 ISO/IEC JTC 1/SC 29/WG 7 N00155

**ISO/IEC JTC 1/SC 29/WG 7  
MPEG 3D Graphics Coding   
Convenorship: AFNOR (France)**

**Document type:** Output Document

**Title:** Description of Exploration Experiment 13.2 on inter prediction

**Status:** Approved

**Date of document:** 2021-08-06

**Source:** ISO/IEC JTC 1/SC 29/WG 7

**Expected action:** None

**Action due date:** None

**No. of pages:** 10 (with cover page)

**Email of Convenor:** marius.preda @ it-sudparis.eu

**Committee URL:** [https://isotc.iso.org/livelink/livelink/open/jtc1sc29wg7](https://isotc.iso.org/livelink/livelink/open/jtc1sc29wg3)

**INTERNATIONAL ORGANIZATION FOR STANDARDIZATION**

**ORGANISATION INTERNATIONALE DE NORMALISATION**

**ISO/IEC JTC 1/SC 29/WG 7 MPEG 3D Graphics Coding**

**ISO/IEC JTC 1/SC 29/WG 7 N00155**

**July 2021, Virtual**

|  |  |
| --- | --- |
| **Title** | **Description of Exploration Experiment 13.2 on inter prediction** |
| **Source** | **WG 7, MPEG 3D Graphics Coding** |
| **Status** | **Approved** |
| **Serial Number** | **20631** |

# Abstract

This document provides the description of the exploratory experiment EE13.2 on inter prediction for G-PCC.

As a result of EE13.2 on inter prediction established during the 134th MPEG meeting [1] and proposals presented in the 135th MPEG meeting, some tools presented in [2][3][4][6][10] were included in the Inter-EM. Several proposals that were presented in the 135th meeting were recommended to be evaluated in this EE, in addition to continuing activities on the other mandates of the EE.

# EE13.2 on inter prediction

## Mandates

The following are the mandates for EE13.2:

1. Consolidate Inter-EM tools in TMC13-v12.0 and upgrade to TMC13-v14.0
2. Continue integrating octree-related tools (angular) with Inter-EM based on TMC13-v12 [3]
3. Continue study of local motion in Inter-EM
4. Evaluate enlarging the region of candidate points in predictive geometry m57351 [7]
5. Comparison of planar regions in m57320 with usage of bigger blocks [6]
6. Investigate why vertical segmentation of motion estimation provides gains in m57316 [5]
7. Evaluate method in m57484 for global motion after integrating local motion in InterEM [9]
8. Evaluate the reference point cloud upsampling method in m57369; investigate means of reducing complexity and alternatives to upsampling [8]
9. Extract global motion information for Ford dataset (reported to be available)

## Participants, description of tools and implementation notes

The following people are participating in this EE. Their specific roles are detailed in the next section. Proposals are based on the input contributions [3][5][6][7][8][9] made at the WG7 meeting in July 2021.

The proponents and cross-checkers are as follows:

### Test 1

| **Name** | **Company** | **E-mail address** | **Type** |
| --- | --- | --- | --- |
|  |  |  |  |
| Luong Pham Van | Qualcomm | [lphamvan@qti.qualcomm.com](mailto:lphamvan@qti.qualcomm.com) | Proponent |
| Ying-Zhan Xu | Bytedance | [xuyingzhan@bytedance.com](mailto:xuyingzhan@bytedance.com) | Cross-checker |
| Kyohei Unno | KDDI | [ky-unno@kddi.com](mailto:ky-unno@kddi.com) | Cross-checker |

### Test 2

| **Name** | **Company** | **E-mail address** | **Type** |
| --- | --- | --- | --- |
|  |  |  |  |
| Junsik Kim | KyungHee University | [junsik@khu.ac.kr](mailto:junsik@khu.ac.kr) | Proponent |
|  |  |  | Cross-checker |

### Test 3

| **Name** | **Company** | **E-mail address** | **Type** |
| --- | --- | --- | --- |
|  |  |  |  |
| Hyejung Hur | LGE | [hj.hur@lge.com](mailto:hj.hur@lge.com) | Proponent |
| Ying-Zhan Xu | Bytedance | [xuyingzhan@bytedance.com](mailto:xuyingzhan@bytedance.com) | