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| **INTERNATIONAL ORGANIZATION FOR STANDARDIZATION ORGANISATION INTERNATIONALE DE NORMALISATION ISO/IEC JTC 1/SC 29/WG 5 MPEG JOINT VIDEO CODING TEAM WITH ITU-T SG 16** |
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| |  |  | | --- | --- | | **Title:** | **Exploration experiment on enhanced compression beyond VVC capability (EE2)** | | **Source:** | **Convenor (Jens-Rainer Ohm)** | | **Type:** | **General** | | **Subtype:** | **N/A** | | **Status:** | **Approved** | | **Date:** | **2022-07-22** | | **Expected Action:** | **Info** | | **Action due date:** | **N/A** | | **No. of pages** | **13** (without this cover page) | | **Email of convenor:** | **ohm @ ient . rwth-aachen . de** | | **Committee URL:** | **https://sd.iso.org/documents/ui/#!/browse/iso/iso-iec-jtc-1/iso-iec-jtc-1-sc-29/iso-iec-jtc-1-sc-29-wg-5** | |

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| **Joint Video Experts Team (JVET)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29**  27th Meeting, by teleconference, 13–22 July 2022 | Document: JVET-AA2024-v1 |

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| --- | --- | --- | --- |
| *Title:* | **Exploration Experiment on Enhanced Compression beyond VVC capability (EE2)** | | |
| *Status:* | Output document to JVET | | |
| *Purpose:* | EE description | | |
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| *Source:* | EE coordinators | | |

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# Abstract

This document describes Exploration Experiments (EEs) planned to be performed between 27th and 28th JVET meetings to evaluate enhanced compression tools beyond VVC capability.

# Introduction

EE focus is to evaluate individual coding technologies and their combinations. Contributions improving compression efficiency further is highly encouraged.

EE related discussions shall happen on JVET and JVET-CE reflectors.

EE tests should be implemented on top the ECM software, ECM-6.0 is used as an anchor in the tests.

Tests shall be performed according to the CTC described in JVET-Y2017.

TGM class tests are required for SCC tool testing and is optional otherwise.

For RPR tests, in addition to ECM CTC the tests are performed following JVET-Q2015, where only LB configuration is mandatory.

AI and RA test configurations are required for intra tool testing, while RA and LB test configurations are required for inter tool testing. LP configuration is optional. In LB and LP configurations, the sequences length is reduced to 5 seconds for all classes.

If encoder modification is included in EE tests, such encoder optimization, if applicable, introduced to the anchor should be tested.

# Timeline

**T1** = 3 weeks (August 12, 2022) after JVET meeting: ECM is released

**T2** = T1 + 1 week (August 19, 2022): EE description is finalized

**T3** = T2 + 2 weeks (September 2, 2022): Initial software release for EE tests

**T4** = JVET meeting start – 3 weeks (September 30, 2022): Software in EE branches is frozen

# List of tests

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Tests** | **Tester** | **Cross-checker** |
| **1 Intra prediction** | | | |
| 1.1 | Reduced complexity spatial GPM | InterDigital  K. Naser |  |
| 1.2 | Reducing the number of GPM partition types and intra mode derivation | Ittiam  J. Arumugam  Dolby  T. Lu |  |
| 1.3 | Smaller and bigger block sizes for spatial GPM | OPPO  F. Wang |  |
| 1.4 | Adaptive blending for spatial GPM | OPPO  F. Wang |  |
| 1.5 | Complexity reduction of spatial GPM | OPPO  F. Wang |  |
| 1.6 | Combination of spatial GPM tests  Test 1.1 + Test 1.2 + Test 1.3 + Test 1.4 + Test1.5 | InterDigital  K. Naser  Ittiam  J. Arumugam  Dolby  T. Lu  OPPO  F. Wang |  |
| 1.7a | CCLM with non-linear term | Alibaba  X. Li |  |
| 1.7b | CCLM with non-linear term as an additional mode | Alibaba  X. Li |  |
| 1.7c | CCLM with non-linear term with CCCM parameter derivation | Alibaba  X. Li |  |
| 1.8a | Gradient linear model with luma value | Alibaba  X. Li |  |
| 1.8b | Gradient linear model with luma value as additional modes | Alibaba  X. Li |  |
| 1.9 | Self-aware filter estimation for CCLM | Bytedance  K. Zhang |  |
| 1.10 | Template-based multiple reference line intra prediction | OPPO  L. Xu |  |
| 1.11a | Intra prediction fusion | Qualcomm  K. Cao |  |
| 1.11b | Intra reference fusion | Qualcomm  K. Cao |  |
| 1.12a | Test 1.10 and Test 1.11a | OPPO  L. Xu  Qualcomm  K. Cao |  |
| 1.12b | Test 1.10 and Test 1.11b | OPPO  L. Xu  Qualcomm  K. Cao |  |
| 1.13a | Template selection scheme for CCCM modes | Qualcomm  Y.-J. Chang |  |
| 1.13b | Test 1.13a and CCCM fusion instead of MMLM fusion | Qualcomm  Y.-J. Chang |  |
| 1.14 | IntraTMP adaptation for camera-captured content | InterDigital  K. Naser |  |
| 1.15 | Horizontal and vertical planar modes | Alibaba  X. Li |  |
| 1.16 | Picture-level geometry transform | Bytedance  W. Jia | Xiaomi  P. Andrivon |
| **2 Inter prediction** | | | |
| 2.1a | AmvpMerge for the low-delay picture | LGE  H. Jang |  |
| 2.1b | Test 2.1a without template matching-based MV refinement | LGE  H. Jang |  |
| 2.2 | Template matching based BCW index derivation for merge mode | Alibaba  R.-L. Liao | OPPO  K. Sato |
| 2.3 | POC based BCW weights derivation | Qualcomm  Z. Zhang |  |
| 2.4a | Test 2.2 + Test 2.3 with removing negative BCW weights | Alibaba  R.-L. Liao  Qualcomm  Z. Zhang |  |
| 2.4b | Test 2.3 + Test 2.2 TM BCW index reordering for merge candidates | Alibaba  R.-L. Liao  Qualcomm  Z. Zhang |  |
| 2.5a | Enhanced temporal motion information derivation | Bytedance  L. Zhao | Tencent  L.-F. Chen |
| 2.5b | Enhanced temporal motion information derivation without template matching for SbTMVP | Bytedance  L. Zhao | Tencent  L.-F. Chen |
| 2.6 | DMVR for affine merge coded blocks | Alibaba  J. Chen |  |
| 2.7 | Extended weights for MHP | OPPO  K. Sato |  |
| **3 Screen content coding** | | | |
| 3.1a | IntraTMP for chroma component | InterDigital  K. Naser | Xiaomi  F. Le Léanec |
| 3.1b | IntraTMP for chroma components using luma block vector | InterDigital  K. Naser |  |
| 3.2 | Using block vector derived from IntraTMP for IBC | ETRI  W. Lim | Xiaomi  F. Le Léannec |
| 3.3 | Using luma and chroma block vectors derived from IntraTMP for IBC | InterDigital  K. Naser  ETRI  W. Lim | Xiaomi  F. Le Léannec |
| **4 Transform** | | | |
| 4.1a | Modification of LFNST for MIP coded blocks | Xidian MMC Lab.  J.-Y. Huo  W.-H. Qiao |  |
| **5 In-loop filtering** | | | |
| 5.1 | Extended fixed-filter-output based taps for ALF | Bytedance  W. Yin |  |

# Tools description

## Intra prediction

### Test 1.1: Reduced complexity spatial GPM (JVET-AA045)

In this test, reduced complexity version of spatial GPM is tested. Specifically, the following is tested:

