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| **Joint Video Experts Team (JVET)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29**  29th Meeting, by teleconference, 11–20 January 2023 | Document: JVET-AC\_Notes\_d1 |

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| *Title:* | **Meeting Report of the 29th Meeting of the Joint Video Experts Team (JVET), by teleconference, 11–20 January 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 twenty-ninth meeting during 11–20 January 2023 as an online-only meeting. For ISO/IEC purposes, JVET is alternatively designated ISO/IEC JTC 1/‌SC 29/‌WG 5, and this was the tenth meeting as WG 5. The JVET meeting was held under the chairmanship of Dr Jens-Rainer Ohm (RWTH Aachen/Germany). For rapid access to particular topics in this report, a subject categorization is found (with hyperlinks) in section 2.14 of this document. It is further noted that work items which had originally been conducted by the Joint Collaborative Team on Video Coding (JCT-VC) were continued in JVET as a single joint team, and explorations towards possible future need of standardization in the area of video coding are also conducted by JVET, as negotiated by the parent bodies.

The JVET meeting began at approximately 1300 hours UTC on Wednesday 11 January 2023. Meeting sessions were held on all days except the weekend days of Saturday and Sunday 14 and 15 January 2023, until the meeting was closed at approximately 00XX hours UTC on Saturday 21 January 2023. Approximately XXX people attended the JVET meeting, and approximately XXX input documents (not counting crosschecks), 15 AHG reports, 2 EE summary reports, X BoG reports, and X incoming liaison documents were discussed. The meeting took place in coordination with a meeting of various SC29 Working Groups and Advisory Groups – where WG 5 is representing the Joint Video Coding Team(s) and their activities from the perspective of the SC 29 parent body, under whose auspices this JVET meeting was held. The subject matter of the JVET meeting activities consisted of work on further development and maintenance of the twin-text video coding technology standards *Advanced Video Coding* (AVC), *High Efficiency Video Coding* (HEVC), *Versatile Video Coding* (VVC)*, Coding-independent Code Points (Video)* (CICP), and *Versatile Supplemental Enhancement Information Messages for Coded Video Bitstreams* (VSEI), as well as related technical reports, reference software and conformance testing packages. Further important goals were reviewing the results of the Exploration Experiment (EE) on Neural Network-based Video Coding, of the EE on Enhanced Compression beyond VVC capability, of other technical input on novel aspects of video coding technology, and to plan next steps for investigation of candidate technology towards further standard development.

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

* JVET-AB1004 Errata report items for VVC, VSEI, HEVC, AVC, Video CICP, and CP usage TR
* JVET-AB1008 Additional colour type identifiers for AVC, HEVC and Video CICP (Draft 2), also issued as WG 5 preliminary WD
* JVET-AB1012 Overview of IT systems used in JVET
* JVET-AB2002 Algorithm description for Versatile Video Coding and Test Model 18 (VTM 18)
* JVET-AB2006 Additional SEI messages for VSEI (Draft 3), also issued as WG 5 DAM
* JVET-AB2010 VTM and HM common test conditions and software reference configurations for SDR 4:2:0 10 bit video
* JVET-AB2016 Common Test Conditions and evaluation procedures for neural network-based video coding technology
* JVET-AB2019 Description of algorithms and software in neural network-based video coding (NNVC)
* JVET-AB2020 Film grain synthesis technology for video applications (Draft 3), also issued as WG 5 WD
* JVET-AB2021 Draft verification test plan for VVC multilayer coding
* JVET-AB2022 Draft plan for subjective quality testing of FGC SEI message
* JVET-AB2023 Exploration Experiment on neural network-based video coding (EE1)
* JVET-AB2024 Exploration Experiment on enhanced compression beyond VVC capability (EE2)
* JVET-AB2025 Algorithm description of Enhanced Compression Model 7 (ECM 7)
* JVET-AB2027 SEI processing order SEI message in VVC (draft 2), also issued as WG 5 preliminary WD
* JVET-AB2028 Additional conformance bitstreams for VVC multilayer configurations
* JVET-AB2029 Visual quality comparison of ECM/VTM encoding

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

* JVET-AB1004 Errata report items for VVC, VSEI, HEVC, AVC, Video CICP, and CP usage TR
* JVET-AB1008 Additional colour type identifiers for AVC, HEVC and Video CICP (Draft 2), also issued as WG 5 preliminary WD
* JVET-AB1012 Overview of IT systems used in JVET
* JVET-AB2002 Algorithm description for Versatile Video Coding and Test Model 18 (VTM 18)
* JVET-AB2006 Additional SEI messages for VSEI (Draft 3), also issued as WG 5 DAM
* JVET-AB2010 VTM and HM common test conditions and software reference configurations for SDR 4:2:0 10 bit video
* JVET-AB2016 Common Test Conditions and evaluation procedures for neural network-based video coding technology
* JVET-AB2019 Description of algorithms and software in neural network-based video coding (NNVC)
* JVET-AB2020 Film grain synthesis technology for video applications (Draft 3), also issued as WG 5 WD
* JVET-AB2021 Draft verification test plan for VVC multilayer coding
* JVET-AB2022 Draft plan for subjective quality testing of FGC SEI message
* JVET-AB2023 Exploration Experiment on neural network-based video coding (EE1)
* JVET-AB2024 Exploration Experiment on enhanced compression beyond VVC capability (EE2)
* JVET-AB2025 Algorithm description of Enhanced Compression Model 7 (ECM 7)
* JVET-AB2027 SEI processing order SEI message in VVC (draft 2), also issued as WG 5 preliminary WD
* JVET-AB2028 Additional conformance bitstreams for VVC multilayer configurations
* JVET-AB2029 Visual quality comparison of ECM/VTM encoding

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 21 – 28 April 2023 under ISO/IEC JTC 1/‌SC 29 auspices, in Antalya, TR; during 11 – 19 July 2023 under ITU-T SG16 auspices in Geneva, CH; during October 2023 under ISO/IEC JTC 1/‌SC 29 auspices, date and location t.b.d.; during January 2024 under ISO/IEC JTC 1/‌SC 29 auspices, date and location t.b.d.; during April 2024 under ITU-T SG16 auspices, date and location t.b.d.; during 12 – 19 July 2024 under ISO/IEC JTC 1/‌SC 29 auspices in Sapporo, JP; during October 2024 under ISO/IEC JTC 1/‌SC 29 auspices, date and location t.b.d.; and during January 2025 under ITU-T SG16 auspices, date and location t.b.d.

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

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

# Administrative topics

## Organization

The ITU-T/ISO/IEC Joint Video Experts Team (JVET) is a group of video coding experts from the ITU-T Study Group 16 Visual Coding Experts Group (VCEG) and ISO/IEC JTC 1/‌SC 29/‌WG 5. The parent bodies of the JVET are ITU-T WP3/16 and ISO/IEC JTC 1/‌SC 29.

The Joint Video Experts Team (JVET) of ITU-T WP3/16 and ISO/IEC JTC 1/‌SC 29 held its twenty-ninth meeting during 11–20 January 2023 as an online-only meeting. For ISO/IEC purposes, JVET is alternatively designated ISO/IEC JTC 1/‌SC 29/‌WG 5, and this was the tenth meeting as WG 5. The JVET meeting was held under the chairmanship of Dr Jens-Rainer Ohm (RWTH Aachen/Germany).

It is further noted that the unabbreviated name of JVET was formerly known as “Joint Video *Exploration* Team”, but the parent bodies modified it when entering the phase of formal development of the *Versatile Video Coding* (VVC) and *Versatile Supplemental Enhancement Information Messages for Coded Video Bitstreams* (VSEI) standards, as well as associated conformance test sets, reference software, verification testing, and non-normative guidance information. Furthermore, starting from the twentieth meeting, work items which had originally been conducted by the Joint Collaborative Team on Video Coding (JCT-VC) were continued to be conducted in JVET as a single joint team, as negotiated by the parent bodies. This particularly consists of work on:

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

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

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

This report contains three important annexes, as follows:

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

## Meeting logistics

Information regarding logistics arrangements for the meeting had been provided via the email reflector [jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de) and at <http://wftp3.itu.int/av-arch/jvet-site/2023_01_AC_Virtual/>.

## Primary goals

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

* JVET-AB1004 Errata report items for VVC, VSEI, HEVC, AVC, Video CICP, and CP usage TR
* JVET-AB1008 Additional colour type identifiers for AVC, HEVC and Video CICP (Draft 2), also issued as WG 5 preliminary WD
* JVET-AB1012 Overview of IT systems used in JVET
* JVET-AB2002 Algorithm description for Versatile Video Coding and Test Model 18 (VTM 18)
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* JVET-AB2028 Additional conformance bitstreams for VVC multilayer configurations
* JVET-AB2029 Visual quality comparison of ECM/VTM encoding

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 Mainz), except as otherwise noted.

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

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

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

### Late and incomplete document considerations

The formal deadline for registering and uploading non-administrative contributions had been announced as Wednesday, 4 January 2023. Any documents uploaded after 1159 hours Paris/Geneva time on Thursday 5 January 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-AC0200 were registered after the “officially late” deadline (and therefore were also uploaded late). However, some documents in the “late” range might include break-out activity reports that were generated during the meetings, 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-AC0XXX (a proposal on …), uploaded 01-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-AC0XXX (a document on …), uploaded 01-XX,
* … .

Most cross-verification reports at this meeting were registered late, and/or uploaded late (except for JVET-AC0117, JVET-AC0133, and JVET-AC0168). In the interest of brevity, the late ones are not specifically identified here. Initial upload times for each document are recorded in Annex A of this report.

The following contribution registrations were noted that were later cancelled, withdrawn, never provided, were cross-checks of a withdrawn contribution, or were registered in error: JVET-AC0102, JVET-AC0157, JVET-AC0289.

The following cross-verification reports were still missing three weeks after the end of the meeting: JVET-AC0XXX, … . They were thus marked by the JVET chair as withdrawn.

“Placeholder” contribution documents that were basically empty of content, or lacking any results showing benefit for the proposed technology, and obviously uploaded with an intent to provide a more complete submission as a revision, had been agreed to be considered unacceptable and to be rejected in the document management system until a more complete version was available (which would then be counted as a late contribution if the update was after the document deadline). At the current meeting, this situation did apply with documents JVET-AC0048, JVET-AC0097, JVET-AC0172, JVET-AC0184, JVET-AC0187, and JVET-AC0199, which were categorized as late in the list above, based on the time of the first reasonable document upload.

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

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

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

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

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

### Outputs of the preceding meeting

All output documents of the previous meeting, particularly the meeting report JVET-AB1000, the Errata report items for VVC, VSEI, HEVC, AVC, Video CICP, and CP usage TR JVET-AB1004, the Additional colour type identifiers for AVC, HEVC and Video CICP (Draft 2) JVET-AB1008, the Overview of IT systems used in JVET JVET-AB1012, the Algorithm description for Versatile Video Coding and Test Model 18 (VTM 18) JVET-AB2002, the Additional SEI messages for VSEI (Draft 3) JVET-AB2006, the VTM and HM common test conditions and software reference configurations for SDR 4:2:0 10 bit video JVET-AB2010, the Common test conditions and evaluation procedures for neural network-based video coding technology JVET-AB2016, the Description of algorithms and software in neural network-based video coding (NNVC) JVET-AB2019, the Film grain synthesis technology for video applications (Draft 3) JVET-AB2020, the Draft verification test plan for VVC multilayer coding JVET-AB2021, the Draft plan for subjective quality testing of FGC SEI message JVET-AB2022, the Description of the EE on Neural Network-based Video Coding JVET-AB2023, the Description of the EE on Enhanced Compression beyond VVC capability JVET-AB2024, the Algorithm description of Enhanced Compression Model 7 (ECM 7) JVET-AB2025, the SEI processing order SEI message in VVC (Draft 1) JVET-AB2027, the Additional conformance bitstreams for VVC multilayer configurations JVET-AB2028, and the Visual quality comparison of ECM/VTM encoding JVET-AB2029, had been completed and were approved. The software implementations of HM (version 17.0), VTM (version 19.0), ECM (version 7.0), and NNVC (version 3.0) were also approved.

Only minor editorial issues were found in the meeting report JVET-AB1000; no need to produce an update was identified (see section 2.12 for details).

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

## Attendance

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

The meeting was open to those qualified to participate either in ITU-T WP3/16 or ISO/IEC JTC 1/‌SC 29/‌WG 5 (including experts who had been personally invited as permitted by ITU-T or ISO/IEC policies).

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

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

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

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

## Agenda

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

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

The agenda was approved as suggested.

The plans for the times of meeting sessions were established as follows, in UTC (which for this meeting was 1 hour behind the time in Geneva and Paris; 8 hours ahead of the time in Los Angeles, etc.). No session was scheduled to last longer than 2 hrs.

* 1300–1500 1st “afternoon” session [break after 2 hours]
* 1520–1720 2nd “afternoon” session
* [“evening” break – nearly 4 hours]
* 2100–2300 1st “night” session [break after 2 hours]
* 2320–0120+1 2nd “night” session

It was also pointed out that the session times had been changed from meeting to meeting, such that different time zones of the world might be treated approximately equally fairly either in one meeting or another. For the current meeting, the same UTC session times were used as in the 25th JVET meeting (which had been the eighth meeting conducted as an online meeting, whereas the current one is the eleventh).

* 1. ***ISO and IEC Code of Conduct reminders***

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

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

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

These include points relating to:

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

## IPR policy reminder

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

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

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

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

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

* <http://www.itu.int/ITU-T/ipr/index.html> (common patent policy for ITU-T, ITU-R, ISO, and IEC, and guidelines and forms for formal reporting to the parent bodies)
* <http://ftp3.itu.int/av-arch/jvet-site> (JVET contribution templates)
* <http://www.itu.int/ITU-T/dbase/patent/index.html> (ITU-T IPR database)

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

## Software copyright disclaimer header reminder

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

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

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

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

## Communication practices

The documents for the meeting can be found at <https://jvet-experts.org/>. It was noted that the previous site <http://phenix.int-evry.fr/jvet/> is still accessible, but was converted to read-only. It was reminded to send a notice to the chairs in cases of changes to document titles, authors, etc.

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

It was emphasized that reflector subscriptions and email sent to the reflector must use real names when subscribing and sending messages and subscribers must respond to inquiries regarding the nature of their interest in the work. The current number of subscribers on the JVET email list was 1184 (as of 10 January 2022). All discussions (including those on AVC, HEVC, VVC, CICP, etc.) shall be conducted on the JVET reflector rather than any of the old reflectors (including JVT, JCT-VC, and JCT-3V) which are retained for archiving purposes.

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

It is further emphasized that the document JVET-AB1012 (to be updated during this meeting) gives valuable hints about communication practices as well as other IT resources used in JVET, such as software, conformance, and test materials.

## Terminology

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

## Opening remarks

Remarks during the opening session of the meeting Wednesday 11 January at 1300 UTC were as follows.

* Timing and organization of the meeting and online access, calendar posting of session plans
* Plans for subsequent F2F meetings in April (Antalya) and July (Geneva)
* Standards, TRs, supplements and technical papers approval and publication status
  + AVC
    - H.264 V14 Consented at 22nd meeting on 2021-04-30 (with annotated regions, shutter interval, and miscellaneous corrections), approved 2021-08-22, published 2021-10-13
    - ISO/IEC 14496-10:2020 (Ed. 9) FDIS ballot closed 2020-11-27, published 2020-12-15
    - ISO/IEC 14496-10:2022 (Ed. 10), had been forwarded from DIS directly for publication 2022-01-21 (with annotated regions, shutter interval, and miscellaneous corrections) with an editing period, submitted to ITTF in 2022-05 after consultation with ISO staff on format of graphics files, upgraded to “DIS approved for registration” in ISO Project system 2022-07-04, published 2022-11-07
    - Preliminary draft text for YCgCo-Re and YCgCo-Ro issued at 26th meeting, second draft including SMPTE ST 2128 issued at 28th meeting (not yet formally requested as a project)
    - Conformance testing
      * 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 43:20153D-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
      * H.264.2 V7 Approved 2016-02-13, published 2016-05-30
      * Various amendments of ISO/IEC 14496-5:2001, including:
        + ISO/IEC 14496-5:2001/AMD 6:2005 Advanced Video Coding (AVC) and High Efficiency Advanced Audio Coding (HE AAC) reference software
        + ISO/IEC 14496-5:2001/AMD 8:2006 AVC fidelity range extensions reference software
        + ISO/IEC 14496-5:2001/AMD 15:2010 Reference software for Multiview Video Coding
        + ISO/IEC 14496-5:2001/AMD 18:2008 Reference software for new profiles for professional applications
        + ISO/IEC 14496-5:2001/AMD 19:2009 Reference software for Scalable Video Coding
        + ISO/IEC 14496-5:2001/AMD 33:2015 Reference software for MVC plus depth extension of AVC
        + ISO/IEC 14496-5:2001/AMD 34:2014 Reference software of the multi-resolution frame compatible stereo coding of AVC
        + ISO/IEC 14496-5:2001/AMD 35:2015 3D-AVC Reference software
        + ISO/IEC 14496-5:2001/AMD 39:2016 Reference software for the Multi-resolution Frame Compatible Stereo Coding with Depth Maps of AVC
        + ISO/IEC 14496-5:2001/AMD 42:2017 Reference software for the alternative depth information SEI message extension of AVC
  + HEVC
    - 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
    - H.265 V8 Consented at the 22nd meeting (shutter interval information SEI message and miscellaneous corrections), published 2020-10-13
    - ISO/IEC 23008-2:2020/AMD 1:2021 (shutter interval information SEI message) published 2021-07-12
    - ISO/IEC 23008-2:202x (Ed. 5) began as CDAM 2 High-range levels output of 25th meeting of January 2022, CDAM ballot closed 2022-04-15, conversion to 5th edition with miscellaneous corrections planned at 26th meeting of April 2022, text submitted for DIS ballot 2022-07-10, DIS ballot closed 2023-01-10
    - Preliminary draft text for YCgCo-Re and YCgCo-Ro issued at 26th meeting, second draft including SMPTE ST 2128 issued at 28th meeting (not yet formally requested as a project)
    - Conformance testing
      * 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
      * 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
    - H.266 V1 approved 2020-08-29, published 2020-11-10
    - ISO/IEC 23090-3:2021 (Ed. 1) published 2021-02-16
    - H.266 V2 with operation range extensions, Consented 2022-01-28, Last Call began 2022-04-01, Approved 2022-04-29, pre-published 2022-06-06, published 2022-07-12
    - ISO/IEC 23090-3:2022 (Ed. 2) with operation range extensions, approval at WG level to proceed to FDIS 2022-01-21, published 2022-09-25
    - ISO/IEC 23090-3:202x (Ed. 2) / Amd.1 New level and systems-related supplemental enhancement information, CDAM 1 issued from 26th meeting, ballot closed 2022-07-14, DAM 1 issued from 27th meeting, ballot closed 2023-01-03 (ready for action at this meeting)
    - Conformance testing
      * H.266.1 V1 Consented 2022-01-28, Last Call began 2022-04-01, Approved 2022-04-29, pre-published 2022-05-17, published 2022-07-12
      * ISO/IEC 23090-15:2022 V1 approval at WG level to proceed to FDIS 2022-10-15, upgraded to “DIS approved for registration” in ISO Projects system 2021-10-24, upgraded to “FDIS registered for formal approval” 2022-07-11, FDIS ballot closed 2022-11-04, published 2022-11-24
      * ISO/IEC 23090-15:202x Amd.1 Operation range extensions – DAM 1 issued from 25th meeting 2022-01-21, upgraded to “CD approved for registration as DIS” status in ISO Projects system 2022-05-31, upgraded to “DIS registered” 2022-06-22, DAM ballot closed 2022-11-15 (ready for action at this meeting)
    - Reference software
      * 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
    - H.274 V1 approved 2020-08-29, published 2020-11-10
    - ISO/IEC 23002-7:2021 (Ed. 1) published 2021-01-28
    - 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, pending DAM ballot
  + CICP
    - ISO/IEC 23091-2:2021 (Ed. 2) had been forwarded from DIS directly for publication in 2021-04 and published 2021-10-18
    - H.273 V2 (with 4:2:0 sampling alignment and corrections for range of values for sample aspect ratio, ICTCP equations for HLG, and transfer characteristics function for sYCC of IEC 61966-2-1) Consented on 2021-04-30, Last Call closed during the 23rd meeting with approval on 2021-07-14, published 2021-09-24
    - ISO/IEC 23091-2:202x (Ed. 3) Request for new edition and CD for new edition (including YCgCo-Re and YCoCg-Ro) issued at 27th meeting, ballot closed 2022-10-10, DIS registered 2022-11-13, pending DIS ballot (no action at this meeting)
    - Preliminary draft text for including SMPTE ST 2128 issued at 28th meeting (not yet formally requested as a project)
  + Conversion and coding practices for HDR/WCG Y′CbCr 4:2:0 video with PQ transfer characteristics
    - H.Sup15 V1, approved 2017-01-27, published 2017-04-12
    - ISO/IEC TR 23008-14:2018 published 2018-08
  + Signalling, backward compatibility and display adaptation for HDR/WCG video coding
    - H.Sup18 V1, approved 2017-10-27, published 2018-01-18
    - ISO/IEC TR 23008-15:2018 published 2018-08
  + Usage of video signal type code points
    - H.Sup19 V3 approved 2021-04-30, published 2021-06-04
    - ISO/IEC TR 23091-4 (Ed. 3) published 2021-05-23
  + Working practices using objective metrics for evaluation of video coding efficiency experiments
    - HSTP-VID-WPOM V1: approved 2020-07-03, published 2020-11
    - ISO/IEC TR 23002-8 (Ed. 1) published 2021-05-20
  + Film grain synthesis technologies for video applications
    - ISO/IEC TR 23002-9 Request for subdivision and WD 1 issued at 25th meeting 2022-01-21, WD 2 issued at 27th meeting, WD 3 issued at 28th meeting
  + The following freely available standards are published here in ISO/IEC:  
    <https://standards.iso.org/ittf/PubliclyAvailableStandards/index.html>
    - Various amendments of ISO/IEC 14496-4:2004
    - Various amendments of ISO/IEC 14496-5:2001
    - ISO/IEC 23008-2:2020 (Ed. 4) HEVC
  + The following standards that have been intended by JVET to be publicly available were not available at <https://standards.iso.org/ittf/PubliclyAvailableStandards/index.html> as of 2023-01-08. (Please see below for record of previously issued requests.)
    - ISO/IEC 23091-2:2021 (Ed. 2) Video CICP (was requested in April 2021, and the 2019 previous edition was also not available there)
    - ISO/IEC 23008-2:2020 (Ed. 4) Amd.1:2021: Shutter interval information SEI message, published 2021-07-12 (has not been requested)
    - ISO/IEC 23008-5:2017 (Ed. 2) Reference software for high efficiency video coding, published 2017-03-01
    - ISO/IEC 23008-5:2017/AMD 1:2017 Reference software for screen content coding extensions, published 2017-11-09
    - ISO/IEC 23008-8:2018 (Ed. 2) Conformance specification for HEVC, published 2018-08, published 2018-08-06
    - ISO/IEC 23008-8:2018/AMD 1:2019 Conformance testing for HEVC screen content coding (SCC) extensions and non-intra high throughput profiles, published 2019-10-15
    - ISO/IEC 14496-10:2022 (Ed. 10) – AVC – final text issued and public availability requested at the 25th meeting (January 2022)
    - ISO/IEC 23002-7:2022 (Ed. 2) – VSEI – FDIS issued and public availability requested at the 25th meeting (January 2022)
    - ISO/IEC 23090-3:2022 (Ed. 2) – VVC – FDIS issued and public availability requested at the 25th meeting (January 2022)
    - ISO/IEC 23090-15:2022 (Ed. 1) – VVC conformance – FDIS issued and public availability requested at the 24th meeting (October 2021)
    - ISO/IEC 23090-16:2022 (Ed. 1) – VVC reference software – FDIS issued and public availability requested at the 25th meeting (January 2022)
  + It appears necessary to check if all older software and conformance packages are publicly available – it might be that it was never requested, e.g. for those that were produced by JCT-3V. This topic was left TBD until the next meeting – perhaps it would be best to compile a list of all relevant software and conformance parts of AVC, HEVC, MPEG-2 aka H.262, CICP, and request these in bulk.
* Draft standards progression status
  + AVC and HEVC colour type indicators for YCgCo-Re, YCgCo-Ro, and SMPTE ST 2128 are drafted and pending formal action
  + HEVC new levels (from JVET-Z1005) – ISO/IEC 23008-2 DIS of new edition of HEVC was issued from 26th meeting, incorporating Amd.1 and corrigenda items (ballot closed 2023-01-10, ballot comments in [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) which might potentially be included based on ballot comments, ITU-T consent is planned for July. It was noted that the referencing of VSEI is also somewhat different [Ed. Clarify] in the ITU-T and ISO/IEC versions of HEVC and AVC, which might be aligned at the next convenient time (basically editorial). Proceeding to FDIS should be considered at the current meeting.
  + VVC new level and systems-related supplemental enhancement information (from JVET-AA2005) – VVC DAM was issued from 27th meeting, ballot closed 2023-01-03, ballot comments in [m61833](https://dms.mpeg.expert/doc_end_user/current_document.php?id=85618&id_meeting=193). The plan is to convert this into FDIS of new edition at the current meeting. ITU-T consent is planned for July 2023 when a new edition of VSEI is also consented, to keep VVC and VSEI aligned.
  + VVC Conformance testing for operation range extensions – (from JVET-Y2026) – the DAM ballot closed 2022-11-15 (ballot comments in [m61832](https://dms.mpeg.expert/doc_end_user/current_document.php?id=85617&id_meeting=193)), and this could progress to FDAM or a new edition at the current meeting. ITU consent is planned for July 2023.
  + VSEI additional SEI messages (from JVET-AB2006) – VSEI DAM (JVET draft 3) was issued from the 28th meeting and was pending a DAM ballot to be issued. To be converted into FDIS of new edition in April (if possible) or July, ITU-T consent in July 2023. No action on this is expected at the current meeting (it is noted that there are numerous input contributions in particular on NNPF, which could be discussed as long as the ballot has not been started yet.).
  + Film grain synthesis technology for video applications (from JVET-AA2020 and JVET-AB0042) – JVET draft 3 was issued at the 28th meeting, and the ISO/IEC 23002-9 PDTR is planned to be issued at the current meeting (a request to start work on the TR had been made at the 25th meeting). The publication limit date is 2023-08-09, so an extension request may be needed, but perhaps not at the current meeting.
  + Video CICP new edition with for YCgCo-Re and YCgCo-Ro (from JVET-Z1003), an ISO/IEC 23091-2 DIS was issued from the 28th meeting and is pending its ballot, so no action on this was expected at the current meeting). ITU-T consent is planned for July 2023.
  + Video CICP colour type indicator for SMPTE ST 2128 is drafted and pending formal action. It was reported that it is expected to become finalized in the SMPTE meeting in March. It was further reported that some clarification on conversion equations is necessary (W. Husak will provide an input on that)
  + 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
* The meeting logistics, agenda, working practices, policies, and document allocation considerations were reviewed.
  + Remote access to the meeting was provided using Zoom. This requires discipline in the meeting room (no microphone to be switched on, podium and room microphones to be under central control).
  + Having text and software available is crucial (and not just arriving at the end of the meeting).
  + There were no objections voiced in the opening plenary to the consideration of late contributions.
* The results of the previous meeting and the meeting report JVET-AB1000 were reviewed. The following small issues in the meeting report were noted and were not considered sufficient to warrant issuing a revision. These are obviously left over from a previous report, and the correct information can be found in other places of the report:
  + In section 2.3, the twenty-seventh JVET meeting should be referenced rather the twenty-fifth.
  + In section 2.4.2, the mentioning of “placeholder” documents should have been removed, as such cases did not happen in the 28th meeting.
  + In section 9, the time when AHG setup happened should have been 1600 CEST rather than 0510 UTC
* There was somewhat less of a problem of late non-cross-check documents.
* There were again a few documents registered where authors’ given names were not abbreviated, and/or company affiliation was missing in the authors’ list. Participants were reminded to stick to JVET’s conventions.
* Experts are asked to inform the chair when the title of a document is changed, or if authors are added. Otherwise, that might not be correct in the meeting notes.
* The primary goals of the meeting were
  + Conformance testing for version 2 of VVC (FDAM to be issued, DAM ballot comments in m61832)
  + New edition for HEVC (FDIS to be issued, DIS ballot comments in m61834)
  + New level and systems-related SEI for VVC (FDAM to be issued, DAM ballot comments in m61833)
  + Additional SEI in VSEI (under DAM ballot) – numerous input contributions
  + Preparation of TR for film grain (draft 4) (PDTR to be issued?)
  + Optimization of encoders and receiving systems for machine analysis of coded video content – WD of TR to be issued?
  + New edition video CICP (under DIS ballot)
  + Any action items on reference software JM/HM/VTM?
  + Additional colour type identifiers for AVC and HEVC (Draft 2 in JVET-AB1008 was issued at the last meeting) – could be included in new edition of H.265 (23008-2 DIS ballot comment on this?), no action was to be taken for AVC at this moment. It was suggested considering new editions of H.264 and ISO/IEC 14496-10 in the near future.
  + Guide to IT systems used in JVET (email reflectors, guide to MPEG and JVET web sites, calendar, ITU-T ftp, ftp for test materials, software git, conformance repositories, ticket reporting system, etc.) First version JVET-AB1012 was recently issued, update planned (also to become WG 5 output).
  + In the last meeting, public availability of experimental software packages was discussed, it was decided that the ECM branch (not the EE branches) shall be made publicly available. This has been implemented. How about NNVC? It was discussed that it would be desirable to make that available in the same way as ECM (not the training branch). It was further suggested to provide links about where to find those software packages (also in document AC1012). Revisit: Clarification needed how to implement that, e.g. regarding size of models, SADL, etc.
  + Exploration Experiments
    - Neural network-based video coding
    - Enhanced compression beyond VVC
* Liaison communication: any need for responding?
  + various from SG16 addressed to MPEG WGs in general, but nothing seems to relate to JVET/WG 5 in particular
  + JPEG has an F2F meeting next week
* Joint meetings: with AG 5 on subjective testing, with WG 2 and VCEG on future video standardization activities, with WG 4 (and potentially WG 1) on VCM, any other (e. g. with WG 7, regarding JVET inputs on point cloud coding)?
* The number of documents was higher than for the previous meeting (150->165)
* Scheduling was discussed, and it was agreed to avoid conducting “track” sessions in parallel (some BoG parallelism could occur)
* Principles of standards development were discussed.

## Scheduling of discussions

The plans for the times of meeting sessions were established as follows, in UTC (1 hour behind the time in Geneva, Paris; 8 hours ahead of the time in Los Angeles, etc.). No session should last longer than 2 hrs.

* 1300–1500 1st “afternoon” session [break after 2 hours]
* 1520–1720 2nd “afternoon” session
* [“evening” break – nearly 4 hours]
* 2100–2300 1st “night” session [break after 2 hours]
* 2320–0120+1 2nd “night” session

Sessions were announced via the calendar in the JVET document site at least 22 hrs. in advance. Particular scheduling notes are shown below, although not necessarily 100% accurate or complete:

* Wed. 11 Jan., 1st day
  + Session 1:
    - 1300–1410 Opening remarks, review of practices, agenda, IPR reminder
    - 1420–1515 Reports of AHGs 1–3
  + Session 2:
    - 1535–1740 Reports of AHGs 4–15
  + Session 3:
    - 2100–2315 Review of EE1 cat. 1 and 2
  + Session 4:
    - 2335-2355 Review of EE1 cat. 3
    - 2355–0120+1 Review of EE2
* Thu. 12 Jan., 2nd day
  + Session 5:
    - 1300–1500 Review of 6.1 NNPF SEI
  + Session 6:
    - 1520–1720 Review of 4.14
  + Session 7:
    - 2100–2300 Review of EE1 and EE1 related
  + Session 8:
    - 2310–0120+1 Review of EE2 and EE2 related
* Fri. 13 Jan., 3rd day
  + Session 9:
    - 1300–1500 Review of …
  + Session 10:
    - 1520–1720 Review of …
  + Session 11:
    - 2100–2300 Review of …
  + Session 12:
    - 2310–0120+1 Review of …
* Mon. 16 Jan., 4th day
  + 0500–0730 MPEG information sharing session
  + Session 13:
    - 1300–1500 Review of …
    - …
* Tue. 17 Jan., 5th day
  + …
* Wed. 18 Jan., 6th day
  + 0500–0600 MPEG information sharing session
  + …
* Thu. 19 Jan., 7th day
  + …
* Fri. 20 Jan., 8th day
  + Plenary:
    - 1300–1500 Remaining business, Approval of output docs, AHGs, recommendations
  + 2100–2300 MPEG information sharing session
  + XXXX+1–XXXX+1 WG 5 Closing plenary: Approval of meeting recommendations

## Contribution topic overview

The approximate subject categories and quantity of contributions per category for the meeting were summarized as follows (note that the noted document counts do not include crosschecks and summary reports, and may not be completely accurate; documents which are allocated to multiple sections are only counted in one of them):

* AHG reports (15) (section 3)
* Project development (section 4)
  + Deployment and advertisement of standards (2)
  + Text development and errata reporting (1)
  + Test conditions (3)
  + Subjective quality testing and verification testing (5)
  + Test Material (0)
  + Quality assessment (1)
  + Conformance test development (0)
  + Software development (3)
  + Implementation studies and complexity analysis (1)
  + AHG7: Low latency and constrained complexity (1)
  + Encoding algorithm optimization (3)
  + Profile/tier/level specification (0)
  + Proposed modification of system interface (0)
  + AHG15: Optimization of encoders and receiving systems for machine analysis of coded video content (8)
* Low-level tool technology proposals (section 5) with subtopics (number counts excluding BoG and summary reports)
  + AHG8: High bit depth and high bit rate coding (0) (section 5.1)
  + AHG11 and EE1: Neural network-based video coding (28) (section 5.2)
  + AHG12 and EE2: Enhanced compression beyond VVC capability (88) (section 5.3)
* AHG9: High-level syntax (HLS) proposals (section 6) with subtopics
  + SEI messages on neural-network post filter (20) (section 6.1)
  + SEI messages on topics other than NNPF (4) (section 6.2)
  + Film grain synthesis (1) (section 6.3)
  + Non-SEI HLS aspects (0) (section 6.4)
* Joint meetings, plenary discussions, BoG reports (0), liaison (2), 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 (15)

These reports were discussed Wednesday 11 Jan. 2023 during 1420–1515 and 1535–1740 UTC (chaired by JRO).

[JVET-AC0001](https://jvet-experts.org/doc_end_user/current_document.php?id=12242) JVET AHG report: Project management (AHG1) [J.-R. Ohm (chair), G. J. Sullivan (vice-chair)]

The work of the JVET overall had proceeded well in the interim period with approximately 10% 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 all output documents from the preceding meeting had been produced.

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/2022_10_AB_Mainz/>). It is noted that the previous document sites <http://phenix.int-evry.fr/jvet/>, <http://phenix.int-evry.fr/jct/>, and <http://phenix.int-evry.fr/jct3v/> are still accessible, but were converted to read-only.

The list of documents produced included the following, particularly:

* The meeting report (JVET-AB1000) [Posted 2022-11-25, also submitted as WG 5 N 156]
* Errata report items for VVC, HEVC, AVC, Video CICP, and CP usage TR (JVET-AB1004) [Posted 2022-12-16]
* Additional colour type identifiers for AVC, HEVC and Video CICP (Draft 2) (JVET-AB1008) [Posted 2023-01-09, also submitted as WG 5 WD N 163]
* Overview of IT systems used in JVET (JVET-AB1012) [Posted 2023-01-10]
* Algorithm description for Versatile Video Coding and Test Model 18 (VTM 18) (JVET-AB2002) [Posted 2022-12-19, last update 2023-01-06, also submitted as WG 5 WD N 161]
* Additional SEI messages for VSEI (Draft 3) (JVET-AB2006) [Posted 2023-01-05, also submitted as WG 5 DAM N 158]
* VTM and HM common test conditions and software reference configurations for SDR 4:2:0 10 bit video (JVET-AB2010) [Posted 2022-12-19]
* Common Test Conditions and evaluation procedures for neural network-based video coding technology (JVET-AB2016) [Posted 2022-12-24]
* Description of algorithms and software in neural network-based video coding (NNVC) (JVET-AB2019) [Posted 2022-12-02, also submitted as WG 5 N 165]
* Film grain synthesis technology for video applications (Draft 3) (JVET-AB2020) [Posted 2022-12-29, also submitted as WG 5 WD N 159]
* Draft verification test plan for VVC multilayer coding (JVET-AB2021) [Posted 2022-11-22, last update 2022-12-16]
* Draft plan for subjective quality testing of FGC SEI message (JVET-AB2022) [Posted 2022-11-22, last update 2022-12-16]
* Exploration experiment on Neural Network-based Video Coding (EE1) (JVET-AB2023) [Posted 2022-10-27, last update 2022-11-29, also submitted as WG 5 N 164]
* Exploration experiment on Enhanced Compression beyond VVC capability (EE2) (JVET-AB2024) [Posted 2022-10-28, last update 2022-11-14, also submitted as WG 5 N 166]
* Algorithm description of Enhanced Compression Model 7 (ECM 7) (JVET-AB2025) [Posted 2022-12-22, also submitted as WG 5 N 167]
* SEI processing order SEI message in VVC (Draft 1) (JVET-AB2027) [Posted 2022-11-15, also submitted as WG 5 WD N 160]
* Additional conformance bitstreams for VVC multilayer configurations (JVET-AB2028) [Posted 2022-12-30]
* Visual quality comparison of ECM/VTM encoding (JVET-AB2029) [Posted 2022-12-23]

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

* Recommendations of the 9th WG 5 meeting (WG 5 N 155)
* Disposition of comments received on ISO/IEC 23002-7:202x (2nd Ed.) CDAM1 (WG 5 N 157)
* Text of ISO/IEC DIS 23091-2:202x Coding-independent code points - Part 2: Video (3rd edition) (WG 5 N 162)
* Request for ISO/IEC 23002-7:202x (2nd Ed.) Amd.1 Additional SEI messages (WG 5 N 125)
* Liaison statement to ISO/IEC JTC 1/SC 29/WG 1 (JPEG) on JPEG AI and NNVC (WG 5 N 168)
* Liaison statement to SMPTE on ITP-PQ-C2 colour space (WG 5 N 169)
* List of AHGs established at the 9th WG 5 meeting (WG 5 N 151)

The fifteen *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 29th meeting had been announced in the JVET reflector, in the JVET logistics document (<https://www.itu.int/wftp3/av-arch/jvet-site/2023_01_AC_Virtual/JVET-AC_Logistics.docx>), and in the WG 5 calling notice (N 171) and agenda (N 172) for the 10th 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 165 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 29th meeting had been made publicly available on the ITU-hosted ftp site <http://wftp3.itu.int/av-arch/jvet-site/2023_01_AC_Virtual/>.

