gain. The proponent suggests that this is mainly because the RDO process is not yet very effective in 4.2a, and if the post processing filter in 4.2b would be brought “in-loop”, it would provide more useful reference for RPR prediction, and could further improve the performance from the normative aspect.

Proponent commented that 4.2a has more potential for gains, which they intend to show in a future proposal. Such a contribution would be welcomed.

Futher study encouraged.

***Test 5 - In-loop filtering***

**Test 5.1: Dynamic scaling of bilateral filter (**[**JVET-AF0112**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0112-v1.zip)**)**

In ECM, the bilateral filter offset applied to a sample is calculated using 5x5 diamond filter shape, which is sum of 12 offsets:

S0,2

S-1,1

S0,1

S1,1

S-2,0

S-1,0

S0,0

S1,0

S2,0

S-1,-1

S0,-1

S1,-1

S0,-2

where is based on a 26x16 LUT of 8-bit integers denoted by (for 26 QPs from 17 to 42 and 16 intervals of sample difference). For the innermost positions, i.e., , the LUT is used as-is, i.e., . For the remaining positions, the LUT output it right shifted: .

The TU-based scale factor is defined from minimum block size as follows.

***TU scale factor in ECM-10.0***

|  |  |  |  |
| --- | --- | --- | --- |
| Prediction mode |  |  |  |
| Inter prediction |  |  |  |
| Intra prediction |  |  |  |

In the test, the LUT and calculation changes are summarized as follows:

1. The TU scale factor depends on the TU shape size and the mean absolute difference (MAD) of the TU,
2. The BIF LUTs are interpolated.

Three scale factors () are used to pre-compute three LUTs for three different neighbor distances , i.e.:

Test 5.1a additionally uses the averaging linear interpolation

where and are successive entries of . For chroma, the right shift is decreased from 3 to 2.

The right shift in the formula for BIF offset calculation is increased from 5 to 8 and

where is based on the TU’s shape sizes and is based on the mean absolute difference (MAD) of the TU. Both and are calculated using LUTs. In total, four 64-byte tables and four 16-byte tables are introduced (for luma/chroma component, for intra/inter prediction).

*Complexity assessment of the tests against ECM-10.0*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| BIF version | Bit depth  (maximum) | Summations  (per sample) | Multiplications  (per sample) | LUT lookups  (per sample) | LUTs memory  (bytes) |
| ECM 10.0 | 12 | 18 | 0 | 6 | 832 |
| Test 5.1a | 15 | 25 | 1 | 12 | 2816 |
| Test 5.1b | 15 | 19 | 1 | 6 | 2816 |

Test 5.1a: Dynamic TU scale factor for BIF with LUTs interpolation.

Test 5.1b: Dynamic TU scale factor for BIF.

**Test 5.2: Luma residual taps in chroma ALF and CCALF (**[**JVET-AF0197**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0197-v1.zip)**)**

In ECM, chroma ALF uses a diamond 9x9 filter shape with 20 taps in total. CCALF filter uses a cross-liked filter shape with 24 taps in total, and all these taps take the spatial luma reconstruction as input.

In the test, all the spatial based taps in chroma ALF and CCALF are kept unchanged. For chroma ALF, only one luma residual tap is added, which takes down-sampled luma residual as input.

图示

描述已自动生成

For CCALF, five luma residual taps in a cross 3x3 shape are added. The extended taps take the co-located and neighbouring luma residual values as input.

**图示

描述已自动生成**

Test 5.2a: Luma residual tap in chroma ALF.

Test 5.2b: Test 5.2a + luma residual tap in CCALF.



Test 5.1: It was asked how “MAD\_TU” is computed: It is the mean absolute difference between the mean value of TU and the samples in it.

Run time and partial results confirmed by cross-checker.

Test 5.1a is slightly more complex than 5.1b (in terms of processing steps), but also has more compression benefit.

Decision: Adopt JVET-AF0112 Test 5.1a.

Test 5.2a/b affects only chroma quality. However, it was critizized that separate results for CCALF modification are not provided (test 5.2b only tests combination with 5.1a). Gain of the combination is significantly higher for LB.

Several experts expressed support for 5.2b, emphasizing the benefit in compression which comes at practically no increase in run time. One concern was raised that some optimization at the encoder is frame size dependent (but it was also said that a similar approach also exists in CCSAO).

Considering that the standalone gain of test 5.2a is relatively small compared to the combination 5.2b, it can be concluded that most benefit in 5.2b (in particular for LB) comes due to the CCALF modification.

Decision: Adopt from JVET-AF0197 the part of luma residual tap in CCALF test 5.2b.

***Test 3 - Entropy coding***

**Test 6.1: Spatial CABAC tuning (**[**JVET-AF0109**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0109-v1.zip)**)**

In ECM, CTUs are scanned in raster scan order, while CUs inside CTUs are scanned in nested tree order. When starting to process the current CTU (CTUC) the processing “jumps” from the bottom-right CU (yellow CU 8) to the top-left CU of the current CTU (blue CU 0) as shown in the next figure. At that stage, the context parameters of the CABAC engine can be expected to be finetuned for the bottom-right area of the previous CTU instead of the ideal case where the context parameters would be finetuned for the actual next CU to be processed.



In the tested method, syntax elements bins of the bottom CUs of the above CTU (the green CUs in the figure) are used to tune the CABAC contexts when starting to process a new CTU.

In the implementation, the certain number of bins are buffered for each CTU of a CTU line, where each entry contains a bin and 10-bit context ID associated with that bin. The buffer size is 512 in Test 6.1a and 256 in Test 6.1b.

Following table summarizes the memory requirement per CTU for the bin buffers.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Test | Bits / element | Number of elements | Total bits / CTU | Total bytes / CTU |
| Test 6.1a | 11 | 512 | 5632 | 704 |
| Test 6.1b | 11 | 256 | 2816 | 352 |

For each context, no more than 8 bins are stored, so 4-bit counter is used. The number of contexts in ECM-10.0 is 852 making the needed size of these counters 4 \* 852 bits = 3408 bits = 426 bytes.

The total worst-case memory requirement then depends on the number of CTUs in a CTU row and summarized as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| Class | CTUs / row | Test 6.1a memory [Bytes] | Test 6.1b memory [Bytes] |
| A1 | 15 | 10986 | 5706 |
| A2 | 15 | 10986 | 5706 |
| B | 15 | 10986 | 5706 |
| C | 7 | 5354 | 2890 |
| D | 4 | 3242 | 1834 |
| E | 10 | 7466 | 3946 |
| F | 15 | 10986 | 5706 |
| TGM | 15 | 10986 | 5706 |

Test 6.1a: Spatial CABAC tuning with 512 buffer.

Test 6.1b: Spatial CABAC tuning with 256 buffer.

**Test 6.2: Updating I-slice context model parameters (**[**JVET-AF0133**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0133-v1.zip)**)**

The context model parameters have not been retrained since ECM-5.0. In this test, the context model parameters for I-slice are retrained. The training scripts are modified from the one used in VVC’s CE on CABAC initialization. The training bitstream are generated using ECM-10.0 and CTC sequences (including class A1, class A2, class B, class C, class D, class E and class F) with QP 17 to QP 42 in AI configuration.

**Test 6.3: Combination of Test 6.1 and Test 6.2 (**[**JVET-AF0110**](https://jvet-experts.org/doc_end_user/documents/32_Hannover/wg11/JVET-AF0110-v1.zip)**)**

Retraining of the contexts Test 6.2 is added first and then the spatial CABAC tuning from Test 6.1 is applied.

Test 6.3a: Test 6.2 + Test 6.1a.

Test 6.3b: Test 6.2 + Test 6.1b.



It was suggested that a regular retraining of CABAC initialization within each meeting cycle would be beneficial. Currently, this was only possible for I slices (as per 6.2). A script is provided, which however is not easy to understand according to crosscheckers.

It was asked why the rate offset parameter was not trained? Because those are shared between intra and inter, such that it would introduce some inconsistency as long as inter initialization is not retrained.

It is agreed that the approach from test 6.2 is a reasonable step forward to perform the re-training, even though futher improvements appear possible and can certainly be investigated in upcoming experiments.

Decision: Adopt the CABAC initialization parameters from JVET-AF0133 Test 6.2. Also the script should be included in the ECM package, such that it can be used by other experts.

The benefit of the 6.1 tests is relatively small, and it has some impact on the memory complexity of the CABAC engine. The combination test with 6.2 had been suggested from the previous meeting to understand possible interaction with an optimized CABAC initialization. This seems not to exist for AI, but some inconsistency is observed e.g. for LB in test 6.3b. Considering that new input is available at this meeting for performing the update of CABAC init also for inter cases, further study in next EE would be valuable in that context.

### EE2 contributions: Enhanced compression beyond VVC capability (24)

There was no presentation or discussion about specific proposals in this category.

For actions decided to be taken, see section 5.2.1, unless otherwise noted.

[JVET-AF0057](https://jvet-experts.org/doc_end_user/current_document.php?id=13305) EE2-3.5: DMVR with robust MV derivation [K. Andersson, R. Yu (Ericsson)]

[JVET-AF0218](https://jvet-experts.org/doc_end_user/current_document.php?id=13481) Cross-check of JVET-AF0057 (EE2-3.5: DMVR with robust MV derivation) H. Huang (Qualcomm)

[JVET-AF0066](https://jvet-experts.org/doc_end_user/current_document.php?id=13314) EE2: Test 2.9 Enable DBV in single tree [H. Huang, H. Wang, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AF0076](https://jvet-experts.org/doc_end_user/current_document.php?id=13324) Crosscheck of JVET-AF0066 (EE2: Test 2.9 Enable DBV in single tree) [L. Xu (OPPO)] [late] [miss]

[JVET-AF0073](https://jvet-experts.org/doc_end_user/current_document.php?id=13321) EE2-3.1 and EE2-3.3: Cross-component prediction merge mode for chroma inter coding [M.-S. Chiang, 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), Z. Deng, K. Zhang, L. Zhang (Bytedance)]

[JVET-AF0213](https://jvet-experts.org/doc_end_user/current_document.php?id=13476) Crosscheck of JVET-AF0073 (EE2-3.1 and EE2-3.3: Cross-component prediction merge mode for chroma inter coding) test 3.1d F. Wang (OPPO) [late] [miss]

[JVET-AF0233](https://jvet-experts.org/doc_end_user/current_document.php?id=13496) Crosscheck of JVET-AF0073 (EE2-3.1b: Cross-component prediction merge mode for chroma inter coding) [Y.-J. Chang (Qualcomm)] [late] [miss]

[JVET-AF0240](https://jvet-experts.org/doc_end_user/current_document.php?id=13503) crosscheck of JVET-AF0073: EE2-3.1a: Cross-component prediction merge mode for chroma inter coding [K. Naser (InterDigital)] [late] [miss]

[JVET-AF0242](https://jvet-experts.org/doc_end_user/current_document.php?id=13505) Crosscheck of JVET-AF0073 (EE2-3.1 and EE2-3.3: Cross-component prediction merge mode for chroma inter coding) test3.3b and test3.1d [Z. Lv (vivo)] [late] [miss]

[JVET-AF0079](https://jvet-experts.org/doc_end_user/current_document.php?id=13327) EE2-2.6: IntraTMP block vector storing [Y. Yu, L. Zhang, L. Xu, H. Yu, J. Gan, F. Wang, Z. Xie, D. Wang (OPPO), P.-H Lin, J. -L Lin, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AF0227](https://jvet-experts.org/doc_end_user/current_document.php?id=13490) Crosscheck of JVET-AF0079 (EE2: Test 2.6a, Test 2.6b and Test 2.6c - Combination of Test 2.6a and Test 2.6b) [W. Lim, S.-C. Lim (ETRI)] [late] [miss]

[JVET-AF0080](https://jvet-experts.org/doc_end_user/current_document.php?id=13328) EE2-2.7: An extrapolation filter-based intra prediction mode [L. Xu, Y. Yu, H. Yu, J. Gan, D. Wang (OPPO)]

[JVET-AF0221](https://jvet-experts.org/doc_end_user/current_document.php?id=13484) Crosscheck of JVET-AF0080 (EE2-2.7: An extrapolation filter-based intra prediction mode) [X. Li (Alibaba)] [late] [miss]

[JVET-AF0230](https://jvet-experts.org/doc_end_user/current_document.php?id=13493) Crosscheck of JVET-AF0080 (EE2-2.7: An extrapolation filter-based intra prediction mode) [H.-J. Jhu (Kwai)] [late] [miss]

[JVET-AF0081](https://jvet-experts.org/doc_end_user/current_document.php?id=13329) EE2-2.8: DBV improvement [L. Xu, Y. Yu, H. Yu, J. Gan, D. Wang (OPPO)]

[JVET-AF0219](https://jvet-experts.org/doc_end_user/current_document.php?id=13482) Cross-check of JVET-AF0081 ( EE2-2.8: DBV improvement) [H. Huang (Qualcomm)] [late] [miss]

[JVET-AF0108](https://jvet-experts.org/doc_end_user/current_document.php?id=13355) EE2-1.1: Non-square quadtree partitioning [Y. Ahn, J. Nam, N. Park, J. Lim, S. Kim (LGE)]

[JVET-AF0249](https://jvet-experts.org/doc_end_user/current_document.php?id=13512) Crosscheck of JVET-AF0108 (EE2-1.1: Non-square quadtree partitioning) [R. Utida, F. Le Léannec, T. Dumas (InterDigital)] [late] [miss]

[JVET-AF0109](https://jvet-experts.org/doc_end_user/current_document.php?id=13356) EE2-6.1: Spatial CABAC tuning [J. Lainema, A. Aminlou, P. Astola, D. B. Sansli (Nokia)]

[JVET-AF0188](https://jvet-experts.org/doc_end_user/current_document.php?id=13446) Cross-check of JVET-AF0109 (EE2-6.1: Spatial CABAC tuning) [P. Nikitin, I. Jumakulyyev (Qualcomm)] [late] [miss]

[JVET-AF0110](https://jvet-experts.org/doc_end_user/current_document.php?id=13357) EE2-6.3: Combination of EE2-6.1 and EE2-6.2 [J. Lainema, A. Aminlou, P. Astola, D. B. Sansli (Nokia), R.-L. Liao, Y. Ye, J. Chen, X. Li (Alibaba)]