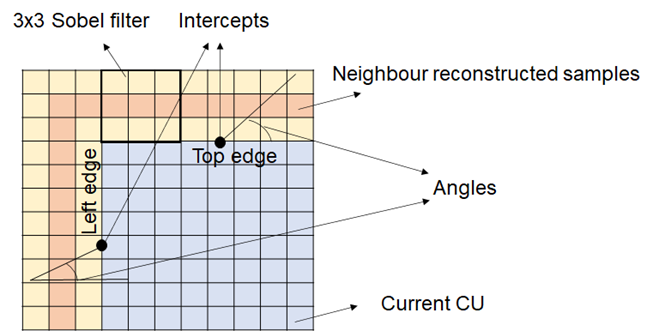
1. Reduced number of tested intra modes and split modes
2. Reduced number of signalled SGPM modes
3. Reduced RDO checks

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.1 | Reduced complexity spatial GPM | InterDigital  K. Naser |

### Test 1.2: Reducing the number of GPM partition types and intra mode derivation (JVET-AA0149)

In this test, GPM partition types are derived by an adaptive GPM partitioning list derivation algorithm. Candidate partitioning types are selected based on the gradients of the top and left neighbours of the CU. Intra modes from the IPM list are used for spatial GPM intra mode.



***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.2 | Reducing the number of GPM partition types and intra mode derivation | Ittiam  J. Arumugam  Dolby  T. Lu |

### Test 1.3: Smaller and bigger block sizes for spatial GPM (JVET-AA0119)

Spatial GPM can be applied to the blocks whose width and height meet the following restrictions: 8<=width<=64, 8<=height<=64, width<height\*8, height<width\*8. In this test, the benefit of extending the spatial GPM to smaller and bigger block sizes is investigated.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.3 | Smaller and bigger block sizes for spatial GPM | OPPO  F. Wang |

### Test 1.4: Adaptive blending for spatial GPM (JVET-AA0119)

In this test, the benefit of adaptive blending for spatial GPM is investigated. Specifically, besides the original blending area (i.e., 2 sample on each side of the spatial GPM partition split boundary), extra blending area sizes are added.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.4 | Adaptive blending for spatial GPM | OPPO  F. Wang |

### Test 1.5: Complexity reduction of spatial GPM (JVET-AA0119)

The encoder strategies and the process of deriving spatial GPM candidates with template, which dictates the encoding and decoding complexity, will be tested. In this test, the complexity reduction methods in JVET-AA0118 (EE2-1.4) and JVET-AA0119 are further investigated.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.5 | Complexity reduction of spatial GPM | OPPO  F. Wang |

### Test 1.6: Combination of spatial GPM tests

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.6 | Test 1.1 + Test 1.2 + Test 1.3 + Test 1.4 + Test1.5 | InterDigital  K. Naser  Ittiam  A. Natesan  Dolby  T. Lu  OPPO  F. Wang |

### Test 1.7: CCLM with non-linear term (JVET-AA0103)

In this test, a non-linear term of the luma value is introduced into the CCLM method. A chroma sample is predicted based on a linear term and a non-linear term of the reconstructed luma sample value, where the model parameters are derived from adjacent samples.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.7a | CCLM with non-linear term | Alibaba  X. Li |
| 1.7b | CCLM with non-linear term as an additional mode | Alibaba  X. Li |
| 1.7c | CCLM with non-linear term with CCCM parameter derivation | Alibaba  X. Li |

### Test 1.8: Gradient linear model with luma value (JVET-AA0138)

Gradient linear model with luma value is tested. A chroma sample is predicted based on both the gradient of luma samples and the reconstructed value of a luma sample with different parameters.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.8a | Gradient linear model with luma value | Alibaba  X. Li |
| 1.8b | Gradient linear model with luma value as additional modes | Alibaba  X. Li |