[JVET-AC0002](https://jvet-experts.org/doc_end_user/current_document.php?id=12243) JVET AHG report: Draft text and test model algorithm description editing (AHG2) [B. Bross, C. Rosewarne (co-chairs), F. Bossen, J. Boyce, A. Browne, S. Kim, S. Liu, J.-R. Ohm, G. J. Sullivan, A. Tourapis, Y.-K. Wang, Y. Ye (vice-chairs)]

**Output documents produced**

**JVET-AB1004 - Errata report items for VVC, VSEI, HEVC, AVC, Video CICP, and CP Usage TR**

Incorporated items at the JVET-AB meeting:

* For VVC, incorporated the following items:
  + JVET-AB0223: Text improvement for Timing / DU information SEI message in HEVC and VVC
  + Added a NOTE in the HRD text to mention that "leading pictures" associated with a DRAP picture may not be correctly decodable, per the discussion of JVET-AB0055 (On leading pictures design in DRAP SEI Message).
  + Added a NOTE to mention that the definition of IRAP in VSEI covers the case of GDR with ph\_recovery\_poc\_cnt equal to 0, per the discussion of JVET-AB0057 (On the associated IRAP for DRAP and EDRAP pictures).
  + Tickets [#1564](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/1564), [#1568](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/1568), [#1569](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/1569), and [#1572](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/1572) (some of them need more confirmation)
  + JVET-AB0120: Addition of interpolation for "initial CPB removal delay offset"
* For HEVC, incorporated the following items:
  + JVET-AB0223: Text improvement for Timing / DU information SEI message in HEVC and VVC
  + On conformance indication of the Multiview Main, Scalable Main, Scalable Main 10, and 3D Main profiles (resulted from a discussion between Alexis Tourapis and Gary Sullivan – thanks!)
  + On inference of high\_precision\_offsets\_enabled\_flag (resulted from a discussion between [Andy Fu](mailto:andy.fu@allegrodvt.com) and Gary Sullivan – thanks!)
  + On a redundant sentence in the definitionn of next\_bits( n ) from Gary Sullivan
  + On addition the parenthetic abbreviation TB to the text in clause 9.3.3.1 (suggested by [Cliff Reader](mailto:cliff@reader.com)– thanks!)
  + On indention of item 3 in the paragraph just below Equation 8-14 in clause 8.4.1 (reported and suggested by [Cliff Reader](mailto:cliff@reader.com) – thanks!)
  + On redudnant call to clause 8.6.1 (reported by [Cliff Reader](mailto:cliff@reader.com) – thanks!)
  + JVET-AB0120: Addition of interpolation for "initial CPB removal delay offset"
* For AVC, incorporated the following items:
  + JVET-AB0120: Addition of interpolation for "initial CPB removal delay offset"

**JVET-AB1008 - Additional colour type identifiers for AVC and HEVC**

This document contains the draft text for the specification of additional colour type identifiers for AVC (Rec. ITU-T H.264 | ISO/IEC 14496-10), HEVC (Rec. ITU-T H.265 | ISO/IEC 23008-2), and CICP (Rec. ITU-T H.273 | ISO/IEC 23091-2). Text modifications are provided for specification of code point identifiers for YCgCo-R colour representation with equal luma and chroma bit depths and for Draft SMPTE ST 2128. The new code points for for YCgCo-R are referred to as YCgCo-Re and YCgCo-Ro, where the number of bits added to a source RGB bit depth is 2 (i.e., even) and 1 (odd), respectively. Draft SMPTE ST 2128 specifies a colour representation referred to as ITP. Revision marking is provided to show modifications relative to the basis texts (based on the 2021-08 edition of Rec. ITU-T H.264 (the most recent edition), the 2020 edition of ISO/IEC 23008-2 (not the 5th edition currently under preparation), and ISO/IEC DIS 23091-2:202x (3rd Ed.), respectively). Equation numbers and their cross-references that are maintained automatically have been updated without revision marking.

**JVET-AB2002 - Algorithm description for Versatile Video Coding and Test Model 19 (VTM19)**

The JVET established the VVC Test Model 19 (VTM19) algorithm description and encoding method at its 28th meeting (20 – 28 October 2022, Mainz). This document serves as a source of general tutorial information on the VVC design and also provides an encoder-side description of VTM19. The VVC has been developed by a joint collaborative team of ITU-T and ISO/IEC experts known as the Joint Video Experts Team (JVET), which is a partnership of ITU-T Study Group 16 Question 6 (known as VCEG) and ISO/IEC JTC 1/SC 29/WG 11 (known as MPEG). This draft new standard has been designed with two primary goals. The first of these is to specify a video coding technology with a compression capability that is substantially beyond that of the prior generations of such standards, and the second is for this technology to be highly versatile for effective use in a broadened range of applications. Some key application areas for the use of this standard particularly include ultra-high-definition video (e.g., with 3840×2160 or 7620×4320 picture resolution and bit depth of 10 or 12 bits as specified in Rec. ITU-R BT.2100), video with a high dynamic range and wide colour gamut (e.g., with the perceptual quantization or hybrid log-gamma transfer characteristics specified in Rec. ITU-R BT.2100), and video for immersive media applications such as 360° omnidirectional video projected using a common projection format such as the equirectangular or cubemap projection format, in addition to the applications that have commonly been addressed by prior video coding standards.

Ed. Notes:

VVC Test Model 19 (VTM19) algorithm description and encoding method v2

* Incorporated JVET-AB0072: VTM Encoder Implementation for Green-MPEG SEI Messaging

VVC Test Model 19 (VTM19) algorithm description and encoding method v1

* Incorporated JVET-AA0110 and JVET-AB0267: phase indication SEI
* Incorporated JVET-AB0070: post-filter hint SEI
* Incorporated JVET-AA0102, JVET-AA0101, JVET-AB0051, and JVET-AB0069: processing order SEI
* MTS signaling bug fix in section 3.5.2
* Incorporated JVET-AB0080 and JVET-AB0081; RPR controls and filters
* Incorporated JVET-V0078; QP control for very smooth blocks

**JVET-AB2006 - Additional SEI messages for VSEI (Draft 3)**

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.

**JVET-AB2027 - SEI processing order SEI message in VVC (Draft 2)**

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.

1. **Related input contributions**

It is noted that document JVET-AC0275 contains comments of the Finnish NB on the 23002-7 DAM1 that are missing from the official ballot response.

1. **Remaining bug tickets**

* [#1564](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/1564) Intra prediction ref pixel array bounds too small for wide angle
* [#1572](https://jvet.hhi.fraunhofer.de/trac/vvc/ticket/1572) Sub clause C.1 -- Regarding number of bitstream conformance tests to be performed

1. **Recommendations**

The AHG recommends to:

* Approve JVET-AB1004, JVET-AB1008, JVET-AB2002, JVET-AB2006, and JVET-AB2027. 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.

(It is noted that some of the recommendations should be formulated more generally, also covering other standards than VVC).

[JVET-AC0003](https://jvet-experts.org/doc_end_user/current_document.php?id=12244) 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 19.0](https://vcgit.hhi.fraunhofer.de/jvet/VVCSoftware_VTM/-/releases/VTM-19.0) (Nov. 2022)
* [HM-17.0](https://vcgit.hhi.fraunhofer.de/jvet/HM/-/releases/HM-17.0) (Jan. 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 19.0](https://vcgit.hhi.fraunhofer.de/jvet/JM/-/tags/JM-19.0)
* [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 0.23](https://gitlab.com/standards/HDRTools/-/tags/v0.23) (October 2021)

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

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 18.1 and 18.2 were tagged on Oct. 24 and Oct. 25, and VTM version 19.0 was tagged on Nov. 30. VTM 19.1 is expected during the 29th JVET meeting.

VTM 18.1 was tagged on Oct. 24, 2022. Changes include:

* Fix memory leaks
* Add the missing setting of temporal filter to RA GOP16 cfg
* fix active picture number for L0 in reference picture list creation
* Fix #1574: SPS ID and PPS ID in encoding writeoutput()
* Add filler payload SEI message
* Fix RPL-based marking and RPL checks in Multilayer context
* Fix a Y4M bug (chroma scaling was not considered)
* fix reference picture lists checking for multilayer scalable
* Use bool constants and operators where appropriate
* Fix variable names
* Fix #1576: use correct interpolation filter size
* Fix DeblockingFilterDisable = 1
* Fix variable name and compile issue on Xcode
* Fix compile error with tracing is enabled
* Fix indentation and braces
* Fix indentation and braces
* Fix #1575: Use per-layer APS ids range for ALF APSs
* Avoid compile issue when using address sanitizer
* Remove JVET\_X0143\_ALF\_APS\_ID\_OFFSET related code
* Fix GDR code to avoid invalid reference
* Fix #1580: L1 RPL filling for incomplete GOP
* Fix: avoid redundant coding of RPL in both SPS and SH in multilayer
* Add QPIncrementFrame description in SW manual

VTM 18.2 was tagged on Oct. 25, 2022. Changes include:

* Remove macros from previous cycle

VTM 19.0 was tagged Nov. 30, 2022. Changes include:

* JVET-AB0085: Support multiple PTL signalling (encoder only)
* JVET-AB0047: Moving the gated syntax that contains nnpfc\_uri\_tag and nnpfc\_uri...
* JVET-AB0080: GOP-based RPR encoder control also including a fix for chroma QP
* JVET-AB0081: Increased length of filters used for upscaling reconstructed pictures
* JVET-AB0072: VTM Encoder Implementation for Green-MPEG SEI Messaging
* Fix which conformance window is used in case of field coding
* Clean up code related to sign derivation
* Fix variable names
* Fix which PTL is used for checks
* Fix trailing white space, variable names, braces
* Fix variable names and spacing
* Fix variable name
* Fix inference of bit-depth for YUV files
* Fix crash during checks for layer ID of ALF APS
* Use static\_vector instead of std::vector for list of subprofiles
* Remove default parameter values and fix braces/indentation
* Use vector object to hold frame-level delta qps
* Avoid code duplication and repeated memory allocation
* Combine redundant ALF constants m\_NUM\_BITS and m\_scaleBits
* Reduce number of calls to Rice parameter derivation
* Use strong-typed enum for BPMType
* Clean up Analyze class and related code
* Updated formatRGB.cfg to include RGBtoGBR conversion
* Address compiler warnings/errors
* Clean up adaptive BT size related code
* Fix variable names
* Clean up GPM encoder code
* Use named constant for maximum CU size for IBC
* Fix !2364: distinguish number of SAD and SATD candidates
* Clean up BDOF condition checking
* Fix typo in function name
* Use bool type and constants for boolean fields
* Fix variable names and indentations
* Remove default parameter values for printOut function
* Use static\_vector instead of custom structures with separate array and item count
* Use strong-typed enum for TransType
* Use strong-typed enum for HashType
* Clean up handling of ALF data in Picture object
* Use named constants for CBF masks
* Clean up SAO code and use strong typed enums
* Remove most default parameters from motion compensation functions
* Clean up matrix multiplication functions
* Clean up HMVP related functions
* Setup general HRD parameters
* Use strong-typed enum for CoeffScanType
* Clean up ComprCUCtx data structure
* Rename JVET\_C0024\_ZERO\_OUT\_TH and clean up related functions
* Clean up deblocking filter code
* Remove -Wno-class-memaccess compiler option
* Don't optimize for deblocking when deblocking is disabled
* Clean up applyDeblockingFilterParameterSelection()
* Clean up checking slice/tile/subpic conditions in deblocking filter
* Clean up filter length handling in deblocking filter
* Clean up edge/bs handling in deblocking filter
* Avoid double braces for init
* Use enumeration for BDPCM mode
* Clean up motion discontinuity processing in deblocking filter
* Define type to hold list of ALF APS Ids and clean up related code
* Allow GREEN\_METADATA\_SEI\_ENABLED to be set externally
* Fix variable names
* Use proper preprocessor guards for GREEN\_METADATA\_SEI\_ENABLED
* Avoid using UNDEFINED which is defined as a macro by HDRLib
* Fix: add check that was removed during integration
* Fix SEIBufferingPeriod::copyTo()
* Fix for zero-sized SEI NAL units
* Fix parsing of pt\_sublayer\_delays\_present\_flag
* Fix activateAPS() to update pointers to APSs
* Store latest DRAP POC in DecLib and set it to Slice
* Fix checkCRA() for field pictures

VTM 19.1 is expected to be tagged during the 29th JVET meeting. Changes include so far:

* JVET-T0056: SEI manifest and SEI prefix indication
* JVET-AB0069 change the length of the po\_sei\_processing\_order[i] syntax element
* JVET-AB0135 and BC#017 Add nnpfc\_total\_kilobyte\_size and replace Remove unused functions
* M60678: ballot comments of FI\_03
* JVET-AB0058: signal frame upsampling in neural network post-filter characteristics
* JVET-AB0051: Modification of SEI processing order SEI message
* JVET-AB0049: Modifications of NNPFC and NNPFA
* JVET-AB0050: Add two flags for NNPFA
* JVET-AB0070: post-filter hint SEI
* Use constant for subblock size in deblocking filter
* Fix variable names
* Define constant for VDPU size and fix function name
* Clean up intra and CIIP code
* Fix variable names
* Fixes in SubpicMergeApp for NumSubPics and SubPicId setters
* Use strong-typed enum for MtsType
* Clean deblocking filter code
* SubPicMergeApp: remove duplicate ceilLog2 function
* Clean up DMVR code
* Fix compilation when disabling REUSE\_CU\_RESULTS
* Use named constants
* Use named variable for unset cost
* Clean up reading/parsing of number of active refs
* Define named reference index for IBC
* Clean up ISP and use strong typed enum
* Use strong typed enum for SEI payload type
* Rename dynamic\_cache to Pool
* nnpfc\_complexity\_idc with a flag
* Rename LFCUParam data structure
* Clean up MMVD related code
* Define RefSetArray template to define arrays indexed by listIdx and refIdx
* Move new macros into section where they are indicated to be removed in next cycle
* Fix compilation when JVET\_R0351\_HIGH\_BIT\_DEPTH\_ENABLED is enabled
* Use python3 as interpreter for cmake/CMakeBuild/bin/cmake.py
* Use single variable to control ENABLE\_TRACING
* Fix a gcc12 compiling warning/error
* Add option to enable RExt\_\_HIGH\_BIT\_DEPTH\_SUPPORT from command line
* Fix variable names
* Clean up hash related functions
* Remove Ubuntu 18.04 from auto-build pipeline
* Use ptrdiff\_t for strides
* Use strong enum type for AffineModel
* Clean buffer usage in merge RD checking functions
* Clean up BCW and AMVR related code
* Clean up merge context data structure
* Use strong typed enum for MESearchMethod
* Remove unused field
* Use strong typed ChannelType
* Use strong typed enum for MergeType
* Fix gcc 12 compiling errors
* Replace m\_subPuMC by a local variable
* Clean up MV precision handling functions and use strong-typed enum
* Define MergeIdxPair type to hold pair of merge indices
* Clean up inter merge related functions
* Clean up width/height in InterPrediction::xPredInterBlk
* Remove m\_iRefListIdx field from InterPrediction class
* Use strong typed enum for APS type
* Remove unused variable
* Use proper data type for RPR scaling
* Fix variable names and use named constants
* Use strong-type enum for DFunc
* Change copyright year to 2023
* Remove unused field
* Fix parameter type in function definition: use ptrdiff\_t instead of uint32\_t
* Clean up MVD encoding
* Group partition contexts for faster copy
* Define enum for MIP size and use Pel elements for buffers
* Improve adherence to coding guidelines in EncGOP.cpp
* Improve adherence to coding guidelines
* Remove mvRefine field from InterPredictionData
* Fix macOS build with trace file enabled
* Use Size type instead of array of two values
* Remove g\_tbMax and use floorLog2 instead
* Move sei\_processing\_order.cfg into sei\_vui subdirectory
* Remove duplicate function and fix data types
* Add Ubuntu 22.04 auto-build
* Remove macros for HLS syntax element read/write

***CTC Performance***

The following tables shows **VTM 19.0** performance over **HM 17.0**.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra Main10** |  |  |
|  |  |  | **Over HM-17.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -29.50% | -32.83% | -33.81% | 1289% | 162% |
| Class A2 | -29.73% | -24.40% | -21.58% | 2117% | 171% |
| Class B | -22.33% | -27.21% | -31.01% | 2370% | 170% |
| Class C | -22.90% | -19.56% | -23.23% | 3432% | 173% |
| Class E | -26.05% | -25.89% | -24.34% | 1883% | 155% |
| **Overall** | -25.50% | -25.76% | -27.06% | 2196% | 167% |
| Class D | -18.79% | -13.79% | -13.86% | 3948% | 163% |
| Class F | -39.48% | -40.18% | -42.90% | 4700% | 162% |
|  |  |  |  |  |  |
|  |  |  | **Random access Main10** |  |  |
|  |  |  | **Over HM-17.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | -40.60% | -40.73% | -47.09% | 548% | 157% |
| Class A2 | -44.00% | -41.71% | -40.78% | 646% | 174% |
| Class B | -37.44% | -50.14% | -48.50% | 633% | 153% |
| Class C | -33.90% | -36.28% | -38.27% | 869% | 162% |
| Class E |  |  |  |  |  |
| **Overall** | -38.44% | -42.88% | -43.95% | 672% | 160% |
| Class D | -31.72% | -32.70% | -31.98% | 998% | 161% |
| Class F | -46.08% | -49.81% | -50.71% | 485% | 132% |
|  |  |  |  |  |  |
|  |  |  | **Low delay B Main10** |  |  |
|  |  |  | **Over HM-17.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -30.44% | -37.38% | -34.86% | 609% | 141% |
| Class C | -28.20% | -21.26% | -21.05% | 769% | 141% |
| Class E | -31.11% | -35.63% | -29.37% | 293% | 117% |
| **Overall** | -29.86% | -31.57% | -28.89% | 548% | 135% |
| Class D | -26.80% | -16.18% | -15.51% | 825% | 150% |
| Class F | -42.24% | -44.07% | -44.19% | 418% | 124% |
|  |  |  |  |  |  |
|  |  |  | **Low delay P Main10** |  |  |
|  |  |  | **Over HM-17.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -34.54% | -38.33% | -36.21% | 564% | 154% |
| Class C | -28.15% | -17.66% | -18.25% | 724% | 162% |
| Class E | -33.00% | -38.21% | -31.27% | 286% | 130% |
| **Overall** | -32.03% | -31.41% | -28.99% | 517% | 150% |
| Class D | -26.70% | -12.74% | -11.61% | 773% | 161% |
| Class F | -40.18% | -41.55% | -41.78% | 446% | 131% |

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

The following tables show **VTM 19.0** performance compared to **VTM 18.0** using SDR CTC:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra Main10** |  |  |
|  |  |  | **Over VTM-18.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.00% | 0.00% | 0.00% | 100% | 98% |
| Class A2 | 0.00% | 0.00% | 0.00% | 100% | 98% |
| Class B | 0.00% | 0.00% | 0.00% | 100% | 94% |
| Class C | 0.00% | 0.00% | 0.00% | 100% | 93% |
| Class E | 0.00% | 0.00% | 0.00% | 100% | 95% |
| **Overall** | 0.00% | 0.00% | 0.00% | 100% | 95% |
| Class D | 0.00% | 0.00% | 0.00% | 100% | 91% |
| Class F | 0.00% | 0.00% | 0.00% | 99% | 94% |
|  |  |  |  |  |  |
|  |  |  | **Random access Main10** |  |  |
|  |  |  | **Over VTM-18.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.00% | 0.00% | -0.01% | 99% | 99% |
| Class A2 | 0.00% | 0.00% | 0.01% | 98% | 100% |
| Class B | 0.00% | 0.00% | -0.01% | 100% | 98% |
| Class C | 0.00% | -0.01% | 0.02% | 99% | 95% |
| Class E |  |  |  |  |  |
| **Overall** | 0.00% | 0.00% | 0.00% | 99% | 98% |
| Class D | -0.01% | 0.01% | -0.01% | 99% | 95% |
| Class F | 0.00% | 0.00% | 0.00% | 99% | 94% |
|  |  |  |  |  |  |
|  |  |  | **Low delay B Main10** |  |  |
|  |  |  | **Over VTM-18.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -0.01% | 0.07% | -0.08% | 98% | 94% |
| Class C | 0.01% | 0.04% | 0.01% | 100% | 97% |
| Class E | 0.01% | -0.02% | -0.10% | 102% | 101% |
| **Overall** | 0.00% | 0.04% | -0.06% | 99% | 96% |
| Class D | 0.00% | -0.08% | 0.09% | 101% | 96% |
| Class F | -0.03% | 0.04% | -0.05% | 100% | 96% |
|  |  |  |  |  |  |
|  |  |  | **Low delay P Main10** |  |  |
|  |  |  | **Over VTM-18.0** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | 0.00% | 0.00% | 0.00% | 98% | 95% |
| Class C | 0.00% | 0.00% | 0.00% | 101% | 98% |
| Class E | 0.00% | 0.00% | 0.00% | 103% | 103% |
| **Overall** | 0.00% | 0.00% | 0.00% | 100% | 98% |
| Class D | 0.00% | 0.00% | 0.00% | 100% | 92% |
| Class F | 0.00% | 0.00% | 0.00% | 100% | 95% |

The following tables shows **VTM 19.0** performance over **HM 17.0** using HDR CTC:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | | | | | | |
|  | **Over HM17.0** | | | | | | | | | |
|  |  |  | **wPSNR** |  |  | **PSNR** |  |  |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | -39.54% | -37.59% | -36.68% | -54.95% | -48.45% | -33.68% | -49.45% | -40.85% | 287% | 90% |
| Class H2 |  |  |  |  |  | -32.01% | -57.74% | -63.32% | 270% | 89% |
| **Overall** | -39.54% | -37.59% | -36.68% | -54.95% | -48.45% | -33.07% | -52.47% | -49.02% | 280% | 89% |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **All Intra** | | | | | | | | | |
|  | **Over HM17.0** | | | | | | | | | |
|  |  |  | **wPSNR** | | | **PSNR** | | |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | -41.42% | -27.31% | -26.80% | -57.74% | -52.84% | -24.00% | -52.95% | -45.18% | 1474% | 101% |
| Class H2 |  |  |  |  |  | -21.76% | -47.21% | -50.55% | 1179% | 94% |
| **Overall** | -41.42% | -27.31% | -26.80% | -57.74% | -52.84% | -23.18% | -50.86% | -47.13% | 1359% | 98% |

The following tables show **VTM 19.0** performance compared to **VTM 18.0** using HDR CTC:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | | | | | | |
|  | **Over VTM18.0** | | | | | | | | | |
|  |  |  | **wPSNR** |  |  | **PSNR** |  |  |  |  |
|  | DE100 | PSNR-L100 | Y | U | V | Y | U | V | EncT | DecT |
| Class H1 | 0.04% | 0.01% | 0.00% | -0.01% | 0.01% | 0.00% | 0.00% | 0.01% | 95% | 92% |
| Class H2 |  |  |  |  |  | 0.00% | 0.00% | 0.00% | 97% | 91% |
| **Overall** | 0.04% | 0.01% | 0.00% | -0.01% | 0.01% | 0.00% | 0.00% | 0.01% | 96% | 92% |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **All Intra** | | | | | | | | | |
|  | **Over VTM18.0** | | | | | | | | | |
|  |  |  | **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% | 0.00% | 96% | 91% |
| Class H2 |  |  |  |  |  | 0.00% | 0.00% | 0.00% | 90% | 88% |
| **Overall** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 94% | 90% |

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

***Issues in VTM affecting conformance***

The following issues in VTM master branch may affect conformance:

* Missing HLS features (see sections below)

Merge request 2343 (“Fix which PTL is used for checks”) fixes which Profile/Tier/Level data structure is used (SPS or VPS) for some conformance checks. After this correction (i.e., VTM versions 19.0 and later), the following conformance streams fail to decode:

* ILRPL\_A\_Huawei\_2
* OLS\_A\_Tencent\_5
* OLS\_B\_Tencent\_5
* OLS\_C\_Tencent\_5
* OPI\_B\_Nokia\_3
* SPATSCAL444\_A\_Qualcomm\_2
* SPATSCAL\_A\_Qualcomm\_3
* VPS\_A\_INTEL\_3
* VPS\_B\_ERICSSON\_1
* VPS\_C\_ERICSSON\_2

***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**

HM 17.0 was tagged on Jan. 5, 2023. Changes include:

* JVET-AA0130: VTM and HM common test conditions for high bit depth
* JVET-AB0271: per-sequence config files for HDR content
* JCTVC-AD0021(JVET-T0056) SEI manifest & SEI prefix indication
* Build fixes for Xcode 14.2
* Remove Ubuntu 18.04 from auto-build pipeline
* Change Python executable to python3 for build environment scripts

The following tables show **HM 17.0** performance compared to **HM 16.26** under SRD CTC:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **All Intra Main10** |  |  |
|  |  |  | **Over HM-16.26** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.00% | 0.00% | 0.00% | 101% | 98% |
| Class A2 | 0.00% | 0.00% | 0.00% | 102% | 97% |
| Class B | 0.00% | 0.00% | 0.00% | 101% | 102% |
| Class C | 0.00% | 0.00% | 0.00% | 100% | 102% |
| Class E | 0.00% | 0.00% | 0.00% | 101% | 101% |
| **Overall** | 0.00% | 0.00% | 0.00% | 101% | 100% |
| Class D | 0.00% | 0.00% | 0.00% | 101% | 100% |
| Class F | 0.00% | 0.00% | 0.00% | 101% | 100% |
|  |  |  |  |  |  |
|  |  |  | **Random access Main10** |  |  |
|  |  |  | **Over HM-16.26** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 | 0.00% | 0.00% | 0.00% | 101% | 102% |
| Class A2 | 0.00% | 0.00% | 0.00% | 101% | 103% |
| Class B | 0.00% | 0.00% | 0.00% | 101% | 105% |
| Class C | 0.00% | 0.00% | 0.00% | 100% | 100% |
| Class E |  |  |  |  |  |
| **Overall** | 0.00% | 0.00% | 0.00% | 100% | 103% |
| Class D | 0.00% | 0.00% | 0.00% | 99% | 99% |
| Class F | 0.00% | 0.00% | 0.00% | 101% | 101% |
|  |  |  |  |  |  |
|  |  |  | **Low delay B Main10** |  |  |
|  |  |  | **Over HM-16.26** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | 0.00% | 0.00% | 0.00% | 100% | 104% |
| Class C | 0.00% | 0.00% | 0.00% | 101% | 115% |
| Class E | 0.00% | 0.00% | 0.00% | 100% | 110% |
| **Overall** | 0.00% | 0.00% | 0.00% | 101% | 109% |
| Class D | 0.00% | 0.00% | 0.00% | 100% | 102% |
| Class F | 0.00% | 0.00% | 0.00% | 100% | 106% |
|  |  |  |  |  |  |
|  |  |  | **Low delay P Main10** |  |  |
|  |  |  | **Over HM-16.26** |  |  |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | 0.00% | 0.00% | 0.00% | 101% | 104% |
| Class C | 0.00% | 0.00% | 0.00% | 101% | 108% |
| Class E | 0.00% | 0.00% | 0.00% | 101% | 106% |
| **Overall** | 0.00% | 0.00% | 0.00% | 101% | 106% |
| Class D | 0.00% | 0.00% | 0.00% | 100% | 104% |
| Class F | 0.00% | 0.00% | 0.00% | 101% | 106% |

The following table shows **HM 17.0** performance compared to **HM 16.26** under HDR CTC:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access** | | | | | | | | | |
|  | **Over HM16.26** | | | | | | | | | |
|  |  |  | **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% | 99% |
| Class H2 |  |  |  |  |  | 0.00% | 0.00% | 0.00% | 98% | 94% |
| **Overall** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 100% | 97% |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **All Intra** | | | | | | | | | |
|  | **Over HM16.26** | | | | | | | | | |
|  |  |  | **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% | 102% | 108% |
| Class H2 |  |  |  |  |  | 0.00% | 0.00% | 0.00% | 102% | 105% |
| **Overall** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 102% | 107% |

The following MRs are pending [with status indicated]:

* JVET-X0048: implementation of film grain characteristics (FGC) SEI message [waiting for proponent feedback]
* 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-17.0+SCM-8.8 should be considered. It may though be helpful to move SCC related functionality into separate source files. Volunteer work towards merging the branches would be appreciated.

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

The [HEVC bug tracker](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:

* 38 tickets for “HM”, most of which are more than 5 years,
* 1 ticket for “HM RExt”, which was created during this reporting period,
* 7 tickets for “HM SCC”, all of which are at least 3 years old,

Help to address these tickets would be appreciated.

One merge request is available related to HM SCC for ticket [#1511](https://hevc.hhi.fraunhofer.de/trac/hevc/ticket/1511" \o "Issue in Custom issue tracker) on SCC reference picture marking. We would appreciate help to confirm that the proposed change matches the SCC text.

1. **360Lib related activities**

The latest 360Lib software (360Lib-13.4) can be found at <https://vcgit.hhi.fraunhofer.de/jvet/360lib/-/tags/360Lib-13.4>

The following table is for the projection formats comparison using VTM-19.0 according to 360-degree video CTC (JVET-U2012) compared to that using VTM-18.0 (VTM-18.0 as anchor).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **PERP: VTM-19.0 over VTM-18.0** | | | | | |
|  | **End-to-end**  **WS-PSNR** | | | **End-to-end**  **S-PSNR-NN** | | |
|  | Y | U | V | Y | U | V |
| Class S1 | 0.00% | 0.00% | 0.01% | 0.00% | -0.01% | 0.01% |
| Class S2 | 0.00% | -0.02% | 0.01% | 0.00% | -0.01% | 0.01% |
| **Overall** | 0.00% | -0.01% | 0.01% | 0.00% | -0.01% | 0.01% |

The following table compares generalized cubemap (GCMP) coding and padded equi-rectangular projection (PERP) coding using VTM-19.0 (PERP as anchor).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **GCMP Over PERP** | | | | | |
|  | **End-to-end WS-PSNR** | | | **End-to-end S-PSNR-NN** | | |
|  | Y | U | V | Y | U | V |
| Class S1 | -11.53% | -5.53% | -6.05% | -11.50% | -5.47% | -6.00% |
| Class S2 | -3.72% | 0.80% | 1.21% | -3.69% | 0.89% | 1.29% |
| **Overall** | -8.40% | -3.00% | -3.14% | -8.38% | -2.93% | -3.08% |

The following tables are for PERP and GCMP coding comparison between VTM-19.0 and HM-16.22 (HM as anchor), respectively.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **VTM-19.0 PERP Over HM-16.22 PERP (anchor)** | | | | | |
|  | **End-to-end WS-PSNR** | | | **End-to-end S-PSNR-NN** | | |
|  | Y | U | V | Y | U | V |
| Class S1 | -30.91% | -38.80% | -41.29% | -30.90% | -38.85% | -41.28% |
| Class S2 | -36.88% | -37.36% | -39.69% | -36.87% | -37.40% | -39.75% |
| **Overall** | -33.30% | -38.23% | -40.65% | -33.29% | -38.27% | -40.67% |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **VTM-19.0 GCMP Over HM-16.22 PCMP (anchor)** | | | | | |
|  | **End-to-end WS-PSNR** | | | **End-to-end S-PSNR-NN** | | |
|  | Y | U | V | Y | U | V |
| Class S1 | -35.61% | -40.88% | -42.79% | -35.57% | -40.81% | -42.74% |
| Class S2 | -39.84% | -39.57% | -41.53% | -39.85% | -39.58% | -41.57% |
| **Overall** | -37.30% | -40.35% | -42.29% | -37.28% | -40.32% | -42.27% |

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.

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 updates of HDRTools.

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

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

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

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**

Following the merger for high-bit depth CTCs (JVET-AA0130), there are currently 7 related JVET CTC documents, namely:

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

Older CTC documents are:

JCTVC-X1007 SHVC test conditions

JCT3V-G1100 3DV test conditions

JCTVC-Z1015 SCM 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**

Guidelines for VVC and HEVC reference software development have been updated and submitted as JVET-AC0166 and JVET-AC0204.

Updates include clarification of existing rules, removal of outdated rules, and updates of supported compiler versions. It is also proposed to bump the C++ version to C++17 such as to have better support for constexpr constructs and additional features such as [[maybe\_unused]] attributes and overaligned memory allocation.

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.
* Review and approve updated guideline documents
* Consider documents (including late documents) related to AHG3 activities

It was discussed that all conformance streams failing to decode as reported above (due to a software bug fix which caused to generate erroneous streams) are relating to multi-layer configurations, and this could be either resolved by a new edition, or in the context of the ongoing multi-layer conformance activity.

Target a new edition of software in the July meeting, to reflect the bug fixing done more recently. This would also avoid misalignment between published software and conformance versions.

[JVET-AC0004](https://jvet-experts.org/doc_end_user/current_document.php?id=12245) JVET AHG report: Test material and visual assessment (AHG4) [V. Baroncini, T. Suzuki, M. Wien (co-chairs), S. Liu, S. Puri, A. Segall, P. Topiwala, S. Wenger, J. Xu, Y. Ye (vice-chairs)]

**Activities**

***Verification test preparation for VVC multilayer coding***

A teleconference was organized by AG5 and JVET AhG4 2022-12-16 08:30h UTC. The topic was the Verification Test preparation for VVC Multilayer Coding. The report of the AhG meeting is available in JVET-AC0042.

***Subjective test preparation for film grain synthesis***

The teleconference was organized by AG5 and JVET AhG4 2022-12-16 17:00h UTC. The topic was the preparation for subjective testing of film grain synthesis. The report of the AhG meeting is available in JVET-AC0043.

***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 chairs for login information).

In the report period, test material related to the CTC for SHVC 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).

**Related contributions**

|  |  |  |
| --- | --- | --- |
| [JVET-AC0041](https://jvet-experts.org/doc_end_user/current_document.php?id=12226) | [AHG4] On visual volumetric video-based coding (V3C) testing conditions | [S. Schwarz](mailto:sebastian.schwarz@nokia.com), M. M. Hannuksela, P. Rondao Alface, L. Kondrad, L. Ilola (Nokia) |
| [JVET-AC0042](https://jvet-experts.org/doc_end_user/current_document.php?id=12227) | AHG4: Report on AHG meeting on verification test preparation for VVC multilayer coding | [M. Wien (RWTH)](mailto:wien@lfb.rwth-aachen.de) |
| [JVET-AC0043](https://jvet-experts.org/doc_end_user/current_document.php?id=12228) | AHG4: Report on AHG meeting on subjective test preparation for film grain synthesis | [M. Wien (RWTH)](mailto:wien@lfb.rwth-aachen.de) |
| [JVET-AC0044](https://jvet-experts.org/doc_end_user/current_document.php?id=12229) | [AHG4] Occupancy-only PSNR calculations for V3C V-PCC coding evaluation | [S. Schwarz](mailto:sebastian.schwarz@nokia.com), M. M. Hannuksela (Nokia) |
| [JVET-AC0145](https://jvet-experts.org/doc_end_user/current_document.php?id=12347) | AHG4: experiments in preparation of dual-layer VVC visual tests | [P. de Lagrange (InterDigital)](mailto:philippe.delagrange@interdigital.com) |
| [JVET-AC0181](https://jvet-experts.org/doc_end_user/current_document.php?id=12385) | AHG4: experiments in preparation of film grain visual tests | [P. de Lagrange (InterDigital)](mailto:philippe.delagrange@interdigital.com) |
| [JVET-AC0267](https://jvet-experts.org/doc_end_user/current_document.php?id=12472) | Training Methods in Visual Assessment: Potential Improvements for Expert Viewing Tests | [M. Wien (RWTH)](mailto:wien@lfb.rwth-aachen.de), [V. Baroncini (VABTech)](mailto:baroncini@gmx.com) |

**Recommendations**

The AHG recommends:

* To review and discuss the input related to the verification test plan for VVC multilayer coding proposed in JVET-AC0145.
* To review and discuss the input related to the subjective tests for the FGC SEI message proposed in JVET-AC0181.
* Review JVET-AC0041 and JVET-AC0044 in a joint meeting with AG5 and WG7
* Review JVET-AC0267 in a joint session with AG 5
* To collect volunteers to conduct further verification tests, including volunteers to encode.
* To continue to discuss and to update the non-finalized categories of the verification test plan, including those which have not been addressed yet.
* To review the set of available test sequences for the verification 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.

It was suggested that the aspects targeted in JVET-AC0041 should be discussed at a higher level with other WGs (2, 4, 7) and VCEG first, e.g. whether it is desirable to develop dedicated tools or profiles for PCC in JVET.

[JVET-AC0005](https://jvet-experts.org/doc_end_user/current_document.php?id=12246) JVET AHG report: Conformance testing (AHG5) [D. Rusanovskyy, I. Moccagatta (co-chairs), F. Bossen, K. Kawamura, T. Ikai, H.-J. Jhu, K. Sühring, Y. Yu (vice-chairs)]

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 28th and 29th 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, ready to proceed to FDAM at current meeting 2023-01
  + H.266.1 V2 Consent planned for 2023-07

1. **Status on bitstream submission**

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

* conformance bitstreams for VVC:
  + 104 bitstream categories have been identified
  + At least one bitstream has been submitted in each identified category
  + 283 total bitstreams have been provided, checked, and made available
  + No changes between 27th and 28th 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 (was 127) bitstreams of 57 (was 56) identified categories have been cross-checked and uploaded.

1. **Activities and Discussion**

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

VVC activities:

Ticket #1581 was filed. According to it the following streams:

* ILRPL\_A\_Huawei\_2
* OLS\_A\_Tencent\_5
* OLS\_B\_Tencent\_5
* OLS\_C\_Tencent\_5
* OPI\_B\_Nokia\_3
* SPATSCAL444\_A\_Qualcomm\_2
* SPATSCAL\_A\_Qualcomm\_3
* VPS\_A\_INTEL\_3
* VPS\_B\_ERICSSON\_1
* VPS\_C\_ERICSSON\_2

need to be re-generated. The issue may be resolved after applying additional encoder fix related to JVET-AB0085.

VVC operation range extensions activities:

None.

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**

No AhG5 related contributions to this meeting.

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-AB2028).
* Maintain and update the conformance bitstream database and contribute to report problems in JVET document 1004.
* Start the generation, cross-checking, and documentation of the conformance streams for the HEVC multiview profiles supporting extended bit depth (JVET-AA1011).

Based on ballot comment JP-006, it would be possible to include the corrected v1 bitstreams into the FDAM/FDIS. Revisit: I. Moccagatta to clarify how long it would need to generate them, in order to define the editing period of the FDIS (converting DAM into FDIS of new edition).

[JVET-AC0006](https://jvet-experts.org/doc_end_user/current_document.php?id=12240) JVET AHG report: ECM software development (AHG6) [V. Seregin (chair), J. Chen, F. Le Léannec, K. Zhang (vice-chairs)]

1. **Software development**

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

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

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

The following adopted aspects were integrated into ECM-7.0:

JVET-AB0155: Spatial GPM (Test 1.6b) (MR 271)

JVET-AB0092: GLM with luma value (Test 1.8b) (MR 267)

JVET-AB0157: Template based MRL and intra fusion (Test 1.12a) (MR 275)

JVET-AB0143: CCCM with template selection (Test 1.13a) (MR 260)

JVET-AB0130: IntraTMP search speedup (Test 1.14). Enable Intra TMP in classes A-E (CTC) (MR 274)

JVET-AB0078: AMVPmerge mode for LB (Test 2.1a) (MR 253)

JVET-AB0079: TM-based BCW index derivation (Test 2.2) (MR 262)

JVET-AB0112: Affine DMVR (Test 2.6) (MR 263)

JVET-AB0061: Using block vector derived from IntraTMP for IBC (Test 3.2) (MR 257)

JVET-AB0067: Modification of LFNST for MIP coded block (Test 4.1) (MR 272)

JVET-AB0184: Extended fixed filter output for ALF (Test 5.1) (MR 261)

JVET-AB0082: Fix for ARMC and use 12-tap filter for picture upscaling (MR 276)

JVET-AB0174: Division free CCCM (MR 257)

JVET-AB0189: RMVF bit length control (MR 265)

Included fixes:

Fix to use unfiltered source for HDRmetrics when MCTF is enabled (MR 273)

Fix ISP CHECKD condition (MR 277)

Fix out of bound access to array EXT\_REF\_LINE\_IDX (MR 281)

Disable EncDbOpt when deblocking filter is disabled (MR 288)

Picture padding to include template (290)

Check if IBC is used before resetting IBC buffer (MR 297)

Memory deallocation for CCSAO (MR 298)

ECM-7.0 was tagged on December 7, 2022.

There are no changes to VTM-11 anchor, the latest version is VTM-11ecm6 which was tagged on September 4, 2022.