[JVET-AF0232](https://jvet-experts.org/doc_end_user/current_document.php?id=13495) Crosscheck of JVET-AF0110 (EE2-6.3: Combination of EE2-6.1 and EE2-6.2) [X. Xiu (Kwai)] [late] [miss]

[JVET-AF0112](https://jvet-experts.org/doc_end_user/current_document.php?id=13359) EE2-5.1: Dynamic Scaling of Bilateral Filter (BIF) [V. Shchukin, P. Wennersten, J. Ström (Ericsson)]

[JVET-AF0203](https://jvet-experts.org/doc_end_user/current_document.php?id=13464) Crosscheck of JVET-AF0112 (EE2-5.1: Dynamic Scaling of Bilateral Filter) [W. Yin (Bytedance)] [late] [miss]

[JVET-AF0120](https://jvet-experts.org/doc_end_user/current_document.php?id=13367) EE2-2.1 DIMD merge [S. Blasi, I. Zupancic, J. Lainema (Nokia)]

[JVET-AF0124](https://jvet-experts.org/doc_end_user/current_document.php?id=13369) Crosscheck of JVET-AF0120 (EE2-2.1: DIMD merge) [P. Andrivon (Ofinno)]

[JVET-AF0126](https://jvet-experts.org/doc_end_user/current_document.php?id=13371) EE2-2.3: Combination of DIMD related tests (EE2-2.1 + EE2-2.2) [S. Blasi, I. Zupancic, J. Lainema (Nokia)]

[JVET-AF0204](https://jvet-experts.org/doc_end_user/current_document.php?id=13465) Crosscheck of JVET-AF0126 (EE2-2.3-AB: Combination of DIMD Related Tests) [W. Yin (Bytedance)] [late] [miss]

[JVET-AF0276](https://jvet-experts.org/doc_end_user/current_document.php?id=13540) crosscheck of JVET-AF0126: EE2-2.3: Combination of DIMD related tests (EE2-2.3c + EE2-2.3d) [K. Naser (InterDigital)] [late] [miss]

[JVET-AF0128](https://jvet-experts.org/doc_end_user/current_document.php?id=13386) EE2-3.2: LIC flag derivation for merge candidates with template costs [N. Zhang, K. Zhang, H. Liu, Y. Wang, L. Zhang (Bytedance)]

[JVET-AF0269](https://jvet-experts.org/doc_end_user/current_document.php?id=13533) Crosscheck of JVET-AF0128 (EE2-3.2: LIC flag derivation for merge candidates with template costs) [Z. Xie (OPPO)] [late] [miss]

[JVET-AF0130](https://jvet-experts.org/doc_end_user/current_document.php?id=13388) EE2-2.4: IntraCIIP as additional mode of IntraTMP [K. Naser, P. Bordes, F. Galpin, K. Reuzé (InterDigital)]

[JVET-AF0286](https://jvet-experts.org/doc_end_user/current_document.php?id=13550) Crosscheck of JVET-AF0130 (EE2-2.4: IntraCIIP as additional mode of IntraTMP) [B. Ray (Qualcomm)] [late]

[JVET-AF0131](https://jvet-experts.org/doc_end_user/current_document.php?id=13389) EE2-2.2: DIMD with filtered template [C. Zhou, Z. Lv (vivo)]

[JVET-AF0235](https://jvet-experts.org/doc_end_user/current_document.php?id=13498) Crosscheck of JVET-AF0131 (EE2-2.2: DIMD with filtered template [J. Chen (Alibaba)] [late] [miss]

[JVET-AF0133](https://jvet-experts.org/doc_end_user/current_document.php?id=13391) EE2-6.2: updating I-slice context model parameters [R.-L. Liao, Y. Ye, J. Chen, X. Li (Alibaba)]

[JVET-AF0239](https://jvet-experts.org/doc_end_user/current_document.php?id=13502) crosscheck of JVET-AF0133: EE2-6.2: updating I-slice context model parameters [K. Naser (InterDigital)] [late] [miss]

[JVET-AF0136](https://jvet-experts.org/doc_end_user/current_document.php?id=13394) EE2-2.5: TIMD with IntraTMP and IBC [K. Naser, F. Le Léannec, P. Bordes, F. Galpin, A. Robert (InterDigital)]

[JVET-AF0125](https://jvet-experts.org/doc_end_user/current_document.php?id=13370) Crosscheck of JVET-AF0136 (EE2-2.5a: TIMD with IntraTMP/IBC merge) [P. Andrivon (Ofinno)]

[JVET-AF0215](https://jvet-experts.org/doc_end_user/current_document.php?id=13478) Crosscheck of JVET-AF0136 (EE2-2.5: TIMD with IntraTMP and IBC) test 2.5b F. Wang (OPPO) [late] [miss]

[JVET-AF0243](https://jvet-experts.org/doc_end_user/current_document.php?id=13506) Crosscheck of JVET-AF0136 (EE2-2.5: TIMD with IntraTMP and IBC) test 2.5b [S. Blasi (Nokia)] [late] [miss]

[JVET-AF0159](https://jvet-experts.org/doc_end_user/current_document.php?id=13417) EE2-3.6: Affine subblock BDOF refinement [Z. Zhang, H. Huang, J.-L Lin, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AF0231](https://jvet-experts.org/doc_end_user/current_document.php?id=13494) Crosscheck of JVET-AF0159 (EE2-3.6: Affine subblock BDOF refinement) [X. Xiu (Kwai)] [late] [miss]

[JVET-AF0163](https://jvet-experts.org/doc_end_user/current_document.php?id=13421) EE2-3.4: Enhanced subblock-based motion compensation [L. Zhao, K. Zhang, L. Zhang (Bytedance)]

[JVET-AF0270](https://jvet-experts.org/doc_end_user/current_document.php?id=13534) Crosscheck of JVET-AF0163 (EE2-3.4: Enhanced subblock-based motion compensation) [Z. Xie (OPPO)] [late] [miss]

[JVET-AF0173](https://jvet-experts.org/doc_end_user/current_document.php?id=13431) EE2-4.2: Weighted edge enhancement filtering [T. Claßen, M. Wien (RWTH)]

[JVET-AF0265](https://jvet-experts.org/doc_end_user/current_document.php?id=13529) Crosscheck of JVET-AF0173 (EE2-2.4: Weighted edge enhancement filtering) [J. Samuelsson-Allendes (Sharp)] [late] [miss]

[JVET-AF0190](https://jvet-experts.org/doc_end_user/current_document.php?id=13451) EE2-Test4.1: Enabling template-based inter tools for the RPR [X. Xiu, H.-J. Jhu, C.-W. Kuo, C. Ma, N. Yan, W. Chen, X. Wang (Kwai)]

[JVET-AF0261](https://jvet-experts.org/doc_end_user/current_document.php?id=13525) Crosscheck of JVET-AF0190 (EE2-Test4.1: Enabling template-based inter tools for the RPR) [Z. Zhang (Qualcomm)] [late] [miss]

[JVET-AF0197](https://jvet-experts.org/doc_end_user/current_document.php?id=13458) EE2-5.2: Luma Residual Taps in Chroma-ALF and CCALF [W. Yin, K. Zhang, Z. Deng, L. Zhang (Bytedance)]

[JVET-AF0225](https://jvet-experts.org/doc_end_user/current_document.php?id=13488) Crosscheck of JVET-AF0197 (EE2-5.2: Luma Residual Taps in Chroma-ALF and CCALF) [V. Shchukin (Ericsson)] [late] [miss]

[JVET-AF0207](https://jvet-experts.org/doc_end_user/current_document.php?id=13468) EE2: Test 2.10 Combination of Test 2.8 and Test 2.9 [H. Huang, H. Wang, V. Seregin, M. Karczewicz (Qualcomm), L. Xu, Y. Yu, H. Yu, J. Gan, D. Wang (OPPO)]

[JVET-AF0220](https://jvet-experts.org/doc_end_user/current_document.php?id=13483) Cross-check of JVET-AF0207 (EE2: Test 2.10 Combination of Test 2.8 and Test 2.9) [C. Zhou (vivo)] [late] [miss]

[JVET-AF0229](https://jvet-experts.org/doc_end_user/current_document.php?id=13492) EE2-2.3: Combination of DIMD/TIMD related tests (EE2-2.3 + EE2-2.5) [K. Naser, F. Le Léannec, P. Bordes, A. Robert (InterDigital), S. Blasi, I. Zupancic, J. Lainema (Nokia), C. Zhou, Z. Lv (Vivo)] [late]

[JVET-AF0244](https://jvet-experts.org/doc_end_user/current_document.php?id=13507) Crosscheck of JVET-AF0229 (EE2-2.11: Combination of DIMD/TIMD related tests) [R. G. Youvalari, M. Abdoli (Xiaomi)] [late] [miss]

### EE2 related contributions (6)

Contributions in this area were discussed at 1415–1615 on Saturday 14 Oct. 2023 (chaired by Y. Ye).

[JVET-AF0053](https://jvet-experts.org/doc_end_user/current_document.php?id=13301) EE2-related: Test 2.5a and TIMD fusion improvement [P. Andrivon, M. Blestel (Ofinno), K. Naser (InterDigital)]

Contribution JVET-AE0184, studied in EE2-2.5a (JVET-AF0136), proposes to extend TIMD candidates list with IntraTMP and IBC intra prediction modes of neighboring blocks. Contribution JVET-AE0137 introduces a non-angular intra predictor (among DC or Planar) in the TIMD fusion process, additionally to the two selected TIMD modes. Besides, the location-dependent sample-based fusion process from DIMD is adjusted for TIMD. This contribution merges both EE2-2.5a and JVET-AE0137 and proposes to add the IntraTMP or IBC mode of neighboring blocks with the lowest template matching cost to the non-angular intra predictor candidates list. On top of ECM-10.0, the reported PSNR-Y, Cb, Cr, BD-rate and {EncT, DecT} results are as follows:

* AI: -0.08%, -0.05%, -0.04% {100.3%, 99.7%}
* RA: -0.03%%, 0.00%, -0.10% {98.8%, 100.1%}

Cross checker confirmed that partial results match, and supported to study in EE. This contribution doubles the gain reported in EE2-2.5a (JVET-AF0136).

It was commented that JVET-AF0132 is a closely related contribution. See notes under JVET-AF0132.

[JVET-AF0245](https://jvet-experts.org/doc_end_user/current_document.php?id=13508) Crosscheck of JVET-AF0053 (EE2-related: Test 2.5a and TIMD fusion improvement) [S. Blasi (Nokia)] [late] [miss]

This contribution proposes an optimization method for reference lines selection in TIMD blending mode. For the second mode, the determination of which reference line to be used is not only based on the second mode, but also on the first mode.

On top of the ECM10.0, simulation results are reported as below:

AI: -0.03% (Y), -0.02% (U), -0.10% (V), 99.8% (EncT), 100.3% (DecT)

Cross checker confirmed that partial results (performance and runtime) match.

Multiple experts considered this to be a simple modification to TIMD blending and supported investigation in EE,

Proponent of the related contribution JVET-AF0053 commented that the proposed changes in this contribution is orthogonal to the blending element in JVET-AF0053, and could be additive on top of the gain from JVET-AF0053.

JVET-AF0053 provided above-average gains for some class A and B sequences.

Investigate in EE JVET-AF0053, JVET-AF0132, as well as the combination of the two proposals in the following way:

* From JVET-AF0053 : Add a non-angular intra predictor (among DC or Planar) in the TIMD fusion process using the TIMD candidate list in the next ECM version
* From JVET-AF0053 : In addition, use location-dependent sample-based fusion process from DIMD in TIMD
* From JVET-AF0132 : determination of reference line in TIMD fusion
* Combination of the above

[JVET-AF0106](https://jvet-experts.org/doc_end_user/current_document.php?id=13353) EE2-related: Non-adjacent spatial candidates for DIMD merge [J. Huo, J. Fan, Z. Zhang, Y. Ma, F. Yang (Xidian Univ.), M. Li (OPPO)]

In EE2 test 2.1 described in document JVET-AE2024, DIMD merge is investigated. This contribution proposes to utilize non-adjacent spatial neighbors to further improve the coding efficiency of DIMD merge. Specifically, several new candidates, derived from non-adjacent spatial blocks, are added to the existing candidate list of DIMD merge.

The proposed method + EE2-2.1a leads to the following gain over ECM-10.0:

AI: {-0.12%, 0.04%, -0.05%, xxx%, xxx%}

The proposed method + EE2-2.1b leads to the following gain over ECM-10.0:

AI: {-0.11%, 0.02%, 0.00%, xxx%, xxx%}

The proposed method + EE2-2.1a leads to the following gain over test2.1a:

AI: {-0.05%, -0.01%, -0.01%, xxx%, xxx%}

The proposed method + EE2-2.1b leads to the following gain over test2.1b:

AI: {-0.04%, -0.02%, -0.02%, xxx%, xxx%}

This proposal includes non-adjacent spatial neighbors into the DIMD merge list. The proponent commented that this will enable more DIMD blocks whose adjacent spatial neighbors are not using DIMD. It was commented that this could cause an increase in runtime.

Cross checker reported that encoding time increase is around 4%, which doubles the runtime increase in EE2-2.1x.

It was commented that performance vs. runtime tradeoff in EE2-2.1x was considered not desirable, and performance vs. runtime tradeoff in this contribution seems to be even less.

It was commented that 0.11%-0.12% gain in AI seems desirable.

Investigate in EE, reduction in encoding time is necessary to bring more desirable performance vs. runtime tradeoff.

[JVET-AF0223](https://jvet-experts.org/doc_end_user/current_document.php?id=13486) Crosscheck of JVET-AF0106 (EE2-related: Non-adjacent spatial candidates for DIMD merge) [X. Li (Alibaba)] [late] [miss]

[JVET-AF0151](https://jvet-experts.org/doc_end_user/current_document.php?id=13409) EE2 related: CABAC parameters retraining [F. Galpin, F. Lo Bianco, C. Salmon-Legagneur, K. Naser (InterDigital)]

This contribution proposes to update context initialization parameters for all slice types. All CABAC parameters (initial probabilities parameters, window sizes, adaptive weights and rate offsets) are retrained and updated. As previous scripts are not suitable anymore, a set of new scripts taking any account new parameters and constraints is proposed. It is reported that on top of ECM-10.0, the overall coding performance impact for {Y, U, V} is {-0.16 %, -0.03%, -0.10% } {-0.15 %, 0.19%, 0.11% } {-0.11 %, 0.91%, -0.06% } in AI, RA and LDB configurations respectively.