### Test 1.9: Self-aware filter estimation for CCLM (JVET-AA0140)

In the tested method, N candidate luma down-sampling filters are predefined. When self-aware filter estimation for CCLM is applied, a linear model between luma and chroma component is derived in the same way as that in ECM for each candidate filter first. Second, prediction values are calculated with each linear model in a testing region including one-column left neighbouring samples and one-row above neighbouring samples. Third, a SAD cost between the reconstructed samples and their corresponding prediction values in the testing region is computed for each filter candidate. Finally, the filter candidate with the least SAD cost is selected as the down-sampling filter to perform the CCLM prediction for the current block. When CCLM is indicated to be used for a block, a mode flag is signaled to indicate the mode usage.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.9 | Self-aware filter estimation for CCLM | Bytedance  K. Zhang |

### Test 1.10: Template-based multiple reference line intra prediction (JVET-AA0120)

A template-based multiple reference line intra prediction is tested, where it replaces the MRL for non-TIMD cases. A candidate list that includes combinations of reference line and intra prediction mode is constructed based on SAD cost calculated in the template area, a list index is signaled to indicate the reference line and intra prediction mode for a current block.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.10 | Template-based multiple reference line intra prediction | OPPO  L. Xu |

### Test 1.11: Intra prediction fusion (JVET-AA0137)

In this test, predicted samples are derived as a weighted combination of two predictions derived from different reference lines. One is the default reference line, the other is the reference line top/left of the default reference line. An alternative method is also tested, which is to weighted combine reference lines instead of predictors.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.11a | Intra prediction fusion | Qualcomm  K. Cao |
| 1.11b | Intra reference fusion | Qualcomm  K. Cao |

### Test 1.12: Combination of Test 1.10 and Tests 1.11 (JVET-AA0246)

Combinations of Test 1.10 and Tests 1.11 are investigated.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.12a | Test 1.10 and Test 1.11a | OPPO  L. Xu  Qualcomm  K. Cao |
| 1.12b | Test 1.10 and Test 1.11b | OPPO  L. Xu  Qualcomm  K. Cao |

### Test 1.13: CCCM improvement (JVET-AA0136)

In this test, the template selection scheme is applied to CCCM modes to use top-only template, left-only template, or top and left template to derive CCCM model. It also tests to replace the MMLM fusion with CCCM fusion on top of the CCCM template selection scheme.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.13a | Template selection scheme for CCCM modes | Qualcomm  Y.-J. Chang |
| 1.13b | Test 1.13a and CCCM fusion instead of MMLM fusion | Qualcomm  Y.-J. Chang |

### Test 1.14: IntraTMP adaptation for camera-captured content (JVET-AA0043)

In this test, IntraTMP is enabled for all CTC sequences, where faster version of is proposed. The speed-up is achieved by:

1. Search range subsampling: It is proposed to subsample each of the search areas by a sampling factor “s=1<<i” (“s” is a variable of power 2).
2. Iterative refinement: After finding the best matching within the subsampled search area, the search is refined around the best match. The refinement is repeated with the sampling factor divided by 2, until the full pixel search.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.14 | IntraTMP adaptation for camera-captured content | InterDigital  K. Naser |

### Test 1.15: Horizontal and vertical planar modes (JVET-AA0104)

Two new additional planar modes are tested where only the horizontal interpolation or only the vertical interpolation is used to obtain the predicted samples.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.15 | Horizontal and vertical planar modes | Alibaba  X. Li |

### Test 1.16: Picture-level geometry transform (JVET-AA0142)

In this test, geometry transforms can be applied at picture level on I frames. It is signaled whether to apply a transform and which transform is applied. A fast encoding strategy is designed.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 1.16 | Picture-level geometry transform | Bytedance  W. Jia |