***CTC Performance***

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

Next tables show ECM-7.0 performance over ECM-6.0 anchor.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **All Intra Main 10** | | | | |
|  | **Over ECM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 | -0.57% | -1.41% | -1.14% | 121% | 104% |
| Class A2 | -1.03% | -2.81% | -3.34% | 119% | 107% |
| Class B | -1.00% | -2.22% | -2.00% | 120% | 110% |
| Class C | -0.83% | -1.17% | -1.16% | 123% | 121% |
| Class E | -1.52% | -1.92% | -1.78% | 125% | 119% |
| **Overall** | -0.98% | -1.90% | -1.86% | 122% | 112% |
| Class D | -0.65% | -0.71% | -0.94% | 115% | 112% |
| Class F | -0.78% | -2.74% | -2.70% | 105% | 105% |
| Class TGM | -1.81% | -5.38% | -4.66% | 102% | 92% |
|  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | |
|  | **Over ECM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 | -0.86% | -0.75% | -1.37% | 104% | 93% |
| Class A2 | -1.08% | -1.93% | -2.16% | 103% | 98% |
| Class B | -0.93% | -1.55% | -1.60% | 110% | 96% |
| Class C | -0.62% | -0.84% | -0.71% | 115% | 107% |
| Class E |  |  |  |  |  |
| **Overall** | -0.86% | -1.28% | -1.43% | 109% | 99% |
| Class D | -0.58% | -0.79% | -0.92% | 115% | 105% |
| Class F | -1.12% | -2.69% | -2.59% | 109% | 102% |
| Class TGM | -1.05% | -3.12% | -2.73% | 108% | 99% |
|  |  |  |  |  |  |
|  | **Low delay B Main 10** | | | | |
|  | **Over ECM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -0.81% | -1.44% | -1.25% | 105% | 93% |
| Class C | -0.67% | -0.93% | -0.90% | 108% | 93% |
| Class E | -0.64% | 0.17% | -0.71% | 115% | 95% |
| **Overall** | -0.72% | -0.87% | -1.00% | 108% | 93% |
| Class D | -0.77% | -0.48% | -0.14% | 117% | 101% |
| Class F | -0.74% | -2.06% | -1.44% | 107% | 100% |
| Class TGM | -0.37% | -1.36% | -1.10% | 102% | 94% |
|  |  |  |  |  |  |
|  | **Low delay P Main 10** | | | | |
|  | **Over ECM-6.0** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -0.46% | -0.79% | -0.49% | 103% | 93% |
| Class C | -0.40% | -0.21% | -0.68% | 105% | 95% |
| Class E | -0.27% | -0.04% | -0.03% | 114% | 99% |
| **Overall** | -0.39% | -0.41% | -0.44% | 106% | 95% |
| Class D | -0.50% | -0.17% | 0.24% | 111% | 98% |
| Class F | -0.42% | -1.65% | -1.25% | 103% | 97% |
| Class TGM | -0.43% | -1.44% | -1.20% | 100% | 92% |

The below tables show ECM-7.0 performance comparing to VTM-11.0ecm6 anchor.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **All Intra Main 10** | | | | |
|  | **Over VTM-11.0ecm6** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 | -8.67% | -17.52% | -24.11% | 617% | 348% |
| Class A2 | -12.88% | -21.39% | -24.64% | 576% | 348% |
| Class B | -7.62% | -20.59% | -18.79% | 630% | 392% |
| Class C | -8.12% | -12.50% | -12.91% | 635% | 411% |
| Class E | -9.72% | -17.97% | -16.91% | 619% | 435% |
| **Overall** | -9.13% | -17.98% | -19.03% | 618% | 387% |
| Class D | -6.68% | -10.00% | -10.01% | 624% | 416% |
| Class F | -18.45% | -26.68% | -26.24% | 444% | 397% |
| Class TGM | -31.47% | -38.80% | -37.65% | 386% | 367% |
|  |  |  |  |  |  |
|  | **Random Access Main 10** | | | | |
|  | **Over VTM-11.0ecm6** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 | -19.46% | -21.91% | -29.05% | 583% | 646% |
| Class A2 | -21.45% | -28.23% | -31.25% | 586% | 894% |
| Class B | -17.65% | -28.04% | -25.93% | 614% | 830% |
| Class C | -19.26% | -22.56% | -22.39% | 605% | 892% |
| Class E |  |  |  |  |  |
| **Overall** | -19.20% | -25.39% | -26.67% | 600% | 817% |
| Class D | -20.25% | -23.80% | -24.06% | 605% | 959% |
| Class F | -22.05% | -29.05% | -29.34% | 520% | 556% |
| Class TGM | -30.00% | -35.63% | -35.75% | 556% | 438% |
|  |  |  |  |  |  |
|  | **Low delay B Main 10** | | | | |
|  | **Over VTM-11.0ecm6** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -16.16% | -30.50% | -28.78% | 529% | 695% |
| Class C | -17.44% | -25.63% | -25.66% | 552% | 714% |
| Class E | -14.58% | -22.41% | -23.17% | 552% | 483% |
| **Overall** | -16.19% | -26.85% | -26.34% | 542% | 640% |
| Class D | -19.65% | -26.43% | -26.39% | 554% | 850% |
| Class F | -20.49% | -29.26% | -27.88% | 514% | 496% |
| Class TGM | -28.89% | -35.39% | -35.06% | 524% | 401% |
|  |  |  |  |  |  |
|  | **Low delay P Main 10** | | | | |
|  | **Over VTM-11.0ecm6** | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -15.41% | -30.16% | -27.87% | 486% | 694% |
| Class C | -16.91% | -24.79% | -24.39% | 460% | 701% |
| Class E | -14.28% | -22.01% | -22.86% | 519% | 501% |
| **Overall** | -15.63% | -26.33% | -25.46% | 485% | 642% |
| Class D | -19.78% | -26.11% | -26.07% | 456% | 758% |
| Class F | -19.49% | -28.95% | -27.62% | 500% | 481% |
| Class TGM | -25.88% | -33.29% | -33.07% | 543% | 399% |

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

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.

[JVET-AC0007](https://jvet-experts.org/doc_end_user/current_document.php?id=12247) JVET AHG report: Low latency and constrained complexity (AHG7) [A. Duenas, T. Poirier, S. Liu (co-chairs), L. Wang, J. Xu (vice-chairs)]

**Related Contributions**

[JVET-AC0180](https://jvet-experts.org/doc_end_user/current_document.php?id=12384) **AHG 7: Reference frame padding for GDR [T.Poirier, F. Aumont (Interdigital)]**

This contribution proposes to pad the dirty area using samples from the clean area instead of setting unavailable samples to 2*BD-1* for reference pictures used by CUs in the clean (refreshed) area.

**Recommendations**

The AHG recommends reviewing input contributions and:

* to study the impact of the padding of reference frames for GDR and the option of enabling GDR for low latency and controlled complexity.

Consider continuing this as part of the encoder optimization activity (with additional mandates), normative aspects could be studied in contxt of ECM.

[JVET-AC0008](https://jvet-experts.org/doc_end_user/current_document.php?id=12248) JVET AHG report: High bit depth, high bit rate, and high frame rate coding (AHG8) [A. Browne, T. Ikai (co-chairs), D. Rusanovskyy, X. Xiu, Y. Yu (vice-chairs)]

The area of work for the AHG in this meeting cycle was the generation of crosschecked results for the combined VTM/HM CTC for high bit depths JVET-AA2018.

1. Contributions

No contributions relevant to the study of high bit depth, high bit rate or high frame rate coding have been registered for the 29th meeting.

1. Benchmarks

The following provide a comparison of VTM19.0 and HM17.0 for 12 and 16 bit content. The tables below report BD-Rate results computed using PSNR only.

*Low QP Range, BD-rate gain on PSNR.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **HDR PQ** |  |  | **AI** |  |  |
|  | **VTM19.0 over HM17.0** | | | | |
|  | psnrY | psnrU | psnrV | EncT | DecT |
| PQ444 | -5.73% | -6.65% | -7.35% | 2932% | 164% |
| PQ422 | -8.96% | -12.80% | -13.44% | 2473% | 158% |
| **Overall** | -7.34% | -9.73% | -10.39% | 2702% | 161% |
|  |  |  |  |  |  |
|  |  |  | **LDB** |  |  |
|  | **VTM19.0 over HM17.0** | | | | |
|  | psnrY | psnrU | psnrV | EncT | DecT |
| PQ444 | -6.65% | -4.92% | -6.94% | 288% | 160% |
| PQ422 | -7.86% | -12.08% | -13.09% | 366% | 157% |
| **Overall** | -7.26% | -8.50% | -10.02% | 327% | 158% |
|  |  |  |  |  |  |
|  |  |  | **RA** |  |  |
|  | **VTM19.0 over HM17.0** | | | | |
|  | psnrY | psnrU | psnrV | EncT | DecT |
| PQ444 | -6.28% | -4.63% | -5.92% | 322% | 160% |
| PQ422 | -7.83% | -11.79% | -12.02% | 450% | 158% |
| **Overall** | -7.05% | -8.21% | -8.97% | 386% | 159% |
|  |  |  |  |  |  |
| **Overall PQ** | -7.22% | -8.81% | -9.79% | 1139% | 159% |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **HDR HLG** |  |  | **AI** |  |  |
|  | **VTM19.0 over HM17.0** | | | | |
|  | psnrY | psnrU | psnrV | EncT | DecT |
| HLG444 | -4.58% | -6.22% | -6.60% | 3569% | 158% |
| HLG422 | -5.32% | -7.62% | -7.71% | 3021% | 152% |
| **Overall** | -4.95% | -6.92% | -7.16% | 3295% | 155% |
|  |  |  |  |  |  |
|  |  |  | **LDB** |  |  |
|  | **VTM19.0 over HM17.0** | | | | |
|  | psnrY | psnrU | psnrV | EncT | DecT |
| HLG444 | -6.30% | -8.70% | -8.34% | 393% | 148% |
| HLG422 | -6.04% | -10.29% | -9.16% | 476% | 148% |
| **Overall** | -6.17% | -9.49% | -8.75% | 435% | 148% |
|  |  |  |  |  |  |
|  |  |  | **RA** |  |  |
|  | **VTM19.0 over HM17.0** | | | | |
|  | psnrY | psnrU | psnrV | EncT | DecT |
| HLG444 | -6.37% | -8.59% | -7.92% | 440% | 150% |
| HLG422 | -6.05% | -9.75% | -8.20% | 594% | 153% |
| **Overall** | -6.21% | -9.17% | -8.06% | 517% | 152% |
|  |  |  |  |  |  |
| **Overall HLG** | -5.78% | -8.53% | -7.99% | 1416% | 152% |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **SVT RGB** |  |  | **AI** |  |  |
|  | **VTM19.0 over HM17.0** | | | | |
|  | psnrG | psnrB | psnrR | EncT | DecT |
| SVT16 | -2.64% | -1.83% | -1.85% | 5548% | 145% |
| SVT12 | -4.29% | -3.19% | -3.28% | 5389% | 145% |
| **Overall** | -3.47% | -2.51% | -2.56% | 5468% | 145% |
|  |  |  |  |  |  |
|  |  |  | **LDB** |  |  |
|  | **VTM19.0 over HM17.0** | | | | |
|  | psnrG | psnrB | psnrR | EncT | DecT |
| SVT16 | -2.52% | -1.14% | -1.13% | 711% | 148% |
| SVT12 | -4.61% | -2.13% | -2.14% | 653% | 145% |
| **Overall** | -3.57% | -1.64% | -1.63% | 682% | 146% |
|  |  |  |  |  |  |
|  |  |  | **RA** |  |  |
|  | **VTM19.0 over HM17.0** | | | | |
|  | psnrG | psnrB | psnrR | EncT | DecT |
| SVT16 | -2.66% | -1.20% | -1.19% | 852% | 149% |
| SVT12 | -4.71% | -2.21% | -2.22% | 793% | 145% |
| **Overall** | -3.69% | -1.71% | -1.71% | 822% | 147% |
|  |  |  |  |  |  |
| **Overall RGB** | -3.57% | -1.95% | -1.97% | 2324% | 146% |

*Standard QP Range, BD-rate gain on PSNR.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **RA** | | | | |
|  | **VTM19.0 over HM17.0** | | | | |
|  | psnrY | psnrU | psnrV | EncT | DecT |
| Class H1 | -26.50% | -69.30% | -56.97% | 290% | 177% |
| Class H2 | -33.05% | -57.93% | -57.02% | 293% | 161% |
| **Overall** | -26.50% | -69.30% | -56.97% | 291% | 169% |
|  |  |  |  |  |  |
|  | **AI**  **VTM19.0 over HM17.0** | | | | |
|  | psnrY | psnrU | psnrV | EncT | DecT |
| Class H1 | -12.58% | -68.09% | -54.83% | 2104% | 185% |
| Class H2 | -23.06% | -49.57% | -50.26% | 2530% | 174% |
| **Overall** | -12.58% | -68.09% | -54.83% | 2307% | 179% |

1. Recommendations

The AHG recommends the following:

* To close the group.

The overall results above are probably only considering class H2. Correct from V2.

It is commented that it would be relevant to continue running the CTC in JVET-AA2018 also for future meeting cycles, but not necessary to retain a separate AHG for that. It is noted that K. Sharman is already one of the AHG3 chairs.

[JVET-AC0009](https://jvet-experts.org/doc_end_user/current_document.php?id=12249) JVET AHG report: SEI message studies (AHG9) [S. McCarthy, Y.-K. Wang (co-chairs), T. Chujoh, S. Deshpande, C. Fogg, P. de Lagrange, G. J. Sullivan, A. Tourapis, S. Wenger (vice-chairs)]

1. **Related contributions**

A total of 27 contributions are identified relating to the mandates of AHG9. The number of contributions relating to each mandate is as follows

* 23 contributions relate to the mandate to study the SEI messages in VSEI, VVC, HEVC, and AVC;
  + 21 contributions relate to the neural-network post-filter SEI messages, including 1 summary of proposals on NNPF SEI messages.
  + 1 contribution relates to the SEI processing order SEI message
  + 1 contribution relates to preparing the FDAM/FDIS text of VVC 2nd Ed.
* 0 contributions relate to the mandate to collect software and showcase information for SEI messages;
* 4 contributions relate to the mandate to identify potential needs for additional SEI messages.

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

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

**Neural-network post filter characteristics and activation SEI messages**

**Summary of proposals related to NNPF SEI messages**

[JVET-AC0208](https://jvet-experts.org/doc_end_user/current_document.php?id=12412) AHG9: Summary of Proposals Related to Neural-Network Post-Filter SEI Messages [S. Deshpande (Sharp)]

**Proposals on NNPF SEI messages**

[JVET-AC0047](https://jvet-experts.org/doc_end_user/current_document.php?id=12232) AHG9: On bugfix for NNPFC and NNPFA SEI messages [T. Chujoh, Y. Yasugi, T. Ikai (Sharp)]

[JVET-AC0061](https://jvet-experts.org/doc_end_user/current_document.php?id=12263) AHG9: Comments on Neural-network Post-filter Characteristics SEI Message [S. Deshpande (Sharp)]

[JVET-AC0062](https://jvet-experts.org/doc_end_user/current_document.php?id=12264) AHG9: On NNPFC SEI Message [S. Deshpande, A. Sidiya (Sharp)]

[JVET-AC0074](https://jvet-experts.org/doc_end_user/current_document.php?id=12276) AHG9: On the VVC use of the NNPFC SEI message for picture rate upsampling [M. M. Hannuksela (Nokia)]

[JVET-AC0075](https://jvet-experts.org/doc_end_user/current_document.php?id=12277) AHG9: On NNPFC and NNPFA SEI messages for picture rate upsampling post-filter [M. M. Hannuksela (Nokia)]

[JVET-AC0076](https://jvet-experts.org/doc_end_user/current_document.php?id=12278) AHG9: AHG15: On the NNPFC SEI message for machine analysis [M. M. Hannuksela, F. Cricri, J. I. Ahonen, H. Zhang (Nokia)]

[JVET-AC0085](https://jvet-experts.org/doc_end_user/current_document.php?id=12287) AHG9: On neural-network post-filter characteristics (NNPFC) SEI message for temporal upsampling towards machine vision [S. Wang, J. Chen, Y. Ye (Alibaba), S. Wang (CityU)]

[JVET-AC0127](https://jvet-experts.org/doc_end_user/current_document.php?id=12329) AHG9: Combination of picture rate upsampling with other NNPF purposes [Y.-K. Wang, J. Xu, Y. Li, L. Zhang, K. Zhang, J. Li, C. Lin (Bytedance)]

[JVET-AC0128](https://jvet-experts.org/doc_end_user/current_document.php?id=12330) AHG9: On the signalling of complexity information in NNPFC SEI message [Hendry, S. Kim (LGE)]

[JVET-AC0129](https://jvet-experts.org/doc_end_user/current_document.php?id=12331) AHG9: On the NNPFC SEI message update and activation [Hendry, J. Nam, H. Jang, S. Kim, J. Lim (LGE)]

[JVET-AC0131](https://jvet-experts.org/doc_end_user/current_document.php?id=12333) AHG9: On NNPFC SEI message repetition [Hendry, J. Nam, H. Jang, S. Kim, J. Lim (LGE)]

[JVET-AC0132](https://jvet-experts.org/doc_end_user/current_document.php?id=12334) AHG9: On design for region-based neural-network post-filter SEI message [Hendry, J. Nam, H. Jang, S. Kim, J. Lim (LGE)]

[JVET-AC0134](https://jvet-experts.org/doc_end_user/current_document.php?id=12336) AHG9: Signalling of NNPF quality improvement [C. Lin, Y.-K. Wang, K. Zhang, J. Li, Y. Li, L. Zhang (Bytedance)]

[JVET-AC0135](https://jvet-experts.org/doc_end_user/current_document.php?id=12337) AHG9: Separate activation of color components for neural-network post-filter [C. Lin, Y. Li, Y.-K. Wang, K. Zhang, J. Li, L. Zhang (Bytedance)]

[JVET-AC0136](https://jvet-experts.org/doc_end_user/current_document.php?id=12338) AHG9: On additional NNPF purposes [C. Lin, Y.-K. Wang, K. Zhang, Y. Li, J. Li, L. Zhang (Bytedance)]

[JVET-AC0152](https://jvet-experts.org/doc_end_user/current_document.php?id=12356) AHG9: Bit-masking based representation of nnpfc\_purpose [J. Xu, Y.-K. Wang, L. Zhang, Y. Li (Bytedance)]

[JVET-AC0153](https://jvet-experts.org/doc_end_user/current_document.php?id=12357) AHG9: Bitdepth increase indication in the NNPFC SEI message [J. Xu, Y.-K. Wang, L. Zhang (Bytedance)]

[JVET-AC0154](https://jvet-experts.org/doc_end_user/current_document.php?id=12358) AHG9: Miscellaneous cleanups of the neural-network post-filter SEI messages [J. Xu, Y.-K. Wang, L. Zhang, C. Lin (Bytedance)]

[JVET-AC0174](https://jvet-experts.org/doc_end_user/current_document.php?id=12378) AHG9: Multiple input pictures for neural-network post-processing filter [Y. Li, Y.-K. Wang, C. Lin, J. Li, J. Xu, K. Zhang, L. Zhang (Bytedance)]

[JVET-AC0299](https://jvet-experts.org/doc_end_user/current_document.php?id=12504) AHG9: On indicating processing order in the NNPFC SEI messag [T. Shao, A. Arora, P. Yin, S. McCarthy, T. Lu, F. Pu, W. Husak (Dolby), Hendry, S. Kim (LGE)]

**SEI processing order SEI message**

[JVET-AC0058](https://jvet-experts.org/doc_end_user/current_document.php?id=12260) AHG9: On the SEI processing order SEI message [Y. He, M. Karczewicz (Qualcomm)]

**Preparation of FDAM/FDIS text of VVC 2nd Ed.**

[JVET-AC0275](https://jvet-experts.org/doc_end_user/current_document.php?id=12480) AHG9: Comments on VVC 2nd Ed. DAM1 [M. M. Hannuksela, M. Santamaria (Nokia)]

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

[JVET-AC0077](https://jvet-experts.org/doc_end_user/current_document.php?id=12279) AHG9/AHG15: On bitstreams that are potentially suboptimal for user viewing [M. M. Hannuksela, F. Cricri, H. Zhang (Nokia)]

[JVET-AC0088](https://jvet-experts.org/doc_end_user/current_document.php?id=12290) AHG9: Generative Face Video SEI Message [B. Chen, J. Chen, S. Wang, Y. Ye (Alibaba), S. Wang (CityU)]

[JVET-AC0122](https://jvet-experts.org/doc_end_user/current_document.php?id=12324) AHG9: Attenuation Map Information SEI for reducing energy consumption of displays [C.-H. Demarty, F. Aumont, E. Reinhard, L. Blondé, O. Le Meur, Z. Ameur, E. Francois (InterDigital)]

[JVET-AC0141](https://jvet-experts.org/doc_end_user/current_document.php?id=12343) AHG9: Alternative Picture Timing SEI [H.-B. Teo, J. Gao, C.-S. Lim, K. Abe (Panasonic)]

**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.

**Recommendations**

The AHG recommends to:

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

[JVET-AC0010](https://jvet-experts.org/doc_end_user/current_document.php?id=12250) 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.

It is noted that some of the mandates of AHG15 are related to test conditions and encoder optimization, and that some level of coordination would probably be beneficial.

***Test conditions***

**JVET-AC0078 – EE1-2.1: Updates on RPR encoder and post-filter**

The JVET-AB0102 contribution listed in the AHG10 report for previous JVET meeting proposed using a secondary anchor for EE1 super-resolution tests, that includes more intermediate resolutions (adding 4/5 ratio), GOP-based decision of coding resolution based on QP and high-frequency content in video source, and longer-tap filters for upscale.

This contribution reports test results in the EE1 context for these three aspects. GOP-based decision brings 0.7% luma gain in RA using only 1/1 and 1/2 resolutions, 1.23% when adding 2/3 and 4/5 resolutions, and longer tap filters bring around 0.3% chroma gain.

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

This contribution proposes four changes to RPR CTCs for both VTM and ECM, to exercise the tool more and adjust viewing conditions:

* Introduce more resolution changes: more often, and more resolution variants (switching every 32 frames and alternating between full resolution and one of the reduced resolutions: 4/5, 2/3, 1/2)
* Harmonize bitrates between the different resolutions by adjusting QPs depending on resolution (-6 for 1/2, -4 for 2/3, -2 for 4/5)
* Evaluate performance by using PSNR of upscaled reconstructed pictures only
* Test in RA configuration in addition to LDB

Performance numbers are reported using the proposed test conditions, for both VTM and ECM, and also for GOP-based RPR using VTM.

**JVET-AC0138 – Adjusting luma/chroma BD-rate balance in ECM**

This contribution proposes updates of ECM CTCs to balance luma/chroma gains compared to VTM. More specifically, adjustments to “CbQpOffset”, “CrQpOffset” and “LMCSOffset” parameters are proposed, depending on SDR/HDR and AI/others.

For AI / RA / LDB where imbalance was around +9% / +6% / +10% gain for chroma, imbalance is reduced to +0% / +4% / +5% respectively, with luma gain improvement of +0.9% / +0.2% / +0.16%.

**JVET-AC0149 – AHG10/12: Reduced I-frame QP for RA**

This contribution proposes to change the QP offset for intra frames in RA CTCs for both VTM and ECM: changing the “IntraQPOffset” config parameter from -3 to -4 is reported to bring 0.28%/2.62%/2.76% Y/Cb/Cr BDRate gains in the VTM, and similar gains for ECM. Subjective benefits are reported for static content, with no subjective problems for other content.

***Encoder optimizations***

**JVET-AC0139 – AHG10: Encoder Optimization of VTM Merge Functions**

In this contribution, an encoder only optimization on merge is proposed for VTM software. 97%, 99% and 92% encoding time is reported with 0.02%, 0.01% and 0.03% luma BD-rate loss for RA, LDB and LDP configurations, respectively.

Three merge functions on regular merge, sub-block merge and geometric merge are replaced with one unified merge function, which is said to remove redundant code. The code changes also include a new data structure to hold candidate information and prediction buffers, and memory optimization of prediction buffers. The maximum number of RDO checks after SATD-based candidate pruning is capped by a new configuration parameter (NumMaxRdCfg). The “Best Skip based Fast Merge” method is removed based on infrequent use in CTCs, marginal impact on encoding time, and losses in specific conditions.

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-AC0011](https://jvet-experts.org/doc_end_user/current_document.php?id=12251) JVET AHG report: Neural network-based video coding (AHG11) [E. Alshina, S. Liu, A. Segall (co-chairs), F. Galpin, J. Li, T. Shao, H. Wang, Z. Wang, M. Wien, P. Wu (vice-chairs)]

***Common Test Conditions***

**Document**

The AHG released revised common test conditions as decided at the 28th meeting. The final version was uploaded as document JVET-AB2016 on December 24, 2022.

**Anchor Encoding**

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

***EE Coordination***

The AHG finalized, conducted and discussed the EE on NN based video coding. The final version of the EE description was uploaded to the document repository on November 14, 2022.

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

|  |  |  |
| --- | --- | --- |
| JVET-AC0023 | EE1: Summary of Exploration Experiments on Neural Network-based Video Coding | E. Alshina, F. Galpin, Y. Li, M. Santamaria, H. Wang, L. Wang, Z. Xie |

**Anchor Encoding**

The performance of the VTM-11.0\_nnvc-3.0 anchor compared to VTM-11.0\_nnvc-2.0 is reported below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Random access Main 10** | | |  |
|  | **BD-rate Over VTM-11.0\_nnvc-2.0** | | |  |
|  | Y-PSNR | U-PSNR | V-PSNR | PSNR Overlap |
| Class A1 | 0.00% | 0.00% | 0.00% | 100% |
| Class A2 | 0.00% | 0.00% | 0.00% | 100% |
| Class B | -0.01% | -0.03% | -0.05% | 100% |
| Class C | 0.00% | 0.00% | 0.01% | 100% |
| Class E | - | - | - | - |
| **Overall** | 0.00% | -0.01% | -0.01% | 100% |
| Class D | 0.00% | 0.00% | 0.00% | 100% |
| Class F | 0.00% | -0.01% | 0.00% | 100% |
| Class H | - | - | - | - |
|  |  |  |  |  |
|  |  | **Low delay B Main 10** |  |  |
|  |  | **BD-rate Over VTM-11.0\_nnvc-2.0** |  |  |
|  | Y-PSNR | U-PSNR | V-PSNR | PSNR Overlap |
| Class A1 | - | - | - | - |
| Class A2 | - | - | - | - |
| Class B | 0.00% | -0.05% | 0.03% | 100% |
| Class C | -0.03% | 0.03% | 0.01% | 100% |
| Class E | 0.00% | 0.00% | 0.03% | 100% |
| **Overall** | -0.01% | -0.01% | 0.02% | 100% |
| Class D | 0.00% | 0.06% | 0.00% | 100% |
| Class F | -0.02% | 0.18% | 0.08% | 100% |
| Class H | - | - | - | - |
|  |  |  |  |  |
|  | **All Intra Main 10** | | |  |
|  | **BD-rate Over VTM-11.0\_nnvc-2.0** | | |  |
|  | Y-PSNR | U-PSNR | V-PSNR | PSNR Overlap |
| Class A1 | 0.00% | 0.00% | 0.00% | 100% |
| Class A2 | 0.00% | 0.00% | 0.00% | 100% |
| Class B | 0.00% | -0.01% | -0.02% | 100% |
| Class C | 0.00% | 0.00% | 0.00% | 100% |
| Class E | 0.00% | 0.00% | 0.00% | 100% |
| **Overall** | 0.00% | 0.00% | -0.01% | 100% |
| Class D | 0.00% | 0.00% | 0.00% | 100% |
| Class F | 0.00% | 0.00% | 0.00% | 100% |
| Class H | - | - | - | - |
|  |  |  |  |  |

*Note that the encoder and decoder run-time data was not accurate and has been removed.*

***Technical Evaluation***

The AHG made meaningful progress on the mandate to evaluate and quantify potential NN based video coding technologies. A summary of AHG11 related non-EE1 contributions provided as input to the 29th meeting is provided below:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Title** | **Common Test Conditions** | **Results** | | | **Training Data** | |
| **RA** | **LDB** | **AI** | **CTC** | **Additional** |
| **Loop Filter** | | | | | | | |
| [JVET-AC0065](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12267) | Non-EE1: On flipping of input and output of model in NNVC filter set 0 | Yes | Yes | Yes | No | - | - |
| [JVET-AC0179](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12383) | AHG11: Swin-Transformer based In-Loop Filter for Natural and Screen Contents | No | No | No | No | - | DIV2K |
| **Post Filtering** | | | | | | | |
| *[JVET-AC0047](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12232)* | *AHG9: On bugfix for NNPFC and NNPFA SEI messages* | No | No | No | No | - | - |
| *[JVET-AC0061](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12263)* | *AHG9: Comments on Neural-network Post-filter Characteristics SEI Message* | No | No | No | No | - | - |
| *[JVET-AC0062](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12264)* | *AHG9: On NNPFC SEI Message* | No | No | No | No | - | - |
| *[JVET-AC0074](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12276)* | *AHG9: On the VVC use of the NNPFC SEI message for picture rate upsampling* | No | No | No | No | - | - |
| *[JVET-AC0075](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12277)* | *AHG9: On NNPFC and NNPFA SEI messages for picture rate upsampling post-filter* | No | No | No | No | - | - |
| *[JVET-AC0076](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12278)* | *AHG9/AHG15: On the NNPFC SEI message for machine analysis* | No | No | No | No | - | - |
| *[JVET-AC0085](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12287)* | *AHG9: On neural-network post-filter characteristics (NNPFC) SEI message for temporal upsampling towards machine vision* | No | No | No | No | - | - |
| *[JVET-AC0127](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12329)* | *AHG9: Combination of picture rate upsampling with other NNPF purposes* | No | No | No | No | - | - |
| *[JVET-AC0128](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12330)* | *AHG9: On the signalling of complexity information in NNPFC SEI message* | No | No | No | No | - | - |
| *[JVET-AC0129](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12331)* | *AHG9: On the NNPFC SEI message update and activation* | No | No | No | No | - | - |
| *[JVET-AC0131](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12333)* | *AHG9: On NNPFC SEI message repetition* | No | No | No | No | - | - |
| *[JVET-AC0132](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12334)* | *AHG9: On design for region-based neural-network post-filter SEI message* | No | No | No | No | - | - |
| *[JVET-AC0134](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12336)* | *AHG9: Signalling of NNPF quality improvement* | No | No | No | No | - | - |
| *[JVET-AC0135](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12337)* | *AHG9: Separate activation of color components for neural-network post-filter* | No | No | No | No | - | - |
| *[JVET-AC0136](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12338)* | *AHG9: On additional NNPF purposes* | No | No | No | No | - | - |
| *[JVET-AC0152](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12356)* | *AHG9: Bit-masking based representation of nnpfc\_purpose* | No | No | No | No | - | - |
| *[JVET-AC0153](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12357)* | *AHG9: Bitdepth increase indication in the NNPFC SEI message* | No | No | No | No | - | - |
| *[JVET-AC0154](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12358)* | *AHG9: Miscellaneous cleanups of the neural-network post-filter SEI messages* | No | No | No | No | - | - |
| *[JVET-AC0174](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12378)* | *AHG9: Multiple input pictures for neural-network post-processing filter* | No | No | No | No | - | - |
| *[JVET-AC0208](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12412)* | *AHG9: Summary of Proposals Related to Neural-Network Post-Filter SEI Messages* | No | No | No | No | - | - |
| **Inter-Prediction** | | | | | | | |
| [JVET-AC0090](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12292) | AHG11: Neural Network-based Reference CU Quality Enhancement for Motion Compensation Prediction | No | No | No | No | BVI-DVC | - |
| [JVET-AC0114](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12316) | AHG11: Deep Reference Frame Generation for Inter Prediction Enhancement | Yes | Yes | Yes | No |  | Vinmeo |
| **E2E Methods** | | | | | | | |
| [JVET-AC0091](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12293) | AHG11: Fourier Series and Laplacian Noise-based Quantization Error Compensation for End-to-End Learning-based Image Compression | No | No | No | No | - | - |

1. **Input contributions**

There are 69 input contributions related to the AHG mandates. Forty-three of the contributions are part of the EE activity, while the remaining 26 contributions are related to AHG11 but not part of the EE. The list of input contributions is provided below.

***EE and Related Input Contributions***

|  |  |  |
| --- | --- | --- |
| **Reporting** | | |
| [JVET-AC0023](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12258) | EE1: Summary report of exploration experiments on neural network-based video coding | E. Alshina, F. Galpin, Y. Li, M. Santamaria, H. Wang, L. Wang, Z. Xie (EE coordinators) |
| **EE Technology** | | |
| [JVET-AC0051](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12236) | EE1-2.3: RPR-Based Super-Resolution Guided by Partition Information Combined with GOP Level Adaptive Resolution | [Q. Han](mailto:hanqihui2013@163.com), [C. Jung (Xidian Univ.)](mailto:zhengzk@xidian.edu.cn), [Y. Liu](mailto:serena@oppo.com), [M. Li (OPPO)](mailto:myron.li@oppo.com), [J. Nam](mailto:junghak.nam@lge.com), [S. Yoo](mailto:sunmi.yoo@lge.com), [J. Lim](mailto:jaehyun.lim@lge.com), [S. H. Kim (LGE)](mailto:seunghwan3.kim@lge.com) |
| [JVET-AC0052](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12237) | EE1-2.4: CNN filter Based on RPR-based SR Combined with GOP Level Adaptive Resolution | [S. Huang](mailto:shimin_huang2022@163.com), [C. Jung (Xidian Univ.)](mailto:zhengzk@xidian.edu.cn), [Y. Liu](mailto:serena@oppo.com), [M. Li (OPPO)](mailto:myron.li@oppo.com), [J. Nam](mailto:junghak.nam@lge.com), [S. Yoo](mailto:sunmi.yoo@lge.com), [J. Lim](mailto:jaehyun.lim@lge.com), [S. H. Kim (LGE)](mailto:seunghwan3.kim@lge.com) |
| [JVET-AC0055](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12241) | EE1-1.11: Content-adaptive post-filter | [M. Santamaria](mailto:maria.santamaria_gomez@nokia.com), R. Yang, F. Cricri, J. Lainema, H. Zhang, R. G. Youvalari, M. M. Hannuksela (Nokia) |
| [JVET-AC0056](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12252) | EE1-3.1 CompressAI models integration using SADL | [F. Galpin](mailto:franck.galpin@interdigital.com), F. Lefebvre, F. Racape (InterDigital) |
| [JVET-AC0063](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12265) | EE1-1.3: On chroma order adjustment in 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-AC0064](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12266) | EE1-1.4: On adjustment of residual 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-AC0078](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12280) | EE1-2.1: Updates on RPR encoder and post-filter | [J. Nam](mailto:junghak.nam@lge.com), [S. Yoo](mailto:sunmi.yoo@lge.com), [J. Lim](mailto:jaehyun.lim@lge.com), [S. Kim (LGE)](mailto:seunghwan3.kim@lge.com) |
| [JVET-AC0089](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12291) | EE1-1.5: Combined intra and inter models for luma and chroma | [D. Liu](mailto:du.liu@ericsson.com), [J. Ström](mailto:jacob.strom@ericsson.com), [M. Damghanian](mailto:mitra.damghanian@ericsson.com), [P. Wennersten](mailto:per.wennersten@ericsson.com), [K. Andersson (Ericsson)](mailto:kenneth.r.andersson@ericsson.com) |
| [JVET-AC0106](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12308) | EE1-1.10: Complexity Reduction on Neural-Network Loop Filter | [J. N. Shingala](mailto:jay.shingala@ittiam.com), A. Shyam, A. Suneia, S. P. Badya (Ittiam), [T. Shao](mailto:tshao@dolby.com), A. Arora, [P. Yin](mailto:pyin@dolby.com), Sean McCarthy (Dolby) |
| [JVET-AC0116](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12318) | EE1-3.2 : neural network-based intra prediction with learned mapping to VVC intra prediction modes | [T. Dumas](mailto:thierry.dumas@interdigital.com), F. Galpin, P. Bordes (Interdigital) |
| [JVET-AC0118](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12320) | EE1-1.8: QP-based loss function design for NN-based in-loop filter | [C. Zhou](mailto:chuan.zhou@vivo.com), [Z. Lv](mailto:zhuoyi.lv@vivo.com), [J. Zhang (vivo)](mailto:jirong.zhang@vivo.com) |
| [JVET-AC0143](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12345) | EE1-1.6: NN chroma model without partitioning input | [J. Ström](mailto:jacob.strom@ericsson.com), [D. Liu](mailto:du.liu@ericsson.com), [K. Andersson](mailto:kenneth.r.andersson@ericsson.com), [P. Wennersten](mailto:per.wennersten@ericsson.com), [M. Damghanian](mailto:mitra.damghanian@ericsson.com), [R. Yu](mailto:ruoyang.yu@ericsson.com) |
| [JVET-AC0155](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12359) | EE1-1.9: Reduced complexity CNN-based in-loop filtering | [S. Eadie](mailto:seadie@qti.qualcomm.com), [M. Coban](mailto:mcoban@qti.qualcomm.com), [M. Karczewicz (Qualcomm)](mailto:martak@qti.qualcomm.com) |
| [JVET-AC0177](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12381) | EE1-1.7: Deep In-Loop Filter with Additional Input Information | [Y. Li](mailto:yue.li@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com) |
| [JVET-AC0194](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12398) | EE1-1.1: More refinements on NN based in-loop filter with a single model | [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-AC0195](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12399) | EE1-1.2: encoder-only optimization for NN based in-loop filter with a single model | [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-AC0196](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12400) | EE1-2.2: GOP Level Adaptive Resampling with CNN-based Super Resolution | [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) |
| **EE Related** | | |
| [JVET-AC0066](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12268) | EE1-related: Improvement on EE1-1.7 | [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-AC0081](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12283) | EE1-related: A CNN Filter for RPR-Based Super-Resolution Using Wavelet Decomposition Combined with GOP Level Adaptive Resolution | [H. Lan](mailto:lanhui_xidian@163.com), [C. Jung (Xidian Univ.)](mailto:zhengzk@xidian.edu.cn), [Y. Liu](mailto:serena@oppo.com), [M. Li (OPPO)](mailto:myron.li@oppo.com), [J. Nam](mailto:junghak.nam@lge.com), [S. Yoo](mailto:sunmi.yoo@lge.com), [J. Lim](mailto:jaehyun.lim@lge.com), [S. H. Kim (LGE)](mailto:seunghwan3.kim@lge.com) |
| [JVET-AC0126](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12328) | EE1-related: Reduced complexity through channel redistribution in NN head | [P. Wennersten](mailto:per.wennersten@ericsson.com), [J. Ström](mailto:jacob.strom@ericsson.com), [D. Liu (Ericsson)](mailto:du.liu@ericsson.com) |
| [JVET-AC0156](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12360) | [EE1-related] RTNN: An In-loop Filter Based on Resblock and Transformer | [H. Zhang](mailto:13227706628@163.com), [C. Jung (Xidian Univ.)](mailto:zhengzk@xidian.edu.cn), [Y. Liu](mailto:serena@oppo.com), [M. Li (OPPO)](mailto:myron.li@oppo.com) |
| [JVET-AC0178](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12382) | EE1-related: In-Loop Filter with Wide Activation and Large Receptive Field | [Y. Li](mailto:yue.li@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com) |
| [JVET-AC0197](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12401) | EE1-1.1-related: More refinements on NN based 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) |
| **Cross Checks** | | |
| [JVET-AC0209](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12413) | Crosscheck of JVET-AC0177 (EE1-1.7: Deep In-Loop Filter with Additional Input Information) | [C. Zhou (vivo)](mailto:chuan.zhou@vivo.com) |
| [JVET-AC0215](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12419) | Crosscheck of JVET-AC0118 (EE1-1.8: QP-based loss function design for NN-based in-loop filter) | [C. Lin (Bytedance)](mailto:linchaoyi.cy@bytedance.com) |
| [JVET-AC0221](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12425) | Crosscheck of JVET-AC0196 (EE1-2.2: GOP Level Adaptive Resampling with CNN-based Super Resolution) | [D. Liu (Ericsson)](mailto:du.liu@ericsson.com) |
| [JVET-AC0222](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12426) | Crosscheck of JVET-AC0051 (EE1-2.3: RPR-Based Super-Resolution Guided by Partition Information Combined with GOP Level Adaptive Resolution) | [D. Liu (Ericsson)](mailto:du.liu@ericsson.com) |
| [JVET-AC0223](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12427) | Crosscheck of JVET-AC0052 (EE1-2.4: CNN filter Based on RPR-based SR Combined with GOP Level Adaptive Resolution) | [D. Liu (Ericsson)](mailto:du.liu@ericsson.com) |
| [JVET-AC0234](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12438) | Cross-check of JVET-AC0143 (EE1-1.6: NN chroma model without partitioning input) | [M. Santamaria (Nokia)](mailto:maria.santamaria_gomez@nokia.com) |
| [JVET-AC0238](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12442) | Crosscheck of JVET-AC0116 (EE1-3.2: neural network-based intra prediction with learned mapping to VVC intra prediction modes) | [Y. Li (Bytedance)](mailto:yue.li@bytedance.com) |
| [JVET-AC0241](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12445) | Crosscheck of JVET-AC0106 (EE1-1.10: Complexity Reduction on Neural-Network Loop Filter) | [Y. Li (Bytedance)](mailto:yue.li@bytedance.com) |
| [JVET-AC0254](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12459) | Crosscheck of JVET-AC0155 (EE1-1.9: Reduced complexity CNN-based in-loop filtering) | [Y. Li (Bytedance)](mailto:yue.li@bytedance.com) |
| [JVET-AC0257](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12462) | Crosscheck of JVET-AC0056(EE1-3.1 CompressAI models integration using SADL) | [T. Chujoh (Sharp)](mailto:chujoh.takeshi@sharp.co.jp) |
| [JVET-AC0270](https://jvet-experts.org/doc_end_user/current_document.php?id=12475) | Crosscheck of EE1-3.2 (JVET-AC0116 : neural network-based intra prediction with learned mapping to VVC intra prediction modes) | [M. Damghanian](mailto:mitra.damghanian@ericsson.com), [J. Ström](mailto:jacob.strom@ericsson.com) |
| [JVET-AC0271](https://jvet-experts.org/doc_end_user/current_document.php?id=12476) | Crosscheck of JVET-AC0063 (EE1-1.3: On chroma order adjustment in NNLF) | [R. Chang (Tencent)](mailto:renjiechang@tencent.com) |
| [JVET-AC0272](https://jvet-experts.org/doc_end_user/current_document.php?id=12477) | Crosscheck of JVET-AC0064 (EE1-1.4: On adjustment of residual for NNLF) | [R. Chang (Tencent)](mailto:renjiechang@tencent.com) |
| [JVET-AC0273](https://jvet-experts.org/doc_end_user/current_document.php?id=12478) | Crosscheck of JVET-AC0089 (EE1-1.5: Combined intra and inter models for luma and chroma) | [R. Chang (Tencent)](mailto:renjiechang@tencent.com) |
| [JVET-AC0274](https://jvet-experts.org/doc_end_user/current_document.php?id=12479) | Crosscheck of JVET-AC0116 (EE1-3.2.2: Low-complexity version of the neural network-based intra prediction mode in 16-bit signed integer) | [T. Shao (Dolby)](mailto:Tong.Shao@dolby.com) |
| [JVET-AC0278](https://jvet-experts.org/doc_end_user/current_document.php?id=12483) | Crosscheck of JVET-AC0194 (EE1-1.1: More refinements on NN based in-loop filter with a single model) | [Z. Xie(OPPO)](mailto:xiezhihuang@oppo.com) |
| [JVET-AC0279](https://jvet-experts.org/doc_end_user/current_document.php?id=12484) | Crosscheck of JVET-AC0195 (EE1-1.2: encoder-only optimization for NN based in-loop filter with a single model) | [Z. Xie(OPPO)](mailto:xiezhihuang@oppo.com) |
| [JVET-AC0286](https://jvet-experts.org/doc_end_user/current_document.php?id=12491) | Crosscheck of JVET-AC0064 (EE1-1.4: On adjustment of residual for NNLF) | [K. Jia (Bytedance)](mailto:%20jiake@bytedance.com) |