It was commented that the U component in LDB and LDP show a non-negligible performance loss.

The cross checker used the retrained contexts from the proponent to run the simulation, but didn’t cross check the training due to lack of scripts. It was suggested to investigate this in EE and include the training scripts in the EE.

Investigate in EE, include the training script in the EE.

[JVET-AF0252](https://jvet-experts.org/doc_end_user/current_document.php?id=13515) Crosscheck of JVET-AF0151 (EE2 related: CABAC parameters retraining) [M. Abdoli, R. G. Youvalari (Xiaomi)] [late] [miss]

[JVET-AF0202](https://jvet-experts.org/doc_end_user/current_document.php?id=13463) EE2 related: CABAC context initialization retraining and slice type based window offsets [V. Seregin, M. Karczewicz (Qualcomm)]

This contribution proposes CABAC context initialization retraining for ECM-10.0 and to split window offsets initialization per slice type as for other CABAC parameters.

The simulation results are not complete at the time of presentation, Class C results are as follows:

CABAC retraining:

|  |  |  |  |
| --- | --- | --- | --- |
| AI | -0.20% | -0.06% | 0.04% |
| RA | -0.14% | -0.14% | -0.25% |
| LB | -0.06% | -0.55% | -0.80% |

CABAC retraining with **slice type based rate offsets**:

|  |  |  |  |
| --- | --- | --- | --- |
| AI | -0.23% | 0.00% | 0.04% |
| RA | -0.16% | -0.15% | -0.44% |
| LB | -0.09% | -0.33% | -0.30% |

This contribution includes the non-normative retraining aspect, as well as a normative aspect that make the offset dependent on slice types. The second aspect provides additional gain over retraining-only.

Training is done somewhat differently from JVET-AF0151. Both proponents suggest to work on a unified training script.

Investigate in EE, retraining only with scripts, and additionally the normative aspect of slice type-dependent offset. For the normative aspect, additional memory cost should be reported.

[JVET-AF0280](https://jvet-experts.org/doc_end_user/current_document.php?id=13544) EE2-related: complete results for EE2-1.1b in JVET-AF0249 [T. Dumas, F. Le Léannec, R. Utida (InterDigital)] [late]

During the 31st JVET meeting, Geneva, 11-19 July 2023, the tests of ECM with various maximum MTT depth increments were requested, c.f. EE2-1.1b in JVET-AE2024. This will provide a fair comparison for EE2-1.1a evaluating ECM with the non-square QT, c.f. JVET-AF0108. JVET-AF0249 reports the cross-check of JVET-AF0108. Besides, JVET-AF0249 gives the final mean BD-rate versus encoding runtime curve resulting from the runs of ECM with different maximum MTT depth increments. This contribution reports all the results used to construct this curve.

It is reported that, in RA configuration, over all classes, at equivalent encoding runtimes, ECM including the non-square QT yields -0.04% of mean BD-rate gains in luma with respect to ECM with the maximum MTT depth increased by 1 on I-slices and the maximum MTT depth increased by 1 for the first two TIDs.

This contribution is for information. It was suggested that in the future, contributions with normative changes to partitioning should always bring runtime vs. gain tradeoff curves as shown in this contribution and compare to non-normative encoder-only changes.

It was commented that this is reasonable request and future partitioning contributions should bring such information to JVET.

[JVET-AF0288](https://jvet-experts.org/doc_end_user/current_document.php?id=13552) Crosscheck of JVET-AF0280 (EE2-related: complete results for EE2-1.1b in JVET-AF0249) [W. Ahmad (Ericsson)] [late]

[JVET-AF0295](https://jvet-experts.org/doc_end_user/current_document.php?id=13559) Crosscheck of JVET-AF0280 (EE2-related: complete results for EE2-1.1b in JVET-AF0249) [A. Filippov, K. Suverov, V. Rufitskiy (Ofinno)] [late]

[JVET-AF0291](https://jvet-experts.org/doc_end_user/current_document.php?id=13555) EE2 related: Encoder time reduction of Test-2.11 [K. Naser, F. Le Léannec, P. Bordes, A. Robert (InterDigital), S. Blasi, I. Zupancic, J. Lainema (Nokia), C. Zhou, Z. Lv (Vivo)] [late] [miss]

TBP

### ECM modifications and software improvements beyond EE2 (38)

Contributions in this area were discussed at 1615–1910 on Saturday 14 Oct. 2023, XXXX-XXXX on XXday XX Oct, 2023 (chaired by Y. Ye).

#### Intra and CIIP (18)

[JVET-AF0059](https://jvet-experts.org/doc_end_user/current_document.php?id=13307) AHG12: Fix to interpolation filter for intra prediction [K. Andersson (Ericsson)]

It was noted that ECM-10.0 can give stripe like visual artifacts and it was discovered that the reason for that was in interpolation in intra prediction due to non-unity gain of one of the 64-phase interpolation filters. It is therefore suggested to correct the filter with non-unity gain using a mirror version of corresponding mirror phase filter.

Objective performance (BDR) versus ECM-10.0 is reported as:

AI: Y: -0,01%, U 0,01%, V -0,05%

It is asserted that fixing the gain of the interpolation filter with non-unity gain also can improve subjective quality.

In ECM-10.0, the intra prediction interpolation at phase 41/64 has filter coefficients { 3, -21, 106, 180, -25, 3 } that sum up to 246 rather than 256. The proposal suggests to use the mirroring coefficients of phase 23/64 for phase 41/64, with coefficients { 3, -20, 106, 189, -25, 3}.

It was commented that this is the only phase that has this unintended behaviour.

It was also shown that fixing the coefficients bring subjective quality improvement.

Decision: adopt JVET-AF0059.

[JVET-AF0072](https://jvet-experts.org/doc_end_user/current_document.php?id=13320) AHG12: FIBC flag inherits IntraTMP-FLM flag [M.-H. Jia, Y. Gao, Y. -X. Bai, S.-W. Xie, P. Wu, C. Huang (ZTE)]

This contribution proposes that FIBC flag in the IBC merge mode can inherit the IntraTMP-FLM flag. In the IBC merge mode, the FIBC flag is inferred from the merge candidate. When the merge candidate is comes from the IntraTMP coded block, the FIBC flag can be inferred through IntraTMP-FLM flag.

The proposed method shows coding gains as follows:

Test A : Proposed method (the FIBC flag inherits the IntraTMP-FLM flag) on top of ECM-10.0

AI:

Class F： -0.02% / 0.04% / 0.02%, 100.4% / 99.8%

ClassTGM：-0.02% / -0.03% /-0.03%, 100.2% / 100.1%

Test B : Proposed method on top of EE2-2.6c (storing quarter-pel resolution IntraTMP BVs + IntraTMP BV storing for HMVP)

AI:

Class F： -0.04% / -0.02% / 0.02%, xx% / xx%

ClassTGM： 0.01% / 0.04% / -0.01%, xx% / xx%

It was commented that the gains are extremely small. One expert commented that in the previous round of EE, proposals with tiny gains were included in EE. Several experts commented that this might not be the most productive way to conduct EE tests.

Further study to bring more gains.

[JVET-AF0074](https://jvet-experts.org/doc_end_user/current_document.php?id=13322) Crosscheck of JVET-AF0072 (AHG12: FIBC flag inherits IntraTMP-FLM flag) [J. Fu, [S. Ma (PKU)](mailto:swma@pku.edu.cn)]

[JVET-AF0084](https://jvet-experts.org/doc_end_user/current_document.php?id=13332) Non-EE2: Update on IBC-LIC Model Merge mode [L. Zhang, Y. Yu, H. Yu, D. Wang (OPPO)]

This contribution proposes an IBC-LIC model merge mode that inherits IBC-LIC model parameters from spatial adjacent and non-adjacent neighbors, history candidates, or default models. The proposed method is implemented on top of ECM-10.0 software, and the performance is reported as follows:

AI: { -0.47% Y, -0.51% U, -0.36% V, 101.0% EncT, 100.6% DecT } for class F

{ -0.15% Y, -0.13% U, -0.11% V, 100.4% EncT, 102.6% DecT} for class TGM

RA: { -0.30% Y, -0.29% U, -0.23% V, 100.5% EncT, 100.0% DecT } for class F

{ -0.07% Y, -0.13% U, -0.10% V, 100.4% EncT, 101.8% DecT } for class TGM

It was asked if this method can be applied to IBC mode in natural content, the proponent commented that this had been tried on natural content and no gain was obtained. However, in the EE setting, results for natural content can be provided as well.

This proposal would require the model parameters from spatial adjacent and non-adjacent neighbors and history candidates to be additionally stored. Decoding time increase is likely due to more effort at the decoder to derive the IBC block vectors.

Investigate in EE, also consider potentially better tradeoff between performance and decoding time in terms of number of inherited models.

[JVET-AF0271](https://jvet-experts.org/doc_end_user/current_document.php?id=13535) Crosscheck of JVET-AF0084 (Non-EE2: Update on IBC-LIC Model Merge mode) [Y. Wang (Bytedance)] [late] [miss]

[JVET-AF0104](https://jvet-experts.org/doc_end_user/current_document.php?id=13351) Non-EE2: Direct Decoder-side Intra Mode Derivation for IntraTMP blocks [J. Huo, N. Qiu, Y. Ma, F. Yang (Xidian Univ.), M. Li (OPPO)]

In ECM10.0, DIMD is used to derive an intra prediction mode for Intra TMP blocks. It is conducted to the prediction signal after filtering, sub-pixel interpolation, or fusion. This contribution is proposed that using the initial predictions to derive *intraTmpDimdMode*. On top of ECM-10.0, simulation results are reported as follows:

AI(Y/U/V): -0.00%/-0.01%/-0.06%, EncT 100.1%, DecT 100.2%

This proposal is for improved parallelism for DIMD, it has no performance impact. However, at this stage of the exploration, refining a small aspect is not our main goal.

No action at this time.

[JVET-AF0222](https://jvet-experts.org/doc_end_user/current_document.php?id=13485) Crosscheck of JVET-AF0104 (Non-EE2: Direct Decoder-side Intra Mode Derivation for IntraTMP blocks) [X. Li (Alibaba)] [late] [miss]

[JVET-AF0115](https://jvet-experts.org/doc_end_user/current_document.php?id=13362) Non-EE2: IBC with a further upward-extended reference area for screen content [Y. Kidani, H. Kato, K. Kawamura (KDDI)]

This contribution proposes an intra block copy (IBC) with a further upward-extended reference area for screen content to enhance the coding performance of IBC. In the current ECM design, the reference area for IBC is extended to two CTU rows above the current CTU, but there is room to achieve additional coding gain for screen content by extending the reference area beyond the referenceable two CTU rows. Therefore, this contribution proposes two further upward extension methods for the IBC reference area, qualitatively comparing their advantages and disadvantages in terms of complexity. Specifically, method 1 extends the reference area to the picture's upper side boundary, while method 2 does four CTU rows above the current CTU.

The experimental results reportedly show the proposed method brings some coding gains over ECM-10.0. The results of method 2 are shown as follows:

AI: Class F {-0.14%, -0.22%, -0.10 %, 100.1%, 99.9%}, Class TGM {-1.21%, -1.21%, -1.20 %, 99.4%, 99.3%};

RA: Class F {-0.06%, -0.01%, -0.04%, 100.1%, 100.0%}, Class TGM {-0.66%, -0.61%, -0.64%, 99.9%, 100.9%}.

It was asked why increased IBC search area doesn’t incur an increase in encoder runtime. The proponent said that encoder search strategy in ECM-10 had not been changed, and the fact that encoding time is not increase could be due to the fact that only integer BVs are used for SCC content, and that hash-based search is used. It was commented that a previous adoption that increased IBC search range also didn’t result in encoder runtime increase for screen content.

It was commented that the IntraTMP search range and IBC search range in ECM-10 are different, and this proposal only suggests to extend the search range for IBC.

It was commented that currently the search range for natural content and screen content is the same, whereas this proposal could create different search ranges depending on the type of content.

The proponent said that no gain was obtained for natural content when the search range was enlarged.

Investigate in EE both methods in JVET-AF0115, results for natural content should be made available as well.

[JVET-AF0116](https://jvet-experts.org/doc_end_user/current_document.php?id=13363) Non-EE2: slope adjustment for IBC LIC [C. Ma, X. Xiu, W. Chen, H.-H.Jhu, C.-W. Kuo, N. Yan, X. Wang (Kwai)]

This contribution proposes to improve IBC LIC with slope adjustment, where an offset parameter is utilized to adjust the slope parameter of IBC LIC. The proposed method is only applied to IBC AMVP CUs. The simulation results on top of ECM-10.0 are summarized as follows:

Screen Content:

AI:

Class F : {-0.21%, -0.14%, -0.26%, 100.9%, 99.6%, 100.0%}, Class TGM : {-0.12%, -0.13 %, -0.19%, 100.5%, 100.3%, 100.0%};

RA:

Class F : {-0.19%, 0.06%, -0.05%, 100.0%, 99.2%, 100.0%}, Class TGM : {-0.13%, -0.15%, -0.14%, 99.5%, 99.8%, 100.0%};

An offset adjustment is determined by encoder through RDO to adjust the slope of IBC LIC. Encoder speedup algorithms are applied to reduce the impact to encoding time due to additional RDO.

The offset is signaled in a similar way as CCLM slope adjustment (range of value is the same). It was requested that the proponent upload a revised contribution that provides more details about the algorithm.

Cross checker confirmed that simulation results are matched, and support study in EE.

The proponent commented that no gain was observed for natural content.

Investigate in EE, results for natural content should be provided as well.