## Inter prediction

### Test 2.1: AmvpMerge for low delay (JVET-AA0069)

In this test, amvpMerge mode is enabled for low delay picture. This test allows amvpMerge to construct reference picture pair with non-true-bidirectional reference pictures in the slice level while the restriction condition on the resampled, long-term, and WP reference pictures are relaxed. Bilateral matching cost of an amvpMerge candidate which is not true bi-directional is set to be the maximum value during merge candidate reordering. Additionally in order to know impact of the template matching-based MV refinement process, amvpMerge mode with template matching-based MV refinement is simulated for low-delay picture in Test 2.1a and in Test 2.1b, amvpMerge mode is applied without template matching-based MV refinement for low-delay picture.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.1a | AmvpMerge for low delay | LGE  H. Jang |
| 2.1b | Test 2.1a without template matching-based MV refinement | LGE  H. Jang |

### Test 2.2: Template matching based BCW index derivation for merge mode (JVET-AA075)

In this test, the BCW index for merge coded CUs is derived based on template matching cost instead of inferring from neighboring blocks. Given a merge candidate, the TM cost values are calculated with different BCW indices setting, and then, the BCW index with minimum TM cost value is used for the merge candidate. In addition, removing the BCW negative weights for low delay and non-low delay pictures is tested.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.2 | Template matching based BCW index derivation for merge mode | Alibaba  R.-L. Liao |

### Test 2.3: POC based BCW weights derivation (JVET-AA0134)

In this test, additional BCW weights are derived based on POC difference as follows:

* If both reference pictures are from the past or from the future relatively to the current picture, the weight pair either (-2, 10) or (-3, 11) is added based on low-delay conditions.
* Otherwise, the (2, 6) weight pair is added.

The larger value from the weight pair is assigned to the closest POC reference picture or list 0 reference picture when the POC distance is the same.

The BCW index list size is increased by one when the proposed method is applied, and the proposed method is not used with MHP for AMVP mode. The proposed BCW weight is assigned to pair-wise and zero merge candidates in addition to BCW default weight.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.3 | POC based BCW weights derivation | Qualcomm  Z. Zhang |

### Test 2.4: Combination of BCW weight tests

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.4a | Test 2.2 + Test 2.3 with removing negative BCW weights | Alibaba  R.-L. Liao  Qualcomm  Z. Zhang |
| 2.4b | Test 2.3 + Test 2.2 TM BCW index reordering for merge candidates | Alibaba  R.-L. Liao  Qualcomm  Z. Zhang |

### Test 2.5: Enhanced temporal motion information derivation (JVET-AA0141)

In this test, two aspects are proposed to further improve temporal motion information derivation, where two collocated frames are utilized and the motion shift to locate sbTMVP/TMVP is adaptively determined from multiple locations in an extended region. Besides, more sbTMVP candidates are introduced and ARMC for the sub-block-based merge candidate list is thereby modified.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.5a | Enhanced temporal motion information derivation | Bytedance  L. Zhao |
| 2.5b | Enhanced temporal motion information derivation without template matching for SbTMVP | Bytedance  L. Zhao |

### Test 2.6: DMVR for affine merge coded blocks (JVET-AA0144)

In this test, DMVR is applied on affine merge coded blocks. Specifically, for the affine merge candidate satisfying the DMVR condition, a local search is performed around the position referred to by the subblock MVs derived by the initial CPMVs of the candidate. The one with minimum difference between list0 predictor and list1 predictor is selected and the corresponding MVs are used as refined MVs for motion compensation for the current affine block.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.6 | DMVR for affine merge coded blocks | Alibaba  J. Chen |

### Test 2.7: Extended weights for MHP (JVET-AA0148)

In this test, extended weight table represented by syntax element add\_hyp\_weight\_idx for multi-hypothesis prediction (MHP) is tested. The various methods for coding add\_hyp\_weight\_idx as well as the corresponding encoder optimization will be investigated and tested for achieving a better trade-off between coding efficiency and complexity.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 2.7 | Extended weights for MHP | OPPO  K. Sato |

## Screen content coding

### Test 3.1: IntraTMP for chroma component (JVET-AA0044)

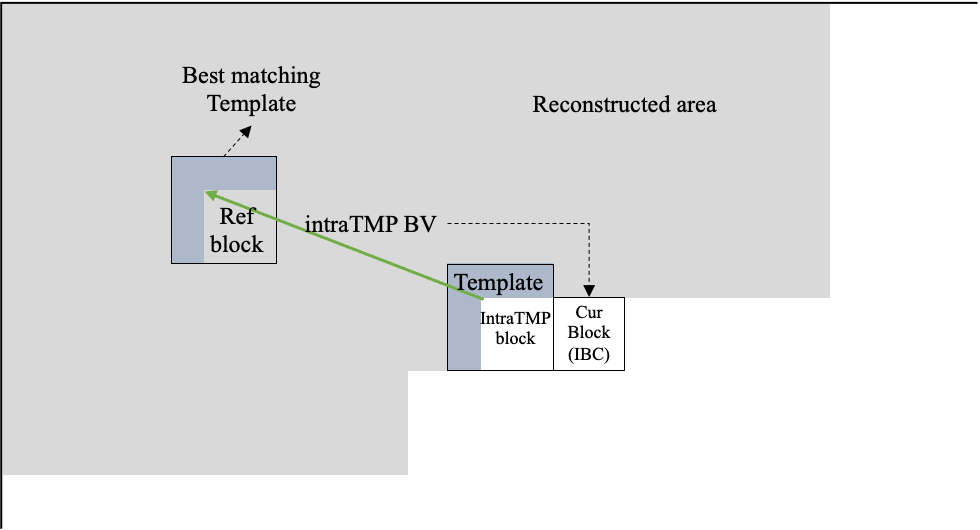
In this test, IntraTMP is performed for both luma and chroma components. Specifically, the same process for luma IntraTMP is reused for each chroma components. In the second test, the block vectors are shared between luma and chroma, specifically for single tree case.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 3.1a | IntraTMP for each chroma component | InterDigital  K. Naser |
| 3.1b | IntraTMP for chroma components using luma block vector | InterDigital  K. Naser |

### Test 3.2: Using block vector derived from IntraTMP for IBC (JVET-AA0053)

In the test, IntraTMP BV is stored as shown below, and IBC block can use both IBC BV and IntraTMP BV of neighbouring block as BV candidate for IBC BV candidate list.



***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 3.2 | Using block vector derived from IntraTMP for IBC | ETRI  W. Lim |

### Test 3.3: Combination of Test 3.1 and 3.2

This test combines both aspects of Test 3.1 and Test 3.2. Specifically, the IntraTMP block vector obtained from luma or chroma components are used for IBC.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 3.3 | Using luma and chroma block vectors derived from IntraTMP for IBC | InterDigital  K. Naser  ETRI  W. Lim |

## Transform

### Test 4.1: Modification of LFNST for MIP coded blocks (JVET-AA0073)

In this test, DIMD is used to derive a traditional intra prediction mode for MIP coded blocks based on the prediction samples before upsampling, then the LFNST transform set and LFNST transpose flag are both determined by the derived intra mode. Moreover, LFNST is enabled for MIP coded blocks of width and height greater than or equal to 4.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 4.1 | Modification of LFNST for MIP coded blocks | Xidian MMC Lab.  J.-Y. Huo  W.-H. Qiao |

## In-loop filtering

### Test 5.1: Extended fixed-filter-output based taps for ALF (JVET-AA0147)

In the current adaptive loop filter (ALF) design, online-trained filters contain 2 kinds of taps: spatial taps and fixed-filter-output based taps. In ECM-5.0, an online-trained filter contains 2 fixed-filter-output based taps. In this test, the number of fixed-filter-output based taps is increased to provide more information for ALF.

***List of tests to be performed***

|  |  |  |
| --- | --- | --- |
| # | Test | Tester |
| 5.1 | Extended fixed-filter-output based taps for ALF | Bytedance  W. Yin |