***Non-EE Input Contributions***

|  |  |  |
| --- | --- | --- |
| **Reporting** | | |
| [JVET-AC0011](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12251) | JVET AHG report: Neural network-based video coding (AHG11) | E. Alshina, S. Liu, A. Segall (co-chairs), F. Galpin, J. Li, T. Shao, H. Wang, Z. Wang, M. Wien, P. Wu (vice-chairs) |
| **Loop Filtering** | | |
| [JVET-AC0065](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12267) | Non-EE1: On flipping of input and output of model in NNVC filter set 0 | [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-AC0179](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12383) | AHG11: Swin-Transformer based In-Loop Filter for Natural and Screen Contents | [J. Li](mailto:lijunru@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [L. Zhang](mailto:lizhang.idm@bytedance.com), M. Wang (Bytedance) |
| **Post Filtering** | | |
| *[JVET-AC0047](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12232)* | *AHG9: On bugfix for NNPFC and NNPFA SEI messages* | *[T. Chujoh](mailto:chujoh.takeshi@sharp.co.jp), Y. Yasugi, T. Ikai (Sharp)* |
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| *[JVET-AC0075](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12277)* | *AHG9: On NNPFC and NNPFA SEI messages for picture rate upsampling post-filter* | *[M. M. Hannuksela (Nokia)](mailto:miska.hannuksela@nokia.com)* |
| *[JVET-AC0076](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12278)* | *AHG9/AHG15: On the NNPFC SEI message for machine analysis* | *[M. M. Hannuksela](mailto:miska.hannuksela@nokia.com), F. Cricri, J. I. Ahonen, H. Zhang (Nokia)* |
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| *[JVET-AC0127](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12329)* | *AHG9: Combination of picture rate upsampling with other NNPF purposes* | *[Y.-K. Wang](mailto:yekui.wang@bytedance.com), [J. Xu](mailto:xujizheng@bytedance.com), [Y. Li](mailto:yue.li@bytedance.com), [L. Zhang](mailto:lizhang.idm@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [J. Li](mailto:lijunru@bytedance.com), [C. Lin (Bytedance)](mailto:linchaoyi.cy@bytedance.com)* |
| *[JVET-AC0128](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12330)* | *AHG9: On the signalling of complexity information in NNPFC SEI message* | *[Hendry](mailto:dr.hendry@lge.com), S. Kim (LGE)* |
| *[JVET-AC0129](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12331)* | *AHG9: On the NNPFC SEI message update and activation* | *[Hendry](mailto:dr.hendry@lge.com), [J. Nam](mailto:junghak.nam@lge.com), H. Jang, S. Kim, J. Lim (LGE)* |
| *[JVET-AC0131](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12333)* | *AHG9: On NNPFC SEI message repetition* | *[Hendry](mailto:dr.hendry@lge.com), [J. Nam](mailto:junghak.nam@lge.com), H. Jang, S. Kim, J. Lim (LGE)* |
| *[JVET-AC0132](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12334)* | *AHG9: On design for region-based neural-network post-filter SEI message* | *[Hendry](mailto:dr.hendry@lge.com), [J. Nam](mailto:junghak.nam@lge.com), H. Jang, S. Kim, J. Lim (LGE)* |
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| *[JVET-AC0135](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12337)* | *AHG9: Separate activation of color components for neural-network post-filter* | *[C. Lin](mailto:linchaoyi.cy@bytedance.com), [Y. Li](mailto:yue.li@bytedance.com), [Y.-K. Wang](mailto:yekui.wang@bytedance.com), [K. Zhang](mailto:zhangkai.video@bytedance.com), [J. Li](mailto:lijunru@bytedance.com), [L. Zhang (Bytedance)](mailto:lizhang.idm@bytedance.com)* |
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| *[JVET-AC0152](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12356)* | *AHG9: Bit-masking based representation of nnpfc\_purpose* | *[J. Xu](mailto:xujizheng@bytedance.com), [Y.-K. Wang](mailto:yekui.wang@bytedance.com), [L. Zhang](mailto:lizhang.idm@bytedance.com), [Y. Li (Bytedance)](mailto:yue.li@bytedance.com)* |
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| *[JVET-AC0208](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12412)* | *AHG9: Summary of Proposals Related to Neural-Network Post-Filter SEI Messages* | *[S. Deshpande (Sharp)](mailto:sdeshpande@sharplabs.com), [Y.-K. Wang (Bytedance)](mailto:yekui.wang@bytedance.com)* |
| **Inter Prediction** | | |
| [JVET-AC0090](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12292) | AHG11: Neural Network-based Reference CU Quality Enhancement for Motion Compensation Prediction | [Yanhan Chu](mailto:yanhan_c@mail.sdu.edu.cn), [Zhikui Wang](mailto:wangzhikui@hisense.com), [Wen Zhang](mailto:zhangwen12@hisense.com), [Shuai Li(Hisense Visual Technology)](mailto:shuaili@sdu.edu.cn) |
| [JVET-AC0114](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12316) | AHG11: Deep Reference Frame Generation for Inter Prediction Enhancement | [J. Jia](mailto:jiajh2021@whu.edu.cn), [Y. Zhang](mailto:yuantongzhang@whu.edu.cn), [H. Zhu](mailto:zhuhanlyx@whu.edu.cn), [Z. Chen (Wuhan Univ.)](mailto:zzchen@whu.edu.cn), [Z. Liu](mailto:zizhengliu@tencent.com), [X. Xu](mailto:xiaozhongxu@tencent.com), [S. Liu (Tencent)](mailto:shanl@tencent.com) |
| **E2E Methods** | | |
| [JVET-AC0091](file:////Users/shanliu-sl/Documents/contribution/jvet29ac/current_document.php%3fid=12293) | AHG11: Fourier Series and Laplacian Noise-based Quantization Error Compensation for End-to-End Learning-based Image Compression | [Shiqi Jiang](mailto:shiqijiang@mail.sdu.edu.cn), [Zhikui Wang](mailto:wangzhikui@hisense.com), [Wen Zhang](mailto:zhangwen12@hisense.com), [Shuai Li (Hisense Visual Technology)](mailto:shuaili@sdu.edu.cn) |

1. **Recommendations**

The AHG recommends:

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

[JVET-AC0012](https://jvet-experts.org/doc_end_user/current_document.php?id=12253) JVET AHG report: Enhanced compression beyond VVC capability (AHG12) [M. Karczewicz, Y. Ye, L. Zhang (co-chairs), B. Bross, G. Li, X. Li, K. Naser, H. Yang (vice-chairs)]

1. **Activities**

The primary activity of the AHG was the “Exploration experiment on enhanced compression beyond VVC capability” (JVET-AB2024). The combined improvements of the ECM-7.0 over VTM-11.0ecm anchorfor AI, RA and LB configurations are:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | All Intra Main10 | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 | -8.67% | -17.52% | -24.11% | 617% | 348% |
| Class A2 | -12.88% | -21.39% | -24.64% | 576% | 348% |
| Class B | -7.62% | -20.59% | -18.79% | 630% | 392% |
| Class C | -8.12% | -12.50% | -12.91% | 635% | 411% |
| Class E | -9.72% | -17.97% | -16.91% | 619% | 435% |
| Overall | **-9.13%** | **-17.98%** | **-19.03%** | **618%** | **387%** |
| Class D | -6.68% | -10.00% | -10.01% | 624% | 416% |
| Class F | -18.45% | -26.68% | -26.24% | 444% | 397% |
| Class TGM | -31.47% | -38.80% | -37.65% | 386% | 367% |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Random Access Main 10 | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 | -19.46% | -21.91% | -29.05% | 583% | 646% |
| Class A2 | -21.45% | -28.23% | -31.25% | 586% | 894% |
| Class B | -17.65% | -28.04% | -25.93% | 614% | 830% |
| Class C | -19.26% | -22.56% | -22.39% | 605% | 892% |
| Class E |  |  |  |  |  |
| Overall | **-19.20%** | **-25.39%** | **-26.67%** | **600%** | **817%** |
| Class D | -20.25% | -23.80% | -24.06% | 605% | 959% |
| Class F | -22.05% | -29.05% | -29.34% | 520% | 556% |
| Class TGM | -30.00% | -35.63% | -35.75% | 556% | 438% |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Low Delay B Main 10 | | | | |
|  | Y | U | V | EncT | DecT |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -16.16% | -30.50% | -28.78% | 529% | 695% |
| Class C | -17.44% | -25.63% | -25.66% | 552% | 714% |
| Class E | -14.58% | -22.41% | -23.17% | 552% | 483% |
| Overall | **-16.19%** | **-26.85%** | **-26.34%** | **542%** | **640%** |
| Class D | -19.65% | -26.43% | -26.39% | 554% | 850% |
| Class F | -20.49% | -29.26% | -27.88% | 514% | 496% |
| Class TGM | -28.89% | -35.39% | -35.06% | 524% | 401% |

The rate reduction for natural sequences over VTM in RA configuration for {Y, U, V} increased from {-18.50%, -24.47%, -25.65%} to {-19.20%, -25.39%, -26.67%}. For SCC sequences (class TGM) the rate reduction for RA configuration increased from {-29.30%, -33.62%, -34.08%} to {-30.00%, -35.63%, -35.57%}.

1. **Contributions**

In addition to 32 EE2 contributions, 57 (comparing to 45 last meeting) EE2-related and ECM-related contributions were received which can be subdivided as follows:

***Intra (24)***

JVET-AC0048, "Non-EE: Modification of TIMD", Y. Yasugi, T. Ikai (Sharp)

JVET-AC0053, "AHG12: Simplified linear model solver", J. Lainema, P. Astola, A. Aminlou, R. G. Youvalari (Nokia)

JVET-AC0067, "Non-EE2: Modifications on template-based multiple reference line intra prediction", L. Xu, Y. Yu, H. Yu, D. Wang (OPPO)

JVET-AC0068, "Non-EE2: multi-candidate IntraTMP", F. Wang, L. Zhang, Y. Yu, H. Yu, D. Wang (OPPO)

JVET-AC0069, "Non-EE2: Intra Template-Matching Prediction Fusion", L. Zhang, F. Wang, Y. Yu, H. Yu, D. Wang (OPPO)

JVET-AC0070, "Non-EE2: combination of JVET-AC0068 and JVET-AC0069", F. Wang, L. Zhang, Y. Yu, H. Yu, D. Wang (OPPO)

JVET-AC0087, "Non-EE2: Intra TMP with half-pel precision", X. Li, R.-L. Liao, J. Chen, Y. Ye (Alibaba)

JVET-AC0097, "Non-EE2: SGPM combined with IntraTMP", C. Fang, S. Peng, D. Jiang, J. Lin, X. Zhang (Dahua)

JVET-AC0107, "AHG12: Fusion of Intra Template Matching", J. R. Arumugam, A. Natesan, V. Valvaiker, J. N. Shingala (Ittiam), T. Lu, P. Yin, F. Pu, T. Shao, A. Arora, S. McCarthy (Dolby)

JVET-AC0108, "Non-EE2: Extend search area in Intra Template Matching Prediction (IntraTMP)", J.-Y. Huo, H.-Q. Du, H.-L. Zhang, Z.-Y. Zhang, W.-H. Qiao, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.)

JVET-AC0109, "Non-EE2: Intra template matching (Intra TMP) based on linear filter model", J.-Y. Huo, W.-H. Qiao, X. Hao, Z.-Y. Zhang, H.-Q. Du, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.)

JVET-AC0110, "Non-EE2: A Fusion method of Intra Template Matching Prediction (Intra TMP)", J.-Y. Huo, H.-Q. Du, H.-L. Zhang, W.-H. Qiao, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.)

JVET-AC0111, "Non-EE2: Combination of JVET-AC0108, JVET-AC0109 and JVET-AC0110 for Intra TMP", J.-Y. Huo, W.-H. Qiao, H.-Q. Du, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.), H. Yuan (Shandong Univ.)

JVET-AC0120, "Non-EE2: template based intra MPM list construction", C. Zhou, Z. Lv, J. Zhang (vivo)

JVET-AC0121, "EE2-related: on GL-CCCM improvement (test 1.12a)", P Bordes, K Naser, F Galpin, E Francois (InterDigital), RG Youvalari, P Astola, J Lainema (Nokia)

JVET-AC0146, "AHG12: Filtered Template Matching based Intra Prediction (FTMP)", R. G. Youvalari, D. Bugdayci Sansli, P. Astola, J. Lainema (Nokia)

JVET-AC0148, "Non-EE2: CCCM using multiple downsampling filters", Y.-J. Chang, V. Seregin, M. Karczewicz (Qualcomm)

JVET-AC0161, "Non-EE2: IBC adaptation for coding of natural content", B. Ray, H. Wang, C.-C. Chen, V. Seregin, M. Karczewicz (Qualcomm)

JVET-AC0170, "Non-EE2: Fuse intra template matching prediction with intra prediction", Y. Wang, K. Zhang, L. Zhang (Bytedance)

JVET-AC0172, "Non-EE2: IBC with fractional block vectors", W. Chen, X. Xiu, C. Ma, H.-J. Jhu, C.-W. Kuo, N. Yan, X. Wang (Kwai)

JVET-AC0175, "Non-EE2: Local-Boosting Cross-Component Prediction", K. Zhang, L. Zhang, Z. Deng (Bytedance)

JVET-AC0176, "Non-EE2: Non-Local Cross-Component Prediction", K. Zhang, L. Zhang, Z. Deng (Bytedance)

JVET-AC0191, "Non-EE2: Modification to MPM list derivation", H. Wang, Y.-J. Chang, V. Seregin, M. Karczewicz (Qualcomm)

JVET-AC0198, "Non-EE2: IntraTMP with multiple modes", P.-H. Lin, J.-L- Lin, V. Seregin, M. Karczewicz (Qualcomm)

***Inter (10)***

JVET-AC0093, "EE2-related: test 2.5a and PROF improvement", F. Galpin, A. Robert, K. Naser (InterDigital)

JVET-AC0103, "Non-EE2: AMVP mode with subblock-based temporal motion vector prediction", R.-L. Liao, J. Chen, Y. Ye, X. Li (Alibaba)

JVET-AC0164, "Non-EE2: Improvements on local illumination compensation in ECM7.0", X. Xiu, N. Yan, H.-J. Jhu, W. Chen, C.-W. Kuo, C. Ma, X. Wang (Kwai)

JVET-AC0182, "Non-EE2: High-Precision MV Refinement for BDOF", M. Salehifar, Y. He, K. Zhang, L. Zhang (Bytedance)

JVET-AC0186, "EE2-related: EE2-2.7 with further encoder optimizations", L. Zhao, K. Zhang, L. Zhang (Bytedance)

JVET-AC0187, "Non-EE2: Template matching-based subblock motion refinement", L. Zhao, K. Zhang, Z. Deng, L. Zhang (Bytedance)

JVET-AC0124, "Non-EE2: Bi-prediction with block-level only out-of-bound management", F. Le F. Le Léannec, M. Blestel, P. Andrivon, M. Radosavljević (Xiaomi)

JVET-AC0213, "Non-EE2: SbTMVP with MMVD", L.-F. Chen, R. Chernyak, X. Zhao, X. Xu, S. Liu (Tencent)

JVET-AC0239, "Non-EE2: Prediction of MVD magnitude suffix bins", A. Filippov, V. Rufitskiy, K. Suverov (Ofinno)

JVET-AC0276, "EE2-related: Complexity reduction for Decoder Side Control Point Motion Vector Refinement (test 2.3b)", M. Bestel, F. Le Léannec, P. Andrivon, M. Radosavljević (Xiaomi), H. Huang, Y. Zhang, Z. Zhang, C.-C. Chen, V. Seregim, M. Karczewicz (Qualcomm)

***Screen Content Coding (13)***

JVET-AC0059, "AHG12: TMP using Reconstruction-Reordered for screen content coding (RR-TMP)", Jung-Kyung Lee, Damian Ruiz Coll, Vikas Warudkar, (Ofinno)

JVET-AC0140, "EE2-related: Additional results for test EE2-3.3", A. Filippov, V. Rufitskiy (Ofinno)

JVET-AC0142, "Non-EE2: Cross-Component Discrete Mapping Model for Screen Content Coding", B. Vishwanath, K. Zhang, L. Zhang (Bytedance)

JVET-AC0159, "Non-EE2: IBC MBVD list derivation", Z. Zhang, P. Nikitin, H. Huang, V. Seregin, M. Karczewicz (Qualcomm)

JVET-AC0160, "Non-EE2: On the condition of OBMC", X. Li (Google)

JVET-AC0165, "EE2-related: Additional results to EE2-3.4", Damian Ruiz Coll, Jung-Kyung Lee, Vikas Warudkar, (Ofinno)

JVET-AC0167, "AHG12: Using block vector derived from IntraTMP as an IBC candidate for the current block", Jung-Kyung Lee, Damian Ruiz Coll, Vikas Warudkar, (Ofinno)

JVET-AC0169, "Non-EE2: Template Matching for RR-IBC", C.-C. Chen, H. Huang, Z. Zhang, V. Seregin, M. Karczewicz (Qualcomm)

JVET-AC0189, "Non-EE2: SGPM without blending", Z. Deng, L. Zhang, K. Zhang, L. Zhao (Bytedance)

JVET-AC0190, "Non-EE2: On OBMC", Z. Deng, K. Zhang, L. Zhang (Bytedance)

JVET-AC0192, "Non-EE2: Temporal block vector prediction", N. Zhang, K. Zhang, L. Zhang (Bytedance)

JVET-AC0193, "Non-EE2: Copy-Padding for IBC", N. Zhang, K. Zhang, L. Zhang (Bytedance)

JVET-AC0203, "AHG12: On LMCS luma mapping in template processing for IBC TM-based tools", A. Filippov, V. Rufitskiy (Ofinno)

***In Loop Filters (1)***

JVET-AC0173, "Non-EE2: ALF classification based on residual data", I. Jumakulyyev, N. Hu, Z. Zhang, V. Seregin, M. Karczewicz, H. Huang (Qualcomm)

***Transform (2)***

JVET-AC0163, "Non-EE2: On non-separable primary transform for intra blocks", N. Yan, X. Xiu, W. Chen, H.-J. Jhu, C.-W. Kuo, C. Ma, X. Wang (Kwai)

JVET-AC0205, "EE2-related: Modifications of MTS and LFNST for IntraTMP", R. G. Youvalari, D. Bugdayci Sansli, J. Lainema (Nokia)

***Entropy (1)***

JVET-AC0200, "AhG12 Dynamic CABAC models", F. Lo Bianco, F. Galpin, E. Francois (InterDigital)

***Other (6)***

JVET-AC0095, "AHG12: Fix related to pixel copy in motion compensation", K. Andersson, R. Yu (Ericsson)

JVET-AC0096, "AHG10/12: Suggestion for new CTC for RPR in VTM and ECM", K. Andersson, R. Yu (Ericsson)

JVET-AC0123, "MTT maximum depth correction for class B sequences at QP 22 in ECM", G. Laroche, P. Onno (Canon)

JVET-AC0138, "Adjusting luma/chroma BD-rate balance in ECM", E. Francois, Y. Chen, C. Salmon-Legagneur (InterDigital)

JVET-AC0149, "AHG10/12: Reduced I-frame QP for RA", K. Andersson, P. Wennersten (Ericsson)

JVET-AC0171, "AHG12: ECM-6 Tool Off Tests", X. Li (Google)

1. Recommendations

The AHG recommends to:

* To review all the related contributions.

It is verbally reported that, by shifting chroma gain to luma, more than 20% might be achieved in RA.

Most gain was achieved recently in intra (which is also increasing RA gain), and this seems again to be the tendency from the contributions at this meeting.

[JVET-AC0013](https://jvet-experts.org/doc_end_user/current_document.php?id=12254) JVET AHG report: Film grain technologies (AHG13) [W. Husak, M. Radosavljević, W. Wan (co-chairs), D. Grois, Y. He, P. de Lagrange, A. Segall, A. Tourapis (vice-chairs)]

The group focused its efforts on updating the technical report during the intermeeting period in preparation of issuing a ballot. The editors met on a biweekly cadence throughout the period. The editorial process consisted of resolving many editorial issues without any major changes in the structure of the document.

1. **Related contributions**

Five contributions related to AHG13 were identified as of 1/11/2023:

* One was the AHG report:
  + JVET-AC0013 JVET AHG report: Film grain technologies (AHG13)
* Two were related to the technical report and explore film grain testing:
  + JVET-AC0151 Proposed text: Film grain synthesis technology for video applications (CD draft)
  + JVET-AC0043 AHG4: Report on AHG meeting on subjective test preparation for film grain synthesis
  + JVET-AC0043 AHG4: Report on AHG meeting on subjective test preparation for film grain synthesis
  + JVET-AC0199 On Film Grain Synthesis Subjective Evaluation

***Contributions***

**JVET-AC0151 Proposed text: Film grain synthesis technology for video applications (CD draft)**

This draft technical report provides guidance on the use of film grain synthesis technology for video applications. Such technology may be used in conjunction with metadata signalling mechanisms, such as the supplemental enhancement information messages available in several video coding standards. The purpose of this document is to provide a publicly referenceable overview of the end-to-end processing steps for film grain synthesis, which may include content analysis, noise/film grain removal and film grain model parameter estimation, parameter encoding, encapsulation, and decoding, and film grain synthesis and blending for consumer distribution applications.

**JVET-AC0199 On Film Grain Synthesis Subjective Evaluation**

The initial version was incomplete (rejected by chair), but an update became available by the beginning of the meeting.

The AHG recommends:

* the related input contributions are reviewed;
* the draft TR text be edited during the JVET meeting period;
* testing of FGC be discussed; and
* continue the study of film grain technologies in JVET.

[JVET-AC0014](https://jvet-experts.org/doc_end_user/current_document.php?id=12255) JVET AHG report: NNVC software development (AHG14) [S. Eadie, F. Galpin, Y. Li, L. Wang, Z. Xie (AHG chairs)]

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-3.0 anchor at <https://vcgit.hhi.fraunhofer.de/jvet-ahg-nnvc/VVCSoftware_VTM> is used for NNVC performance evaluation.

***Software changes***

The following changes were integrated into NNVC-3.0:

* add missing license headers in training scripts [MR17]
* JVET-AB0083: EE1-1.8: More refinements on NN based in-loop filter with a single model (Test 1) [MR 18]
* JVET-AB0068: EE1-1.6: RDO Considering Deep In-Loop Filtering [MR 20]
* Update to SADL v3.0 [MR 19]
* JVET-AB0053: EE1-1.2: Removed attention branch and partitioning input from filter set 1. [MR 21] [MR 23]

The following fixes:

* Add missing license headers in training scripts
* refactor code of filter set #1: correct variable name, remove constant [MR 22]

NNVC 3.0 was tagged December 1st 2022.

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

NNVC 2.0 was tagged August 4th 2022 (add deblocking in RDO).

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

***CTC performance***

In this section, NNVC test results following NNVC CTC configuration descried in JVET-AB2016 are summarized.

**Filter set 0**

The following tables show NNVC-3.0 NN-based filter set #0 (int16 precision) performance over NNVC-3.0 anchor.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | |
|  | **BD-rate Over NNVC-3.0 anchor** | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | EncT | DecT CPU |
| Class A1 | -9.26% | -13.15% | -18.91% | 160% | 56967% |
| Class A2 | -9.51% | -19.53% | -14.74% | 151% | 51368% |
| Class B | -8.59% | -19.05% | -20.78% | 158% | 57030% |
| Class C | -8.62% | -20.95% | -20.76% | 136% | 48210% |
| Class E |  |  |  |  |  |
| **Overall** | -8.91% | -18.47% | -19.19% | 151% | 53391% |
| Class D | -9.74% | -20.01% | -21.14% | 141% | 40159% |
| Class F | -3.79% | -12.18% | -11.09% | 191% | 23529% |
|  |  |  |  |  |  |
|  | **Low delay B Main10** | | | | |
|  | **BD-rate Over NNVC-3.0 anchor** | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | EncT | DecT CPU |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -7.78% | -18.19% | -20.35% | 144% | 56136% |
| Class C | -8.26% | -20.07% | -20.45% | 124% | 45792% |
| Class E | -8.89% | -15.66% | -16.70% | 217% | 47327% |
| **Overall** | -8.22% | -19.03% | -20.39% | 152% | 50260% |
| Class D | -9.61% | -18.73% | -20.58% | 133% | 39906% |
| Class F | -4.19% | -10.69% | -8.72% | 195% | 23635% |
|  |  |  |  |  |  |
|  | **All Intra Main10** | | | | |
|  | **BD-rate Over NNVC-3.0 anchor** | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | EncT | DecT CPU |
| Class A1 | -6.12% | -14.26% | -17.26% | 196% | 43391% |
| Class A2 | -5.73% | -15.81% | -12.98% | 168% | 33962% |
| Class B | -5.93% | -15.53% | -17.44% | 148% | 35682% |
| Class C | -6.40% | -16.42% | -18.16% | 129% | 21838% |
| Class E | -8.83% | -15.25% | -16.12% | 173% | 38475% |
| **Overall** | -6.51% | -15.52% | -16.61% | 158% | 33197% |
| Class D | -6.41% | -15.30% | -18.56% | 116% | 19535% |
| Class F | -4.02% | -11.81% | -11.71% | 128% | 29605% |

The following tables show NNVC-3.0 NN-based filter set #0 (int16 precision) performance over NCS-1.0 NN-based filter set #0.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | |
|  | **BD-rate Over NCS-1.0 filter set #0** | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | EncT | DecT CPU |
| Class A1 | -0.12% | 0.89% | -0.28% | 129% | 110% |
| Class A2 | -0.14% | -0.54% | -0.33% | 128% | 108% |
| Class B | -0.29% | -0.50% | -0.50% | 122% | 113% |
| Class C | -0.26% | -0.87% | -0.52% | 115% | 112% |
| Class E |  |  |  |  |  |
| **Overall** | -0.22% | -0.33% | -0.43% | 122% | 111% |
| Class D | -0.18% | -0.74% | -0.89% | 119% | 102% |
| Class F | -0.08% | -0.36% | -0.21% | 119% | 107% |
|  |  |  |  |  |  |
|  | **Low delay B Main10** | | | | |
|  | **BD-rate Over NCS-1.0 filter set #0** | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | EncT | DecT CPU |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -0.50% | -0.80% | -0.18% | 119% | 112% |
| Class C | -0.46% | 0.16% | -0.07% | 113% | 115% |
| Class E | -0.50% | 1.70% | -0.26% | 126% | 135% |
| **Overall** | -0.49% | -0.37% | -0.13% | 118% | 118% |
| Class D | -0.44% | 0.03% | -1.36% | 114% | 107% |
| Class F | -0.05% | -0.56% | 0.17% | 126% | 111% |
|  |  |  |  |  |  |
|  | **All Intra Main10** | | | | |
|  | **BD-rate Over NCS-1.0 filter set #0** | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | EncT | DecT CPU |
| Class A1 | 0.00% | 0.00% | 0.00% | 111% | 110% |
| Class A2 | 0.00% | 0.00% | 0.00% | 124% | 113% |
| Class B | 0.00% | 0.00% | 0.00% | 113% | 112% |
| Class C | 0.00% | 0.00% | 0.00% | 106% | 102% |
| Class E | 0.00% | 0.00% | 0.00% | 114% | 106% |
| **Overall** | 0.00% | 0.00% | 0.00% | 113% | 109% |
| Class D | 0.00% | 0.00% | 0.00% | 105% | 100% |
| Class F | 0.00% | 0.00% | 0.00% | 112% | 109% |

**Filter Set 1**

The following tables show NNVC-3.0 NN-based filter set #1 (int16 precision) performance over NNVC-3.0 anchor.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | |
|  | **BD-rate Over NNVC-3.0 anchor** | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | EncT | DecT CPU |
| Class A1 | -8.89% | -15.92% | -18.72% | 189% | 39242% |
| Class A2 | -10.23% | -20.25% | -17.44% | 177% | 35733% |
| Class B | -9.05% | -23.01% | -21.66% | 197% | 39779% |
| Class C | -9.92% | -21.77% | -22.30% | 166% | 36427% |
| Class E |  |  |  |  |  |
| **Overall** | -9.49% | -20.71% | -20.40% | 183% | 37928% |
| Class D | -11.48% | -23.64% | -23.95% | 167% | 32995% |
| Class F | -5.02% | -11.79% | -10.59% | 256% | 16584% |
|  |  |  |  |  |  |
|  | **Low delay B Main10** | | | | |
|  | **BD-rate Over NNVC-3.0 anchor** | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | EncT | DecT CPU |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -7.83% | -15.97% | -13.81% | 177% | 38000% |
| Class C | -9.14% | -15.25% | -14.54% | 154% | 35569% |
| Class E | -8.79% | -17.14% | -17.21% | 307% | 30032% |
| **Overall** | -8.51% | -15.65% | -14.14% | 194% | 35048% |
| Class D | -10.82% | -19.44% | -18.51% | 156% | 30052% |
| Class F | -4.94% | -9.35% | -6.37% | 249% | 16689% |
|  |  |  |  |  |  |
|  | **All Intra Main10** | | | | |
|  | **BD-rate Over NNVC-3.0 anchor** | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | EncT | DecT CPU |
| Class A1 | -6.59% | -17.96% | -19.97% | 173% | 28224% |
| Class A2 | -6.84% | -20.30% | -17.54% | 148% | 21252% |
| Class B | -6.82% | -21.91% | -21.71% | 142% | 22586% |
| Class C | -7.61% | -18.66% | -21.87% | 131% | 14756% |
| Class E | -10.20% | -20.84% | -20.64% | 151% | 24992% |
| **Overall** | -7.52% | -20.08% | -20.58% | 147% | 21469% |
| Class D | -7.46% | -19.01% | -21.05% | 118% | 12569% |
| Class F | -5.28% | -11.80% | -10.96% | 124% | 19230% |

The following tables show NNVC-3.0 NN-based filter set #1 (int16 precision) performance over NCS-1.0 NN-based filter set #1.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Random access Main10** | | | | |
|  | **BD-rate Over NCS-1.0 filter set #1** | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | EncT | DecT CPU |
| Class A1 | 0.03% | 0.04% | -0.25% | 111% | 105% |
| Class A2 | -0.09% | -0.05% | -0.16% | 112% | 105% |
| Class B | -0.05% | 0.06% | 0.08% | 114% | 108% |
| Class C | -0.11% | 0.01% | 0.04% | 103% | 103% |
| Class E |  |  |  |  |  |
| **Overall** | -0.06% | 0.02% | -0.04% | 110% | 105% |
| Class D | -0.05% | -0.18% | -0.09% | 100% | 105% |
| Class F | -0.35% | -0.10% | 0.09% | 105% | 95% |
|  |  |  |  |  |  |
|  | **Low delay B Main10** | | | | |
|  | **BD-rate Over NCS-1.0 filter set #1** | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | EncT | DecT CPU |
| Class A1 |  |  |  |  |  |
| Class A2 |  |  |  |  |  |
| Class B | -0.03% | 0.02% | 0.24% | 107% | 102% |
| Class C | -0.04% | -0.06% | 0.40% | 108% | 109% |
| Class E | -0.18% | 0.13% | -0.13% | 111% | 107% |
| **Overall** | -0.07% | -0.02% | 0.31% | 108% | 106% |
| Class D | -0.05% | -0.80% | -0.56% | 101% | 104% |
| Class F | 0.00% | -0.26% | -0.21% | 110% | 107% |
|  |  |  |  |  |  |
|  | **All Intra Main10** | | | | |
|  | **BD-rate Over NCS-1.0 filter set #1** | | | | |
|  | Y-PSNR | U-PSNR | V-PSNR | EncT | DecT CPU |
| Class A1 | -0.14% | -0.05% | -0.13% | 98% | 88% |
| Class A2 | -0.37% | 0.19% | 0.33% | 106% | 86% |
| Class B | -0.32% | -0.11% | -0.22% | 103% | 86% |
| Class C | -0.24% | 0.23% | -0.15% | 94% | 82% |
| Class E | -0.37% | 0.01% | 0.03% | 97% | 85% |
| **Overall** | -0.29% | 0.05% | -0.06% | 100% | 85% |
| Class D | -0.15% | 0.55% | 0.42% | 88% | 82% |
| Class F | -1.24% | -0.04% | -0.02% | 104% | 107% |

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

1. **Discussions**

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

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

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 pointed out that training scripts should be aligned/merged with the base software, and not come as separate packages.

It was suggested to develop more formal “software guidelines” for NNVC (new mandate).

[JVET-AC0015](https://jvet-experts.org/doc_end_user/current_document.php?id=12257) JVET AHG report: Optimization of encoders and receiving systems for machine analysis of coded video content (AHG15) [C. Hollmann, S. Liu, S. Wang, M. Zhou (AHG chairs)]

There are nine input contriubtions related to AHG15 mandates submitted to this meeting. They are listed below.

***Common Test Conditions***

Draft common test conditions (CTC) for AHG15: Optimization of encoders and receiving systems for machine analysis of coded video content, are summarized in document JVET-AC0073. This document includes detailed descriptions of test datasets, anchor software and configurations, anchor generation processes, machine task networks used, test and training conditions, evaluation methodologies and metrics. A reporting template in Excel format and a set of configuration files are also included in the same contribution package.

**Test datasets**

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

The SFU-HW (SFU-HW-objects-v1) dataset is a video dataset consisting of 17 sequences which are known from previous standardization efforts in JCT-VC and JVET. The sequences can be found on <ftp://hevc@mpeg.tnt.uni-hannover.de>. The annotations are available at <https://data.mendeley.com/datasets/hwm673bv4m/1>.

The Tencent Video Dataset (TVD) is a video dataset consisting of three sequences in 1920x1080 resolution used for object tracking with lengths of 3000, 636 and 2334 frames, respectively. An overview of the three sequences can be found in Table 3 of JVET-AC0073. The dataset with corresponding annotations is available at <https://multimedia.tencent.com/resources/tvd>.

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

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

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

More detailed information about these test datasets can be found in JVET-AC0073.

**Anchor software**

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

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

**Anchor configuration**

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

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

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

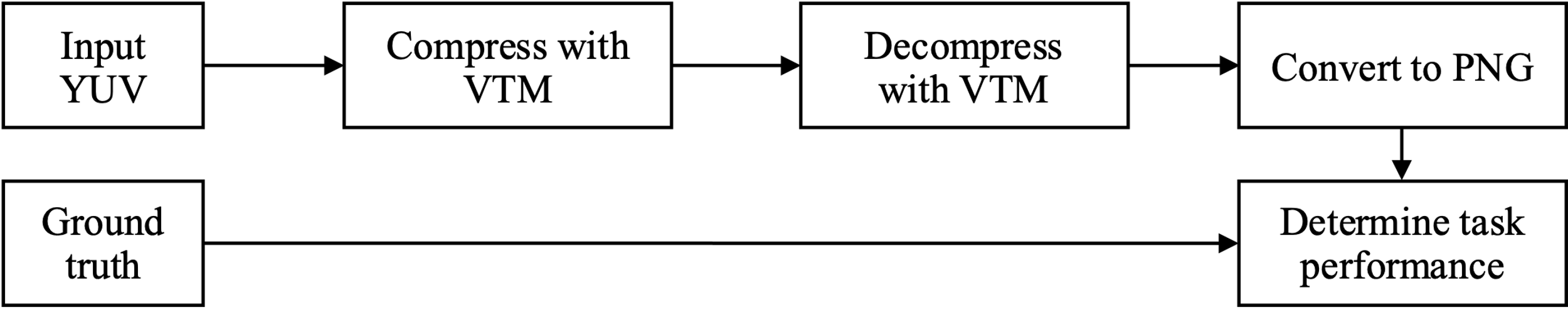


Figure 1. Anchor generation pipeline

The process to generate anchor results is described in Figure 1. Detailed description about anchor generation process is referred to JVET-AC0073. It is worthwhile to mention that for machine consumption, machine task networks are applied to compressed and reconstructed videos to obtain corresponding machine task performance. The task network Faster R-CNN X101-FPN which is part of Detectron2 (<https://github.com/facebookresearch/detectron2>) is used to evaluate object detection (SFU-HW dataset and image dataset), the model is available [here](https://dl.fbaipublicfiles.com/detectron2/COCO-Detection/faster_rcnn_X_101_32x8d_FPN_3x/139173657/model_final_68b088.pkl). The task network JDE-1088x608 which is part of the Towards Realtime MOT framework (<https://github.com/Zhongdao/Towards-Realtime-MOT>) is used to evaluate object tracking (TVD dataset), the model is available [here](https://drive.google.com/open?id=1nlnuYfGNuHWZztQHXwVZSL_FvfE551pA). More details about these machine task networks and how they are used for AHG15 anchor generation are in referred to JVET-AC0073.

**Evaluation methodology and metrics**

Proposed technologies are evaluated based on their compression performance, measured by bitrate, PSNR, mAP and MOTA, as well as encoding and decoding runtime to reflect the complexity of the proposed technology, to some extent. Definitions and detailed descriptions of these metrics can be found in JVET-AC0073. It is noted that the mean Average Precision (mAP) is used to measure object detection performance, and Multiple Object Tracking Accuracy (MOTA) is used to measure object tracking performance.

For the purpose of reporting encoding and decoding running times, the anchor and proposal should be simulated on the same platform, e.g. similar CPU and GPU configuration, to have reliable time comparison. Parallel encoding and decoding as described in JVET-B0036 may be applied for RA configurations.

In addition, relevant inference and training information should be reported if the proposed technology consists of learning-based components, such as network structure, number of network parameters, precision of network parameters, number of multiply–accumulate operations (MAC) per pixel, patch size, batch size, epoch, training time, training datasets, lost function, number of iterations, optimizer, and any pre- and post-processings used. More details can be found in JVET-AC0073.

**Reporting template**

A reporting template in Excel file format has been prepared to illustrate results following CTC and evaluation methodology described in JVET-AC0073. It is attached in JVET-AC0073 package.



Figure 2. Reporting template summary

***Anchor Results***

Anchor results were generated following the CTC described in JVET-AC0073 and crosschecked by Tencent and Ericsson.

***Technical Report Preparation***

An initial draft of technical report has been prepared and uploaded as JVET-AC0049.

***AHG Coordination***

Offline discussions were conducted about harmonization and difference on testing materials and conditions between this AHG and the VCM AHG in WG4.

**Input contributions**

There are nine input contriubtions related to AHG15 mandates. They are listed below.

|  |  |  |
| --- | --- | --- |
| **Report** | | |
| JVET-AC0015 | JVET AHG report: Optimization of encoders and receiving systems for machine analysis of coded video content (AHG15) | C. Hollmann, S. Liu, S. Wang, M. Zhou (AHG chairs) |
| **Proposal** | | |
| JVET-AC0049 | [AHG15] Draft technical report on optimizations for encoders and receiving systems for machine analysis of coded video content | [C. Hollmann (Ericsson)](mailto:christopher.hollmann@ericsson.com), [S. Liu (Tencent)](mailto:shanl@tencent.com), [S. Wang (Alibaba)](mailto:shurun.wsr@alibaba-inc.com) |
| JVET-AC0073 | AHG15: On common test conditions for optimization of encoders and receiving systems for machine analysis of coded video content | [S. Liu (Tencent)](mailto:shanl@tencent.com), [C. Hollmann (Ericsson)](mailto:christopher.hollmann@ericsson.com) |
| JVET-AC0076 | AHG9/AHG15: On the NNPFC SEI message for machine analysis | [M. M. Hannuksela](mailto:miska.hannuksela@nokia.com), F. Cricri, J. I. Ahonen, H. Zhang (Nokia) |
| JVET-AC0077 | AHG9/AHG15: On bitstreams that are potentially suboptimal for user viewing | [M. M. Hannuksela](mailto:miska.hannuksela@nokia.com), F. Cricri, H. Zhang (Nokia) |
| JVET-AC0079 | [AHG15] Effect of the perceptual QP adaptation (QPA) on machine task performance | C. Kim, D. Gwak, J. Lim (LGE) |
| JVET-AC0086 | AHG15: Feature based Encoder-only algorithms for the Video Coding for Machines | [B. Li](mailto:libinzhe.lbz@alibaba-inc.com), [S. Wang](mailto:shurun.wsr@alibaba-inc.com), [Y. Ye (Alibaba)](mailto:yan.ye@alibaba-inc.com), [S. Wang (CityU)](mailto:shiqwang@cityu.edu.hk) |
| JVET-AC0092 | AHG15: Investigations on the common test conditions of Video Coding for Machines (VCM) | [S. Wang](mailto:srwang3-c@my.cityu.edu.hk), [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) |
| **Information** | | |
| JVET-AC0050 | [AHG15] Information about datasets used in VCM | [C. Hollmann (Ericsson)](mailto:christopher.hollmann@ericsson.com) |

**Recommendations**

The AHG recommends:

* Review all input contributions.
* Discuss and refine test conditions, evalution and reporting procedures.
* Discuss and refine anchor generation processes and results.
* Discuss existing and continue collecting new test materials.
* Discuss and establish software development and experiment environment.
* 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.

# Project development (25)

## Deployment and advertisement of standards (2)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0020](https://jvet-experts.org/doc_end_user/current_document.php?id=12354) Deployment status of the HEVC standard [G. J. Sullivan (SC 29 chair)]

[JVET-AC0021](https://jvet-experts.org/doc_end_user/current_document.php?id=12355) Deployment status of the VVC standard [G. J. Sullivan (SC 29 chair)]

## Text development and errata reporting (1)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0275](https://jvet-experts.org/doc_end_user/current_document.php?id=12480) AHG9: Comments on VVC 2nd Ed. DAM1 [M. M. Hannuksela, M. Santamaria (Nokia)] [late]

Input expected on the SMPTE 2128 color conversion clarification related to JVET-AB1008 (W. Husak to take action). Revisit.

Input expected on some of the tickets/errata items reported in JVET-AB0002 (Hendry/Y. Sanchez/Y.-K. Wang to take action). Revisit.

## Test conditions (3)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0041](https://jvet-experts.org/doc_end_user/current_document.php?id=12226) [AHG4] On visual volumetric video-based coding (V3C) testing conditions [S. Schwarz, M. M. Hannuksela, P. Rondao Alface, L. Kondrad, L. Ilola (Nokia)]

[JVET-AC0044](https://jvet-experts.org/doc_end_user/current_document.php?id=12229) [AHG4] Occupancy-only PSNR calculations for V3C V-PCC coding evaluation [S. Schwarz, M. M. Hannuksela (Nokia)]

[JVET-AC0137](https://jvet-experts.org/doc_end_user/current_document.php?id=12339) AHG3: On Affine AMVR setting for VTM CTC [X. Li (Google)]

[JVET-AC0256](https://jvet-experts.org/doc_end_user/current_document.php?id=12461) Cross-check of JVET-AC0137: On Affine AMVR setting for VTM CTC [A. Henkel (HHI)] [late]

## Subjective quality testing and verification testing (5)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0042](https://jvet-experts.org/doc_end_user/current_document.php?id=12227) AHG4: Report on AHG meeting on verification test preparation for VVC multilayer coding [M. Wien (RWTH)]

[JVET-AC0043](https://jvet-experts.org/doc_end_user/current_document.php?id=12228) AHG4: Report on AHG meeting on subjective test preparation for film grain synthesis [M. Wien (RWTH)]

[JVET-AC0145](https://jvet-experts.org/doc_end_user/current_document.php?id=12347) AHG4: experiments in preparation of dual-layer VVC visual tests [P. de Lagrange (InterDigital)]

[JVET-AC0181](https://jvet-experts.org/doc_end_user/current_document.php?id=12385) AHG4: experiments in preparation of film grain visual tests [P. de Lagrange (InterDigital)]

[JVET-AC0199](https://jvet-experts.org/doc_end_user/current_document.php?id=12403) AHG13: On Film Grain Synthesis Subjective Evaluation [X. Meng, W. Zhang, S. Labrozzi (Disney Streaming)] [late]

Initial version rejected as “placeholder”.

## Test material (0)

This section is kept as a template for future use.

## Quality assessment methodology (1)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0267](https://jvet-experts.org/doc_end_user/current_document.php?id=12472) Training Methods in Visual Assessment: Potential Improvements for Expert Viewing Tests [M. Wien (RWTH), V. Baroncini (VABTech)] [late]

## Conformance test development (0)

This section is kept as a template for future use.

## Software development (3)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0057](https://jvet-experts.org/doc_end_user/current_document.php?id=12256) AhG14 SADL v4 changes [F. Galpin, T. Dumas, P. Bordes, E. François (InterDigital)] [late]

[JVET-AC0166](https://jvet-experts.org/doc_end_user/current_document.php?id=12370) AHG3: Guidelines for VVC reference software development [F. Bossen, X. Li, K. Sühring (software coordinators)]

[JVET-AC0204](https://jvet-experts.org/doc_end_user/current_document.php?id=12408) AHG3: Guidelines for HEVC reference software development [K. Sühring, F. Bossen, X. Li (software coordinators)]

## Implementation studies and complexity analysis (1)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0266](https://jvet-experts.org/doc_end_user/current_document.php?id=12471) Update on open, optimized VVC implementations VVenC and VVdeC [A. Wieckowski, J. Brandenburg, C. Bartnik, V. George, J. Güther, G. Hege, C. Helmrich, A. Henkel, T. Hinz, C. Lehmann, C. Stoffers, B. Bross, H. Schwarz, D. Marpe, T. Schierl (HHI)] [late]

## AHG7: Low latency and constrained complexity (1)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0180](https://jvet-experts.org/doc_end_user/current_document.php?id=12384) AHG 7: Reference frame padding for GDR [T. Poirier, F. Aumont (InterDigital)]

## AHG10: Encoding algorithm optimization (3)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0096](https://jvet-experts.org/doc_end_user/current_document.php?id=12298) AHG10/12: Suggestion for new CTC for RPR in VTM and ECM [K. Andersson, R. Yu (Ericsson)]

[JVET-AC0139](https://jvet-experts.org/doc_end_user/current_document.php?id=12341) AHG10: Encoder Optimization of VTM Merge Functions [X. Li (Google)]

[JVET-AC0149](https://jvet-experts.org/doc_end_user/current_document.php?id=12351) AHG10/12: Reduced I-frame QP for RA [K. Andersson, P. Wennersten (Ericsson)]

[JVET-AC0255](https://jvet-experts.org/doc_end_user/current_document.php?id=12460) Cross-check of JVET-AC0149: AHG10/12: Reduced I-frame QP for RA [A. Henkel (HHI)] [late]

## Profile/tier/level specification (0)

This section is kept as a template for future use.

## Proposed modification of system interface (0)

This section is kept as a template for future use.

## AHG15: Optimization of encoders and receiving systems for machine analysis of coded video content (8)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0049](https://jvet-experts.org/doc_end_user/current_document.php?id=12234) [AHG15] Draft technical report on optimizations for encoders and receiving systems for machine analysis of coded video content [C. Hollmann (Ericsson), S. Liu (Tencent), S. Wang (Alibaba)]

[JVET-AC0050](https://jvet-experts.org/doc_end_user/current_document.php?id=12235) [AHG15] Information about datasets used in VCM [C. Hollmann (Ericsson)]

[JVET-AC0073](https://jvet-experts.org/doc_end_user/current_document.php?id=12275) AHG15: On common test conditions for optimization of encoders and receiving systems for machine analysis of coded video content [S. Liu (Tencent), C. Hollmann (Ericsson)]

[JVET-AC0076](https://jvet-experts.org/doc_end_user/current_document.php?id=12278) AHG9/AHG15: On the NNPFC SEI message for machine analysis [M. M. Hannuksela, F. Cricri, J. I. Ahonen, H. Zhang (Nokia)]

[JVET-AC0077](https://jvet-experts.org/doc_end_user/current_document.php?id=12279) AHG9/AHG15: On bitstreams that are potentially suboptimal for user viewing [M. M. Hannuksela, F. Cricri, H. Zhang (Nokia)]

[JVET-AC0079](https://jvet-experts.org/doc_end_user/current_document.php?id=12281) [AHG15] Effect of the perceptual QP adaptation (QPA) on machine task performance [C. Kim, D. Gwak, J. Lim (LGE)]

[JVET-AC0086](https://jvet-experts.org/doc_end_user/current_document.php?id=12288) AHG15: Feature based Encoder-only algorithms for the Video Coding for Machines [B. Li, S. Wang, Y. Ye (Alibaba), S. Wang (CityU HK)]

[JVET-AC0092](https://jvet-experts.org/doc_end_user/current_document.php?id=12294) AHG15: Investigations on the common test conditions of Video Coding for Machines (VCM) [S. Wang, J. Chen, Y. Ye (Alibaba), S. Wang (CityU HK)]

# Low-level tool technology proposals

## AHG8: High bit rate and high bit depth coding for VVC (0)

This section is kept as a template for future use. The possibility of removing this section and discontinuing AHG8 was considered, but AHG8 was reconstituted for another meeting cycle.

## AHG11: Neural network-based video coding (28)

### Summary, BoG reports, and information documents

Contributions in this area were discussed in session 3 at 2100–2315 UTC and in session 4 at 2335–2355 UTC on Wednesday 11 Jan. 2023 (chaired by JRO).

[JVET-AC0023](https://jvet-experts.org/doc_end_user/current_document.php?id=12258) EE1: Summary report of exploration experiments on neural network-based video coding [E. Alshina, F. Galpin, Y. Li, M. Santamaria, J. Ström, H. Wang, L. Wang, Z. Xie (EE coordinators)]

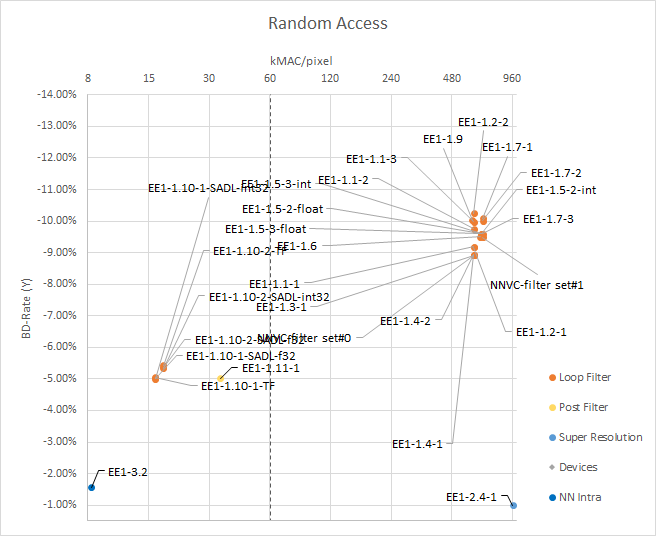
This document summarizes Exploration Experiment 1 (EE1) tests performed between the JVET-AB and JVET-AC meetings to evaluate **Neural Network-based Video Coding (**NNVC) technologies, analyze their performance and complexity aspects. EE1 conducted tests in three categories: NN-based in-loop and post-filters, adaptive resolution coding with “classical” and NN-based filters, NN-based Intra coding. Average across JVET test set compression gain over VVC anchor achieved in those categories for random access configuration is 10.2% (filters), 2.1% (adaptive resolution coding with NN-re-sampler), 1.6% (NN-based Intra).

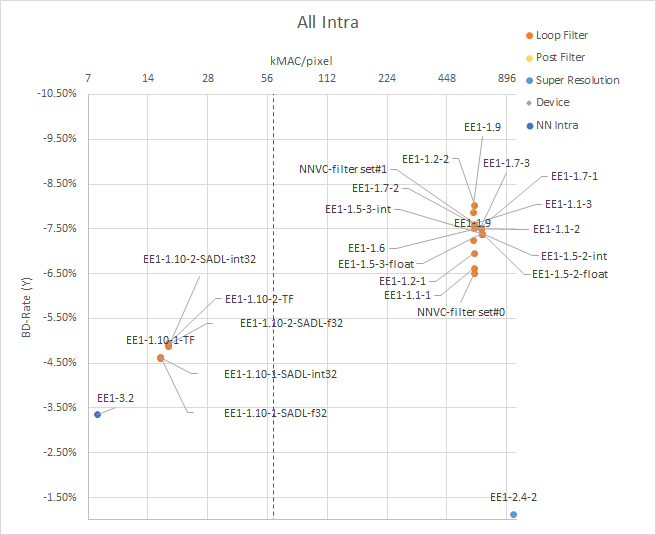
NNVC common SW base (***NNVC***) and training scripts are highly encouraged to be used by all EE1 proponents. All proponents were asked to report results relatively to the AhG11 anchor NNVC-3.0 [1] and use up-to-date version of results reporting template recommended by AhG11. It was the case for all EE1 test except test on end-to-end AI picture coding (which was tested using very different test conditions). Some proponents still don’t report MS-SSIM metric, even support for it was added long time ago.

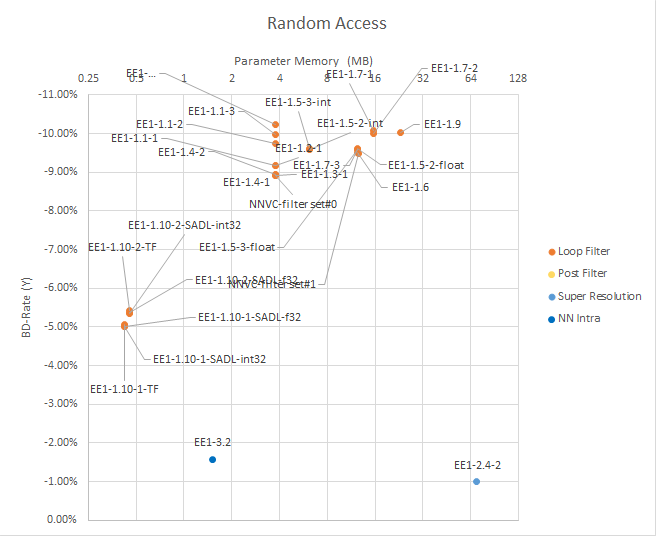
During this round of Exploration Experiment tests were massively cross-checked, which indicates that more and more JVET members become familiar with testing and training NN-based video coding technologies. Massive cross-check was performed for both model training and for inference (coding).

In testing the performance difference up to 0.1% BD-rate is reported. It must be asserted that with NN-based filters enabled in NNVC SW same level of performance deviation is observed (even for quantized to int16 models). It was explained by NNVC SW coordinators that issue is known and likely called by usage of different compilers. Hopefully this issue will be solved in AhG14.

The most promising technologies recommended by JVET **undergo procedure of cross-check for the training**. If NN model was re-trained by cross-checker and then in test performance difference between model from proponent and cross-checker is even larger (up to 0.5 %).





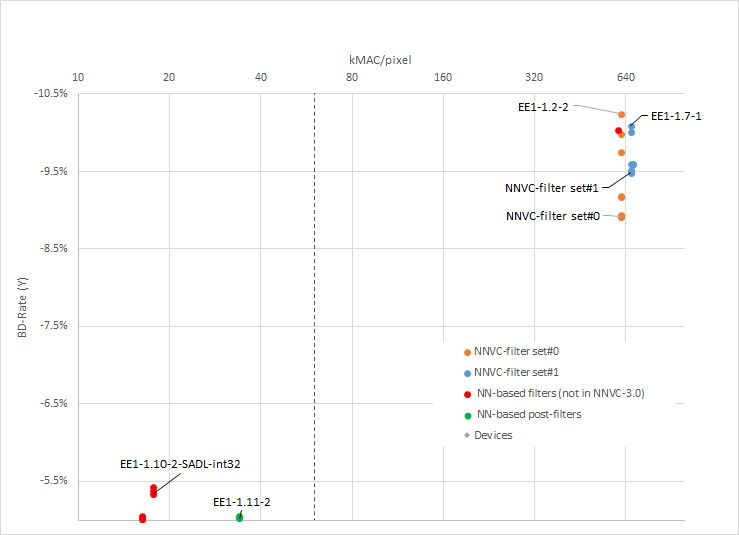


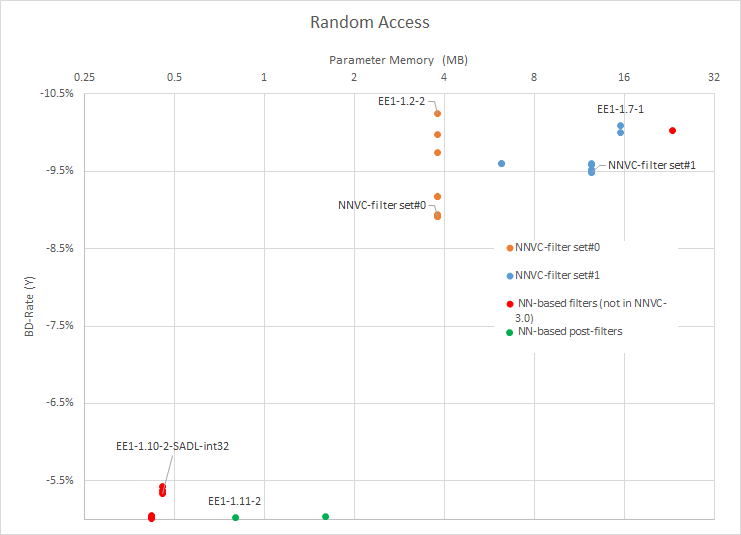
*Figure 1 Complexity performance analysis of all EE1 test: Random Access cfg BD-rate vs kMAC/pxl (top), All intra cfg. BD-rate vs kMAC/pxl (middle), Random Access cfgBD-rate vs kMAC/pxl (bottom).*

Complexity for all EE1 test has been analyzed and summarized according to AhG 11 recommendations. BD-rate vs computational complexity (kMAC/pxl) and total memory for model parameters is shown in Figure 1.

1. **Exploration experiments on Enhancement filters**

There are two technologies in this category, which are part of NNVC SW, known as ***filter set #0*** and ***filter set#1***. Those technologies are clustering around level of complexity 600~700 kMAC/pxl and demonstrate BD-rate gain vs VVC anchor 9~10%. ***Filter set#0*** filters family got slightly higher performance improvement during this EE1 round (compare to ***filter set#1*** family) w/o increment kMAC/pxl and memory.

**



*Figure 2 Typical representatives of exploration experiment tests on NN-based enhancement filters: BD-rate gain over VVC in random access configuration vs kMAC/px (top); vs total memory size for all models (bottom).*

***NNVC filter set#0 based***

*Table 1 EE1 tests for filter set#0 architecture*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| EE1- Test | document | Random access, AhG11 CTC | | | All Intra, AhG11 CTC | | |
| Y | Cb | Cr | Y | Cb | Cr |
| **NNVC-filter set#0** | **[JVET-AC0014](https://jvet-experts.org/doc_end_user/current_document.php?id=12255)** | **-8.9%** | **-18.5%** | **-19.2%** | **-6.5%** | **-15.5%** | **-16.6%** |
| EE1-1.1-1 | [JVET-AC0194](https://jvet-experts.org/doc_end_user/current_document.php?id=12398) | -9.2% | -19.6% | -19.2% | -6.6% | -15.3% | -16.4% |
| EE1-1.1-2 | [JVET-AC0194](https://jvet-experts.org/doc_end_user/current_document.php?id=12398) | -9.8% | -21.1% | -20.6% | -7.5% | -16.8% | -17.4% |
| EE1-1.1-3 | [JVET-AC0194](https://jvet-experts.org/doc_end_user/current_document.php?id=12398) | -10.0% | -21.4% | -20.9% | -7.6% | -16.7% | -17.5% |
| EE1-1.2-1 | [JVET-AC0195](https://jvet-experts.org/doc_end_user/current_document.php?id=12399) | -9.2% | -18.5% | -19.2% | -7.0% | -15.6% | -16.7% |
| EE1-1.2-2 | [JVET-AC0195](https://jvet-experts.org/doc_end_user/current_document.php?id=12399) | -10.2% | -21.4% | -20.9% | -8.0% | -16.8% | -17.6% |
| EE1-1.3-1 | [JVET-AC0063](https://jvet-experts.org/doc_end_user/current_document.php?id=12265) | -8.9% | -19.7% | -19.7% |  |  |  |
| EE1-1.4-1 | [JVET-AC0064](https://jvet-experts.org/doc_end_user/current_document.php?id=12266) | -8.9% | -19.4% | -19.4% |  |  |  |
| EE1-1.4-2 | [JVET-AC0064](https://jvet-experts.org/doc_end_user/current_document.php?id=12266) | -8.9% | -20.2% | -19.9% |  |  |  |

In all tests NN parameters precision is Int 16, total number of parameters is 1.9 Million, computational complexity 615 kMAC/pxl (assuming block wise processing).

**EE1-1.1** is about filter set#0 model refinement to address change in NNVC CTC (enabling EncDbOpt). Performance of filter set#0 improved by 1.2% (all configuration) in test EE1-1.1-3 called real-iterative training. This training hint looks useful and deserves to be presented and explained to the group in details.

**EE1-1.2** consideration of filter application is RDO process. In RDO simplified model is used. Similar encoder only technology is already part of NNVC for ***filter set #1***. Performance improvement from encoder only change is 0.3% (RA cfg). The combination with “normative” modifications from EE1-1.1-3 improves performance of ***filter set#0*** by 1.5%. The best in ***filter set#0*** family test EE1-1.2.2 achieves 10.2% gain over VVC anchor; computational complexity 615 kMAC/pxl, only one model with 1.9 M parameters.

In test **EE1-1.3** Chroma components are swapped prior to start NN-based filter, so filter trained for “Cr” component is used for “Cb” (and vice versa). Experiment was done for both filter architectures in NNVC. BD-rate gain is mostly visible for Chroma component (1...2%).

In test **EE1-1.4** residual adjustment by reducing residual magnitude by value {1, 2} (content adaptively). Performance improvement looks not that impressive for random access configuration, but in low-delay B configuration the gain of this tool is 0.9% (on top of ***NNVC filter set#0***). This fact indicates the lack of NNVC filters adaptively or not sufficient enough training of them for low-delay use case.

***NNVC filter set#1 based***

*Table 2 1 EE1 tests for filter set#1 architecture*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| EE1-test | document | Total params, M | kMAC/pxl | Random access, AhG11 CTC | | | All Intra, AhG11 CTC | | |
| Y | Cb | Cr | Y | Cb | Cr |
| **filter set#1** | **[JVET-AC0014](https://jvet-experts.org/doc_end_user/current_document.php?id=12255)** | **6.2** | **664** | **-9.5%** | **-20.7%** | **-20.4%** | **-7.5%** | **-20.1%** | **-20.6%** |
| 1.5-2 float | [JVET-AC0089](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0089-v1.zip) | 3.1 | 677 | -9.6% | -21.3% | -22.0% | -7.4% | -18.2% | -20.0% |
| 1.5-2 int16 | [JVET-AC0089](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0089-v1.zip) | 3.1 | 677 | -9.6% | -21.0% | -22.1% | -7.4% | -18.3% | -20.1% |
| 1.5-3 float | [JVET-AC0089](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0089-v1.zip) | 3.1 | 673 | -9.6% | -21.0% | -21.5% | -7.4% | -18.2% | -19.9% |
| 1.5-3 int16 | [JVET-AC0089](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0089-v1.zip) | 3.1 | 673 | -9.6% | -20.9% | -21.5% | -7.4% | -18.3% | -19.9% |
| 1.6 int16 | [JVET-AC0143](https://jvet-experts.org/doc_end_user/current_document.php?id=12345) | 6.2 | 664 | -9.5% | -20.7% | -20.4% | -7.5% | -20.0% | -20.8% |
| 1.7-1 int16 | [JVET-AC0177](https://jvet-experts.org/doc_end_user/current_document.php?id=12381) | 7.8 | 664 | -10.1% | -20.7% | -20.4% | -7.5% | -20.1% | -20.6% |
| 1.7-2 int16 | [JVET-AC0177](https://jvet-experts.org/doc_end_user/current_document.php?id=12381) | 7.8 | 664 | -10.0% | -20.7% | -20.4% | -7.5% | -20.1% | -20.6% |
| 1.7-3 int16 | [JVET-AC0177](https://jvet-experts.org/doc_end_user/current_document.php?id=12381) | 6.2 | 664 | -9.6% | -20.7% | -20.3% | -7.5% | -20.1% | -20.6% |
| 1.8 int16 | [JVET-AC0118](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0118-v1.zip) | 6.2 | 664 |  |  |  | -7.5% | -20.6% | -21.3% |

In test **EE1-1.5** same model is used for intra and inter (both Luma and Chroma), NNVC filter set#1 architecture slightly modified by removing attention modules. So, total size of memory needed for NNVC filter set #1 is reduced by half, computational complexity (kMAC/pxl) about the same; compression performance of ***NNVC filter set#1*** preserved (or even slightly better). Architecture with and w/o IBP information as input to Chroma NNVC filter network was tried, performance difference is very small. Cross-check for training is still running. Inference results have been cross-checked. Modification is recommended to be considered for adoption to NNVC (need to complete training cross-check).

Test **EE1-1.6** shows that partitioning information can be safely (w/o performance drop) removed from Intra Chroma models in ***NNVC filter set#1***. In the inter chroma model, there is already no partitioning input. The training and inference were cross-checked. After re-training, the BD-rates between proponent and cross-checker deviate up to 0.05% in luma and 0.20% in chroma.

Test **EE1-1.7** studies two aspects: 1) adding reference frame as extra input to ***NNVC filter set#1***; 2) flipping input to ***NNVC filter set#1.*** Aspect#1 provides gain of 0.6% (but extra model is used and so total memory size for filter set#1 increases (6.2 🡪 7.8 million parameters). Aspect#2 provides 0.1% (RA) /0.2% (LDB) gain, doesn’t increase number of multiplications or memory for filter parameters. The best in ***filter set#1*** family test EE1-1.7.1 achieves 10.1% gain over VVC anchor; computational complexity 664 kMAC/pxl, five models with 7.8 M parameters (instead of four in the original filter set#1).

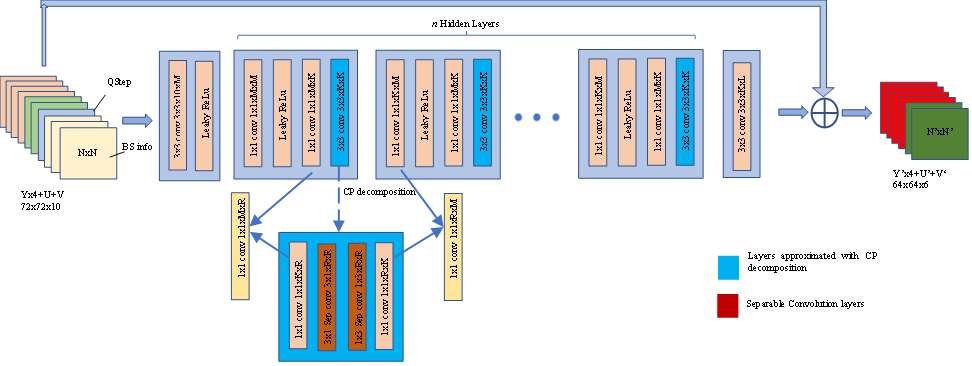
In test **EE1-1.8** loss function in training was modified: weighted sum of L1 and L2 was used, weight depends on QP. Some minor Chroma gain is observed. (no results for RA)

***Not in NNVC NN-filters***

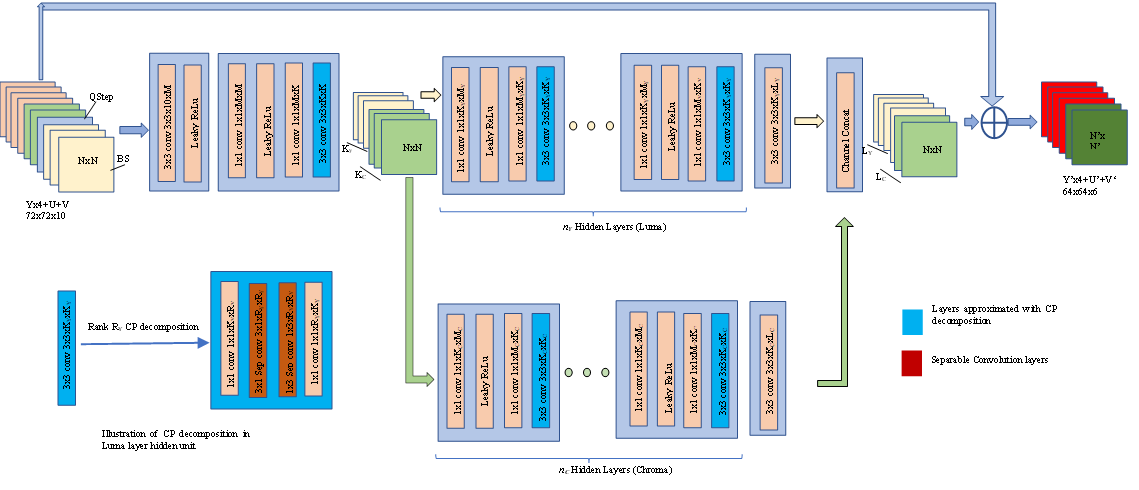
Experiment **EE1-1.9** is trying to combine network architecture design elements of filter ***filter set #0*** and ***filter set#1***. Gain and complexity are at the same level with filters already included into NNVC.

Filters tested in experiment **EE1-1.10** operate at ~30 times smaller computational complexity and ~20 times smaller model size compared to filters in NNVC SW, demonstrating promising 5% BD-rate gain over VVC anchor.

This filter is not yet cross-checked. Key elements of two variants of low complexity NN-based filter design in EE1-1.10 are decomposition if 2D convolution (3×3) to the sequence of two 1D convolution (3×1 and 1×3) separable convolutions with same number of channels (R=K) coupled with linear fusion of adjacent 1x1 convolutions and split of Luma and Chroma layers (Chroma layers uses less channels). Details of simple NN-based filter in EE1-10 are shown of figures below. Note that 3x1 and 1x3 convolutions are both spatial and depth-wise separable.



*Figure 3 CP Decomposition + fusion of 1x1 conv layers of JVET-X0140 Baseline Model*



*Figure 4 Split luma and chroma model + CP Decomposition + fusion of 1x1 conv layer*

**Test 1.10.1** Test the model with CP decomposition and fusing adjacent 1x1 convolution with following model parameters:

* Number of hidden layers: n = 11
* Feature maps and rank: K = 24, R = 24, M = 72
* Model complexity = 16.2 kMAC/pixel

**Test** **1.10.2** Test the model with CP decomposition, fusing adjacent 1x1 convolution and split architecture for luma and chroma components with following model parameters:

* Number of hidden layers for luma and chroma: nY = nC = 10
* Feature maps and rank for luma and chroma split (24L, 8C):
  + Luma: KY = 24, RY = 24, MY = 72
  + Chroma: KC = 8, RC = 8, MC = 24
* Model complexity: 17.7 kMAC/pixel

***NN-based post-filters***

Post-filter in experiment **EE1-1.11** was recommended for the cross-check of training. Retraining was done by proponent. Performance deviation from original proposal after re-training is up 0.5%, this issue is under investigation jointly by proponent and cross-checker.

It was verbally reported that a part of the problem coul be the way of extracting training data (e.g., 8- to 10-bit conversion for some of the data).

Recommendations from the summary report:

* Proponents should ensure smooth integration of adopted NN-based tools to NNVC SW (including well described training scripts)
* Adopt improvements in EE1-1.2 for NNVC filter set #0 verified though this round of EE1 (a total of 1.5% gain by a combination of RDO optimization which gives approx. 0.3% and iterative training which gives the remaining gain) – revisit: Candidate for adoption, contribution JVET-AC0195 to be reviewed – is the training cross-checked already?
* Adopt improvements EE1-1.5 and EE1-1.7 for NNVC filter set #1 verified though this round of EE1; EE-1.5 reduces number of models from 4 to 2 without performance degradation, but has not been fully cross-checked (revisit after cross-check is finished); EE-1.7 gives gain, but also increases the number of models from 4 to 5. It might not be a good tradeoff standalone, but might be combined with EE-1.5, but there is no proposal for such a combination.
* Establish training cross-check for of EE1-1.10 (simple NN-based filter) in the next round of EE – this could be attractive as another point of lower-complexity operation in the NNVC software.
* Adopt EE1-1.4 for the next version of NNVC SW as generic technique improving performance of NN-based filters (it does not give relevant gain for RA and AI, but gives gain for LB, but this could be due to the fact that no LB data were used in training) – further investigate in EE, also on top of EE1-1.2
* Adopt EE1-1.11 for the next version of NNVC SW as an example of post-filter (revisit after clarification of cross-check)

As a general remark, it would be desirable to have only one filter architecture in the range of “High complexity/high gain” in NNVC. Currently, the combination idea for both filter sets (EE1-1.9) is not competitive with the best-performing versions of the standalone sets from the EE. It should be further studied in the next EE if some of the aspects such as RDO optimization and iterative training would be beneficial for this method as well. Revisit: Contribution JVET-AC0155 would be of interest to be reviewed.

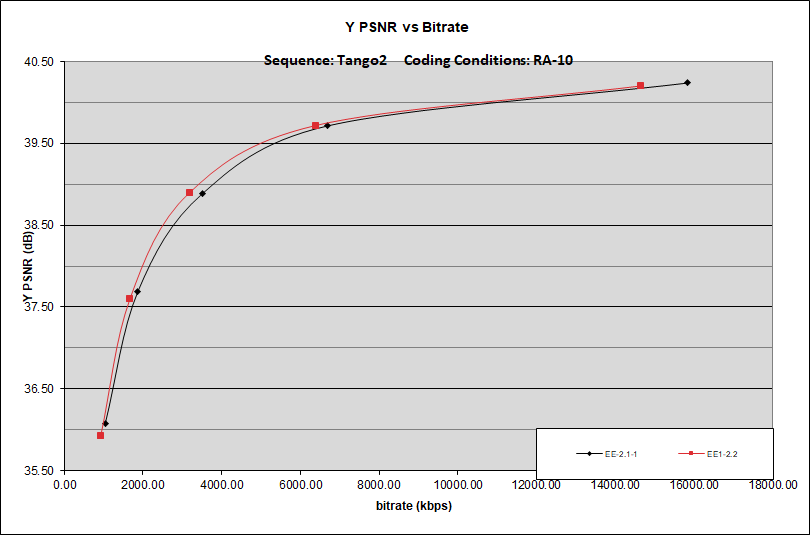
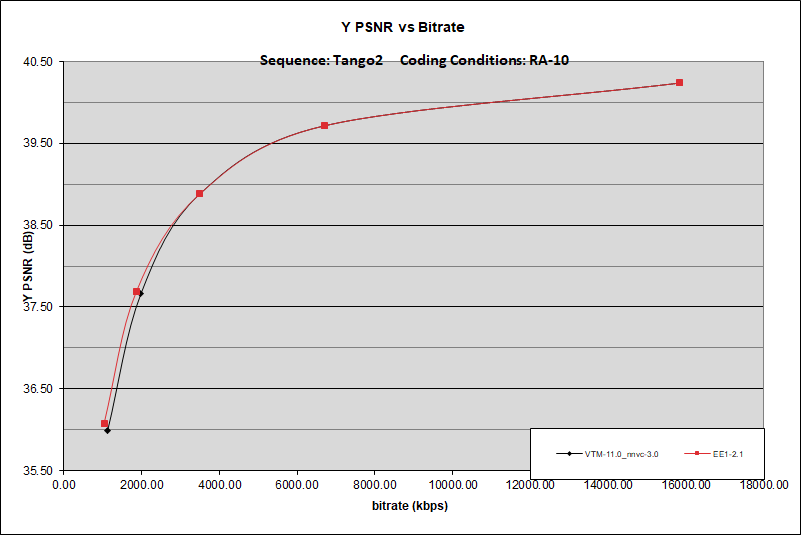
**Adaptive resolution coding and super-resolution NN-based post-filters**

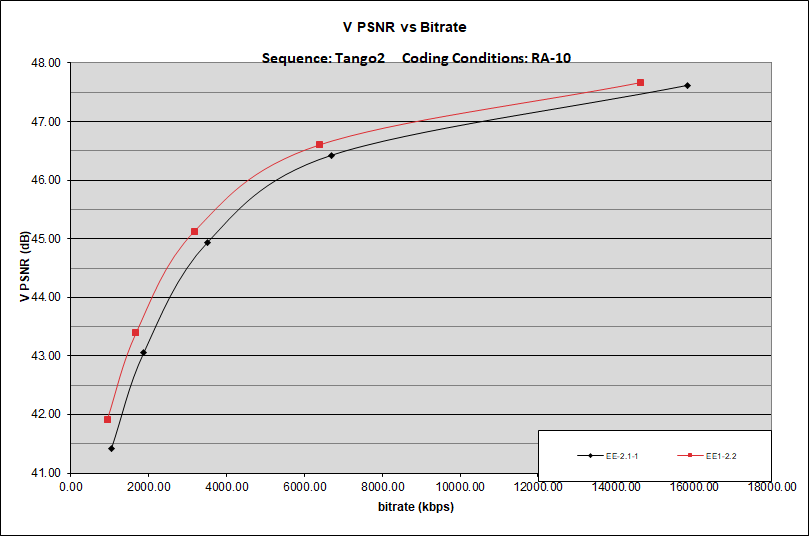
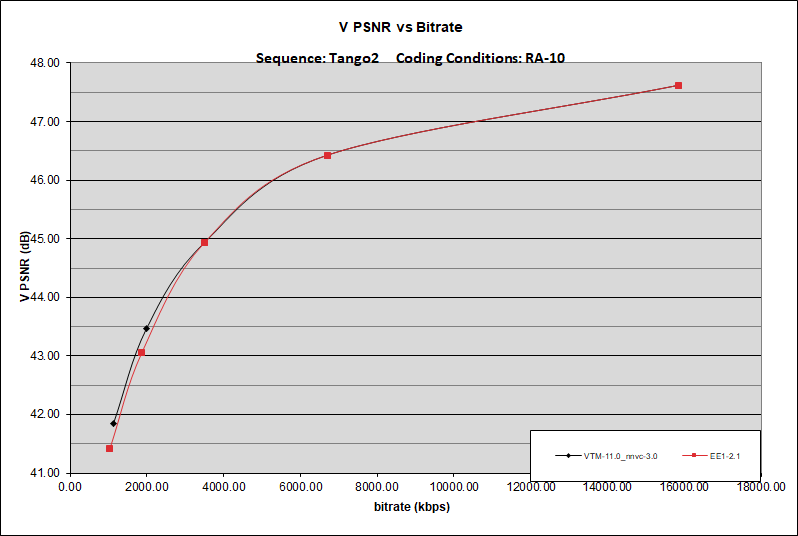
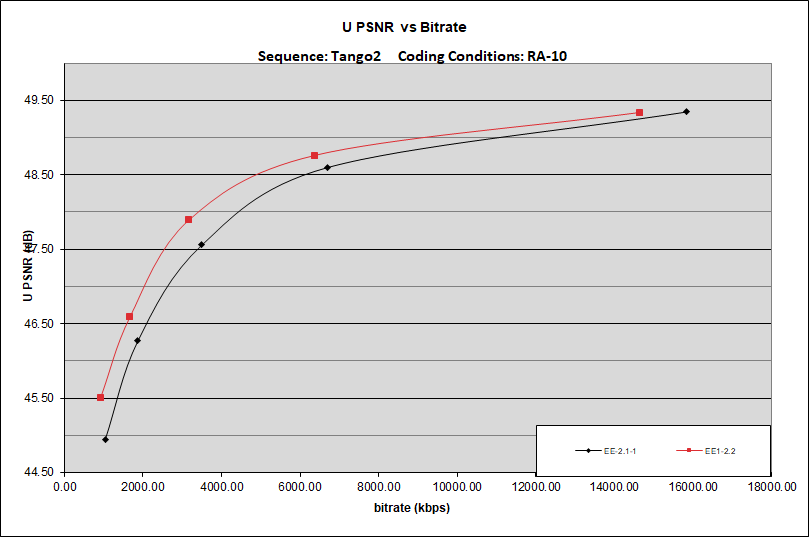
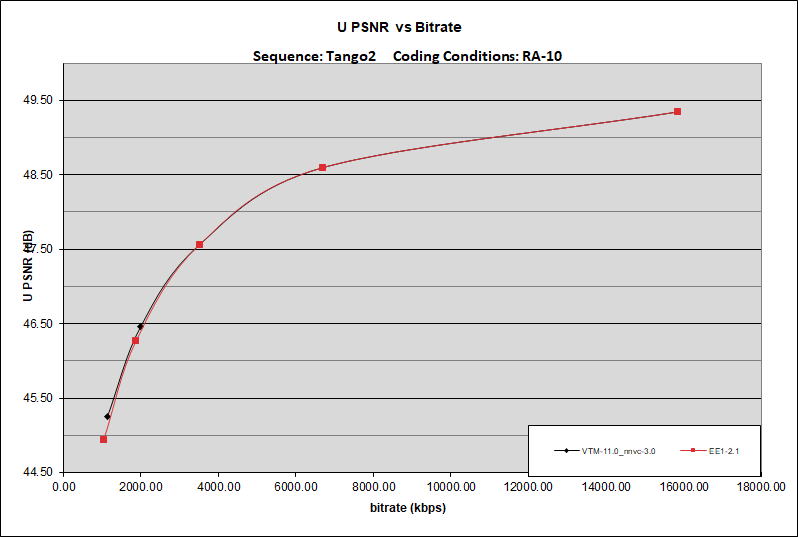
In **EE1-2.1** adaptive resolution coding is used in combination with “no NN-based” filters: RPR filters and long-tap post filter (8-tap for luma, 6-tap for chroma). Coding resolution is selected adaptively w/o multi-pass coding. At least 0.5% gain can be achieved by extending coded picture selection by scaling factor 1.25 and 1.5 additionally to 1.0 and 2.0.

Other three tests in this category use NN-based re-sampling filters. Test results for RA configuration (average among all resolutions, not only 4K) are summarized in Table 4. Figure 5 shows example of RD-curves for VVC full resolution coding, adaptive scaling factors 1.0 or 2.0 with RPR and “NN-based filters. Curves are (almost) not crossing, quality level is close enough, bit-rate saving is obvious.

*Table 4 Adaptive resolution coding with “non-NN based” (“classical”) and NN-based filters.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| EE1 test | scale | filter | BD-rate-Y | BD-rate-U | BD-rate-V |
| **2.1-1** | 1.0, 2.0 | RPR | -0.7% | 0.5% | 0.6% |
| **2.1-2** | 1.0, 2.0, 1.25, 1.5 | RPR | -1.2% | 3.2% | 2.7% |
| **2.1-3** | 1.0, 2.0, 1.25, 1.5 | RPR & long | -1.2% | 2.9% | 2.4% |
| **2.2** | 1.0, 2.0 | NN-based, 469kMAC/pxl | -2.1% | -1.0% | -0.8% |
| **2.3** | 1.0, 2.0 | NN-based, 926kMAC/pxl | -0.2% | 1.3% | 1.8% |
| **2.4** | 1.0, 2.0 | NN-based, 964kMAC/pxl | -1.0% | -0.2% | 0.5% |



**

*Figure 5 Example of RD-curves for RA, Tango: VTM anchor (full size coding), EE1-2.1 (adaptive scale 1.0 or 2.0), RPR filters and EE2.2 (adaptive scale 1.0 or 2.0), NN-based filters*

It is noted that the average results reported above are over all sequences in all classes. In case of 4K content, gains are higher.

2.2 has the most attractive gain, better than RPR filters and less complex/better than other NN based proposals. Both training and inference have been cross-checked.

Recommendation from EE1 summary report:

* Adopt EE1-2.2 for the next version of NNVC SW as an example of adaptive resolution coding with NN-based re-sampler

Decision: Adopt JVET-AC0196 into NNVC 4.0 (EE1-2.2)

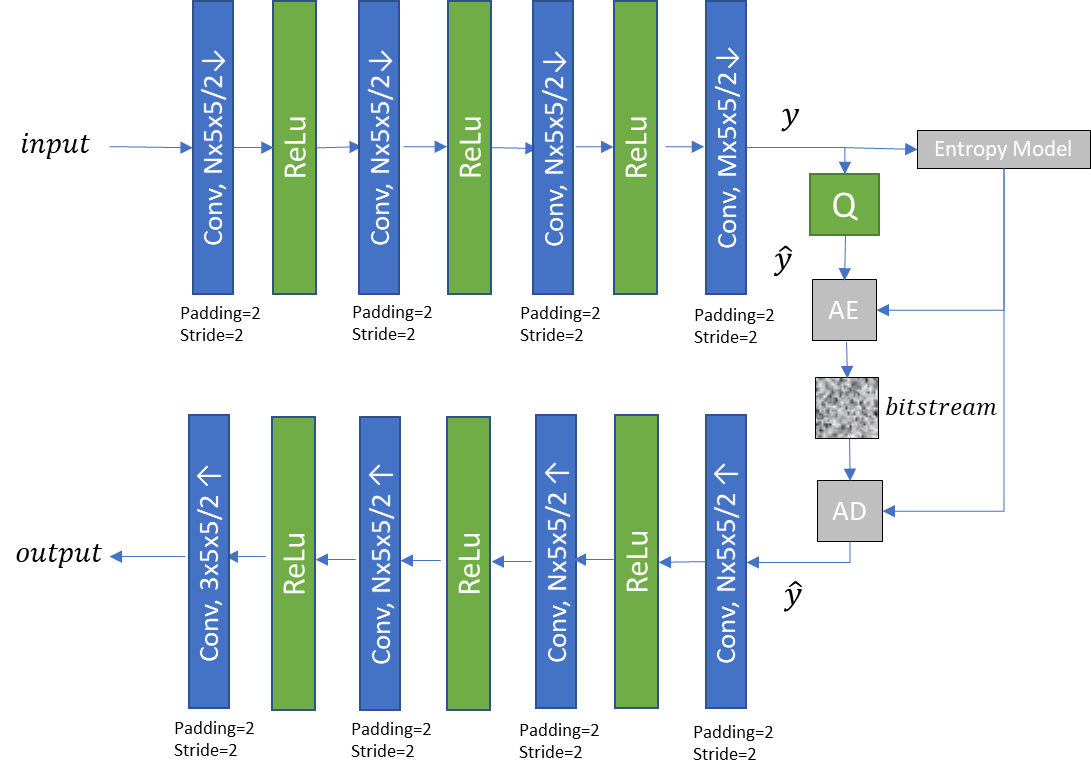
It was pointed out that the usage of RPR filters as a post processing upsampler (with GOP-wise switching) is already implemented in VTM 19 (from JVET-AB0080), and an equivalent implementation should be incuded in the NNVC software as an additional comparison point. This should be done as part of the integration of EE1-2.2.

It was also requested to provide the option of an integer implementation using SADL.

A comment was made that even better performance might be achieved when a downsampler that matches the upsampler (e.g., based on NN technology) would be used, i.e. non-normative preprocessing

1. **NN-Intra coding**

In test **EE1-3.1** one well known end-to-end AI based picture coding (Figure 6) was implemented with SADL, tested together with RDOQ. Test set is KODAK, anchor is not AhG 11 anchor, so results of this test are not shown in EE1 summary. Through this test it was shown that quantization aware training allows solving performance problem at high rate, which shows up if static quantization is used.



*Figure 6 Overview of the model architecture. N=128 and M=192.*

Test **EE1-3.2** studies NN-based Intra, block level NN-tool incorporated into VVC hybrid coding. Inference cross-check for this technology was done few meetings ago. This is the time for training cross-check (JVET-AC0290) and combination test with NNVC filter set#0 and NNVC filter set #1. The cross check was divided into three evaluation points. Two are finished and the last one is still running.

Test results are summarized in Table 5. There is no conflict in performance between NN-based Intra and filters, gain is more or less additive. This tool can be recommended to adoption to NNVC if training cross-check is successful.

*Table 5 Combination results for NN-based Intra and NNVC filters.*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| NN-Intra | NN-filter | # params | kMAC/pxl | BD-rate vs VVC (RA cfg) | | | BD-rate vs VVC (all intra cfg) | | |
| **Y** | U | V | **Y** | U | V |
| YES | no | 1.5 | 7.8 | **-1.6%** | -1.1% | -1.2% | **-3.4%** | -3.6% | -3.7% |
| NO | filter set#0 | 1.9 | 615 | **-8.9%** | -18.5% | -19.2% | **-6.5%** | -15.5% | -16.6% |
| YES | filter set#0 | 3.4 | 623 | **-10.3%** | -19.4% | -20.2% | **-9.6%** | -18.6% | -19.7% |
| NO | filter set#1 | 6.2 | 682 | **-9.5%** | -20.7% | -20.4% | **-7.5%** | -20.1% | -20.6% |
| YES | filter set#1 | 7.7 | 690 | **-10.9%** | -21.6% | -21.4% | **-10.5%** | -22.9% | -23.3% |

Recommendation from EE summary:

* Adopt EE1-1.3.2 for the next version of NNVC SW as an example of NN-based Intra tool

Candidate for adoption. Revisit after finalization of training cross-checks

### EE1 contributions: Neural network-based video coding (17)

Beyond the EE summary report JVET-AC0023, selected contributions in this area were discussed at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

For actions decided to be taken, see section 5.2.1, unless otherwise noted.

[JVET-AC0051](https://jvet-experts.org/doc_end_user/current_document.php?id=12236) EE1-2.3: RPR-Based Super-Resolution Guided by Partition Information Combined with GOP Level Adaptive Resolution [Q. Han, C. Jung (Xidian Univ.), Y. Liu, M. Li (OPPO), J. Nam, S. Yoo, J. Lim, S. H. Kim (LGE)]

[JVET-AC0222](https://jvet-experts.org/doc_end_user/current_document.php?id=12426) Crosscheck of JVET-AC0051 (EE1-2.3: RPR-Based Super-Resolution Guided by Partition Information Combined with GOP Level Adaptive Resolution) [D. Liu (Ericsson)] [late]

[JVET-AC0052](https://jvet-experts.org/doc_end_user/current_document.php?id=12237) EE1-2.4: CNN filter Based on RPR-based SR Combined with GOP Level Adaptive Resolution [S. Huang, C. Jung (Xidian Univ.), Y. Liu, M. Li (OPPO), J. Nam, S. Yoo, J. Lim, S. H. Kim (LGE)]

[JVET-AC0223](https://jvet-experts.org/doc_end_user/current_document.php?id=12427) Crosscheck of JVET-AC0052 (EE1-2.4: CNN filter Based on RPR-based SR Combined with GOP Level Adaptive Resolution) [D. Liu (Ericsson)] [late]

[JVET-AC0055](https://jvet-experts.org/doc_end_user/current_document.php?id=12241) EE1-1.11: Content-adaptive post-filter [M. Santamaria, R. Yang, F. Cricri, J. Lainema, H. Zhang, R. G. Youvalari, M. M. Hannuksela (Nokia)]

[JVET-AC0056](https://jvet-experts.org/doc_end_user/current_document.php?id=12252) EE1-3.1 CompressAI models integration using SADL [F. Galpin, F. Lefebvre, F. Racapé (InterDigital)]

[JVET-AC0257](https://jvet-experts.org/doc_end_user/current_document.php?id=12462) Crosscheck of JVET-AC0056 (EE1-3.1 CompressAI models integration using SADL) [T. Chujoh (Sharp)] [late]

[JVET-AC0063](https://jvet-experts.org/doc_end_user/current_document.php?id=12265) EE1-1.3: On chroma order adjustment in NNLF [Z. Dai, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AC0271](https://jvet-experts.org/doc_end_user/current_document.php?id=12476) Crosscheck of JVET-AC0063 (EE1-1.3: On chroma order adjustment in NNLF) [R. Chang (Tencent)] [late]

[JVET-AC0064](https://jvet-experts.org/doc_end_user/current_document.php?id=12266) EE1-1.4: On adjustment of residual for NNLF [Z. Dai, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AC0272](https://jvet-experts.org/doc_end_user/current_document.php?id=12477) Crosscheck of JVET-AC0064 (EE1-1.4: On adjustment of residual for NNLF) [R. Chang (Tencent)] [late]

[JVET-AC0286](https://jvet-experts.org/doc_end_user/current_document.php?id=12491) Crosscheck of JVET-AC0064 (EE1-1.4: On adjustment of residual for NNLF) [K. Jia (Bytedance)] [miss] [late]

[JVET-AC0078](https://jvet-experts.org/doc_end_user/current_document.php?id=12280) EE1-2.1: Updates on RPR encoder and post-filter [J. Nam, S. Yoo, J. Lim, S. Kim (LGE)]

[JVET-AC0290](https://jvet-experts.org/doc_end_user/current_document.php?id=12495) Cross-check of JVET-AC0078 (EE1-2.1: Updates on RPR encoder and post-filter) [K. Andersson (Ericsson)] [late]

[JVET-AC0089](https://jvet-experts.org/doc_end_user/current_document.php?id=12291) EE1-1.5: Combined intra and inter models for luma and chroma [D. Liu, J. Ström, M. Damghanian, P. Wennersten, K. Andersson (Ericsson)]

[JVET-AC0273](https://jvet-experts.org/doc_end_user/current_document.php?id=12478) Crosscheck of JVET-AC0089 (EE1-1.5: Combined intra and inter models for luma and chroma) [R. Chang (Tencent)] [late]

[JVET-AC0106](https://jvet-experts.org/doc_end_user/current_document.php?id=12308) EE1-1.10: Complexity Reduction on Neural-Network Loop Filter [J. N. Shingala, A. Shyam, A. Suneia, S. P. Badya (Ittiam), T. Shao, A. Arora, P. Yin, S. McCarthy (Dolby)]

[JVET-AC0241](https://jvet-experts.org/doc_end_user/current_document.php?id=12445) Crosscheck of JVET-AC0106 (EE1-1.10: Complexity Reduction on Neural-Network Loop Filter) [Y. Li (Bytedance)] [miss] [late]

[JVET-AC0116](https://jvet-experts.org/doc_end_user/current_document.php?id=12318) EE1-3.2: neural network-based intra prediction with learned mapping to VVC intra prediction modes [T. Dumas, F. Galpin, P. Bordes (InterDigital)]

[JVET-AC0238](https://jvet-experts.org/doc_end_user/current_document.php?id=12442) Crosscheck of JVET-AC0116 (EE1-3.2: neural network-based intra prediction with learned mapping to VVC intra prediction modes) [Y. Li (Bytedance)] [late]

[JVET-AC0270](https://jvet-experts.org/doc_end_user/current_document.php?id=12475) Crosscheck of EE1-3.2 (JVET-AC0116: neural network-based intra prediction with learned mapping to VVC intra prediction modes) [M. Damghanian, J. Ström (Ericsson)] [late]

[JVET-AC0274](https://jvet-experts.org/doc_end_user/current_document.php?id=12479) Crosscheck of JVET-AC0116 (EE1-3.2.2: Low-complexity version of the neural network-based intra prediction mode in 16-bit signed integer) [T. Shao (Dolby)] [miss] [late]

[JVET-AC0298](https://jvet-experts.org/doc_end_user/current_document.php?id=12503) Cross-check of EE1-3.2 (Neural network-based intra prediction with learned mapping to VVC intra prediction modes) [M. Abdoli (IRT b-com)] [miss] [late]

[JVET-AC0118](https://jvet-experts.org/doc_end_user/current_document.php?id=12320) EE1-1.8: QP-based loss function design for NN-based in-loop filter [C. Zhou, Z. Lv, J. Zhang (vivo)]

[JVET-AC0215](https://jvet-experts.org/doc_end_user/current_document.php?id=12419) Crosscheck of JVET-AC0118 (EE1-1.8: QP-based loss function design for NN-based in-loop filter) [C. Lin (Bytedance)] [late]

[JVET-AC0143](https://jvet-experts.org/doc_end_user/current_document.php?id=12345) EE1-1.6: NN chroma model without partitioning input [J. Ström, D. Liu, K. Andersson, P. Wennersten, M. Damghanian, R. Yu (Ericsson)]

[JVET-AC0234](https://jvet-experts.org/doc_end_user/current_document.php?id=12438) Cross-check of JVET-AC0143 (EE1-1.6: NN chroma model without partitioning input) [M. Santamaria (Nokia)] [late]

[JVET-AC0155](https://jvet-experts.org/doc_end_user/current_document.php?id=12359) EE1-1.9: Reduced complexity CNN-based in-loop filtering [S. Eadie, M. Coban, M. Karczewicz (Qualcomm)]

TBP

[JVET-AC0177](https://jvet-experts.org/doc_end_user/current_document.php?id=12381) EE1-1.7: Deep In-Loop Filter with Additional Input Information [Y. Li, [K. Zhang](mailto:zhangkai.video@bytedance.com), L. Zhang (Bytedance)]

[JVET-AC0209](https://jvet-experts.org/doc_end_user/current_document.php?id=12413) Crosscheck of JVET-AC0177 (EE1-1.7: Deep In-Loop Filter with Additional Input Information) [C. Zhou (vivo)] [late]

[JVET-AC0194](https://jvet-experts.org/doc_end_user/current_document.php?id=12398) EE1-1.1: More refinements on NN based in-loop filter with a single model [R. Chang, L. Wang, X. Xu, S. Liu (Tencent)]

[JVET-AC0278](https://jvet-experts.org/doc_end_user/current_document.php?id=12483) Crosscheck of JVET-AC0194 (EE1-1.1: More refinements on NN based in-loop filter with a single model) [Z. Xie (OPPO)] [late]

[JVET-AC0195](https://jvet-experts.org/doc_end_user/current_document.php?id=12399) EE1-1.2: encoder-only optimization for NN based in-loop filter with a single model [R. Chang, L. Wang, X. Xu, S. Liu (Tencent)]

TBP

[JVET-AC0279](https://jvet-experts.org/doc_end_user/current_document.php?id=12484) Crosscheck of JVET-AC0195 (EE1-1.2: encoder-only optimization for NN based in-loop filter with a single model) [Z. Xie (OPPO)] [late]

[JVET-AC0196](https://jvet-experts.org/doc_end_user/current_document.php?id=12400) EE1-2.2: GOP Level Adaptive Resampling with CNN-based Super Resolution [R. Chang, L. Wang, X. Xu, S. Liu (Tencent)]

[JVET-AC0221](https://jvet-experts.org/doc_end_user/current_document.php?id=12425) Crosscheck of JVET-AC0196 (EE1-2.2: GOP Level Adaptive Resampling with CNN-based Super Resolution) [D. Liu (Ericsson)] [late]

### EE1 related contributions: Neural network-based video coding (6)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0066](https://jvet-experts.org/doc_end_user/current_document.php?id=12268) EE1-related: Improvement on EE1-1.7 [Z. Xie, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AC0081](https://jvet-experts.org/doc_end_user/current_document.php?id=12283) EE1-related: A CNN Filter for RPR-Based Super-Resolution Using Wavelet Decomposition Combined with GOP Level Adaptive Resolution [H. Lan, C. Jung (Xidian Univ.), Y. Liu, M. Liu (OPPO), J. Nam, S. Yoo, J. Lim, S. H. Kim (LGE)]

[JVET-AC0126](https://jvet-experts.org/doc_end_user/current_document.php?id=12328) EE1-related: Reduced complexity through channel redistribution in NN head [P. Wennersten, J. Ström, D. Liu (Ericsson)]

[JVET-AC0156](https://jvet-experts.org/doc_end_user/current_document.php?id=12360) [EE1-related] RTNN: An In-loop Filter Based on Resblock and Transformer [H. Zhang, C. Jung (Xidian Univ.), Y. Liu, M. Li (OPPO)]

[JVET-AC0178](https://jvet-experts.org/doc_end_user/current_document.php?id=12382) EE1-related: In-Loop Filter with Wide Activation and Large Receptive Field [Y. Li, K. Zhang, L. Zhang (Bytedance)]

[JVET-AC0197](https://jvet-experts.org/doc_end_user/current_document.php?id=12401) EE1-1.1-related: More refinements on NN based in-loop filter [R. Chang, L. Wang, X. Xu, S. Liu (Tencent)]

### Improvements of NNVC software beyond EE1 (1)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0065](https://jvet-experts.org/doc_end_user/current_document.php?id=12267) Non-EE1: On flipping of input and output of model in NNVC filter set 0 [Z. Xie, Y. Yu, H. Yu, D. Wang (OPPO)]

### Other aspects of neural network-based video coding (4)

[JVET-AC0090](https://jvet-experts.org/doc_end_user/current_document.php?id=12292) AhG11: Neural Network-based Reference CU Quality Enhancement for Motion Compensation Prediction [Y. Chu, Z. Wang, W. Zhang, S. Li (Hisense)]

[JVET-AC0091](https://jvet-experts.org/doc_end_user/current_document.php?id=12293) AhG11: Fourier Series and Laplacian Noise-based Quantization Error Compensation for End-to-End Learning-based Image Compression [S. Jiang, Z. Wang, W. Zhang, S. Li (Hisense)]

[JVET-AC0114](https://jvet-experts.org/doc_end_user/current_document.php?id=12316) AHG11: Deep Reference Frame Generation for Inter Prediction Enhancement [J. Jia, Y. Zhang, H. Zhu, Z. Chen (Wuhan Univ.), Z. Liu, X. Xu, S. Liu (Tencent)]

[JVET-AC0179](https://jvet-experts.org/doc_end_user/current_document.php?id=12383) AHG11: Swin-Transformer based In-Loop Filter for Natural and Screen Contents [J. Li, K. Zhang, L. Zhang, M. Wang (Bytedance)]

## AHG12: Enhanced compression beyond VVC capability (88)

### Summary and BoG reports

Contributions in this area were discussed in session 4 at 2355–XXXX UTC on Wednesday 11 Jan. 2023 (chaired by JRO).

[JVET-AC0024](https://jvet-experts.org/doc_end_user/current_document.php?id=12259) EE2: Summary report of exploration experiments on enhanced compression beyond VVC capability [V. Seregin, J. Chen, G. Li, K. Naser, J. Ström, F. Wang, M. Winken, X. Xiu, K. Zhang (EE coordinators)]

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

The software basis for this EE is ECM-7.0, released at <https://vcgit.hhi.fraunhofer.de/ecm/ECM/-/tags/ECM-7.0>. ECM-7.0 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-ab-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-ab-ee2/simulation-results> if cross-check reports are not submitted as they are optional for EE tests.

**List of tests**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Tests** | **Tester** | **Cross-checker** |
| **1 Intra prediction** | | | |
| 1.1 | Directional planar prediction | LGE  S. Yoo  [JVET-AC0082](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0082-v1.zip) | InterDigital  K. Naser  [JVET-AC0261](https://jvet-experts.org/doc_end_user/current_document.php?id=12466) |
| 1.2 | Improvements on planar horizontal and planar vertical mode | WILUS  K. Kim  [JVET-AC0105](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0105-v1.zip) | InterDigital  K. Naser  [JVET-AC0262](https://jvet-experts.org/doc_end_user/current_document.php?id=12467) |
| 1.3 | Horizontal and vertical planar modes | Alibaba  X. Li  [JVET-AC0084](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0084-v1.zip) | OPPO  F. Wang  [JVET-AC0243](https://jvet-experts.org/doc_end_user/current_document.php?id=12447) |
| 1.4 | Combination of directional planar prediction methods (Test 1.1 + Test 1.2 + Test 1.3) | LGE  S. Yoo  WILUS  K. Kim  Alibaba  X. Li  [JVET-AC0083](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0083-v1.zip) | ETRI  W. Lim |
| 1.6 | Chroma fusion | vivo  C. Zhou  [JVET-AC0119](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0119-v1.zip) | Alibaba  J. Chen |
| 1.7 | Adaptive reference region DIMD | Sharp  Z. Fan  [JVET-AC0045](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0045-v1.zip) | Xiaomi  P. Andrivon |
| 1.8 | Location-dependent DIMD | Nokia  S. Blasi  [JVET-AC0098](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0098-v1.zip) | Xiaomi  P. Andrivon |
| 1.9 | TIMD with directional blending | Nokia  S. Blasi  [JVET-AC0099](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0099-v1.zip) | Xiaomi  P. Andrivon |
| 1.10 | Optimizing the use of available decoded reference samples | InterDigital  T. Dumas  [JVET-AC0094](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0094-v2.zip) | Kwai  H.-J. Jhu  [JVET-AC0168](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0168-v1.zip) |
| 1.11a | Test 1.8 + Test 1.9 | Nokia  S. Blasi  [JVET-AC0100](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0100-v1.zip) | Xiaomi  P. Andrivon |
| 1.11b | Test 1.8 + Test 1.9 + Test 1.10 | Nokia  S. Blasi  InterDigital  T. Dumas  [JVET-AC0101](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0101-v1.zip) | Xiaomi  P. Andrivon |
| 1.11c | Test 1.7 + Test 1.8 + Test 1.9 + Test 1.10 | Sharp  Z. Fan  Nokia  S. Blasi  InterDigital  T. Dumas  [JVET-AC0046](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0046-v1.zip) | Xiaomi  P. Andrivon |
| 1.12a | Gradient and location based CCCM | Nokia  R. G. Youvalari  [JVET-AC0054](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0054-v1.zip) | Qualcomm  Y.-J. Chang  [JVET-AC0281](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0281-v1.zip) |
| 1.12b | Gradient based CCCM | Nokia  R. G. Youvalari  [JVET-AC0054](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0054-v1.zip) | Qualcomm  Y.-J. Chang  [JVET-AC0281](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0281-v1.zip) |
| 1.13 | CCCM using non-downsampled luma samples | Kwai  H.-J. Jhu  [JVET-AC0147](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0147-v1.zip) | Alibaba  X. Li  [JVET-AC0247](https://jvet-experts.org/doc_end_user/current_document.php?id=12452) |
| 1.14 | No luma subsampling for CCCM | Qualcomm  V. Seregin  [JVET-AC0147](https://jvet-experts.org/doc_end_user/documents/29_Teleconference/wg11/JVET-AC0147-v1.zip) | Alibaba  X. Li  [JVET-AC0247](https://jvet-experts.org/doc_end_user/current_document.php?id=12452) |
| 1.15 | Test 1.13 + Test 1.14 | Kwai  H.-J. Jhu  Qualcomm  V. Seregin | withdrawn |



In the “planar” category, 1.2 provides best tradeoff. Run time is confirmed by cross-checkers, who also report that no additional RDO checks are done; the gain seems to be due to introduction of additional mode.

Decision: Adopt JVET-AC0105 (test 1.2)

1.6 improves the chroma fusion method from ECM (approx. doubling the gain) by introducing switchable fusion models.

Decision: Adopt JVET-AC0119 (test 1.6)

1.7-1.10 relate to DIMD/TIMD, 1.11 are combinations. 1.8 and 1.10 have the best tradeoff in terms of encoder runtime. 1.8 does not increase decoder runtime, while 1.10 does (probably due to additional usage of wide-angular modes). The decoder run time is not critical in the exploration at this point. A combination of 1.8+1.10 was not tested, but from the combinations 1.11a vs. 1.11b it can be concluded that the gains would be almost additive.

Decision: Adopt JVET-AC0098 (test 1.8)

Decision: Adopt JVET-AC0094 (test 1.10)

1.12 extends CCCM by an additional mode, where 1.12a uses the position of a sample, wheeas 1.12b does not. 1.12a clearly performs better and gives good gain (somewhat better than 1.6 which also targets chroma improvement). A combination with 1.6 was no tested, but it was argued by the proponents that conceptually 1.6 and 1.12a do not target the same source of gain (1.6 uses collocated luma samples, whereas 1.12a uses surrounding chroma samples). The contribution JVET-AC0054 also reports results that the gains of 1.12a are additive with 1.13/1.14.

Decision: Adopt JVET-AC0054 (test 1.12a)

1.13 and 1.14 disable downsampling in CCCM to improve its performance in particular for screen content. It is notd that CCCM as tool gave 0.8%/1.1% for class F, and 2.7%/1.5% for TGM (in AI/RA). The feature can be switched at block level. It was further reported that the switching is necessary, otherwise there would be loss in particular for camera captured content. The version with encoder optimization is straightforward and gives additional run time reduction and gain.

Decision: Adopt JVET-AC0147 (test 1.13)

### EE2 contributions: Enhanced compression beyond VVC capability (31)

Contributions in this area were discussed in the context of the EE summary report JVET-AC0024 unless otherwise noted.

For actions decided to be taken, see section 5.3.1, unless otherwise noted.

[JVET-AC0045](https://jvet-experts.org/doc_end_user/current_document.php?id=12230) EE2-1.7: Adaptive Reference Region DIMD [Z. Fan, Y. Yasugi, T. Ikai (Sharp)]

[JVET-AC0226](https://jvet-experts.org/doc_end_user/current_document.php?id=12430) Cross-check of JVET-AC0045 (EE2-1.7: Adaptive Reference Region DIMD) [P. Andrivon (Xiaomi)] [late]

[JVET-AC0046](https://jvet-experts.org/doc_end_user/current_document.php?id=12231) EE2-1.11c: Combination of EE2-1.7, EE2-1.8, EE2-1.9, and EE2-1.10 [Z. Fan, Y. Yasugi, T. Ikai (Sharp), S. Blasi, J. Lainema (Nokia), T. Dumas, K. Reuzé (InterDigital)]

[JVET-AC0054](https://jvet-experts.org/doc_end_user/current_document.php?id=12239) EE2-1.12: Gradient and location based convolutional cross-component model (GL-CCCM) for intra prediction [R. G. Youvalari, P. Astola, J. Lainema (Nokia)]

[JVET-AC0281](https://jvet-experts.org/doc_end_user/current_document.php?id=12486) Crosscheck of JVET-AC0054 (EE2-1.12: Gradient and location based convolutional cross-component model (GL-CCCM) for intra prediction) [Y.-J. Chang (Qualcomm)] [miss] [late]

[JVET-AC0060](https://jvet-experts.org/doc_end_user/current_document.php?id=12262) EE2-3.4: BVP candidates clustering and BVD sign derivation for Reconstruction-Reordered IBC mode [D. Ruiz Coll, J.-K. Lee, V. Warudkar (Ofinno)]

[JVET-AC0233](https://jvet-experts.org/doc_end_user/current_document.php?id=12437) Crosscheck of JVET-AC0060 (EE2-3.4: BVP candidates clustering and BVD sign derivation for Reconstruction-Reordered IBC mode) [H. Zhang (Tencent)] [late]

[JVET-AC0071](https://jvet-experts.org/doc_end_user/current_document.php?id=12273) EE2-3.1: Direct block vector mode for chroma prediction [J.-Y. Huo, X. Hao, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.), M. Li, L. Zhang, J. Ren (OPPO)]

[JVET-AC0245](https://jvet-experts.org/doc_end_user/current_document.php?id=12450) Crosscheck of JVET-AC0071 (EE2-3.1: Direct block vector mode for chroma prediction) [X. Li (Alibaba)] [miss] [late]

[JVET-AC0072](https://jvet-experts.org/doc_end_user/current_document.php?id=12274) EE2-3.2: Block vector difference sign prediction for IBC blocks [J.-Y. Huo, Z.-Y. Zhang, X. Hao, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.), M. Li, L. Zhang, J. Ren (OPPO)]

[JVET-AC0246](https://jvet-experts.org/doc_end_user/current_document.php?id=12451) Crosscheck of JVET-AC0072 (EE2-3.2: Block vector difference sign prediction for IBC blocks) [X. Li (Alibaba)] [miss] [late]

[JVET-AC0080](https://jvet-experts.org/doc_end_user/current_document.php?id=12282) EE2-3.7: Chroma IBC method as in VTM-5.0 [Y. Wang, X. Xu, X. Zhao, R. Chernyak, S. Liu (Tencent)]

[JVET-AC0133](https://jvet-experts.org/doc_end_user/current_document.php?id=12335) Cross-check of JVET-AC0080 EE2-3.7 on Chroma IBC method as in VTM-5.0 [X. Li (Google)]

[JVET-AC0082](https://jvet-experts.org/doc_end_user/current_document.php?id=12284) EE2-1.1: Directional planar prediction [S. Yoo, J. Choi, J. Nam, M. Hong, J. Lim, S. Kim (LGE)]

[JVET-AC0261](https://jvet-experts.org/doc_end_user/current_document.php?id=12466) crosscheck of JVET-AC0082 (EE2-1.1 : Directional planar prediction) [K. Naser (InterDigital)] [late]

[JVET-AC0083](https://jvet-experts.org/doc_end_user/current_document.php?id=12285) EE2-1.4: Combination of directional planar prediction methods [S. Yoo, J. Choi, J. Nam, M. Hong, J. Lim, S. Kim (LGE), K. Kim, D. Kim, J.-H. Son, J. S. Kwak (Wilus), X. Li, R.-L. Liao, J. Chen, Y. Ye (Alibaba)]

[JVET-AC0301](https://jvet-experts.org/doc_end_user/current_document.php?id=12506) Crosscheck of JVET-AC0083 (EE2-1.4: Combination of directional planar prediction methods) [W. Lim, S.-C. Lim (ETRI)] [miss] [late]

[JVET-AC0084](https://jvet-experts.org/doc_end_user/current_document.php?id=12286) EE2-1.3: Horizontal and vertical planar modes [X. Li, R.-L. Liao, J. Chen, Y. Ye (Alibaba)]

[JVET-AC0243](https://jvet-experts.org/doc_end_user/current_document.php?id=12447) Crosscheck of JVET-AC0084 (EE2-1.3: Horizontal and vertical planar modes) [F. Wang (OPPO)] [miss] [late]

[JVET-AC0094](https://jvet-experts.org/doc_end_user/current_document.php?id=12296) EE2-1.10: Optimizing the use of reference samples [K. Reuzé, T. Dumas, K. Naser, Y. Chen (InterDigital)]

[JVET-AC0168](https://jvet-experts.org/doc_end_user/current_document.php?id=12372) Crosscheck of JVET-AC0094 (EE2-1.10: Optimizing the use of reference samples) [H.-J. Jhu (Kwai)]

[JVET-AC0098](https://jvet-experts.org/doc_end_user/current_document.php?id=12300) EE2-1.8: Location-dependent DIMD [S. Blasi, J. Lainema (Nokia)]

[JVET-AC0227](https://jvet-experts.org/doc_end_user/current_document.php?id=12431) Cross-check of JVET-AC0098 (EE2-1.8: Location-dependent DIMD) [P. Andrivon (Xiaomi)] [late]

[JVET-AC0099](https://jvet-experts.org/doc_end_user/current_document.php?id=12301) EE2-1.9: TIMD with directional blending [S. Blasi, J. Lainema (Nokia)]

[JVET-AC0228](https://jvet-experts.org/doc_end_user/current_document.php?id=12432) Cross-check of JVET-AC0099 (EE2-1.9: TIMD with directional blending) [P. Andrivon (Xiaomi)] [late]

[JVET-AC0100](https://jvet-experts.org/doc_end_user/current_document.php?id=12302) EE2-1.11a: Combination of Test 1.8 and Test 1.9 [S. Blasi, J. Lainema (Nokia)]

[JVET-AC0229](https://jvet-experts.org/doc_end_user/current_document.php?id=12433) Cross-check of JVET-AC0100 (EE2-1.11a: Combination of Test 1.8 and Test 1.9) [P. Andrivon (Xiaomi)] [late]

[JVET-AC0101](https://jvet-experts.org/doc_end_user/current_document.php?id=12303) EE2-1.11b: Combination of Test 1.8, Test 1.9 and Test 1.10 [S. Blasi, J. Lainema (Nokia), T. Dumas, K. Reuzé (InterDigital)]

[JVET-AC0230](https://jvet-experts.org/doc_end_user/current_document.php?id=12434) Cross-check of JVET-AC0101 (EE2-1.11b: Combination of Test 1.8, Test 1.9 and Test 1.10) [P. Andrivon (Xiaomi)] [late]

[JVET-AC0231](https://jvet-experts.org/doc_end_user/current_document.php?id=12435) Cross-check of JVET-AC0102 (EE2-1.11c: Combination of Test 1.7, Test 1.8, Test 1.9 and Test 1.10) [P. Andrivon (Xiaomi)] [late]

Cross-check of a withdrawn document?