[JVET-AF0289](https://jvet-experts.org/doc_end_user/current_document.php?id=13553) Crosscheck of JVET-AF0116 (Non-EE2: slope adjustment for IBC LIC) [Y. Wang (Bytedance)] [late] [miss]

[JVET-AF0117](https://jvet-experts.org/doc_end_user/current_document.php?id=13364) Non-EE2: extensions of IBC GPM [C. Ma, X. Xiu, W. Chen, H.-H.Jhu, C.-W. Kuo, N. Yan, X. Wang (Kwai)]

This contribution proposes to extend IBC GPM scheme in ECM10.0 from two aspects: First, IBC GPM with block vector difference (IBC GPM BVD) is introduced. Second, the split mode of IBC GPM is reordered with template matching methods. The simulation results on top of ECM-10.0 are summarized as follows:

1. IBC GPM BVD:

Screen Content:

AI:

Class F : {-0.20%, -0.12%, 0.01%, 103.4%, 99.1%, 100.0%}, Class TGM : {-0.26%, -0.24 %, -0.23%, 103.3%, 99.8%, 100.0%};

RA:

Class F : {-0.10%, 0.04%, 0.02%, 102.3%, 99.8%, 99.9%}, Class TGM : {-0.21%, -0.14%, -0.17%, 101.4%, 99.4%, 100.0%};

Natural Content :

AI : {0.00%, 0.00%, 0.00%, 100.0%, 100.0%, 100.0%}, RA : {0.00%, 0.00 %, 0.00%, 100.0%, 100.0%, 100.0%};

1. IBC GPM BVD + Split mode reordering :

Screen Content:

AI:

Class F : {-0.21%, -0.22%, -0.05%, 105.6%, 99.9%, 101.4%}, Class TGM : {-0.39%, -0.34 %, -0.36%, 106.4%, 99.5%, 101.1%};

RA:

Class F : {-0.16%, 0.22 %, -0.04%, 103.4%, 99.8%, 101.2%}, Class TGM : {-0.26%, -0.16%, -0.26%, 102.3%, 99.1%, 100.7%};

Natural Content :

AI : {0.00%, 0.00%, 0.00%, 100.0%, 100.0%, 100.0%}, RA : {0.00%, 0.00 %, 0.00%, 100.0%, 100.0%, 100.0%};

It was commented that the split mode reordering seems to provide performance vs. runtime tradeoff that is less than IBC GPM BVD. The proponent said current encoder could be further optimized.

It was asked why there is no decoding time increase for split mode.

Presentation interrupted, to be continued

[JVET-AF0290](https://jvet-experts.org/doc_end_user/current_document.php?id=13554) Crosscheck of JVET-AF0117 (Non-EE2: extensions of IBC GPM) [R.-L. Liao (Alibaba)] [late] [miss]

[JVET-AF0129](https://jvet-experts.org/doc_end_user/current_document.php?id=13387) Non-EE2: Auto relocated block vector prediction [N. Zhang, K. Zhang, L. Zhang (Bytedance)]

TBP

[JVET-AF0137](https://jvet-experts.org/doc_end_user/current_document.php?id=13395) AHG12: IntraTMP with Merge Candidates [K. Naser, F. Le Léannec, A. Robert, F. Galpin (InterDigital)]

In the current IntraTMP design, the template matching is performed on a predefined search area to obtain a candidate list of predictors specified by their block vectors. Compared to IBC mode, the readily available block vectors from neighboring merge candidates are not explored in IntraTMP mode despite being more correlated with the properties of the current block. This contribution proposes extending the IntraTMP candidate list with all the merge candidates block vectors. The following results are obtained for natural content:

AI: -0.05% 0.01% -0.02% EncT 100.6% DecT 101.3%

For screen content, AI configuration, the following results are provided:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Class F | -0.16% | -0.11% | 0.09% | 99.0% | 99.6% | 99.9% |
| Class TGM | -0.20% | -0.16% | -0.14% | 96.5% | 93.4% | 99.7% |

The provided results show a reduction in encoding/decoding time for Class TGM, but according to the proponent, such runtime may not be accurate. Close to 100% runtime is expected.

One expert expressed support for investigating in EE.

Investigate in EE.

[JVET-AF0161](https://jvet-experts.org/doc_end_user/current_document.php?id=13419) AHG12: Harmonized IBC/ITMP search area with adaptive sampling [D. Ruiz Coll, B. Chen (Ofinno), K. Naser, P. Bordes, F. Le Léannec, F. Galpin (InterDigital)]

TBP

[JVET-AF0166](https://jvet-experts.org/doc_end_user/current_document.php?id=13424) Non-EE2: Intra TMP fusion probing [J.-L. Lin, P.-H. Lin, Y.-J. Chang, Z. Zhang, V. Seregin, M. Karczewicz (Qualcomm)]

This contribution proposes an Intra TMP fusion probing method to select a fusion candidate with minimum probing cost from a fusion candidate list. The probing cost is derived as the SAD between the reference and current block’s probing lines. The simulation results on top of ECM-10.0 are summarized as follows:

AI(Y/U/V): -0.09 %/ -0.04 %/ -0.11 %, EncT 102.1 %, DecT 101.5 %

It was asked why there is a 2% runtime increase. According to the proponent, there are two factors that could cause the runtime increase: the calculation of the probing cost, and an additional RDO that is conditionally triggered.

Encoding time should be further reduced to provide better tradeoff.

Several experts expressed interest in studying this in EE.

Investigate in EE, better performance vs. runtime tradeoff should be investigated.

[JVET-AF0170](https://jvet-experts.org/doc_end_user/current_document.php?id=13428) Non-EE2: CIIP with subblock-based motion compensation [L. Zhao, K. Zhang, L. Zhang (Bytedance)]

TBP

[JVET-AF0171](https://jvet-experts.org/doc_end_user/current_document.php?id=13429) Non-EE2: Sample distance-based weighting for CIIP [J. Zhao, S. Kim (LGE)]

TBP

[JVET-AF0184](https://jvet-experts.org/doc_end_user/current_document.php?id=13442) Non-EE2: Search range optimization for Intra TMP [G. Verba, Z. Zhang, V. Seregin, M. Karczewicz (Qualcomm)]

This contribution proposes to extend Intra TMP search area by enlarging the existed rectangular search area, adding horizontal and vertical oriented areas relative to the current block to the left and above of the rectangular search area, and adding areas around BV candidates. The experimental results on top of ECM-10.0 for SCC classes are reported as follows:

AI:

Overall: { -0.06%, -0.12%, -0.10%, 105.0%, 111.4%},

Class F: {-0.48%, -0.55%, -0.48%, 102.1%, 109.4%},

Class TGM: {-0.53%, -0.52%, -0.43%, 102.8%, 115.1%}

It was commented that the decoder runtime increase is quite substantial, and given this is intraTMP that relies on decoder search, encoder-only algorithm will not be able to solve the decoding time increase.

It was commented that looking for a better performance vs. runtime tradeoff for this contribution would require changing the normative aspects during EE, which is not in alignment with the purpose of an EE test.

Proponent claim that an individual element in the contribution provides better performance vs. runtime tradeoff, but this information is not yet uploaded. Proponent is requested to provide a revised contribution with detailed information about this aspect as well as its performance.

[JVET-AF0199](https://jvet-experts.org/doc_end_user/current_document.php?id=13460) Non-EE2: Bilateral Filtering for Intra Prediction [W. Yin, K. Zhang, Y. Wang, L. Zhang (Bytedance)]

TBP

[JVET-AF0226](https://jvet-experts.org/doc_end_user/current_document.php?id=13489) AHG12: SGPM with IntraTMP and IBC [K. Naser, F. Le Léannec, P. Bordes, Y. Chen (InterDigital)] [late]

SGPM is an intra mode with prediction signal generated by blending 2 intra prediction modes with specific split line. This contribution proposes further including block-vector based prediction obtained from IntraTMP or IBC modes of the neighboring blocks in the candidate list of SGPM. The results are obtained:

AI: -0.04% -0.05% -0.07% EncT 100.6% DecT 100.5%

In SC classes (classF and TGM)

AI: -0.54% -0.44% -0.46% EncT 99.65% DecT 102.35%

IntraTMP and IBC modes are made available to SGPM, which seems to be a straightforward extension.

It was asked why decoding time fluctuates from class to class. The proponent said some small increase in decoding time is expected, and more accurate decoding time could be provided during EE.

Several experts expressed interest in studying this in EE.

Investigate in EE.

[JVET-AF0275](https://jvet-experts.org/doc_end_user/current_document.php?id=13539) AHG12: Intra TMP extension to DIMD, LIC and SGPM [F. Le Léannec, K. Naser, G. Rath, T. Dumas, P. Bordes, Y. Chen (InterDigital)] [late]

This contribution proposes 3 extensions to the intra TMP prediction mode in ECM.

First extension concerns DIMD. It is proposed to adaptively select between planar or block-vector based prediction obtained from IntraTMP or IBC mode of neighboring blocks for the blending with an angular intra prediction.

Second extension consists in allowing Local Illumination Compensation in blocks coded in IntraTMP mode. LIC is already allowed for IBC blocks. Thus, extending it to IntraTMP harmonizes IntraTMP and IBC with regards to LIC usage.

Last, block-vector-based prediction obtained from IntraTMP or IBC modes of the neighboring blocks are included in the candidate list of SGPM, as proposed in contribution JVET-AF0226.

The following results are obtained for AI and RA configurations.

AI: -0,09% (Y) -0,01% (U) -0,12% (V) 100,8% (EncT) 100,6% (DecT)

For screen contents in AI configuration:

Class F: -0,40% -0,36% -0,29% 101,7% (EncT) 100,5% (DecT)

Class TGM: -0,78% -0,79% -0,78% 99,9% (EncT) 100,3% (DecT)

The two elements (LIC and DIMD) in this contribution that are not in JVET-AF0226 bring more gain for natural content, but have limited additional benefit for screen content.

One expert expressed support for studying in EE, considering all elements are intraTMP related.

Investigate in EE, conduct separate tests on individual elements (LIC, DIMD, SGPM) as well as combination tests.

#### Inter (13)

[JVET-AF0082](https://jvet-experts.org/doc_end_user/current_document.php?id=13330) Non-EE2: on LFNST/NSPT for inter coding [F. Wang, J. Gan, Y. Yue, H. Yu, D. Wang (OPPO)]

This contribution proposes to utilize LFNST/NSPT for inter coding. For inter coded block, an intra prediction mode is first derived according to the inter prediction block. Then the derived intra prediction mode is used to select an LFNST/NSPT transform set and the transform can be processed with the selected LFNST/NSPT kernel, like in the intra coding process. On top of ECM-10.0, the performance of the proposed inter LFNST/NSPT is reported as follows:

RA {-0.37% Y, 0.14% U, 0.09% V, 114.0% EncT, 101.3% DecT, 100.0% VmPeak}

It was asked if this would create any parsing dependency, it was confirmed by multiple experts that this proposal doesn’t have parsing dependency issues.

It was asked if new transform kernels for inter coding are trained, the answer is no. Only signaling (of which kernel is used) is different from intra coding.

Some preliminary results of improved encoding time are shown in the uploaded PPT package.

Several experts commented that the gains are attractive, and that there is evidence that encoding time can be reduced.

It was asked if there is a block size restriction, the answer is that current implementation has no such limitation.

It was suggested to enable intra LFNST in LDB and use that as the anchor for EE test in LDB config. This was agreed.

Is this applied to luma only? Yes.

Investigated in EE, with reduction in encoding time desirable.

[JVET-AF0273](https://jvet-experts.org/doc_end_user/current_document.php?id=13537) Crosscheck of JVET-AF0082 (Non-EE2: On LFNST/NSPT for inter coding) [C. Zhou (vivo)] [late] [miss]

[JVET-AF0113](https://jvet-experts.org/doc_end_user/current_document.php?id=13360) Non-EE2: Modifications of affine merge candidates [K. Kim, D. Kim, J.-H. Son, [J.-S. Kwak (WILUS)](mailto:jinsam.kwak@wilusgroup.com)]

[JVET-AF0251](https://jvet-experts.org/doc_end_user/current_document.php?id=13514) Crosscheck of JVET-AF0113 (Non-EE2: Modifications of affine merge candidates) [R.-L. Liao (Alibaba)] [late] [miss]

[JVET-AF0118](https://jvet-experts.org/doc_end_user/current_document.php?id=13365) Non-EE2: Regression-based GPM blending [P. Bordes, F. Galpin, K. Naser, F. Urban, K. Reuzé, F. Le Léannec, E. François (InterDigital)]

[JVET-AF0297](https://jvet-experts.org/doc_end_user/current_document.php?id=13561) Crosscheck of JVET-AF0118 (Non-EE2: Regression-based GPM blending) [M. Blestel (Ofinno)] [late] [miss]

[JVET-AF0121](https://jvet-experts.org/doc_end_user/current_document.php?id=13368) AHG12: Adjusting out-of-boundary prediction samples [P. Astola, J. Lainema (Nokia)]

[JVET-AF0134](https://jvet-experts.org/doc_end_user/current_document.php?id=13392) AHG12: AMVP with SbTMVP mode [R.-L. Liao, J. Chen, Y. Ye, X. Li (Alibaba)]

[JVET-AF0250](https://jvet-experts.org/doc_end_user/current_document.php?id=13513) Crosscheck of JVET-AF0134 (AHG12: AMVP with SbTMVP mode) [F. Pu (Dolby)] [late] [miss]

[JVET-AF0135](https://jvet-experts.org/doc_end_user/current_document.php?id=13393) AHG12: Additional SbTMVP candidates [R.-L. Liao, J. Chen, Y. Ye, X. Li (Alibaba)]

[JVET-AF0238](https://jvet-experts.org/doc_end_user/current_document.php?id=13501) Crosscheck of JVET-AF0135 (AHG12: Additional SbTMVP candidates) [L. Zhao (Bytedance)] [late] [miss]

[JVET-AF0160](https://jvet-experts.org/doc_end_user/current_document.php?id=13418) Non-EE2: On DMVR Extensions [M. Salehifar, Y. He, K. Zhang, L. Zhang (Bytedance)]

[JVET-AF0162](https://jvet-experts.org/doc_end_user/current_document.php?id=13420) AHG12: Fixes to template matching [J. Chen, R.-L. Liao, X. Li, Y. Ye (Alibaba)]

[JVET-AF0264](https://jvet-experts.org/doc_end_user/current_document.php?id=13528) Crosscheck of JVET-AF0162 (AHG12: Fixes to template matching) [Y. Wang (Bytedance)] [late] [miss]

[JVET-AF0168](https://jvet-experts.org/doc_end_user/current_document.php?id=13426) Non-EE2: Geometric partitioning mode with affine prediction [K. Zhang, Z. Deng, L. Zhang (Bytedance)]

[JVET-AF0191](https://jvet-experts.org/doc_end_user/current_document.php?id=13452) Non-EE2: Enhancements on local illumination compensation [X. Xiu, C. Ma, N. Yan, H.-J. Jhu, C.-W. Kuo, W. Chen, X. Wang (Kwai)]