[JVET-AC0104](https://jvet-experts.org/doc_end_user/current_document.php?id=12306) EE2-3.3: Block Vector Difference Prediction for IBC blocks [A. Filippov, V. Rufitskiy (Ofinno)]

[JVET-AC0210](https://jvet-experts.org/doc_end_user/current_document.php?id=12414) Crosscheck of JVET-AC0104 (EE2-3.3: Block Vector Difference Prediction for IBC blocks) [R.-L. Liao (Alibaba)] [late]

[JVET-AC0265](https://jvet-experts.org/doc_end_user/current_document.php?id=12470) crosscheck of JVET-AC0104 (EE2-3.3: Block Vector Difference Prediction for IBC blocks) [K. Naser (InterDigital)] [late]

[JVET-AC0268](https://jvet-experts.org/doc_end_user/current_document.php?id=12473) Crosscheck of JVET-AC0104 (EE2-3.3: Block Vector Difference Prediction for IBC blocks) [M. Radosavljević (Xiaomi)] [miss] [late]

[JVET-AC0105](https://jvet-experts.org/doc_end_user/current_document.php?id=12307) EE2-1.2: Improvements on planar horizontal and planar vertical mode [K. Kim, D. Kim, J.-H. Son, J.-S. Kwak (WILUS)]

[JVET-AC0262](https://jvet-experts.org/doc_end_user/current_document.php?id=12467) crosscheck of JVET-AC0105 (EE2-1.2: Improvements on planar horizontal and planar vertical mode) [K. Naser (InterDigital)] [late]

[JVET-AC0112](https://jvet-experts.org/doc_end_user/current_document.php?id=12314) EE2-3.6: IBC-CIIP, IBC-GPM, and IBC-LIC [Y. Wang, K. Zhang, L. Zhang, N. Zhang (Bytedance), C. Ma, X. Xiu, W. Chen, H.-J. Jhu, C.-W. Kuo, N. Yan, X. Wang (Kwai)]

[JVET-AC0202](https://jvet-experts.org/doc_end_user/current_document.php?id=12406) Crosscheck EE2-3.6-ef: IBC-CIIP, IBC-GPM, and IBC-LIC [X. Li (Google)] [late]

[JVET-AC0244](https://jvet-experts.org/doc_end_user/current_document.php?id=12448) Crosscheck of JVET-AC0112 (EE2-3.6 a, b & d: IBC-CIIP, IBC-GPM, and IBC-LIC) [L. Zhang (OPPO)] [late]

[JVET-AC0113](https://jvet-experts.org/doc_end_user/current_document.php?id=12315) EE2-3.5: Combination of test EE2-3.1, test EE2-3.2, test EE2-3.3, and test EE2-3.4 [A. Filippov, V. Rufitskiy, D. Ruiz Coll, J.-K. Lee, V Warudkar (Ofinno), J.-Y. Huo, X. Hao, Z.-Y. Zhang, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.), M. Li, L. Zhang, J. Ren (OPPO)]

[JVET-AC0211](https://jvet-experts.org/doc_end_user/current_document.php?id=12415) Crosscheck of JVET-AC0113 (EE2-3.5: Combination of test EE2-3.1, test EE2-3.2, test EE2-3.3, and test EE2-3.4) [R.-L. Liao (Alibaba)] [late]

[JVET-AC0115](https://jvet-experts.org/doc_end_user/current_document.php?id=12317) EE2-4.1a: modifications of MTS and LFNST for Intra TMP coded blocks [D. Kim, K. Kim, J.-H. Son, J. Kwak (WILUS), K. Naser, T. Poirier, F. Galpin, A. Robert (InterDigital)]

[JVET-AC0240](https://jvet-experts.org/doc_end_user/current_document.php?id=12444) Crosscheck of JVET-AC0115 (EE2-4.1: Experimental results of EE2-4.1a, EE2-4.1b, and EE2-4.1c) [F. Wang (OPPO)] [late]

[JVET-AC0119](https://jvet-experts.org/doc_end_user/current_document.php?id=12321) EE2-1.6: On Chroma Fusion improvement [C. Zhou, Z. Lv, J. Zhang (vivo)]

[JVET-AC0291](https://jvet-experts.org/doc_end_user/current_document.php?id=12496) Crosscheck of JVET-AC0119 (EE2-1.6: On Chroma Fusion improvement) [J. Chen (Alibaba)] [miss] [late]

[JVET-AC0125](https://jvet-experts.org/doc_end_user/current_document.php?id=12327) EE2-3.8: Combination of chroma IBC tests [Y. Wang, X. Xu, X. Zhao, R. Chernyak, S. Liu (Tencent), J. Huo, X. Hao, Y. Ma, F. Yang (Xidian Univ.), J. Ren, M. Li (OPPO)]

[JVET-AC0206](https://jvet-experts.org/doc_end_user/current_document.php?id=12410) Crosscheck JVET-AC0125 EE2-3.8 on Combination of chroma IBC tests [X. Li (Google)] [late]

[JVET-AC0130](https://jvet-experts.org/doc_end_user/current_document.php?id=12332) EE2-4.2: Non-Separable Primary Transform for Intra Coding [P. Garus, M. Coban, B. Ray, V. Seregin, M. Karczewicz (Qualcomm), M. Koo, J. Zhao, J. Lim, S. Kim (LGE)]

[JVET-AC0264](https://jvet-experts.org/doc_end_user/current_document.php?id=12469) crosscheck of JVET-AC0130 (EE2-4.2: Non-Separable Primary Transform for Intra Coding) [K. Naser (InterDigital)] [late]

[JVET-AC0144](https://jvet-experts.org/doc_end_user/current_document.php?id=12346) EE2 Test 2.1, 2.2, 2.3 and 2.4: Affine DMVR [H. Huang, Y. Zhang, Z. Zhang, C.-C. Chen, V. Seregin, M. Karczewicz (Qualcomm), J. Chen, R.-L. Liao, X. Li, Y. Ye (Alibaba)]

[JVET-AC0277](https://jvet-experts.org/doc_end_user/current_document.php?id=12482) Cross-check of JVET-AC0144 tests 2.2 and 2.4b [M. Blestel (Xiaomi)] [late]

[JVET-AC0285](https://jvet-experts.org/doc_end_user/current_document.php?id=12490) Crosscheck of JVET-AC0144 Test 2.4a/b [L. Zhao (Bytedance)] [late]

[JVET-AC0287](https://jvet-experts.org/doc_end_user/current_document.php?id=12492) Cross-check of JVET-AC0144 (EE2-2.1: affine DMVR) [W. Chen (kwai)] [late]

[JVET-AC0147](https://jvet-experts.org/doc_end_user/current_document.php?id=12349) EE2-1.13 and 1.14: CCCM using non-downsampled luma samples [H.-J. Jhu, C.-W. Kuo, X. Xiu, W. Chen, N. Yan, C. Ma, X. Wang (Kwai), V. Seregin, Y.-J. Chang, B. Ray, M. Karczewicz (Qualcomm)]

[JVET-AC0117](https://jvet-experts.org/doc_end_user/current_document.php?id=12319) Cross-check of EE2-1.13: CCCM using non-downsampled luma samples [T. Dumas (InterDigital)]

[JVET-AC0247](https://jvet-experts.org/doc_end_user/current_document.php?id=12452) Crosscheck of JVET-AC0147 (EE2-1.13 and 1.14: CCCM using non-downsampled luma samples) [X. Li (Alibaba)] [miss] [late]

[JVET-AC0150](https://jvet-experts.org/doc_end_user/current_document.php?id=12352) EE2-2.6: ARMC merge candidate list reordering for AMVP-merge mode [K. Cui, C. S. Coban, Z. Zhang, H. Huang, V. Seregin, M. Karczewicz (Qualcomm), H. Jang (LGE)]

[JVET-AC0297](https://jvet-experts.org/doc_end_user/current_document.php?id=12502) Cross-check of JVET-AC0150 "EE2-2.6: ARMC merge candidate list reordering for AMVP-merge mode" [F. Le Léannec (Xiaomi)] [late]

[JVET-AC0158](https://jvet-experts.org/doc_end_user/current_document.php?id=12362) EE2-2.5: Pixel based affine motion compensation [Z. Zhang, H. Huang, Y. Zhang, P. Garus, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AC0280](https://jvet-experts.org/doc_end_user/current_document.php?id=12485) Crosscheck of JVET-AC0158 (EE2-2.5: Pixel based affine motion compensation) [X. Xiu (Kwai)] [late]

[JVET-AC0162](https://jvet-experts.org/doc_end_user/current_document.php?id=12366) EE2-5.1: Using prediction samples or residual samples for adaptive loop filter [C. Ma, X. Xiu, C.-W. Kuo, W. Chen, H.-J. Jhu, N. Yan, X. Wang (Kwai)]

[JVET-AC0188](https://jvet-experts.org/doc_end_user/current_document.php?id=12392) Crosscheck of JVET-AC0162 (EE2-5.1: Using prediction or residual samples for adaptive loop filter) [W. Yin (Bytedance)] [late]

[JVET-AC0294](https://jvet-experts.org/doc_end_user/current_document.php?id=12499) Crosscheck of JVET-AC0162 (EE2-5.1: Using prediction samples or residual samples for adaptive loop filter) [J. Chen (Alibaba)] [miss] [late]

[JVET-AC0183](https://jvet-experts.org/doc_end_user/current_document.php?id=12387) EE2-5.2: ALF with Diversified Extended Taps [W. Yin, K. Zhang, L. Zhang (Bytedance)]

[JVET-AC0288](https://jvet-experts.org/doc_end_user/current_document.php?id=12493) Crosscheck of JVET-AC0183 (EE2-5.2: ALF with Diversified Extended Taps) [C. Ma (Kwai)] [late]

[JVET-AC0184](https://jvet-experts.org/doc_end_user/current_document.php?id=12388) EE2-5.3: Combination Tests of 5.1 and 5.2 [W. Yin, K. Zhang, L. Zhang (Bytedance), C. Ma, X. Xiu, C.-W. Kuo, W. Chen, H.-J. Jhu, N. Yan, X. Wang (Kwai)] [late]

Initial version rejected as “placeholder”.

[JVET-AC0214](https://jvet-experts.org/doc_end_user/current_document.php?id=12418) Crosscheck of JVET-AB0184 on EE2-5.3: Combination Tests of 5.1 and 5.2 [X. Li (Google)] [miss] [late]

[JVET-AC0224](https://jvet-experts.org/doc_end_user/current_document.php?id=12428) Crosscheck of JVET-AC0184 on Test 5.3b: Combination Tests of 5.1b and 5.2 [L.-F. Chen (Tencent)] [miss] [late]

[JVET-AC0185](https://jvet-experts.org/doc_end_user/current_document.php?id=12389) EE2-2.7: Enhanced temporal motion information derivation [L. Zhao, K. Zhang, L. Zhang (Bytedance), L.-F. Chen, R. Chernyak, X. Zhao, X. Xu, S. Liu (Tencent)]

[JVET-AC0292](https://jvet-experts.org/doc_end_user/current_document.php?id=12497) Crosscheck of JVET-AC0185 (EE2-2.7: Enhanced temporal motion information derivation) [J. Chen (Alibaba)] [miss] [late]

[JVET-AC0216](https://jvet-experts.org/doc_end_user/current_document.php?id=12420) Crosscheck of EE2-2.7b: Enhanced temporal motion information derivation [X. Li (Google)] [miss] [late]

### EE2 related contributions (7)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0093](https://jvet-experts.org/doc_end_user/current_document.php?id=12295) EE2-related: test 2.5a and PROF improvement [F. Galpin, A. Robert, K. Naser (InterDigital)] [late]

[JVET-AC0121](https://jvet-experts.org/doc_end_user/current_document.php?id=12323) EE2-related: on GL-CCCM improvement (test 1.12a) [P. Bordes, K. Naser, F. Galpin, E. François (InterDigital), R. G. Youvalari, P. Astola, J. Lainema (Nokia)]

[JVET-AC0232](https://jvet-experts.org/doc_end_user/current_document.php?id=12436) Cross-check of JVET-AC0121 (EE2-related: on GL-CCCM improvement (test 1.12a)) [P. Andrivon (Xiaomi)] [late]

[JVET-AC0140](https://jvet-experts.org/doc_end_user/current_document.php?id=12342) EE2-related: Additional results for test EE2-3.3 [A. Filippov, V. Rufitskiy (Ofinno)] [late]

[JVET-AC0269](https://jvet-experts.org/doc_end_user/current_document.php?id=12474) Crosscheck of JVET-AC0140 (EE2-related: Additional results for test EE2-3.3) [M. Radosavljević (Xiaomi)] [miss] [late]

[JVET-AC0165](https://jvet-experts.org/doc_end_user/current_document.php?id=12369) EE2-related: Additional results to EE2-3.4 [D. Ruiz Coll, J.-K. Lee, V Warudkar (Ofinno)]

[JVET-AC0186](https://jvet-experts.org/doc_end_user/current_document.php?id=12390) EE2-related: EE2-2.7 with further encoder optimizations [L. Zhao, K. Zhang, L. Zhang (Bytedance)]

[JVET-AC0293](https://jvet-experts.org/doc_end_user/current_document.php?id=12498) Crosscheck of JVET-AC0186 (EE2-related: EE2-2.7 with further encoder optimizations) [J. Chen (Alibaba)] [miss] [late]

[JVET-AC0205](https://jvet-experts.org/doc_end_user/current_document.php?id=12409) EE2-related: Modifications of MTS and LFNST for IntraTMP [R. G. Youvalari, D. Bugdayci Sansli, J. Lainema (Nokia)] [late]

[JVET-AC0276](https://jvet-experts.org/doc_end_user/current_document.php?id=12481) EE2-related: Complexity reduction for Decoder Side Control Point Motion Vector Refinement (test 2.3b) [M. Bestel, F. Le Léannec, P. Andrivon, M. Radosavljević (Xiaomi), H. Huang, Y. Zhang, Z. Zhang, C.-C. Chen, V. Seregin, M. Karczewicz (Qualcomm)] [late]

[JVET-AC0300](https://jvet-experts.org/doc_end_user/current_document.php?id=12505) Crosscheck of JVET-AC0276 EE2-related: Complexity reduction for Decoder Side Control Point Motion Vector Refinement (test 2.3b) [V. Rufitskiy, A. Filippov (Ofinno)] [miss] [late]

### ECM modifications beyond EE2 (50)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0048](https://jvet-experts.org/doc_end_user/current_document.php?id=12233) Non-EE: Modification of TIMD [Y. Yasugi, T. Ikai (Sharp)] [late]

Initial version rejected as “placeholder”.

[JVET-AC0248](https://jvet-experts.org/doc_end_user/current_document.php?id=12453) Crosscheck of JVET-AC0048 (Non-EE: Modification of TIMD) [X. Li (Alibaba)] [miss] [late]

[JVET-AC0053](https://jvet-experts.org/doc_end_user/current_document.php?id=12238) AHG12: Simplified linear model solver [J. Lainema, P. Astola, A. Aminlou, R. G. Youvalari (Nokia)]

[JVET-AC0282](https://jvet-experts.org/doc_end_user/current_document.php?id=12487) Crosscheck of JVET-AC0053 (AHG12: Simplified linear model solver) [Y.-J. Chang (Qualcomm) [miss] [late]

[JVET-AC0059](https://jvet-experts.org/doc_end_user/current_document.php?id=12261) AHG12: TMP using Reconstruction-Reordered for screen content coding (RR-TMP) [J.-K. Lee, D. Ruiz Coll, V. Warudkar (Ofinno)]

[JVET-AC0242](https://jvet-experts.org/doc_end_user/current_document.php?id=12446) Crosscheck of JVET-AC0059 (AHG12: TMP using Reconstruction-Reordered for screen content coding (RR-TMP)) [?? (??)][miss] [late]

[JVET-AC0067](https://jvet-experts.org/doc_end_user/current_document.php?id=12269) Non-EE2: Modifications on template-based multiple reference line intra prediction [L. Xu, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AC0068](https://jvet-experts.org/doc_end_user/current_document.php?id=12270) Non-EE2: multi-candidate IntraTMP [F. Wang, L. Zhang, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AC0259](https://jvet-experts.org/doc_end_user/current_document.php?id=12464) Crosscheck of JVET-AC0068 (Non-EE2: multi-candidate IntraTMP) [Z. Lv (vivo)] [miss] [late]

[JVET-AC0069](https://jvet-experts.org/doc_end_user/current_document.php?id=12271) Non-EE2: Intra Template-Matching Prediction Fusion [L. Zhang, F. Wang, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AC0260](https://jvet-experts.org/doc_end_user/current_document.php?id=12465) Crosscheck of JVET-AC0069 (Non-EE2: Intra Template-Matching Prediction Fusion) [Z. Lv (vivo)] [miss] [late]

[JVET-AC0070](https://jvet-experts.org/doc_end_user/current_document.php?id=12272) Non-EE2: combination of JVET-AC0068 and JVET-AC0069 [F. Wang, L. Zhang, Y. Yu, H. Yu, D. Wang (OPPO)]

[JVET-AC0087](https://jvet-experts.org/doc_end_user/current_document.php?id=12289) Non-EE2: Intra TMP with half-pel precision [X. Li, R.-L. Liao, J. Chen, Y. Ye (Alibaba)]

[JVET-AC0095](https://jvet-experts.org/doc_end_user/current_document.php?id=12297) AHG12: Fix related to pixel copy in motion compensation [K. Andersson, R. Yu (Ericsson)]

[JVET-AC0096](https://jvet-experts.org/doc_end_user/current_document.php?id=12298) AHG10/12: Suggestion for new CTC for RPR in VTM and ECM [K. Andersson, R. Yu (Ericsson)]

[JVET-AC0097](https://jvet-experts.org/doc_end_user/current_document.php?id=12299) Non-EE2: SGPM combined with IntraTMP [C. Fang, S. Peng, D. Jiang, J. Lin, X. Zhang (Dahua)] [late]

Initial version rejected as “placeholder”.

[JVET-AC0103](https://jvet-experts.org/doc_end_user/current_document.php?id=12305) Non-EE2: AMVP mode with subblock-based temporal motion vector prediction [R.-L. Liao, J. Chen, Y. Ye, X. Li (Alibaba)]

[JVET-AC0220](https://jvet-experts.org/doc_end_user/current_document.php?id=12424) Crosscheck of JVET-AC0103 (Non-EE2: AMVP mode with subblock-based temporal motion vector prediction) [X. Xiu (Kwai)] [miss] [late]

[JVET-AC0107](https://jvet-experts.org/doc_end_user/current_document.php?id=12309) AHG12: Fusion of Intra Template Matching [J. R. Arumugam, A. Natesan, V. Valvaiker, J. N. Shingala (Ittiam), T. Lu, P. Yin, F. Pu, T. Shao, A. Arora, S. McCarthy (Dolby)]

[JVET-AC0108](https://jvet-experts.org/doc_end_user/current_document.php?id=12310) Non-EE2: Extend search area in Intra Template Matching Prediction (IntraTMP) [J.-Y. Huo, H.-Q. Du, H.-L. Zhang, Z.-Y. Zhang, W.-H. Qiao, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.)]

[JVET-AC0249](https://jvet-experts.org/doc_end_user/current_document.php?id=12454) Crosscheck of JVET-AC0108 (Non-EE2: Extend search area in Intra Template Matching Prediction (IntraTMP)) [X. Li (Alibaba)] [miss] [late]

[JVET-AC0109](https://jvet-experts.org/doc_end_user/current_document.php?id=12311) Non-EE2: Intra template matching (Intra TMP) based on linear filter model [J.-Y. Huo, W.-H. Qiao, X. Hao, Z.-Y. Zhang, H.-Q. Du, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.)]

[JVET-AC0250](https://jvet-experts.org/doc_end_user/current_document.php?id=12455) Crosscheck of JVET-AC0109 (Non-EE2: Intra template matching (Intra TMP) based on linear filter model) [X. Li (Alibaba)] [miss] [late]

[JVET-AC0110](https://jvet-experts.org/doc_end_user/current_document.php?id=12312) Non-EE2: A Fusion method of Intra Template Matching Prediction (Intra TMP) [J.-Y. Huo, H.-Q. Du, H.-L. Zhang, W.-H. Qiao, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.)]

[JVET-AC0251](https://jvet-experts.org/doc_end_user/current_document.php?id=12456) Crosscheck of JVET-AC0110 (Non-EE2: A Fusion method of Intra Template Matching Prediction (Intra TMP)) [X. Li (Alibaba)] [miss] [late]

[JVET-AC0111](https://jvet-experts.org/doc_end_user/current_document.php?id=12313) Non-EE2: Combination of JVET-AC0108, JVET-AC0109 and JVET-AC0110 for Intra TMP [J.-Y. Huo, W.-H. Qiao, H.-Q. Du, Y.-Z. Ma, F.-Z. Yang (Xidian Univ.), H. Yuan (Shandong Univ.)]

[JVET-AC0252](https://jvet-experts.org/doc_end_user/current_document.php?id=12457) Crosscheck of JVET-AC0111 (Non-EE2: Combination of JVET-AC0108, JVET-AC0109 and JVET-AC0110 for Intra TMP) [X. Li (Alibaba)] [miss] [late]

[JVET-AC0120](https://jvet-experts.org/doc_end_user/current_document.php?id=12322) Non-EE2: template based intra MPM list construction [C. Zhou, Z. Lv, J. Zhang (vivo)]

[JVET-AC0284](https://jvet-experts.org/doc_end_user/current_document.php?id=12489) Crosscheck of JVET-AC0120 (Non-EE2: template based intra MPM list construction) [F. Wang (OPPO)] [miss] [late]

[JVET-AC0123](https://jvet-experts.org/doc_end_user/current_document.php?id=12325) MTT maximum depth correction for class B sequences at QP 22 in ECM [G. Laroche, P. Onno (Canon)]

[JVET-AC0235](https://jvet-experts.org/doc_end_user/current_document.php?id=12439) Cross-check of JVET-AC0123 "MTT maximum depth correction for class B sequences at QP 22 in ECM" [F. Le Léannec (Xiaomi)] [late]

[JVET-AC0124](https://jvet-experts.org/doc_end_user/current_document.php?id=12326) Non-EE2: Bi-prediction with block-level only out-of-bound management [F. Le Léannec, M. Blestel, P. Andrivon, M. Radosavljević (Xiaomi)]

[JVET-AC0219](https://jvet-experts.org/doc_end_user/current_document.php?id=12423) Crosscheck of JVET-AC0124 (Non-EE2: Bi-prediction with block-level only out-of-bound management) [X. Xiu (Kwai)] [miss] [late]

[JVET-AC0263](https://jvet-experts.org/doc_end_user/current_document.php?id=12468) Crosscheck of JVET-AC0124 (Non-EE2: Bi-prediction with block-level only out-of-bound management) [F. Galpin (InterDigital)] [late]

[JVET-AC0138](https://jvet-experts.org/doc_end_user/current_document.php?id=12340) Adjusting luma/chroma BD-rate balance in ECM [E. François, Y. Chen, C. Salmon-Legagneur (InterDigital)]

[JVET-AC0236](https://jvet-experts.org/doc_end_user/current_document.php?id=12440) Cross-check of JVET-AC0138 [F. Le Léannec (Xiaomi)] [late]

[JVET-AC0142](https://jvet-experts.org/doc_end_user/current_document.php?id=12344) Non-EE2: Cross-Component Discrete Mapping Model for Screen Content Coding [B. Vishwanath, K. Zhang, L. Zhang (Bytedance)]

[JVET-AC0146](https://jvet-experts.org/doc_end_user/current_document.php?id=12348) AHG12: Filtered Template Matching based Intra Prediction (FTMP) [R. G. Youvalari, D. Bugdayci Sansli, P. Astola, J. Lainema (Nokia)]

[JVET-AC0148](https://jvet-experts.org/doc_end_user/current_document.php?id=12350) Non-EE2: CCCM using multiple downsampling filters [Y.-J. Chang, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AC0302](https://jvet-experts.org/doc_end_user/current_document.php?id=12507) Crosscheck of JVET-AC0148 (Non-EE2: CCCM using multiple downsampling filters) [J. Lainema (Nokia)] [miss] [late]

[JVET-AC0149](https://jvet-experts.org/doc_end_user/current_document.php?id=12351) AHG10/12: Reduced I-frame QP for RA [K. Andersson, P. Wennersten (Ericsson)]

[JVET-AC0159](https://jvet-experts.org/doc_end_user/current_document.php?id=12363) Non-EE2: IBC MBVD list derivation [Z. Zhang, P. Nikitin, H. Huang, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AC0296](https://jvet-experts.org/doc_end_user/current_document.php?id=12501) Cross-check of JVET-AC0159 (Non-EE2: IBC MBVD list derivation) [K. Andersson (Ericsson)] [miss] [late]

[JVET-AC0160](https://jvet-experts.org/doc_end_user/current_document.php?id=12364) Non-EE2: On the condition of OBMC [X. Li (Google)]

[JVET-AC0218](https://jvet-experts.org/doc_end_user/current_document.php?id=12422) Crosscheck of JVET-AC0160 (Non-EE2: On the condition of OBMC) [H.-J. Jhu, X. Xiu (Kwai)] [late]

[JVET-AC0161](https://jvet-experts.org/doc_end_user/current_document.php?id=12365) Non-EE2: IBC adaptation for coding of natural content [B. Ray, H. Wang, C.-C. Chen, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AC0163](https://jvet-experts.org/doc_end_user/current_document.php?id=12367) Non-EE2: On non-separable primary transform for intra blocks [N. Yan, X. Xiu, W. Chen, H.-J. Jhu, C.-W. Kuo, C. Ma, X. Wang (Kwai)]

[JVET-AC0253](https://jvet-experts.org/doc_end_user/current_document.php?id=12458) Crosscheck of JVET-AC0163 on Non-EE2: On non-separable primary transform for intra blocks [X. Li (Google)] [miss] [late]

[JVET-AC0164](https://jvet-experts.org/doc_end_user/current_document.php?id=12368) Non-EE2: Improvements on local illumination compensation in ECM7.0 [X. Xiu, N. Yan, H.-J. Jhu, W. Chen, C.-W. Kuo, C. Ma, X. Wang (Kwai)]

[JVET-AC0225](https://jvet-experts.org/doc_end_user/current_document.php?id=12429) Crosscheck of JVET-AC0164 (Non-EE2: on Improvements on local illumination compensation in ECM7.0) [L.-F. Chen (Tencent)] [miss] [late]

[JVET-AC0167](https://jvet-experts.org/doc_end_user/current_document.php?id=12371) AHG12: Using block vector derived from IntraTMP as an IBC candidate for the current block [J.-K. Lee, D. Ruiz Coll, V. Warudkar (Ofinno)]

[JVET-AC0283](https://jvet-experts.org/doc_end_user/current_document.php?id=12488) Crosscheck of JVET-AC0167 (AHG12: Using block vector derived from IntraTMP as an IBC candidate for the current block) [K. Kim (WILUS)] [miss] [late]

[JVET-AC0169](https://jvet-experts.org/doc_end_user/current_document.php?id=12373) Non-EE2: Template Matching for RR-IBC [C.-C. Chen, H. Huang, Z. Zhang, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AC0207](https://jvet-experts.org/doc_end_user/current_document.php?id=12411) Crosscheck of JVET-AC0169 (Non-EE2: Template Matching for RR-IBC) [D. Ruiz Coll, J.-K. Lee, V. Warudkar (Ofinno)] [late]

[JVET-AC0170](https://jvet-experts.org/doc_end_user/current_document.php?id=12374) Non-EE2: Fuse intra template matching prediction with intra prediction [Y. Wang, K. Zhang, L. Zhang (Bytedance)]

[JVET-AC0171](https://jvet-experts.org/doc_end_user/current_document.php?id=12375) AHG12: ECM-6 Tool Off Tests [X. Li (Google)]

[JVET-AC0172](https://jvet-experts.org/doc_end_user/current_document.php?id=12376) Non-EE2: IBC with fractional block vectors [W. Chen, X. Xiu, C. Ma, H.-J. Jhu, C.-W. Kuo, N. Yan, X. Wang (Kwai)] [late]

Initial version rejected as “placeholder”.

[JVET-AC0173](https://jvet-experts.org/doc_end_user/current_document.php?id=12377) Non-EE2: ALF classification based on residual data [I. Jumakulyyev, N. Hu, Z. Zhang, V. Seregin, M. Karczewicz, H. Huang (Qualcomm)]

[JVET-AC0175](https://jvet-experts.org/doc_end_user/current_document.php?id=12379) Non-EE2: Local-Boosting Cross-Component Prediction [K. Zhang, L. Zhang, Z. Deng (Bytedance)]

[JVET-AC0176](https://jvet-experts.org/doc_end_user/current_document.php?id=12380) Non-EE2: Non-Local Cross-Component Prediction [K. Zhang, L. Zhang, Z. Deng (Bytedance)]

[JVET-AC0182](https://jvet-experts.org/doc_end_user/current_document.php?id=12386) Non-EE2: High-Precision MV Refinement for BDOF [M. Salehifar, Y. He, K. Zhang, L. Zhang (Bytedance)]

[JVET-AC0187](https://jvet-experts.org/doc_end_user/current_document.php?id=12391) Non-EE2: Template matching-based subblock motion refinement [L. Zhao, K. Zhang, Z. Deng, L. Zhang (Bytedance)] [late]

Initial version rejected as “placeholder”.

[JVET-AC0189](https://jvet-experts.org/doc_end_user/current_document.php?id=12393) Non-EE2: SGPM without blending [Z. Deng, L. Zhang, K. Zhang, L. Zhao (Bytedance)]

[JVET-AC0295](https://jvet-experts.org/doc_end_user/current_document.php?id=12500) Crosscheck of JVET-AC0189(Non-EE2: SGPM without blending) [J. Chen (Alibaba)] [miss] [late]

[JVET-AC0190](https://jvet-experts.org/doc_end_user/current_document.php?id=12394) Non-EE2: On OBMC [Z. Deng, K. Zhang, L. Zhang (Bytedance)]

[JVET-AC0191](https://jvet-experts.org/doc_end_user/current_document.php?id=12395) Non-EE2: Modification to MPM list derivation [H. Wang, Y.-J. Chang, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AC0258](https://jvet-experts.org/doc_end_user/current_document.php?id=12463) Crosscheck of JVET-AC0191 (Non-EE2: Modification to MPM list derivation) [Z. Lv (vivo)] [miss] [late]

[JVET-AC0192](https://jvet-experts.org/doc_end_user/current_document.php?id=12396) Non-EE2: Temporal block vector prediction [N. Zhang, K. Zhang, L. Zhang (Bytedance)]

[JVET-AC0193](https://jvet-experts.org/doc_end_user/current_document.php?id=12397) Non-EE2: Copy-Padding for IBC [N. Zhang, K. Zhang, L. Zhang (Bytedance)]

[JVET-AC0198](https://jvet-experts.org/doc_end_user/current_document.php?id=12402) Non-EE2: IntraTMP with multiple modes [P.-H. Lin, J.-L- Lin, V. Seregin, M. Karczewicz (Qualcomm)]

[JVET-AC0200](https://jvet-experts.org/doc_end_user/current_document.php?id=12404) AhG12 Dynamic CABAC models [F. Lo Bianco, F. Galpin, E. François (InterDigital)] [late]

[JVET-AC0237](https://jvet-experts.org/doc_end_user/current_document.php?id=12441) Cross-check of JVET-AC0200 [F. Le Léannec (Xiaomi)] [late]

[JVET-AC0201](https://jvet-experts.org/doc_end_user/current_document.php?id=12405) AHG12: CIIP extension with Intra Template Matching [K. Naser, P. Bordes, F. Galpin, K. Reuzé, A. Robert (InterDigital)] [late]

[JVET-AC0203](https://jvet-experts.org/doc_end_user/current_document.php?id=12407) AHG12: On LMCS luma mapping in template processing for IBC TM-based tools [A. Filippov, V. Rufitskiy (Ofinno)] [late]

[JVET-AC0212](https://jvet-experts.org/doc_end_user/current_document.php?id=12416) Non-EE2: Template matching for IBC BVD suffix derivation [P. Nikitin, Z. Zhang, H. Huang, V. Seregin, M. Karczewicz (Qualcomm)] [late]

[JVET-AC0213](https://jvet-experts.org/doc_end_user/current_document.php?id=12417) Non-EE2: SbTMVP with MMVD [L.-F. Chen, R. Chernyak, X. Zhao, X. Xu, S. Liu (Tencent)] [late]

[JVET-AC0217](https://jvet-experts.org/doc_end_user/current_document.php?id=12421) Crosscheck of JVET-AC0213 on SbTMVP with MMVD [X. Li (Google)] [miss] [late]

[JVET-AC0239](https://jvet-experts.org/doc_end_user/current_document.php?id=12443) Non-EE2: Prediction of MVD magnitude suffix bins [A. Filippov, V. Rufitskiy, K. Suverov (Ofinno)] [late]

# High-level syntax (HLS) and related proposals (30)

## AHG9: SEI messages on neural-network post filter (21)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0208](https://jvet-experts.org/doc_end_user/current_document.php?id=12412) AHG9: Summary of Proposals Related to Neural-Network Post-Filter SEI Messages [S. Deshpande (Sharp), Y.-K. Wang (Bytedance)]

[JVET-AC0047](https://jvet-experts.org/doc_end_user/current_document.php?id=12232) AHG9: On bugfix for NNPFC and NNPFA SEI messages [T. Chujoh, Y. Yasugi, T. Ikai (Sharp)]

[JVET-AC0061](https://jvet-experts.org/doc_end_user/current_document.php?id=12263) AHG9: Comments on Neural-network Post-filter Characteristics SEI Message [S. Deshpande (Sharp)]

[JVET-AC0062](https://jvet-experts.org/doc_end_user/current_document.php?id=12264) AHG9: On NNPFC SEI Message [S. Deshpande, A. Sidiya (Sharp)]

[JVET-AC0074](https://jvet-experts.org/doc_end_user/current_document.php?id=12276) AHG9: On the VVC use of the NNPFC SEI message for picture rate upsampling [M. M. Hannuksela (Nokia)]

[JVET-AC0075](https://jvet-experts.org/doc_end_user/current_document.php?id=12277) AHG9: On NNPFC and NNPFA SEI messages for picture rate upsampling post-filter [M. M. Hannuksela (Nokia)]

[JVET-AC0076](https://jvet-experts.org/doc_end_user/current_document.php?id=12278) AHG9/AHG15: On the NNPFC SEI message for machine analysis [M. M. Hannuksela, F. Cricri, J. I. Ahonen, H. Zhang (Nokia)]

[JVET-AC0085](https://jvet-experts.org/doc_end_user/current_document.php?id=12287) AHG9: On neural-network post-filter characteristics (NNPFC) SEI message for temporal upsampling towards machine vision [S. Wang, J. Chen, Y. Ye (Alibaba), S. Wang (CityU HK)]

[JVET-AC0127](https://jvet-experts.org/doc_end_user/current_document.php?id=12329) AHG9: Combination of picture rate upsampling with other NNPF purposes [Y.-K. Wang, J. Xu, Y. Li, L. Zhang, K. Zhang, J. Li, C. Lin (Bytedance)]

[JVET-AC0128](https://jvet-experts.org/doc_end_user/current_document.php?id=12330) AHG9: On the signalling of complexity information in NNPFC SEI message [Hendry, S. Kim (LGE)]

[JVET-AC0129](https://jvet-experts.org/doc_end_user/current_document.php?id=12331) AHG9: On the NNPFC SEI message update and activation [Hendry, J. Nam, H. Jang, S. Kim, J. Lim (LGE)]

[JVET-AC0131](https://www.jvet-experts.org/doc_end_user/current_document.php?id=12333) AHG9: On NNPFC SEI message repetition [Hendry, J. Nam, H. Jang, S. Kim, J. Lim (LGE)]

[JVET-AC0132](https://www.jvet-experts.org/doc_end_user/current_document.php?id=12334) AHG9: On design for region-based neural-network post-filter SEI message [Hendry, J. Nam, H. Jang, S. Kim, J. Lim (LGE)]

[JVET-AC0134](https://jvet-experts.org/doc_end_user/current_document.php?id=12336) AHG9: Signalling of NNPF quality improvement [C. Lin, Y.-K. Wang, K. Zhang, J. Li, Y. Li, L. Zhang (Bytedance)]

[JVET-AC0135](https://jvet-experts.org/doc_end_user/current_document.php?id=12337) AHG9: Separate activation of color components for neural-network post-filter [C. Lin, Y. Li, Y.-K. Wang, K. Zhang, J. Li, L. Zhang (Bytedance)]

[JVET-AC0136](https://jvet-experts.org/doc_end_user/current_document.php?id=12338) AHG9: On additional NNPF purposes [C. Lin, Y.-K. Wang, K. Zhang, Y. Li, J. Li, L. Zhang (Bytedance)]

[JVET-AC0152](https://jvet-experts.org/doc_end_user/current_document.php?id=12356) AHG9: Bit-masking based representation of nnpfc\_purpose [J. Xu, Y.-K. Wang, L. Zhang, Y. Li (Bytedance)]

[JVET-AC0153](https://jvet-experts.org/doc_end_user/current_document.php?id=12357) AHG9: Bitdepth increase indication in the NNPFC SEI message [J. Xu, Y.-K. Wang, L. Zhang (Bytedance)]

[JVET-AC0154](https://jvet-experts.org/doc_end_user/current_document.php?id=12358) AHG9: Miscellaneous cleanups of the neural-network post-filter SEI messages [J. Xu, Y.-K. Wang, L. Zhang, C. Lin (Bytedance)]

[JVET-AC0174](https://jvet-experts.org/doc_end_user/current_document.php?id=12378) AHG9: Multiple input pictures for neural-network post-processing filter [Y. Li, Y.-K. Wang, C. Lin, J. Li, J. Xu, K. Zhang, L. Zhang (Bytedance)]

[JVET-AC0299](https://jvet-experts.org/doc_end_user/current_document.php?id=12504) AHG9: On indicating processing order in the NNPFC SEI message [T. Shao, A. Arora, P. Yin, S. McCarthy, T. Lu, F. Pu, W. Husak (Dolby), Hendry, S. Kim (LGE)] [late]

## AHG9: SEI messages on topics other than NNPF (5)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0058](https://jvet-experts.org/doc_end_user/current_document.php?id=12260) AHG9: On the SEI processing order SEI message [Y. He, M. Coban, M. Karczewicz (Qualcomm)]

[JVET-AC0077](https://jvet-experts.org/doc_end_user/current_document.php?id=12279) AHG9/AHG15: On bitstreams that are potentially suboptimal for user viewing [M. M. Hannuksela, F. Cricri, H. Zhang (Nokia)]

[JVET-AC0088](https://jvet-experts.org/doc_end_user/current_document.php?id=12290) AHG9: Generative Face Video SEI Message [B. Chen, J. Chen, S. Wang, Y. Ye (Alibaba), S. Wang (CityU HK)]

[JVET-AC0122](https://jvet-experts.org/doc_end_user/current_document.php?id=12324) AHG9: Attenuation Map Information SEI for reducing energy consumption of displays [C.-H. Demarty, F. Aumont, E. Reinhard, L. Blondé, O. Le Meur, Z. Ameur, E. François (InterDigital)]

[JVET-AC0141](https://jvet-experts.org/doc_end_user/current_document.php?id=12343) AHG9: Alternative Picture Timing SEI [H.-B. Teo, J. Gao, C.-S. Lim, K. Abe (Panasonic)]

## Film grain synthesis (4)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

[JVET-AC0043](https://jvet-experts.org/doc_end_user/current_document.php?id=12228) AHG4: Report on AHG meeting on subjective test preparation for film grain synthesis [M. Wien (RWTH)]

[JVET-AC0151](https://jvet-experts.org/doc_end_user/current_document.php?id=12353) AHG13: Proposed text: Film grain synthesis technology for video applications (CD draft) [D. Grois (Comcast), Y. He (Qualcomm), W. Husak (Dolby), P. de Lagrange (InterDigital), A. Norkin (Netflix), M. Radosavljević (Xiaomi), A. Tourapis (Apple), W. Wan (Broadcom)]

[JVET-AC0181](https://jvet-experts.org/doc_end_user/current_document.php?id=12385) AHG4: experiments in preparation of film grain visual tests [P. de Lagrange (InterDigital)]

[JVET-AC0199](https://jvet-experts.org/doc_end_user/current_document.php?id=12403) AHG13: On Film Grain Synthesis Subjective Evaluation [X. Meng, W. Zhang, S. Labrozzi (Disney Streaming)] [late]

Initial version rejected as “placeholder”.

## Non-SEI HLS aspects (0)

Contributions in this area were discussed in session X at XXXX–XXXX UTC on XXday X Jan. 2023 (chaired by XXX).

# Plenary meetings, joint meetings, BoG reports, and liaison communications

## JVET plenaries

No intermediate plenaries were held, as document review and decisions were made in single-track mode at this meeting (with some BoG activity as noted). Further detail on scheduling is recorded in section 2.13.

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 Jan. 0900–1130, Wednesday 18 Jan. 0900–1000, and Friday 20 Jan. 2100–2300 UTC. The status of the work in the MPEG WGs and AGs was reviewed at these information sharing sessions.

## Joint meeting with … on XXday XX Jan. XX:XX-XX:XX UTC on …

## BoGs (0)

The following break-out groups were established at this meeting to conduct discussion and develop recommendations on particular subjects

* A BoG on …. See section XX and the report JVET-AC0XXX for details.

## Liaison communications

[m60701](https://dms.mpeg.expert/doc_end_user/current_document.php?id=84196&id_meeting=192) Liaison statement from SC 29/WG 1 to WG 5 on JPEG AI [WG 1 via SC 29 Secretariat]

[TD 80/Gen](https://www.itu.int/md/T22-SG16-221017-TD-GEN-0080/en) LS on JPEG AI [from JPEG]

JVET, as SC 29/WG 5 and Q6/16, received similar liaison letters from SC 29/WG 1 JPEG related to its JPEG AI project. The evaluation of responses to the JPEG AI Call for Proposals had taken place at the 96th JPEG meeting of 25-29 July 2022. In total, ten teams replied to the CfP in the standard reconstruction category, two submissions were received on compressed-domain de-noising, one submission was received on compressed-domain super resolution, and three submissions were received on compressed-domain image classification.

In the standard image reconstruction category, five teams successfully passed cross-check; among them three outperformed a VVC anchor, demonstrating BD-rate gain from 18% to 32% based on seven objective metrics. In subjective quality evaluation, the best submissions outperformed the VVC anchor on average. For half of the tested rates and images, the learning-based codec outperformed the VVC anchor with non-overlapping confidence intervals.

WG1 had agreed to create a JPEG AI Verification Model under Consideration (VMuC) by combining two of the best submissions. Several core experiments exploring potential improvements over the VMuC had also been established.

In the compressed-domain image classification track, two submissions demonstrated that image classification when applied directly in the compressed domain became more efficient when compared to image classification after full decoding, while at the same time requiring significantly less computational resources.

Further information about the JPEG AI CfP results, VMuC and Core experiments could be found in the following JPEG output documents:

* wg1n100279-096-ICQ-Description of JPEG AI Verification Model under Consideration and assocated software integration procedure
* wg1n100250-096-REQ-Report on the JPEG AI Call for Proposals Results
* wg1n100284-096-ICQ-JPEG AI Core Experiment 1

WG1 looked forward to further interactions with JVET on learning-based coding and neural network based coding tools.

A reply was drafted by JVET as WG 5 N 168.

JVET thanked JPEG for its liaison reply and its update on the status of the JPEG AI project.

The reply reported that for JVET, in the exploration of neural network-based video coding (NNVC), JVET had updated our common software codebase based on improvements and further training crosschecks that had been performed on neural network-based loop filtering. JVET said a document describing algorithms and software modules contained in the NNVC common software base would be issued as JVET-AB2019 and WG 5 N 165, following an editing period and that JVET-AB0023 is a summary of our Exploration Experiment 1 evaluating performance and complexity aspects of NNVC technologies. The reply said JVET plans to continue to explore neural-network based loop filtering, super resolution, intra prediction, and intra auto-encoding in the next round of exploration experiments.

The JVET reply also reported that a DAM of the VSEI standard (Rec. ITU-T H.274 | ISO/IEC 23002-7) was issued containing definitions of neural-network post-filter characteristics (NNPFC) and neural-network post-filter activation (NNPFA) SEI messages. An NNPFC SEI message specifies a neural network that may be used as a post-processing filter. The use of specified post-processing filters for specific pictures is indicated with NNPFA SEI messages. JVET looked forward to further communicating with JPEG on items of mutual interest.

(ITU-T SG16 also sent a reply on behalf of Q6/16 expressing similar sentiments, with somewhat less detail.)

# Project planning (update)

## Software timeline

ECM7 software (including all adoptions) was planned to be available 3 weeks after the meeting.

The NNVC 3.0 codebase software was planned to be available 3 weeks after the meeting.

VTM19.0 software was planned to be available on 2022-11-30. (Note that further updates may be released later)

HM17.0 software was planned to be available on 2022-12-16.

## Core experiment and exploration experiment planning

An EE on neural network-based video coding was established, as recorded in output document JVET-AB2023.

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-AB2024.

Initial versions of these documents were presented and approved in the first plenary session on Friday 22 July.

## Drafting of specification text, encoder algorithm descriptions, and software

The following agreement has been established: the editorial team has the discretion to not integrate recorded adoptions for which the available text is grossly inadequate (and cannot be fixed with a reasonable degree of effort), if such a situation hypothetically arises. In such an event, the text would record the intent expressed by the committee without including a full integration of the available inadequate text.

## Plans for improved efficiency and contribution consideration

The group considered it important to have the full design of proposals documented to enable proper study.

Adoptions need to be based on properly drafted working draft text (on normative elements) and HM/VTM encoder algorithm descriptions – relative to the existing drafts. Proposal contributions should also provide a software implementation (or at least such software should be made available for study and testing by other participants at the meeting, and software must be made available to cross-checkers in EEs).

Suggestions for future meetings included the following generally-supported principles:

* No review of normative contributions without draft specification text
* VTM algorithm description text is strongly encouraged for non-normative contributions
* Early upload deadline to enable substantial study prior to the meeting
* Using a clock timer to ensure efficient proposal presentations (5 min) and discussions

As general guidance, it was suggested to avoid usage of company names in document titles, software modules etc., and not to describe a technology by using a company name.

## General issues for experiments

It was emphasized that those rules which had been set up or refined during the 12th JVET meeting should be observed. In particular, for some CEs of some previous meetings, results were available late, and some changes in the experimental setup had not been sufficiently discussed on the JVET reflector.

Group coordinated experiments have been planned as follows:

* “Core experiments” (CEs) are the coordinated experiments on coding tools which are deemed to be interesting but require more investigation and could potentially become part of a draft standard by the next meeting or in the near future.
* “Exploration experiments” (EEs) are also coordinated experiments. These are conducted on technology which is not foreseen to become part of a draft standard in the near future. The investigating methodology for assessment of such technology can also be an important part of an EE. (Further general rules for EEs, as far as deviating from the CE rules below, should be discussed in a future meeting. For the current meeting, procedures as described in the EE description document are deemed to be sufficient.)
* A CE is a test of a specific fully described technology in a specific agreed way. It is not a forum for thinking of new ideas (like an AHG). The CE coordinators are responsible for making sure that the CE description is complete and correct and has adequate detail. Reflector discussions about CE description clarity and other aspects of CE plans are encouraged.
* A description of each experiment is to be approved at the meeting at which the experiment plan is established. This should include the issues that were raised by other experts when the tool was presented, e.g., interference with other tools, contribution of different elements that are part of a package, etc. The experiment description document should provide the names of individual people, not just company names.
* Software for tools investigated in a CE will be provided in one or more separate branches of the software repository. Each CE will have a “fork” of the software, and within the CE there may be multiple branches established by the CE coordinator. The software coordinator will help coordinate the creation of these forks and branches and their naming. All JVET members will have read access to the CE software branches (using shared read-only credentials as described below).
* During the experiment, revisions of the experiment plans can be made, but not substantial changes to the proposed technology.
* The CE description must match the CE testing that is done. The CE description needs to be revised if there has been some change of plans.
* The CE summary report must describe any changes that were made in the process of finalizing the CE.
* By the next meeting it is expected that at least one independent cross-checker will report a detailed analysis of each proposed feature that has been tested and confirm that the implementation is correct. Commentary on the potential benefits and disadvantages of the proposed technology in cross-checking reports is highly encouraged. Having multiple cross-checking reports is also highly encouraged (especially if the cross-checking involves more than confirmation of correct test results). The reports of cross-checking activities may (and generally should) be integrated into the CE report rather than submitted as separate documents.
* It is mandatory to report encoder optimizations made for the benefit of a tool, and if an equivalent optimization could be applied on the anchor, a comparison against the improved anchor shall be provided.
* A new proposal can be included in a CE based on group decision, regardless if an independent party has already performed a cross-check in the meeting when it was first proposed.

It is possible to define sub-experiments within particular CEs, for example designated as CEX.a, CEX.b, etc., where X is the basic CE number.

As a general rule, it was agreed that each CE should be run under the same testing conditions using one software codebase, which should be based on the group test model software codebase. An experiment is not to be established as a CE unless there is access given to the participants in (any part of) the CE to the software used to perform the experiments.

The general agreed common conditions for single-layer coding efficiency experiments for SDR video are described in the prior output document JVET-T2010.

Experiment descriptions should be written in a way such that it is understood as a JVET output document (written from an objective “third party perspective”, not a proponent perspective – e.g. not referring to methods as “improved”, “optimized”, “enhanced”, etc.). The experiment descriptions should generally not express opinions or suggest conclusions – rather, they should just describe what technology will be tested, how it will be tested, who will participate, etc. Responsibilities for contributions to CE work should identify individuals in addition to company names.

CE descriptions contain a basic description of the technology under test, but should not contain excessively verbose descriptions of a technology (at least not unless the technology is not adequately documented elsewhere). Instead, the CE descriptions should refer to the relevant proposal contributions for any necessary further detail. However, the complete detail of what technology will be tested must be available – either in the CE description itself or in documents that are referenced in the CE description that are also available in the JVET document archive.

Any technology must have at least one cross-check partner to establish a CE – a single proponent is not enough. It is highly desirable have more than just one proponent and one cross-checker.

The CE development workflow is described at:

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

CE read access is available using shared accounts: One account exists for MPEG members, which uses the usual MPEG account data. A second account exists for VCEG members with account information available in the TIES informal ftp area (IFA) system at:

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

Some agreements relating to CE activities were established as follows:

* Only qualified JVET members can participate in a CE.
* Participation in a CE is possible without a commitment of submitting an input document to the next meeting. Participation is requested by contacting the CE coordinator.
* All software, results, and documents produced in the CE should be announced and made available to JVET in a timely manner.
* A JVET CE reflector will be established and announced on the main JVET reflector. Discussion of logistics arrangements, exchange of data, minor refinement of the test plans, and preparation of documents shall be conducted on the JVET CE reflector, with subject lines prefixed by “[CEx: ]”, where “x” is the number of the CE. All substantial communications about a CE other than such details shall take place on main JVET reflector. In the case that large amounts of data are to be distributed, it is recommended to send a link to the data rather than the data itself, or upload the data as an input contribution to the next meeting.

General timeline for CEs

T1= 3 weeks after the JVET meeting: To revise the CE description and refine questions to be answered. Questions should be discussed and agreed on JVET reflector. Any changes of planned tests after this time need to be announced and discussed on the JVET reflector. Initially assigned description numbers shall not be changed later. If a test is skipped, it is to be marked as “withdrawn”.

T2 = Test model software release + 2 weeks: Integration of all tools into a separate CE branch of the VTM is completed and announced to JVET reflector.

* Initial study by cross-checkers can begin.
* Proponents may continue to modify the software in this branch until T3.
* 3rd parties are encouraged to study and make contributions to the next meeting with proposed changes

T3: 3 weeks before the next JVET meeting or T2 + 1 week, whichever is later: Any changes to the CE test branches of the software must be frozen, so the cross-checkers can know exactly what they are cross-checking. A software version tag should be created at this time. The name of the cross-checkers and list of specific tests for each tool under study in the CE plan description shall be documented in an updated CE description by this time.

T4: Regular document deadline minus 1 week: CE contribution documents including specification text and complete test results shall be uploaded to the JVET document repository (particularly for proposals targeting to be promoted to the draft standard at the next meeting).

The CE summary reports shall be available by the regular contribution deadline. This shall include documentation about crosscheck of software, matching of CE description and confirmation of the appropriateness of the text change, as well as sufficient crosscheck results to create evidence about correctness (crosscheckers must send this information to the CE coordinator at least 3 days ahead of the document deadline). Furthermore, any deviations from the timelines above shall be documented. The numbers used in the summary report shall not be changed relative to the description document.

CE reports may contain additional information about tests of straightforward combinations of the identified technologies. Such supplemental testing needs to be clearly identified in the report if it was not part of the CE plan.

New branches may be created which combine two or more tools included in the CE document or the VTM (as applicable).

It is not necessary to formally name cross-checkers in the initial version of the CE description document. To adopt a proposed feature at the next meeting, JVET would like to see comprehensive cross-checking done, with analysis of whether the description matches the software, and a recommendation of the value of the tool and given tradeoffs.

The establishment of a CE does not indicate that a proposed technology is mature for adoption or that the testing conducted in the CE is fully adequate for assessing the merits of the technology, and a favourable outcome of CE does not indicate a need for adoption of the technology into a standard or test model.

Availability of specification text is important to have a detailed understanding of the technology and also to judge what its impact on the complexity of the specification will be. There must also be sufficient time to study this in detail. CE contributions without sufficiently mature draft specification text in the CE input document should not be considered for adoption.

Lists of participants in CE documents should be pruned to include only the active participants. Read access to software will be available to all members.

# Establishment of ad hoc groups

The ad hoc groups established to progress work on particular subject areas until the next meeting are described in the table below. The discussion list for all of these ad hoc groups was agreed to be the main JVET reflector ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de)). The previously approved rules for MPEG ad hoc groups established in document [SC29/AG2 N 46](https://www.mpegstandards.org/wp-content/uploads/2022/01/ISO-IECJTC1-SC29-AG2_N0046_AhG.pdf) were agreed to apply to these ad hoc groups.

Review of AHG plans was conducted during the plenary on XXday XX January 2023 at XXXX UTC.

|  |  |  |
| --- | --- | --- |
| **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-AB1008, JVET-AB2002, JVET-AB2006, and JVET-AB2027). * Collect reports of errata for the VVC, VSEI, HEVC, AVC, CICP, the codepoint usage TR specification and the published HDR-related technical reports and produce the JVET-AB1004 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, J. Boyce, A. Browne, S. Kim, S. Liu, J.‑R. Ohm, G. J. Sullivan, A. Tourapis, Y.-K. Wang, Y. Ye (vice-chairs) | N |
| **Test model software development (AHG3)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Coordinate development of test models (VTM, HM, SCM, SHM, HTM, MFC, MFCD, JM, JSVM, JMVM, 3DV-ATM, 360Lib, and HDRTools) software and associated configuration files. * Produce documentation of software usage for distribution with the software. * Enable software support for recently standardized additional SEI messages. * Discuss and make recommendations on the software development process. * Propose improvements to the guideline document for developments of the test model software. * Perform comparative tests of test model behaviour using common test conditions. * 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. * Update the CTC document JVET-AB2010, and prepare drafts of merged CTC documents for HM and VTM, as applicable. | F. Bossen, X. Li, K. Sühring (co-chairs), E. François, Y. He, K. Sharman, V. Seregin, A. Tourapis (vice‑chairs) | N |
| **Test material and visual assessment (AHG4)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Consider plans for additional verification testing of VVC capability, particularly target establishing a test plan for VVC scalability features by the next meeting. * Maintain the video sequence test material database for testing the VVC and HEVC standards and potential future extensions, as well as exploration activities. * Study coding performance and characteristics of available and proposed video test material. * Identify and recommend appropriate test material for testing the VVC standard and potential future extensions, as well as exploration activities. * Identify and characterize missing types of video material, solicit contributions, collect, and make available a variety of video sequence test material. * Maintain and update the directory structure for the test sequence repository, as necessary. * Collect information about test sequences that have been made available by other organizations. * Prepare and conduct remote expert viewing for purposes of subjective quality evaluation. * Coordinate with AG 5 in studying and developing further methods of subjective quality evaluation, e.g. based on crowd sourcing. * Prepare availability of viewing equipment and facilities arrangements for future meetings. | V. Baroncini, T. Suzuki, M. Wien (co-chairs), S. Liu, S. Puri, A. Segall, P. Topiwala, S. Wenger, J. Xu, Y. Ye (vice-chairs) | Y (tel., 2 weeks notice) |
| **Conformance testing (AHG5)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study the draft conformance testing for operation range extensions JVET-Y2026 and the additional conformance bitstreams for VVC multilayer configurations JVET-AB2028, and investigate the need for improvements. * Study the requirements of VVC, HEVC, and AVC conformance testing to ensure interoperability. * Maintain and update the conformance bitstream database, and contribute to report problems, and suggest actions to resolve these. * Study additional testing methodologies to fulfil the needs for VVC conformance testing. | D. Rusanovskyy, I. Moccagatta (co-chairs), F. Bossen, K. Kawamura, T. Ikai, H.-J. Jhu, K. Sühring, Y. Yu (vice-chairs) | N |
| **ECM software development (AHG6)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Coordinate development of the ECM software and associated configuration files. * Produce documentation of software usage for distribution with the software. * Prepare and deliver ECM-7.0 software version and the reference configuration encodings according to the ECMcommon test conditions. * Investigate encoder speedup and other encoder software optimization. * Coordinate with ECM algorithm description editors to identify any mismatches between software and text, make further updates and cleanups to the software as appropriate. | V. Seregin (chair), J. Chen, F. Le Léannec, K. Zhang (vice-chairs) | Y (tel., 2 weeks notice) |
| **Low latency and constrained complexity (AHG7)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Identify additional application scenarios and their requirements for low latency and constrained complexity, taking into account aspects of real-time encoding and decoding. * Discuss requirements of already identified scenario such as cloud gaming, game casting, video conferencing, video surveillance and remote control of systems. * Evaluate and refine new CTC for low latency and constrained complexity application scenarios, including the option of enabling GDR according to requirements of gaming applications. * Investigate a set of tools that provide a reasonable tradeoff regarding complexity vs. compression, as well as latency constraints. * Conduct tests with ECM and VTM to determine the impact of discussed configurations on coding efficiency and run time. * Refine the set of test sequences for gaming applications, and if necessary collect new test materials that are suitable for the intended application domains, and establish an applicable dataset in coordination with AHG4. * Coordinate with AHG3 and AHG12 to discuss and recommend configuration(s) applicable to ECM and VTM, taking into account complementarity with existing CTCs. | A. Duenas, T. Poirier, S. Liu (co-chairs), L. Wang, J. Xu (vice-chairs) | N |
| **High bit depth, high bit rate, and high frame rate coding (AHG8)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study the benefits and characteristics of VVC coding tools for high bit depth, high bit rate, and high frame rate coding. * Produce test results with JVET-AA2018 testing conditions for high bit depth and high bit rate coding in coordination with AHG3. * Contribute to the development of software and conformance testing for operation range extensions in coordination with AHG3 and AHG5. | A. Browne, T. Ikai (co-chairs), D. Rusanovskyy, X. Xiu, Y. Yu (vice-chairs) | N |
| **SEI message studies (AHG9)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study the SEI messages in VSEI, VVC, HEVC and AVC. * Collect software and showcase information for SEI messages, including encoder and decoder implementations and bitstreams for demonstration and testing. * Identify potential needs for additional SEI messages, including the study of SEI messages defined in HEVC and AVC for potential use in the VVC context. * Coordinate with AHG3 for software support of SEI messages. | S. McCarthy, Y.-K. Wang (co-chairs), T. Chujoh, S. Deshpande, C. Fogg, 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 pre processing 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. * 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. * Refine the test conditions for NN-based video coding in JVET-AB2016. Generate and distribute anchor encoding, and develop supporting software as needed. * Study the impact of training (including the impact of loss functions) on the performance of candidate technologies, and identify suitable material for testing and training. * Analyse complexity characteristics, perform complexity analysis, and develop complexity reductions of candidate technology. * Finalize and discuss the EE on neural network-based video coding. * Coordinate with other relevant groups, including SC29/AG5 on the evaluation and assessment of visual quality and AHG12 on the interaction with ECM coding tools. In the case of conducting subjective viewing, provide support to AHG4 for the timely availability of test materials and test subjects. * Coordinate with AHG14 on items related to NNVC software development. | E. Alshina, S. Liu, A. Segall (co‑chairs), F. Galpin, J. Li, T. Shao, H. Wang, Z. Wang, M. Wien, P. Wu (vice‑chairs) | Y (tel., 2 weeks notice) |
| **Enhanced compression beyond VVC capability (AHG12)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Solicit and study non-neural-network video coding tools with enhanced compression capabilities beyond VVC. * Discuss and propose refinements to the ECM7 algorithm description JVET-AB2025. * Study the performance and complexity tradeoff of these video coding tools. * Coordinate with AHG6 on ECM software development. * Support AHG6 in generating anchors according to the test conditions in JVET-Y2017. * Analyse the results of exploration experiments described in JVET-AB2024 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, G. Li, X. Li, K. Naser, H. Yang (vice-chairs) | Y (tel., 2 weeks notice) |
| **Film grain technologies (AHG13)**  ([jvet@lists.rwth-aachen.de](mailto:jvet@lists.rwth-aachen.de))   * Study the benefits and characteristics of film grain technologies, including autoregressive and frequency-filtering technologies. * Discuss the JVET-AB2020 draft of the Technical Report on Film grain synthesis technology for video applications and suggest improvements as necessary. * Study alternative film grain models and their associated documentation. * Study preprocessing and encoder technologies for determining values for FGC (Film Grain Characteristics) SEI message syntax elements. * Identify potential need for additional film grain technology and signalling, if needed. * Coordinate development of film grain technology software and configuration files. * Coordinate with AG 5 on finalizing the draft plan for subjective quality testing of the FGC SEI message JVET-AB2022, and conduct preparations for such testing. * Coordinate with AHG3 for software support of the FGC SEI message. | W. Husak, M. Radosavljević, W. Wan (co-chairs), D. Grois, Y. He, P. de Lagrange, A. Segall, A. Tourapis (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-3.0 software version and the reference configuration encodings according to the NNVC common test conditions JVET-AB2016. Prepare and release anchor data for all configurations of the software. * Study and maintain the SADL (Small Adhoc Deep-Learning Library). Identify gaps in functionality and develop improvements as needed. * Coordinate with NNVC algorithm and software description (JVET-AB2019) editors to identify any mismatches between software and description document, suggest further updates to the description document as appropriate. * Develop software guidelines … * Coordinate with AHG11 on items related to NNVC activities. | S. Eadie, F. Galpin, Y. Li, L. Wang, Z. Xie (AHG chairs) |  |
| **Optimization of encoders and receiving systems for machine analysis of coded video content (AHG15)**  ([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. * Define test conditions and generate anchors. * Define evaluation framework, procedure and methodologies. * Coordinate software development and experiments. * Evaluate proposed technologies and their suitability for machine analysis applications. * Prepare a draft technical report on optimization of encoders and receiving systems for machine analysis of coded video content. * Coordinate with MPEG VCM AHG on common interests and activities such as test materials, studying characteristics and requirements of targeted machine analysis tasks, etc. | C. Hollmann, S. Liu, S. Wang, M. Zhou (AHG chairs) |  |

It was confirmed that the rules which can be found in document ISO/IEC JTC 1/‌SC 29/‌AG 2 [N 046](https://www.mpegstandards.org/wp-content/uploads/2022/01/ISO-IECJTC1-SC29-AG2_N0046_AhG.pdf) “Ad hoc group rules for MPEG AGs and WGs” (available at <https://www.mpegstandards.org/adhoc/>), are consistent with the operation mode of JVET AHGs. It is pointed out that JVET does not maintain separate AHG reflectors, such that any JVET member is implicitly a member of any AHG. This shall be mentioned in the related WG Recommendations. The list above was also issued as a separate WG 5 document (ISO/IEC JTC 1/‌SC 29/‌WG 5 N 170) 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 170, as noted in section 9.

[JVET-AB1000](https://jvet-experts.org/doc_end_user/current_document.php?id=12210) Meeting Report of the 28th JVET Meeting [J.-R. Ohm] [WG 5 N 156] (2022-11-25)

Initial versions of the meeting notes (d0 … d9) were made available on a daily basis during the meeting.

Remains valid – not updated: [JCTVC-H1001](http://phenix.it-sudparis.eu/jct/doc_end_user/current_document.php?id=5095) HEVC software guidelines [K. Sühring, D. Flynn, F. Bossen (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-Z1003](https://jvet-experts.org/doc_end_user/current_document.php?id=11705) Coding-independent code points for video signal type identification (Draft 1 of 3rd edition) [WG 5 DIS N 162] [G. J. Sullivan, A. Tourapis] (2022-11-18)

The drafted revision was issued without changes as WG 5 N 162 Text of ISO/IEC DIS 23091-2:202x Coding-independent code points – Part 2: Video (3rd edition), with due date 2022-11-09. As no changes were suggested in the CD ballot, a DoCR was not issued.

[JVET-AB1004](https://jvet-experts.org/doc_end_user/current_document.php?id=12211) Errata report items for VVC, VSEI, HEVC, AVC, Video CICP, and CP usage TR [B. Bross, I. Moccagatta, C. Rosewarne, G. J. Sullivan, Y. Syed, Y.-K. Wang] (2022-12-17, near next meeting)

New aspects included the issues pointed out in JVET-AB0223 on the Timing / DU information SEI message in HEVC and VVC. Furthermore, the change discussed in context of JVET-AB0267 (cropped width and height) should be included.

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] (2022-05-06)

Remains valid – not updated [JVET-T1006](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=10538) Annotated regions and shutter interval information SEI messages for AVC (Draft 2) [J. Boyce, S. McCarthy, Y.-K. Wang]

(This can be removed after publication of the new edition of ISO/IEC 14496-10.)

Remains valid – not updated: [JCTVC-V1007](http://phenix.it-sudparis.eu/jct/doc_end_user/current_document.php?id=10312) SHVC Test Model 11 (SHM 11) Introduction and Encoder Description [G. Barroux, J. Boyce, J. Chen, M. M. Hannuksela, Y. Ye] [WG 11 N 15778]

[JVET](https://jvet-experts.org/doc_end_user/current_document.php?id=12212)-AB1008 Additional colour type identifiers for AVC, HEVC and Video CICP (Draft 2) [G. J. Sullivan, W. Husak, A. Tourapis] (2022-11-25) [WG 5 Preliminary WD N163]

This includes identifiers for ITP-PQ-C2 colour representation proposed in JVET-AB0172. It is planned to be assigned the new codepoint number 17, to be integrated with the codepoint tables currently in JVET-Z1008 for AVC and HEVC (currently for YCoCg-R), and another table for Video CICP (only ITP-PQ-C2).

Remains valid – not updated: [JCTVC-X1009](http://phenix.it-sudparis.eu/jct/doc_end_user/current_document.php?id=10572) Common Test Conditions for SHVC [V. Seregin, Y. He]

Note that this requires update, as it refers to an outdated location of test sequences

Remains valid – not updated [JCTVC-O1010](http://phenix.it-sudparis.eu/jct/doc_end_user/current_document.php?id=8511) Guidelines for Conformance Testing Bitstream Preparation [T. Suzuki, W. Wan]

Remains valid – not updated [JVET-AA1011](https://jvet-experts.org/doc_end_user/current_document.php?id=11944) HEVC multiview profiles supporting extended bit depth (draft 1) [A. Tourapis, W. Husak] [WG 5 preliminary WD N 143] (2022-08-26)

This output arises from JVET-AA0239.

Proponents of the new profiles were requested to develop conformance bitstreams, and contribute to HTM software changes if necessary.

JVET-[AB1012](https://jvet-experts.org/doc_end_user/current_document.php?id=12213) Overview of IT systems used in JVET [J.-R. Ohm, I. Moccagatta, K. Sühring, M. Wien] (2022-12-23)

No output: JVET-T1013

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 for HM – not updated: [JCTVC-Z1015](http://phenix.it-sudparis.eu/jct/doc_end_user/current_document.php?id=10689) Common Test Conditions for Screen Content Coding [H. Yu, R. Cohen, K. Rapaka, J. Xu]

Note that this requires update, as it refers to an outdated location of test sequences

Establish links or updates (and the related test models):

JCT3V-G1100 3DV test conditions

No output: JVET-X1016 through JVET-X1019

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] (2022-08-19)

This specifies only the CTC for non-4:2:0 colour formats. The corresponding document for VVC is JVET-T2013, with no unification yet.

Remains valid – not updated: [JVET-T2001](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=10540) Versatile Video Coding Draft 10 [B. Bross, J. Chen, S. Liu, Y.-K. Wang]

[JVET-AB2002](https://jvet-experts.org/doc_end_user/current_document.php?id=12214) Algorithm description for Versatile Video Coding and Test Model 18 (VTM 18) [A. Browne, Y. Ye, S. Kim] [WG 5 N 161] (2022-01-06, near next meeting)

Updates include descriptions of new SEI message processing, in particular for the SEI processing order SEI), Green metadata, and potentially some other SEI messages as listed under JVET-AB0269. Further non-normative modifications adopted for VTM are the contributions on RPR encoder, and upsanpling filters (JVET-AB0080 and JVET-AB0081).

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-N1003](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=6638) Guidelines for VVC reference software development [K. Sühring]

If ever a new version is made, this should become 2003.

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]

Remains valid – not updated [JVET-AA2005](https://jvet-experts.org/doc_end_user/current_document.php?id=11946) New level and systems-related supplemental enhancement information for VVC (Draft 3) [B. Bross, E. François, A. Tourapis, Y.-K. Wang] [WG 5 DAM 1 N 145] (2022-07-29)

[JVET-AB2006](https://jvet-experts.org/doc_end_user/current_document.php?id=12215) Additional SEI messages for VSEI (Draft 3) [S. McCarthy, T. Chujoh, M. M. Hannuksela, G. J. Sullivan, Y.-K. Wang] [WG 5 DIS N 158] (2022-11-09)

A DoCR for ballot responses on CDAM 1 (WG 5 N 157) was reviewed Thursday 27 October at 0920.

The aspect of having several NNPFC messages activated in one picture was discussed (comment #056). It was agreed to allow this, as it is the choice of the decoding device to operate those which are fitting the purpose of the local output or its capabilities. Examples are SEI messages with different purposes, or SEI messages with the same purpose and different degrees of complexity.

It was agreed to convert this into the FDIS of a new edition after DAM ballot (comment #70). Due to short editing period, it is not practical to do this at the current stage.

The elements to be modified are indicated with yellow highlights as “decision” or “agreed” in sections 6.1 and 6.2.

Remains valid – not updated: [JVET-S2007](http://phenix.it-sudparis.eu/jvet/doc_end_user/current_document.php?id=9679) Versatile supplemental enhancement information messages for coded video bitstreams Draft 5 [J. Boyce, V. Drugeon, G. J. Sullivan, Y.-K. Wang]

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]

[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] (2022-11-11)

Remains valid – not updated: [JVET-Z2011](https://jvet-experts.org/doc_end_user/current_document.php?id=11712) VTM and HM common test conditions and evaluation procedures for HDR/WCG video [A. Segall, E. François, W. Husak, S. Iwamura, D. Rusanovskyy] (2022-05-13)

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] (2021-03-31)

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-AB2016](https://jvet-experts.org/doc_end_user/current_document.php?id=12217) Common Test Conditions and evaluation procedures for neural network-based video coding technology [E. Alshina, R.-L. Liao, S. Liu, A. Segall] (2022-11-11)

Update in the methodology of kMAC/pixel computation (recommendation from JVET-AB0023).

Remains valid – not updated: [JVET-Y2017](https://jvet-experts.org/doc_end_user/current_document.php?id=11473) Common Test Conditions and evaluation procedures for enhanced compression tool testing [M. Karczewicz and Y. Ye]

Only a change of config file for JVET-AA0098 was noted (and probably some other CTC related decision noted elsewhere). It was further decided to enable palette mode for classes F and TGM in the CTC both for VTM anchor and ECM. As these affected only the config files rather than the document, no need to produce a revised document was identified.

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] (2022-08-19)

[JVET-AB2019](https://jvet-experts.org/doc_end_user/current_document.php?id=12218) Description of algorithms and software in neural network-based video coding (NNVC) [Y. Li, H. Wang, L. Wang, F. Galpin, J. Ström] [WG 5 N 165] (2022-12-02)

Developed from JVET-AB0183 (see notes there, and under EE1 summary JVET-AB0023 about what else to added).

[JVET-AB2020](https://jvet-experts.org/doc_end_user/current_document.php?id=12219) Film grain synthesis technology for video applications (Draft 3) [D. Grois, Y. He, W. Husak, P. de Lagrange, A. Norkin, M. Radosavljević, A. Tourapis, W. Wan] [WG 5 N 159] (2022-12-16)

Developed from JVET-AB0042.

[JVET-AB2021](https://jvet-experts.org/doc_end_user/current_document.php?id=12220) Draft verification test plan for VVC multilayer coding [S. Iwamura, P. de Lagrange, M. Wien] (2022-12-16)

A draft of this document was presented in JVET at 1610 on Thursday 27 Oct. This document had been developed in the joint BoG with AG 5 (meeting at 1600-1730 on Wednesday 26 Oct.); no separate BoG report was produced, as the presented draft document reflected the results of the BoG.

[JVET-AB2022](https://jvet-experts.org/doc_end_user/current_document.php?id=12221) Draft plan for subjective quality testing of FGC SEI message [P. de Lagrange, W. Husak, M. Radosavljević, M. Wien] (2022-12-16)

A draft of this document was presented in JVET at 1630 on Thursday 27 Oct. This document had been developed in the joint BoG with AG 5 (meeting at 1600-1730 on Wednesday 26 Oct.), no separate BoG report was produced, as the presented draft document reflected the results of the BoG.

It was asked if also tests are planned using HM. This aspect is left open for now; it might be done if it is demonstrated that such an additional comparison would have additional benefit in terms of what the test is intending to study. Is it about showing the advantages of the SEI message (which could be used for both VVC and HEVC), or could it also demonstrate that VVC has more advantage than HEVC if the SEI message is used.

It was commented that testing the quality of the synthesized film grain is very important (goal 2 of the plan).

(It was mentioned that a merge request on the SEI message implementation on top of the HM had already been made, and it was waiting for release of a new version.)

[JVET-AB2023](https://jvet-experts.org/doc_end_user/current_document.php?id=12208) Exploration Experiment on Neural Network-based Video Coding (EE1) [E. Alshina, F. Galpin, Y. Li, M. Santamaria, J. Ström, H. Wang, L. Wang, Z. Xie] [WG 5 N 164] (2022-11-11)

An initial draft of this document was reviewed and approved at 0905-0945 on Friday 28 October.

Categories are loop filters, post filters, superresolution upsampling, intra coding (AE integerization), and intra prediction.

It was suggested that it would be interesting to perform subjective quality investigation with some of the super-resolution proposals in a future meeting (provided that close enough rate/quality matching with anchor is achieved).

[JVET-AB2024](https://jvet-experts.org/doc_end_user/current_document.php?id=12209) Exploration Experiment on Enhanced Compression beyond VVC capability (EE2) [V. Seregin, J. Chen, G. Li, K. Naser, J. Ström, F. Wang, M. Winken, X. Xiu, K. Zhang] [WG 5 N 166] (2022-11-25)

An initial draft of this document was reviewed and approved at 0945-1015 on Friday 28 October. JVET-AB0150 was added as test 2.7b. Clarification is necessary about the training set to be used in test 4.2b (referred to as “LFNST set”).

Categories are intra prediction, inter prediction, screen content coding, transforms, and in-loop filters.

[JVET-AB2025](https://jvet-experts.org/doc_end_user/current_document.php?id=12222) Algorithm description of Enhanced Compression Model 7 (ECM 7) [M. Coban, F. Le Léannec, R.-L. Liao, K. Naser, J. Ström, L. Zhang] [WG 5 N 167] (2022-12-31)

New elements from notes elsewhere in this report:

* Decision: Adopt JVET-AC0XXX test X.

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-Y2026](https://jvet-experts.org/doc_end_user/current_document.php?id=11477) Conformance testing for VVC operation range extensions (Draft 3) [WG 5 DAM [N 110](https://dms.mpeg.expert/doc_end_user/current_document.php?id=81998&id_meeting=189)] [D. Rusanovskyy, T. Hashimoto, H.-J. Jhu, I. Moccagatta, Y. Yu]

Editorial improvements are recorded in JVET-AA0109, no need for a new output at the current meeting was identified.

[JVET-AB2027](https://jvet-experts.org/doc_end_user/current_document.php?id=12223) SEI processing order SEI message in VVC (draft 2) [S. McCarthy, M. Hannuksela, Y.-K. Wang] [WG 5 preliminary WD 2 N 160] (2022-11-18)

New version (see discussion under JVET-AB0051 and JVET-AB0069)

[JVET-AB2028](https://jvet-experts.org/doc_end_user/current_document.php?id=12224) Additional conformance bitstreams for VVC multilayer configurations [S. Iwamura, I. Moccagatta] (2022-12-31)

Developed from JVET-AB0085.

[JVET-AB2029](https://jvet-experts.org/doc_end_user/current_document.php?id=12225) Visual quality comparison of ECM/VTM encoding [V. Baroncini, J.-R. Ohm, M. Wien] [AG 5 N75] (2022-12-09)

An initial version was reviewed on Friday 28 October at 1030.

# Future meeting plans, expressions of thanks, and closing of the meeting

Future meeting plans were established according to the following guidelines (assuming face-to-face meetings):

* Meeting under ITU-T SG16 auspices when it meets (ordinarily starting meetings on the Wednesday of the first week and closing it on the Wednesday of the second week of the SG16 meeting – a total of 8 meeting days), and
* Otherwise meeting under ISO/IEC JTC 1/‌SC 29 auspices when its MPEG WGs meet (ordinarily starting meetings on the Friday prior to the main week of such meetings and closing it on the same day as other MPEG WGs – a total of 8 meeting days).

In cases where an exceptionally high workload is expected for a meeting, an earlier starting date may be defined. In cases of online meetings, no sessions should be held on weekend days. This may imply an earlier starting date as well.

Some specific future meeting plans (to be confirmed) were established as follows:

* Wed. 11 – Fri. 13 and Mon. 16 – Fri. 20 January 2023, 29th meeting under ISO/IEC JTC 1/‌SC 29 auspices, to be held as teleconference meeting.
* During Fri. 21 – Fri. 28 April 2023, 30th meeting under ISO/IEC JTC 1/‌SC 29 auspices in Antalya, TR
* During Fri. 14 – Fri. 21 July 2023, 31st meeting under ITU-T SG16 auspices in Geneva, CH (date to be confirmed)
* During October 2023, 32nd meeting under ISO/IEC JTC 1/‌SC 29 auspices, date and location t.b.d.
* During January 2024, 33rd meeting under ISO/IEC JTC 1/‌SC 29 auspices, date and location t.b.d.
* During April 2024, 34th meeting under ITU-T SG16 auspices, date and location t.b.d.
* During Fri. 12 – Fri. 19 July 2024, 35th meeting under ISO/IEC JTC 1/‌SC 29 auspices in Sapporo, JP
* During October 2024, 36th meeting under ISO/IEC JTC 1/‌SC 29 auspices, date and location t.b.d.

The agreed document deadline for the 29th JVET meeting was planned to be Wednesday 4 January 2023.

Kenzler Conference Management and the entire team were thanked for the excellent hosting and organization of the 28th meeting of the JVET. Qualcomm was thanked for financially supporting the social event. Vittorio Baroncini and Mathias Wien were thanked for conducting subjective quality tests related to the ECM. VABTech was thanked for providing resources to run tests with non-expert viewers. HHI was thanked for providing equipment used in the experts viewing in Mainz. The following companies were thanked for preparing encoded bitstreams: Alibaba, Bytedance, Ericsson, InterDigital, Qualcomm, and Xiaomi. Experts who volunteered to participate in the viewing were also thanked.

It was suggested that in the next meeting, perspectives should be discussed for the ongoing JVET explorations, in terms of potentially developing standardization projects and realistic timelines. In particular, from the current status of the exploration on enhanced compression capability beyond current VVC profiles, evidence has been shown about visual quality improvement. Market needs and related requirements could be considered at the level of the parent bodies.

The 28th JVET meeting was closed at approximately 1645 hours on Friday 28 October 2022.

# Annex A to JVET report: List of documents

# Annex B1 to JVET report: List of meeting participants attending in person

The participants who were personally present at the meeting site of the twenty-ninth meeting of the JVET, according to an attendance sheet circulated during the meeting sessions (approximately 0 people in total), were as follows (note: Annex kept for future use):

# Annex B2 to JVET report: List of meeting participants attending remotely

The remote participants of the twenty-eighth meeting of the JVET, according to the participation records from the Zoom teleconferencing tool used for the meeting sessions (approximately XXX people in total, not including those who had attended the meeting in person at least part-time (see annex B1), and not including those who attended only the joint sessions with other groups), were as follows:

# Annex C to JVET report: Recommendations of the 10th meeting of ISO/IEC JTC 1/SC 29/WG 5 MPEG Joint Video Coding Team(s) with ITU-T SG 16

**ISO/IEC JTC 1/SC 29/WG 5 N XXX**