[JVET-AF0194](https://jvet-experts.org/doc_end_user/current_document.php?id=13455) Non-EE2: On LIC flag in merge mode [Y. Zhang, V. Seregin, H. Wang, Z. Zhang, C.-C. Chen, H. Huang, M. Karczewicz (Qualcomm)]

[JVET-AF0200](https://jvet-experts.org/doc_end_user/current_document.php?id=13461) Non-EE2: Extension of local illumination compensation [Y. Wang, K. Zhang, Y. He, H. Liu, L. Zhang (Bytedance)]

#### Cross Component Prediction (3)

[JVET-AF0083](https://jvet-experts.org/doc_end_user/current_document.php?id=13331) Non-EE2: Enhancements on CCP merge [H. Huang, Y. Yu, H. Yu, D. Wang (OPPO), Z. Deng, K. Zhang, L. Zhang (Bytedance)]

[JVET-AF0299](https://jvet-experts.org/doc_end_user/current_document.php?id=13563) Crosscheck of JVET-AF0083 (Non-EE2: Enhancements on CCP merge for chroma intra coding) [C. Zhou (vivo)] [late] [miss]

[JVET-AF0114](https://jvet-experts.org/doc_end_user/current_document.php?id=13361) AHG12: Local-Boosting on Cross-Component Merge Mode [H. Qin, K. Ding, Z. Xu (TCL)]

[JVET-AF0176](https://jvet-experts.org/doc_end_user/current_document.php?id=13434) Non-EE2: Decoder Derived Cross-Component Prediction [Y.-J. Chang, P.-H. Lin, V. Seregin, J.-L. Lin, M. Karczewicz (Qualcomm)]

[JVET-AF0301](https://jvet-experts.org/doc_end_user/current_document.php?id=13565) AHG12: SbTMVP with MMVD [L.-F. Chen, R. Chernyak, X. Zhao, X. Xu, S. Liu (Tencent)] [late] [miss]

#### In-Loop Filters (3)

[JVET-AF0178](https://jvet-experts.org/doc_end_user/current_document.php?id=13436) Non-EE2: Applying fixed filters to output of the Gaussian filter [N. Hu, M. Karczewicz, V. Seregin (Qualcomm)]

[JVET-AF0179](https://jvet-experts.org/doc_end_user/current_document.php?id=13437) Non-EE2: Fixed filter for Chroma ALF [N. Hu, M. Karczewicz, H. Wang, V. Seregin (Qualcomm)]

[JVET-AF0198](https://jvet-experts.org/doc_end_user/current_document.php?id=13459) Non-EE2: Coefficient Precision Adjustment for ALF [W. Yin, K. Zhang, L. Zhang (Bytedance)]

[JVET-AF0298](https://jvet-experts.org/doc_end_user/current_document.php?id=13562) Crosscheck of JVET-AF0198 (Non-EE2: Coefficient Precision Adjustment for ALF) [C. Ma (Kwai)] [late] [miss]

#### Entropy coding and transform coefficient coding (3)

[JVET-AF0164](https://jvet-experts.org/doc_end_user/current_document.php?id=13422) AHG12: CABAC inter/intra model switch [F. Lo Bianco, F. Galpin, C. Salmon-Legagneur (InterDigital)]

[JVET-AF0169](https://jvet-experts.org/doc_end_user/current_document.php?id=13427) Non-EE2: Adaptive clipping with signaled lower and upper bounds [K. Cui, Z. Zhang, H. Huang, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AF0185](https://jvet-experts.org/doc_end_user/current_document.php?id=13443) Non-EE2: Transform Coefficient Coding [P. Nikitin, M. Karczewicz, M. Coban, V. Seregin (Qualcomm)]

#### RPR (1)

[JVET-AF0058](https://jvet-experts.org/doc_end_user/current_document.php?id=13306) AHG12: GOP-based RPR encoder control for ECM [K. Andersson, J. Ström, R. Yu, W. Ahmad, P. Wennersten (Ericsson)]

### CTC for EE2/ECM and general ECM improvements (7)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0090](https://jvet-experts.org/doc_end_user/current_document.php?id=13337) AHG6: Encoder memory profiling on ECM software [Y. Yasugi, T. Ikai (Sharp), R. Chernyak, Shan Liu (Tencent)]

[JVET-AF0101](https://jvet-experts.org/doc_end_user/current_document.php?id=13348) AHG12: ECM software cleanup for decoder side intra predictions acceleration [Z. Fan, Y. Yasugi, T. Ikai (Sharp)]

[JVET-AF0212](https://jvet-experts.org/doc_end_user/current_document.php?id=13475) Crosscheck of JVET-AF0101 (AHG12: ECM software cleanup for decoder side intra predictions acceleration) F. Wang (OPPO) [late] [miss]

[JVET-AF0156](https://jvet-experts.org/doc_end_user/current_document.php?id=13414) AHG6: ECM software optimizations [F. Urban, T. Poirier, F. Le Léannec (InterDigital)]

[JVET-AF0287](https://jvet-experts.org/doc_end_user/current_document.php?id=13551) Crosscheck of JVET-AF0156 (AHG6: ECM software optimizations) [Y. Yasugi (Sharp)] [late] [miss]

[JVET-AF0165](https://jvet-experts.org/doc_end_user/current_document.php?id=13423) Ahg7/Ahg12: On VTM-11ecm anchor low-delay test conditions [F. Le Léannec, S. Puri, E. François, K. Naser (InterDigital)]

[JVET-AF0177](https://jvet-experts.org/doc_end_user/current_document.php?id=13435) AHG6: Memory reduction for ECM encoder [N. Hu, V. Seregin, M. Karczewicz (Qualcomm), Y. Yasugi, T. Ikai (Sharp)]

[JVET-AF0201](https://jvet-experts.org/doc_end_user/current_document.php?id=13462) AHG6: On ECM SW memory consumption [R. Chernyak, M. Xu, S. Liu (Tencent), Y. Yasugi, T. Ikai (Sharp)]

[JVET-AF0237](https://jvet-experts.org/doc_end_user/current_document.php?id=13500) AHG6: ECM encoder memory reduction [C.-W. Kuo, X. Xiu, W. Chen, H.-J. Jhu, N. Yan, C. Ma, X. Wang (Kwai)] [late]

[JVET-AF0293](https://jvet-experts.org/doc_end_user/current_document.php?id=13557) Crosscheck of JVET-AF0237 (AHG6: ECM encoder memory reduction) [N. Hu (Qualcomm)] [late] [miss]

# High-level syntax (HLS) and related proposals (43)

## AHG9: SEI messages on NNPF aspects other than grouping (1)

Contributions in this area were discussed at 1330–1410 on Saturday 14 Oct. 2023 (chaired by JRO).

[JVET-AF0045](https://jvet-experts.org/doc_end_user/current_document.php?id=13289) AHG2/AHG9: On the use of NNPF SEI messages in AVC [M. M. Hannuksela (Nokia)]

JVET-AE1016 includes the draft text for changes of the AVC, including the new subclause D.3.3 specifying the use of the neural-network post-filter characteristics (NNPFC) and neural-network post-filter activation (NNPFA) SEI messages in AVC. This input document proposes the following changes to subclause D.3.3:

1. It is proposed to specify that the non-nested NNPFC and NNPFA SEI messages apply to decoded pictures resulting from the decoding process specified in Clauses 2 to 9 and to remove references to nuh\_layer\_id, which does not exist in AVC.
2. It is proposed to remove the constraint and the NOTE that refer to output\_flag, since output\_flag is present only in the NAL unit header SVC extension and is therefore meaningless unless subclause D.3.3 would be extended to apply to layer representations of SVC.
3. Since AVC does not define picture unit, it is proposed to replace the term picture unit with the term access unit in constraints related to the occurrence and content of NNPFC SEI messages within a picture unit.
4. It is proposed to fix the following syntax element and variable names:
   1. fp\_arrangement\_type 🡪 frame\_packing\_arrangement\_type
   2. SliceQpY 🡪 SliceQPY

Item 1 (nuh\_layer\_id not defined in AVC): Another option suggested is defining a variable layer\_id to generate the corresponding syntax element that is not existing in AVC. Revisit.

Item 2 (output\_flag not defined in AVC): Could be resolved similarly by variable. Revisit after studying the aspect that prefix NAL unit is not mandatory in AVC.

Item 3 (picture unit not defined in AVC): In non-nested case (single layer), replacing it by “access unit” would be OK. Revisit.

Item 4: editorial – agreed.

It was discussed whether it would be appropriate to restrict usage of NNPF to single layer (not SVC/MVC). In that case, it would need to be explicitly stated. Text would be simpler. However, it is commented that so far, usage of SEI messages had not been restricted to certain profiles.

The question whether there was also a problem in context of AVC’s definition of cropping was raised, but accrding to other experts’ opinion that should not be a problem.

Offline consideration (M. Hannuksela, Y.-K. Wang, Y. Sanchez) to discuss and provide text to resolve the issues. Revisit.

This should also be reflected in CD ballot response. JRO to ask B. Bross, to coordinate with Y.-K. Wang.

## AHG9: General direction of grouping of post-processing filters (PPFs), including NNPFs (3)

Contributions in this area were discussed at 1410–1925 on Saturday 14 Oct. 2023 (chaired by JRO).

[JVET-AF0050](https://jvet-experts.org/doc_end_user/current_document.php?id=13298) AHG9: On NNPF groups [M. M. Hannuksela, F. Cricri (Nokia)]

Item 3 of this contribution belongs to this category.

Item 3: Except for the changes proposed in items 1 and 2 in this contributiion, other aspects of the NNPF group design in the VSEI TuC are considered mature in this contribution and are proposed to be included in the VSEI output document of the JVET-AF meeting, which may either be a working draft or a new version of the VSEI TuC document.

During the presentation of the document, it was suggested to get a conclusion on whether a specific SEI message is needed for the case of combining different NNPF devices, or if the processing order SEI can also be used here. It is also commented that evidence about real need for specific cases would be needed.

The contribution gives arguments why a separate SEI is needed for NNPF

1. Different types of grouping (alternatives, alternating, parallel) – it was commented that some of this may be resolved by other proposals
2. Optional processing steps – it is agreed that this is identical with the “essential” definition of SEIPO, if it is not essential, it can be condidered optional.
3. Signalling complexity of NNPF group – it was commented that a decoder could also retrieve the complexity information from the different NNPF SEI messages, and decide which operations are possible with its capability (e.g. skipping optional ones, or choosing the simpler one of alternating ones)

It was discussed which complexity would be signalled? Would it be the maximum or the minimum that would be possible? What would a decoder conclude, if has several options that would be possible by its capabilities

It was suggested that another option could be to signal complexity of the different contained NNPF messages in the prefix.

[JVET-AF0061](https://jvet-experts.org/doc_end_user/current_document.php?id=13309) AHG9: On grouping of post-processing filters [Y.-K. Wang, W. Jia, J. Xu, L. Zhang (Bytedance)]

At the 30th JVET meeting in April 2023, the BoG on NNPF and SEI processing order SEI messages agreed and the JVET endorsed that it is desirable to support all the following NNPF related capabilities in v4 of VSEI and VVC:

1. Multiple activated NNPFs for a picture in a cascading manner.
2. Multiple activated NNPFs (with the same or different purposes) for a picture in an alternative manner (e.g. choose to apply none, filter a only, or filter b only).
3. Multiple activated NNPFs (with the same or different purposes) for a picture in a cascading plus alternative manner (e.g. choose to apply none, filter a only, filter b only, or both filter a and b in a cascading manner in the indicated order).
4. Multiple activated NNPFs for a picture while the receiver may process the bitstream multiple times to generate multiple different results (e.g. for each time, to choose to apply none, filter a only, or filter b only).
5. Multiple activated NNPF cascades in an alternative manner (e.g. choose to apply none, both filter a and b in a cascading manner in the indicated order, or both filter c and d in a cascading manner in the indicated order).

JVET-AE2032 (Technologies under consideration for future extensions of VSEI (draft 1)) includes a NNPF grouping design resulted from proposals motivated by the above agreement and endorsement. The design involves addition of two new SEI messages, the neural-network post-filter group characteristics (NNPFGC) SEI message and the neural-network post-filter group activation (NNPFGA) SEI message, among other changes.

This contribution asserts that the NNPF grouping design is complicated and hard to understand. The design is also limited to only support NN-based post-processing filters (PPFs).

To address the agreed/endorsed NNPF related capabilities in v4 of VSEI and VVC, and extend the scope to both NN-based and non-NN-based PPFs, this contribution proposes the following changes:

1. Add a ue(v)-coded syntax element po\_id to the SEI processing order (SPO) SEI message, replace reserved\_alignment\_6bits in the SPO SEI message with byte alignment checking followed by po\_alignment\_zero\_bit, and specify the following PPF grouping mechanism (either as part of the semantics of the SPO SEI message or as part of the general post-processing filtering process):
   1. For each picture, there can be multiple PPFs activated and belonging to one or more PPF groups. PPF groups are alternative to each other, i.e., at most one group can be chosen to be applied.
   2. For backward compatibitiy with v3 of VVC/VSEI, a special PPF cascading case is defined, as the case when such two PPFs are both activated for a picture: the two PPFs are both NNPFs, one of the two NNPFs has nnpfc\_purpose equal to 4 and the other has multiple input pictures, and neither of the two NNPFs is associated with an SPO SEI message. In this case, the two NNPFs are implicitly considered as belonging to one PPF group, and the NNPF with nnpfc\_purpose equal to 4 is applied first.
   3. Except for the special PPF cascading case, each PPF group containing multiple PPFs is associated with an SPO SEI message with a particular value of po\_id.
   4. Except for the special PPF cascading case, any PPF not associated with an SPO SEI message is in its own PPF group.
   5. One or more PPFs in the chosen PPF group can be applied. When multiple PPFs (in the chosen PPF group) are applied, they are applied in the cascading manner where they are applied in the order indicated by the SPO SEI message associated with the chosen PPF group, and for each applied PPF that is not the last applied PPF, the output is used as the input of the next applied PPF.
2. Update the filtering process to apply to both NNPFs and non-NN-based PPFs and to enable the use of multiple activated PPFs from one PPF group in the cascading manner. Accordingly, both the NNPFC semantics in VSEI and the interface text in VVC are updated, such that when the PPF is not the first PPF that is applied for the current picture, the input to the PPF is the output of the previously applied PPF.

About 5), it was asked if a v3 legacy decoder might operate in non-desirable manner. It was commented that wrapping concepts could resolve that, i.e. make the NNPF SEI within a group invisible if its standalone usage is undesirable.

From the concepts of JVET-AF0050, “alternating” and “parallel” are missing according to opinion of its proponents. It is explained that one application of “parallel” would be to generate two outputs, e.g. one for human vision, one for machine vision. The view of “alternating” would be more from encoder perspective, compared to “alternative” where a decoder chooses which one to use.

It was commented that similar could be achieved by an encoder activating both of the “parallel” or “alternating” NNPFs, and let the decoder decide which to use.

It is understood that the concept of JVET-AF0061 is, that if it is possible to activate (and choose at the decoder to run) more than one group, such intended behaviour could be accommodated.

It was commented that a case where number of inputs and outputs in the cascade is not matching (e.g., a temporal upsampler expecting two separately post-filtered frames) might not be supported.

[JVET-AF0174](https://jvet-experts.org/doc_end_user/current_document.php?id=13432) AHG9: On the SEI processing order SEI message and NNPF groups [Y. Sanchez, C. Hellge, T. Schierl (Fraunhofer HHI)]

In this document a proposal is described that suggests modifications to the SEI processing order SEI message to allow referencing payload type and Id for association of an SEI message, as well as to specify a length of the prefix of an SEI indicting the bits that are used to identify the SEI message which a particular order id refers to. The proposal also suggests to allow that an SEI processing order SEI message can reference another SEI processing order SEI message and thereby the processing order specified in the latter is inherited by the first SEI processing order SEI message. Besides, a group activation SEI message is proposed that activates all NNPF filters that are associated with an SEI processing order SEI message.

Similar concept as JVET-AF0061, multiple SPO messages with different content would be allowed, but they need to have different id. Concepts of identifying and activating different SPO more explicitly introduced here.

The additionally proposed NNPF group activation SEI message would activate all NNPF SEI contained in an SPO together. The SPO could still contain other (non-NNPF) SEIs. It commented that one functionality of TuC (activating an update of a specific NNPF in a group individually) is discarded by this concept. It was further commented that when an NNPFA would be sent separately, it might be misinterpreted by a legacy decoder.

Some more aspects related to this category are contained in JVET-AF0049 item 1, JVET-AF0065, JVET-AF0067, and JVET-AF0189 (mainly aspect of persistence). After presentation of these (see below), following aspects were summarized to be clarified as intermediate conclusion:

* Which amount in flexibility is needed in processing order in terms of sequential, parallel, alternating/alternative?
* Need for separate messages for processing order (only supporting non-NNPF) and NNPF grouping?
* Allowing for several SPO with different processing order?
* Concepts of nesting (with or without a separate SEI)
* Aspects of persistence

Why should NNPF be treated differently than other SEI messages?

Can we expect in the near future (e.g., targeting v4 of VVC/VSEI) a sophisticated combination of different NNPF SEI messages, rather than combining NNPF with “conventional” SEI?

NNPF would work in the current definition of SPO, if the scope/persistence issue is resolved.

It is agreed to proceed with an approach based on modifying SPO such that

* Scope/persistence is resolved (possible solutions in JVET-AF0049/JVET-AF0174/JVET-AF0189)
* Add po\_id to support for alternative cascaded SEI messages (possible solutions in JVET-AF0061/JVET-AF0067/JVET-AF0174)

This is the general design concept to be implemented towards v4 of VVC/VSEI. Some other aspects from the discussion are secondary.

Revisit: Proponents of the contributions listed above are asked to provide a text proposal.

For further study of potential future aspects, the NNPF group design shall be kept in TuC.

## AHG9: Detailed aspects of NNPF grouping (9)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0050](https://jvet-experts.org/doc_end_user/current_document.php?id=13298) AHG9: On NNPF groups [M. M. Hannuksela, F. Cricri (Nokia)]

Items 1 and 2 of this contribution belong to this category.

[JVET-AF0051](https://jvet-experts.org/doc_end_user/current_document.php?id=13299) AHG9: Signalling the gain provided by NNPFs and NNPF groups [M. M. Hannuksela, F. Cricri, A. Hallapuro (Nokia)]

[JVET-AF0067](https://jvet-experts.org/doc_end_user/current_document.php?id=13315) AHG9: On the SEI processing order SEI message (Part 2) [L. Chen, O. Chubach, Y.-W. Huang, S. Lei (MediaTek)]

This contribution proposes to restructure the SEI processing order SEI message in JVET-AE2027 into SEI processing order group characteristic SEI message and SEI processing order group activation SEI message with the following brief description.

1. The SEI processing order group characteristic SEI message carries information indicating the preferred initial processing order type for different types of SEI messages that may be present in a CVS. The use of SEI processing order groups combined with any other types of SEI messages that may be present in a CVS for specific pictures is indicated with SEI processing order group activation SEI messages indicating the preferred final processing order types.
2. The SEI processing order group activation SEI message activates or de-activates the use of the combination of target SEI messages and/or target SEI processing order groups with the preferred final processing order type for processing of a set of pictures.
3. When no SEI processing order groups specified by SEI processing order group characteristic SEI messages rather than SEI messages indicated in the activation message are present for activation, the SEI processing order group activation SEI message may be used without a preceding SPOGC SEI message.

Contains definition of purpose (unspec/human/machine), and type (cascade/alternate/parallel). However, in the current concept, parallel could not be used as one branch to human, one for machine.

Wrapping is supported, as well as importance signalling.

There could several of these SEI messages be present and activated.

[JVET-AF0091](https://jvet-experts.org/doc_end_user/current_document.php?id=13338) [AHG9] On design for signalling purpose information for NNPFGC [[Hendry](mailto:dr.hendry@lge.com), J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0092](https://jvet-experts.org/doc_end_user/current_document.php?id=13339) [AHG9] On the output pictures from NNPFGC with parallel grouping type [[Hendry](mailto:dr.hendry@lge.com), J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0093](https://jvet-experts.org/doc_end_user/current_document.php?id=13340) [AHG9] On intermediary output picture(s) from activation of an NNPFGC [[Hendry](mailto:dr.hendry@lge.com), J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0094](https://jvet-experts.org/doc_end_user/current_document.php?id=13341) [AHG9] On activation of an NNPFGC that contains another NNPFGC [[Hendry](mailto:dr.hendry@lge.com), J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0095](https://jvet-experts.org/doc_end_user/current_document.php?id=13342) [AHG9] On order of output pictures when skipped candidate input pictures are present in NNPFGA [Hendry, J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0096](https://jvet-experts.org/doc_end_user/current_document.php?id=13343) [AHG9] On miscellaneous aspects of NNPFGC and NNPFGA [Hendry, J. Nam, S. Kim, J. Lim (LGE)]

## AHG9: SEI processing order SEI message aspects other than PPF grouping (5)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

Remaining aspects of JVET-AF0174 (such as referencing/nesting different SPO SEI) also to be discussed here.

[JVET-AF0049](https://jvet-experts.org/doc_end_user/current_document.php?id=13297) AHG9: On the SEI processing order SEI message [M. M. Hannuksela (Nokia)]

This contribution proposes the following changes related to the SEI processing order SEI message:

1. Removal of the capability of wrapping SEI messages within the SEI processing order SEI message and addition of a processing order nesting SEI message that includes one or more SEI messages having the same persistence and are used in an indicated position within the processing order.
2. Removal of the following constraints, which are asserted to be imposed elsewhere: "It is a requirement of bitstream conformance that, within an SEI processing order SEI message, there shall be at least two pairs of the syntax elements po\_sei\_payload\_type[ i ] and po\_sei\_processing\_order[ i ], and there shall be at least two values of po\_sei\_processing\_order[ i ] that are not equal."
3. Indication of the increment po\_sei\_processing\_order\_incr\_flag[ i ] relative to the previous derived processing order value, instead of an absolute processing order value po\_sei\_processing\_order[ i ].
4. Indication of the number of bits instead of bytes for SEI message prefixes included in the SEI processing order SEI message.

Item 1 points out a problem that persistence of various SEI messages contained in an SPO might be different.

Could this also be resolved by an encoder constraint?

More flexibility is introduced by the processing order nesting SEI (not replacing SPO) the syntax element pon\_processing\_order[i] could allow gaps, and be not strictly sequential. Some similarity with JVET-AF0174, but the latter does not require a separate SEI.

SEI messages can be contained as payload (but don’t need to), to hide them from legacy decoders (similar to wrapping).

[JVET-AF0062](https://jvet-experts.org/doc_end_user/current_document.php?id=13310) AHG9: Some syntax and semantics changes for the SEI processing order SEI message [Y.-K. Wang (Bytedance)]

[JVET-AF0065](https://jvet-experts.org/doc_end_user/current_document.php?id=13313) AHG9: On the SEI processing order SEI message (Part 1) [L. Chen, O. Chubach, Y.-W. Huang, S. Lei (MediaTek)]

This contribution addresses comments related to the JVET-AE2027 made at the recent JVET-AE meeting. It is proposed to add following aspects in the JVET-AE2027 - SEI processing order SEI message in VVC (draft 5):

1. Scope of persistence
2. Processing order type, such as Cascade, Parallel, and Alternate etc.
3. Processing purpose, such as general visual quality improvement, processing for human viewing, and processing for machine etc.
4. Support of the neural network post filter (NNPF) SEI messages with two options

Introduces functionality from NNPF grouping SEI into SPO SEI.

There can not be more than one SPO SEI in this concept.

[JVET-AF0070](https://jvet-experts.org/doc_end_user/current_document.php?id=13318) AHG9: On the SEI processing order SEI message [T. Chujoh, Y. Yasugi, T. Ikai (Sharp)]

[JVET-AF0189](https://jvet-experts.org/doc_end_user/current_document.php?id=13449) AHG9: Proposed modifications of the draft SEI processing order SEI message in VVC [G. J. Sullivan, S. McCarthy, P. Yin (Dolby Labs)]

This document contains proposed some modifications of 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. The proposed modifications include the following:

* Using separate loops for the payload type and processing order information and the wrapped and prefixed other SEI messages;
* Modifying the persistence scope and constraints to allow changes of the content of the associated other SEI messages but not changes of their processing order or their way of being handled within the SEI processing order SEI message;
* Making the syntax and semantics of the SEI processing order SEI message more consistent with the existing SEI prefix indication and scalable nesting SEI messages by using similar syntax, variable names and semantics;
* Removing the constraint that “The value of po\_sei\_processing\_order[ po\_num\_sei\_messages\_‌minus2 + 1 ] shall not be equal to 0”, since, for example, if an alternative transfer characteristics SEI message and a colour transform information SEI message are both indicated with processing order 0, the input of the colour transform should be interpreted as having the alternative transfer characteristics, and the output of the colour transform could be intended for some other display characteristics associated with the ID value sent in the colour transform information SEI message.
* Modifying the SeiProcessingOrderSeiList that determines which SEI messages are allowed to appear in an SEI processing order SEI message.

Revision marks are used to show the proposed changes relative to the Draft 5 text of the JVET output document JVET-AE2027.

It is also suggested to consider future clarification action of the existing text of VVC by appending “in decoding order” after “in the first access unit of the CVS” in the semantics of the SEI manifest and SEI prefix indication SEI messages.

Persistence can change for individual SEI messages, also prefix can change, but the overall order cannot change.

Several SPO SEI shall define same overall order (including the presence of wrapping and prefix). Enforcing wrapping in all of them may cause need for largely duplicating payload. It was pointed out that nesting (e.g. JVET-AF0049) may be better on that.

For usage with NNPF, further modification would be necessary due to separate activation.

The proposal also points out a possible need of clarification of semantics for the existing SEI manifest and SEI prefix messages. Agreed to include this aspect in JVET-AF1004.

## AHG9: SEI messages related to generative face video (3)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0048](https://jvet-experts.org/doc_end_user/current_document.php?id=13296) A Study on Decoder Interoperability of Generative Face Video Compression [B. Chen, S. Yin, J. Chen, Y. Ye (Alibaba), S. Wang (CityU HK)]

[JVET-AF0146](https://jvet-experts.org/doc_end_user/current_document.php?id=13404) AHG9: On Face Motion Information for Generative Face Video [H.-B. Teo, J.-Y Thong, K. Jayashree, C.-S. Lim, K. Abe (Panasonic)]

[JVET-AF0234](https://jvet-experts.org/doc_end_user/current_document.php?id=13497) AHG9: Common text for proposed generative face video SEI message [B. Chen, J. Chen, Y. Ye (Alibaba), S. Wang (CityU), S. McCarthy, P. Yin, G.-M. Su, A. K. Choudhury, W. Husak (Dolby)] [late] [miss]

## AHG9: Source picture timing information SEI message aspects (6)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0055](https://jvet-experts.org/doc_end_user/current_document.php?id=13303) AHG9: On Source Picture Timing Information (SPTI) SEI message [[J. Samuelsson-Allendes](mailto:samuelssonj@sharplabs.com), S. Deshpande (Sharp)]

[JVET-AF0069](https://jvet-experts.org/doc_end_user/current_document.php?id=13317) AHG9: On source picture timing information SEI message [S. McCarthy, G. J. Sullivan, P. Yin (Dolby)]

[JVET-AF0097](https://jvet-experts.org/doc_end_user/current_document.php?id=13344) [AHG9] On description of picture 0 in source picture timing information SEI message [Hendry, J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0098](https://jvet-experts.org/doc_end_user/current_document.php?id=13345) [AHG9] On temporal reversal feature in source picture timing information SEI message [Hendry, J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0099](https://jvet-experts.org/doc_end_user/current_document.php?id=13346) [AHG9] On signaling of source picture interval scale factor and sublayer synthesized flag in source picture timing information SEI message [Hendry, J. Nam, S. Kim, J. Lim (LGE)]

[JVET-AF0100](https://jvet-experts.org/doc_end_user/current_document.php?id=13347) [AHG9] On miscellaneous aspects of source picture timing information SEI message [Hendry, J. Nam, S. Kim, J. Lim (LGE)]

## AHG9: Encoder optimization information SEI message aspects (4)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0052](https://jvet-experts.org/doc_end_user/current_document.php?id=13300) AHG9: Proposed updates on the encoder optimization information SEI message [M. M. Hannuksela, F. Cricri (Nokia)]

[JVET-AF0068](https://jvet-experts.org/doc_end_user/current_document.php?id=13316) AHG8/AHG9: Signalling of encoder preprocessing information [W. Jia, Y. Li, Y.-K. Wang, K. Zhang, L. Zhang (Bytedance)]

[JVET-AF0105](https://jvet-experts.org/doc_end_user/current_document.php?id=13352) AHG9: On color vision deficiency optimization type for encoder optimization info SEI message [C. Kim, Hendry, D. Gwak, J. Lim, S. Kim (LGE)]

[JVET-AF0107](https://jvet-experts.org/doc_end_user/current_document.php?id=13354) AHG9: On miscellaneous aspects for encoder optimization info SEI message [C. Kim, Hendry, D. Gwak, J. Lim, S. Kim (LGE)]

## AHG9: Object mask information SEI message aspects (2)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0087](https://jvet-experts.org/doc_end_user/current_document.php?id=13335) AHG9: Experimental results of object mask auxiliary picture coding [Z. Zhang, [J. Chen](mailto:jiechen.cj@alibaba-inc.com), Y. Ye, S. Wang (Alibaba)]

[JVET-AF0088](https://jvet-experts.org/doc_end_user/current_document.php?id=13336) AHG9: Software implementation and further fixes of the object mask information SEI message [J. Chen, Z. Zhang, Y. Ye, S. Wang (Alibaba)]

## AHG9: Other SEI topics (10)

Contributions in this area were discussed at XXXX–XXXX on XXday XX Oct. 2023 (chaired by XXX).

[JVET-AF0138](https://jvet-experts.org/doc_end_user/current_document.php?id=13396) AHG8/AHG9: Truncated bit depth support SEI messages [D. Ding, X. Zhao, S. Liu, G. Teniou, S. Wenger (Tencent)]

[JVET-AF0140](https://jvet-experts.org/doc_end_user/current_document.php?id=13398) [AHG9] Inter Picture Dependency SEI message [G. Teniou, S. Wenger, S. Liu (Tencent)]

[JVET-AF0141](https://jvet-experts.org/doc_end_user/current_document.php?id=13399) AHG9: SEI messages for common image metadata formats [A. Hinds, S. Wenger (Tencent)]

[JVET-AF0142](https://jvet-experts.org/doc_end_user/current_document.php?id=13400) [AHG9] Local Film Grain Synthesis using Annotated Regions SEI [G. Teniou, S. Wenger (Tencent)]

[JVET-AF0144](https://jvet-experts.org/doc_end_user/current_document.php?id=13402) [AHG9] Adaptive Film grain synthesis using Alpha Channel Information SEI message [G. Teniou, S. Wenger (Tencent)]

[JVET-AF0145](https://jvet-experts.org/doc_end_user/current_document.php?id=13403) AHG9: SEI message for text for generative AI [A. Hinds, S. Wenger (Tencent)]

[JVET-AF0147](https://jvet-experts.org/doc_end_user/current_document.php?id=13405) AHG8/AHG9: On Picture Modality Type [J. Gao, H.-B. Teo, C.-S. Lim, K. Abe (Panasonic)]

[JVET-AF0148](https://jvet-experts.org/doc_end_user/current_document.php?id=13406) [AHG9] Large SEI message signalling [G. Teniou, S. Wenger (Tencent)]

[JVET-AF0149](https://jvet-experts.org/doc_end_user/current_document.php?id=13407) [AHG9] Application-required SEI NAL Units [G. Teniou, S. Wenger (Tencent)]

[JVET-AF0167](https://jvet-experts.org/doc_end_user/current_document.php?id=13425) AHG9: On the Proposed Multiplane Image Information SEI Message [T. Lu, P. Yin, S. Oh, S. McCarthy, W. Husak, G. J. Sullivan (Dolby)]

[JVET-AF0255](https://jvet-experts.org/doc_end_user/current_document.php?id=13518) Crosscheck of JVET-AF0167 (AHG9: On the Proposed Multiplane Image Information SEI Message) [R.-L. Liao (Alibaba)] [late] [miss]

## 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 2.15.

Joint meetings involving JVET were held as follows:

* JVET, XXX on XXX topics, on XXday XX Oct. at XXXX–XXXX
* Further detail about these sessions with other groups is provided in the other subsections of this section.

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 16 Oct. 0900–1130, Wednesday 18 Oct. 0900–1030, and Friday 20 Oct. 1400–1600.

The status and plans for the work in the MPEG WGs and AGs was reviewed at these information sharing sessions.

## Joint meeting of JVET, XXXX on XXX related topics

This joint session was held on XXday XX Oct. at XXXX–XXXX. About XXX people were present in the room and about XXX were connected on Zoom (substantially overlapping with those present in the room).

Agenda

* …

## BoGs (3)

The following break-out groups were established at this meeting to conduct discussion and develop recommendations on particular subjects.

## Liaison communications (1)

JPEG liaison [m64537](https://dms.mpeg.expert/doc_end_user/current_document.php?id=88881&id_meeting=195) provided an update on the status of work in the JPEG AI project. The JPEG AI VM2 evaluation reportedly showed 28% and 32% compression efficiency gains over the VVC Intra anchor, for the tools-off and tools-on configurations, respectively, requiring approximately 800 kMAC/pxl at the decoder side. A lightweight model was also adopted targeting mobile devices, reportedly providing 10% compression efficiency gains (tools off) over VVC at 20 kMAC/pxl and 15% gains (tools on) at ~30 kMAC/pxl.

DIS was scheduled for Oct. 2023.

A reply was drafted as WG 5 N 234, and was reviewed in JVET on Wednesday 19 July 1045. The draft reply was also presented in the AG 3 meeting Thursday 20 July at 1000.

# Project planning

## Software timeline

ECM 10 software (including all adoptions) was planned to be available 3 weeks after the meeting.

The NNVC 6.0 codebase software (integrating HOP loop filter with stage 2 optimization plus some bug fixes) was planned to be available 2 weeks after the meeting. An update 6.1 (including verified HOP stage 3 and verified simplified intra prediction) was planned to be available 4 weeks after the meeting.

VTM22.0 software was planned to be available on 2023-09-01. (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-AF2023.

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-AF2024.

Initial versions of these documents were presented and approved.

## 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:

* Normative contributions (relating to changes in bitstream/decoder) shall include draft specification text
* Proposals shall contain all details relevant for understanding and be self-contained. In cases where the document is a follow-up of a previous contribution, the overall concept and the novelties should be highlighted at minimum
* Coding tool and encoder optimization proposals shall contain Excel sheets that allow assessment on a per-sequence basis
* Algorithm description text is strongly encouraged for non-normative contributions that are intended to be included in model description documents (VTM, ECM, etc.), and that is required for inclusion in TR drafts.
* Early upload deadline to enable substantial study prior to the meeting
* Using a clock timer to ensure efficient proposal presentations (5 min) and discussions (nott exercised currently)

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. Withdrawing parts of experiments that were intended to show the individual benefits of a tool or parts of a tool is strongly discouraged. Combination tests may not be considered in such cases. Any changes made to individual tools in a combination shall be documented.
* 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 Tuesday 18 July 2023 at 1500, with some refinements on Wednesday 19 July 2023 at 1045.

|  |  |  |
| --- | --- | --- |
| **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-AE1006, JVET-AE1016, JVET-AE2005, JVET-AE2006, and JVET-AE2027. * Collect reports of errata for the VVC, VSEI, HEVC, AVC, CICP, and the published related technical reports and produce the JVET-AE1004 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. * 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 conducting a first test for VVC multi-layer features by the next meeting, and update the test plan according to subsequent tests. * Coordinate with AHG13 on assessing new test material; improve and update the draft test plan for subjective quality testing of the FGC SEI message. * 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 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), W. Husak, S. Iwamura, P. de Lagrange, S. Liu, S. Puri, A. Segall, S. Wenger (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 of additional conformance bitstreams for VVC multilayer configurations JVET-AE2028, and investigate the need for future improvements of conformance testing specifications. * Study the conformance needs for HEVC multi-view profiles, and develop a set of conformance bitstreams as appropriate. * 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. | I. Moccagatta (chair), F. Bossen, K. Kawamura, P. de Lagrange, T. Ikai, S. Iwamura, H.-J. Jhu, S. Paluri, 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-10.0 software version and the reference configuration encodings according to the ECM common test conditions. * Investigate encoder speedup and other software optimization such as reduction of memory consumption. * 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, R. Chernyak, F. Le Léannec, K. Zhang (vice-chairs) | N |
| **ECM tool assessment (AHG7)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Investigate methodology of tool assessment. * Coordinate with AHG6 on resolving tool-off test related software issues (missing tool controls and software bugs). * Prepare configuration files and generate bitstreams and results of tool-on/tool-off testing. * Prepare reporting of tool assessment results. * Collect simulation results on non-CTC sequences, and report any issues identified with non-CTC sequences * Develop methodology of more reliable runtime measurement | X. Li (chair), L.-F. Chen, Z. Deng, J. Gan, E. François, H.-J. Jhu, X. Li, H. Wang (vice‑chairs) | N |
| **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. * Generate anchors according to the common test conditions JVET-AE2031. * Discuss improvements on the evaluation framework, including evaluation procedures and methodologies. * Coordinate software development, and continue to migrate the software basis used in AHG8 to newest VTM version. * Coordinate experiments on optimization of encoders and receiving systems for machine analysis of coded video content. * Maintain the software implementation example algorithms in the repository, including sufficient documentation in terms of operation and performance. * Evaluate proposed technologies and their suitability for machine analysis applications. * Propose improvements to the draft technical report JVET-AE2030 on optimization of encoders and receiving systems for machine analysis of coded video content. * Study the potentials of using SEI messages for the purpose of machine analysis in coordination with AHG9. * Coordinate with WG 4 VCM AHG on aspects such as common test conditions, evaluation metrics, test and training materials, usage of SEI messages, and on studying characteristics and requirements of targeted machine analysis tasks, etc. | C. Hollmann, S. Liu, S. Wang, M. Zhou (AHG chairs) | Y (tel., 2 weeks notice) |
| **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. * Discuss the document for technologies under consideration for VSEI JVET-AE2032, and propose improvements as appropriate. * 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. * Study the alignments of the same SEI messages in different standards * 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-AE2016. 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. * Assess the results on 3rd stage of HOP filter training and simplified intra prediction training crosscheck for a possible inclusion in NNVC6 software. * 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 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. | E. Alshina, F. Galpin, S. Liu, A. Segall (co‑chairs), J. Li, R.-L. Liao, D. Rusanovskyy, T. Shao, M. Wien, P. Wu (vice‑chairs) | Y (tel., 2 weeks notice), first on Aug. 9 |
| **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 ECM10 algorithm description JVET-AE2025. * 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-AE2017. * Analyse the results of exploration experiments described in JVET-AE2024 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, Y. Yu (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. * Study alternative film grain models and their associated documentation. * In consultation with AHG4, study and define content characteristics and test conditions that are desirable for the study and testing of film grain technologies, and perform an assessment of newly available test materials in that regard. * Given the study of desirable content characteristics, solicit or create new test material for further determining the operational characteristics of, testing, and developing any related 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 improving the draft plan for subjective quality testing of the FGC SEI message JVET-AD2022, and conduct preparations for such testing. * Coordinate with AHG3 for software support of the FGC SEI message. | W. Husak, P. de Lagrange (co-chairs), A. Duenas, D. Grois, Y. He, X. Meng, M. Radosavljević, 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-6.0 software version and the reference configuration encodings according to the NNVC common test conditions as described in JVET-AE2016. * Investigate combinations of tools included in the NNVC software, prepare and release anchor data for all configurations of the software, including anchors for High and Low Operation Point (HOP/LOP) configurations. * 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-AE2019) editors to identify any mismatches between software and description document, suggest further updates to the description document as appropriate. * Coordinate with AHG11 on items related to NNVC activities. | F. Galpin (chair), Y. Li, Y. Li, J. Shingala, L. Wang, Z. Xie (vice chairs) | Y (tel., 2 weeks notice), first on Aug. 9 |

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 235) 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 235, as noted in section 9.

[JVET-AE1000](https://jvet-experts.org/doc_end_user/current_document.php?id=13264) Meeting Report of the 31st JVET Meeting [J.-R. Ohm] [WG 5 N 216] (2023-08-16)

Initial versions of the meeting notes (d0 … d8) were made available on a daily basis during the meeting.

Remains valid – not updated: [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)]

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-AD1003](https://jvet-experts.org/doc_end_user/current_document.php?id=12970) Coding-independent code points for video signal type identification (Draft 2 of 3rd edition) [WG 5 preliminary FDIS N 206] [G. J. Sullivan, A. Tourapis] (2023-06-30)

The technical content was submitted for ITU consent (but will not be published until ST 2128 is available); ISO FDIS was to be delayed until it is available.

Post-meeting note: Expected *de facto* primary editor for ITU consent text: G. J. Sullivan.

[JVET-AE1004](https://jvet-experts.org/doc_end_user/current_document.php?id=13265) Errata report items for VVC, VSEI, HEVC, AVC, and Video CICP [Y.-K. Wang, B. Bross, I. Moccagatta, C. Rosewarne, G. J. Sullivan] (2023-09-30, near next meeting)

Post-meeting note: *De facto* primary editor: Y.-K. Wang.

Errata on post-filter hint SEI message in AVC and HEVC to be added from JVET-AE0155.

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 (along with some errata corrections from JVET-AD1004) was included in a new edition of HEVC submitted for ITU consent (and had previously been included in the FDIS submitted as WG 5 N 179 issued from the January 2023 meeting).

Post-meeting note: *De facto* primary editor for ITU consent text: Y.-K. Wang.

(JVET-Z1005 can be removed after publication of the new edition of ISO/IEC 23008-2.)

[JVET-AE1006](https://jvet-experts.org/doc_end_user/current_document.php?id=13266) New profiles, colour descriptors, and SEI messages for HEVC (draft 1) [WG 5 CDAM N 226] [B. Bross, T. Ikai, G. J. Sullivan, A. Tourapis, Y.-K. Wang] (2023-08-11) [2023-08-11]

Post-meeting note: *De facto* primary editor for this document and WG 5 N 226: Y.-K. Wang.

NNPF and phase indication SEI messages from JVET-AE0101, colour descriptors from JVET-AD1008, fix for FGC SEI message (see notes under BoG report JVET-AE0294), and new multiview profiles from JVET-AE0296, plus an additional Multiview Monochrome 10 profile.

A request document was issued as WG 5 N 225.

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]

Remains valid – not updated: [JVET-AD1008](https://jvet-experts.org/doc_end_user/current_document.php?id=12972) Additional colour type identifiers for AVC and HEVC (Draft 4) [G. J. Sullivan, W. Husak, A. Tourapis] [WG 5 Preliminary WD N 200] (2023-06-30)

Remains valid – not updated: [JCTVC-AC1009](https://jvet-experts.org/doc_end_user/current_document.php?id=12569) Common test conditions for SHVC [K. Sühring]

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]

[JVET-AE1011](https://jvet-experts.org/doc_end_user/current_document.php?id=13267) HEVC multiview profiles supporting extended bit depth (draft 2) [S. Paluri, W. Husak, A. Tourapis] [2023-08-11]

From JVET-AE0296. The specification of these profiles was also included in [JVET-AE1006](https://jvet-experts.org/doc_end_user/current_document.php?id=13266) and WG 5 N 226. This document, basically duplicating part of JVET-AE1006, was not issued as a separate WG 5 N document. See JVET-AE1006 for editorship note.

Draft 1 had been issued as preliminary WD WG 5 N 143.

(Number 1011 can be re-used when JVET-AE1006 progresses.)

Remains valid – not updated: JVET-[AD1012](https://jvet-experts.org/doc_end_user/current_document.php?id=12973) Overview of IT systems used in JVET [J.-R. Ohm, I. Moccagatta, K. Sühring, M. Wien] (2023-05-19)

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-AE1013](https://jvet-experts.org/doc_end_user/current_document.php?id=13268) Common test conditions of 3DV experiments [K. Sühring, M. Wien] [2023-09-01]

New licensing available from JVET-AE0179. Other owners have not responded, therefore we can assume that they don’t have a problem that the sequences are used.

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]

Remains valid – not updated: [JVET-AC1015](https://jvet-experts.org/doc_end_user/current_document.php?id=12571) Common test conditions for SCM-based screen content coding [K. Sühring]

This requires an update, as the previous version referred to an outdated location of test sequences.

[JVET-AE1016](https://jvet-experts.org/doc_end_user/current_document.php?id=13269) AVC with extensions and corrections (draft 1) [WG5 CD of 11th ed. N 218] [B. Bross, T. Ikai, G. J. Sullivan, A. Tourapis, Y.-K. Wang] [2023-08-11]

Post-meeting note: *De facto* primary editor and WG 5 N 218: B. Bross.

Target 15th edition of ITU-T H.264 in April 2024.

NNPF and phase indication SEI messages from JVET-AE0101, colour descriptors from JVET-AD1008, fix for FGC SEI message (see notes under BoG report JVET-AE0294 and corrigenda items from JVET-AD1004.

A request document was issued as WG 5 N 217.

No output: JVET-Axx1017 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**

Remains valid – not updated: [JVET-AD2002](https://jvet-experts.org/doc_end_user/current_document.php?id=12974) Algorithm description for Versatile Video Coding and Test Model 20 (VTM 20) [A. Browne, Y. Ye, S. Kim] [WG 5 N 204] (2023-07-07, near next meeting)

(Text kept for future use.) 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.

Remains valid – not updated: [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]

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-AE2005](https://jvet-experts.org/doc_end_user/current_document.php?id=13270) New level and systems-related supplemental enhancement information for VVC (Draft 6) [B. Bross, E. François, M. M. Hannuksela, A. Tourapis, Y.-K. Wang] (2023-08-18)

This was also delivered for ITU-T Consent as part of H.266 3rd ed.

The content of this delta (amendment style) document was included in a new edition of VVC. A DoCR on ISO/IEC 23090-3/DAM1 was issued as WG 5 N 227 (reviewed Tuesday 18 July 1245), and the FDIS text was issued as WG 5 N 228 with delivery date 2023-09-15.

Post-meeting note: *De facto* primary editor for this document, the corresponding ITU consent text, and the corresponding FDIS text WG 5 N 228: B. Bross.

See BoG report JVET-AE0272 for SEI elements included.

[JVET-AE2006](https://jvet-experts.org/doc_end_user/current_document.php?id=13271) Additional SEI messages for VSEI (Draft 5) [S. McCarthy, T. Chujoh, M. M. Hannuksela, G. J. Sullivan, Y.-K. Wang] (2023-08-18)

Post-meeting note: *De facto* primary editor for this document, the corresponding ITU consent text, and the corresponding FDIS text WG 5 N 220: Y.-K. Wang.

Text related to the remaining revisit from the BoG report JVET-AE0272 was presented on Tuesday 18 July at 1035. This is related to the issue that for frame interpolation between frames A and B only one activation shall be performed for all frames that are to be interpolated altogether. It was commented that the purpose may be difficult to understand for implementers. It was suggested to add a NOTE explaining the purpose of that constraint.

Decision (Ed./clarification): Adding such a note was agreed.

The technical content of this was also delivered for ITU-T consent as part of draft Rec. H.274 3rd ed.

The content of this delta (amendment style) document was included in a new edition of VSEI. A DoCR on ISO/IEC 23007-7/DAM1 was issued as WG 5 N 219 (reviewed Tuesday 18 July 1255), and the FDIS text was issued as WG 5 N 220 with delivery date 2023-09-15.

See BoG report JVET-AE0272 for elements included. Additionally, this should include the fix for the FGC SEI message (see notes under BoG report JVET-AE0294).

Remains valid – not updated: [JVET-AD2007](https://jvet-experts.org/doc_end_user/current_document.php?id=12977) Guidelines for NNVC software development [F. Galpin, S. Eadie, L. Wang, Z. Xie, Y. Li] (2023-05-26)

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]

Remains valid – not updated: [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]

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-AE2016](https://jvet-experts.org/doc_end_user/current_document.php?id=13272) Common test conditions and evaluation procedures for neural network-based video coding technology [E. Alshina, R.-L. Liao, S. Liu, A. Segall] (2023-07-28)

This includes some editorial updates.

[JVET-AE2017](https://jvet-experts.org/doc_end_user/current_document.php?id=13273) Common test conditions and evaluation procedures for enhanced compression tool testing [M. Karczewicz, Y. Ye] (2023-08-04)

This is to include a modified Excel sheet, and mention the requirement of documenting memory consumption (see discussion under JVET-AE0180).

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-AE2019](https://jvet-experts.org/doc_end_user/current_document.php?id=13274) Description of algorithms and software in neural network-based video coding (NNVC) version 4 [F. Galpin, Y. Li, D. Rusanovskyy, J. Ström, L. Wang] [WG 5 N 231] (2023-09-01)

New elements from notes elsewhere in this report:

* Decision: Adopt JVET-AE0191 and JVET-AE0291 to NNVC6 SW and JVET-AE2019, subject to possible further changes from stage 3 training (post-meeting note: it was later confirmed in an AHG meeting on Aug. 9 that the model from stage 3 training will be included).

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-AE2020](https://jvet-experts.org/doc_end_user/current_document.php?id=13275) Film grain synthesis technology for video applications (Draft 5) [D. Grois, Y. He, W. Husak, P. de Lagrange, A. Norkin, M. Radosavljević, A. Tourapis, W. Wan] [WG 5 DTR N 223] (2023-09-08)

It was remarked that we would want the ballot results in time for the January meeting.

A DoCR on ISO/IEC 23007-9/CDTR was issued as WG 5 N 222 (reviewed Tuesday 18 July 1305-1350).

[JVET-AE2021](https://jvet-experts.org/doc_end_user/current_document.php?id=13276) Verification test plan for VVC multilayer coding (update 1) [S. Iwamura, P. de Lagrange, M. Wien] (2023-09-29)

See notes under section 4.5 for updates.

Remains valid – not updated: [JVET-AD2022](https://jvet-experts.org/doc_end_user/current_document.php?id=12982) Draft plan for subjective quality testing of FGC SEI message [P. de Lagrange, W. Husak, M. Radosavljević, M. Wien] (2023-06-16)

As new sequences were not available yet for viewing during the JVET meeting, an update of this document of this document was agreed to be postponed.

[JVET-AE2023](https://jvet-experts.org/doc_end_user/current_document.php?id=13261) 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 230] (2023-08-11)

An initial draft of this document was reviewed and approved at 1200-1210 on Tuesday 18 July.

Categories are:

* Unified LOP
* Architectural changes of HOP
* Filter usage aspects of LOP and HOP
* Additional models for HOP (e.g., temporal filter)
* Inter prediction

[JVET-AE2024](https://jvet-experts.org/doc_end_user/current_document.php?id=13263) 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 232] (2023-08-18)

An initial draft of this document was reviewed and approved at 1210-1240 on Tuesday 18 July.

Categories are:

* Partitioning
* Intra prediction
* Inter prediction
* RPR
* In-loop filters
* Entropy coding

It was requested to add details to test 6.2, which changes are intended for the training script. Also a combination (retraining 6.1a with method from 6.2) was requested.

[JVET-AE2025](https://jvet-experts.org/doc_end_user/current_document.php?id=13277) Algorithm description of Enhanced Compression Model 10 (ECM 10) [M. Coban, R.-L. Liao, K. Naser, J. Ström, L. Zhang] [WG 5 N 233] (2023-09-29)

New elements from notes elsewhere in this report:

* Decision: Adopt JVET-AE0100, test 2.1b.
* Decision: Adopt JVET-AE0169 Test 2.2c, in CTC enabled only for screen content.
* Decision: Adopt JVET-AE0169 Test 2.3b, in CTC enabled only for camera-captured content.
* Decision: Adopt JVET-AE0169 Test 2.4a, in CTC enabled only for screen content.
* Decision: Adopt JVET-AE0159 Test 2.5c (enabled only for screen content).
* Decision: Adopt JVET-AE0094 Test 2.6c (enabled only for screen content).
* Decision: Adopt JVET-AE0043 test 2.7.
* Decision: Adopt JVET-AE 0077 test 2.9.
* Decision: Adopt JVET-AE0084 Test 2.11b. In the combination, both 2.10a and 2.11a should be enabled for camera captured content, also in CTC.
* Decision: Adopt JVET-AE0059 Test 3.1b.
* Decision: Adopt JVET-AE0046 Test 3.2.
* Decision: Adopt JVET-AE0091 Test 3.8.
* Decision: Adopt JVET-AE0125 Test 4.1.
* Decision: Adopt JVET-AE0086 Test 4.2.
* Decision: Adopt JVET-AE0102 Test 4.3.
* Decision: Adopt JVET-AE0151 Test 5.1b.
* Decision: Adopt JVET-AE0139 Test 5.2c.
* Decision: Adopt JVET-AE0097.

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.

Remains valid – not updated: [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)

This was integrated with v1 (JVET-X2008) and delivered for ITU-T consent as H.266.1 2nd ed.

Post-meeting note: *De facto* primary editor for the ITU consent text: I. Moccagatta.

[JVET-AE2027](https://jvet-experts.org/doc_end_user/current_document.php?id=13278) SEI processing order SEI message in VVC (draft 5) [S. McCarthy, M. M. Hannuksela, Y.-K. Wang] [WG 5 preliminary WD 5 N 229] (2023-09-01)

Updated from JVET-AE0156.

[JVET-AE2028](https://jvet-experts.org/doc_end_user/current_document.php?id=13279) Additional conformance bitstreams for VVC multilayer configurations [S. Iwamura, P. de Lagrange, I. Moccagatta] (2023-09-01)

This is to include the new bitstream from JVET-AE0111.

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 N 75]

[JVET-AE2030](https://jvet-experts.org/doc_end_user/current_document.php?id=13280) Optimization of encoders and receiving systems for machine analysis of coded video content (draft 3) [J. Chen, C. Hollmann, S. Liu] [WG 5 N 224)] (2023-09-15)

See notes under JVET-AE0081, JVET-AE0081, and JVET-AE0099.

[JVET-AE2031](https://jvet-experts.org/doc_end_user/current_document.php?id=13281) Common test conditions for optimization of encoders and receiving systems for machine analysis of coded video content [S. Liu, C. Hollmann] (2023-08-11)

This is to contain editorial improvements, plus anchors from VTM20 as per JVET-AE0096 as additional anchors in the Excel sheet.

[JVET-AE2032](https://jvet-experts.org/doc_end_user/current_document.php?id=13282) Technologies under consideration for future extensions of VSEI (draft 1) [M. M. Hannuksela, J. Chen, S. Deshpande, S. McCarthy] [WG 5 N 221)] (2023-09-15)

Elements from JVET-AE0061, JVET-AE0298, JVET-AE0064, JVET-AE0079, JVET-AE0095; see detailed notes under these document numbers.

JVET-AF2033 Report on multi-layer VVC verification testing (first version content layering tested in Geneva)

# 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 Tuesday or Wednesday of the first week and closing it on the Wednesday of the second week of the SG16 meeting – a total of 8-9 meeting days), and
* Otherwise meeting under ISO/IEC JTC 1/‌SC 29 auspices when its MPEG WGs meet (ordinarily starting meetings on the Thursday or Friday prior to the main week of such meetings and closing it on the same day as other MPEG WGs – a total of 8-9 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 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 Fri. 19 – Fri. 26 April 2024, 34th meeting under ITU-T SG16 auspices in Rennes, FR,
* 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 Thu. 26 June – Fri. 4 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 33rd JVET meeting was planned to be Wednesday 10 January 2024.

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.

Silke Kenzler was thanked for … The following members of KCM staff were thanked for their dedication and continuous help in the technical setup of meeting facilities: XXX.

The 32nd JVET meeting was closed at approximately XXXX hours CEST (UTC+2) on Friday 20 Oct. 2023.

# Annex A to JVET report: List of documents

(Dates and times in the table below are in Paris/Geneva time.)

# Annex B1 to JVET report: List of meeting participants attending in person

The participants who were personally present at the meeting site of the thirty-second meeting of the JVET, according to confirming in a sign-in sheet regularly circulated in the JVET meeting rooms (approximately XXX people in total), were as follows:

1. XXX (XXX – XX)

# Annex B2 to JVET report: List of meeting participants attending remotely

The remote participants of the thirty-second 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:

1. XXX (XXX – XX)

# Annex C to JVET report: Recommendations of the 13th meeting of ISO/IEC JTC 1/SC 29/WG 5 MPEG Joint Video Experts Team with ITU-T SG 16

**ISO/IEC JTC 1/SC 29/WG 5 N XXX**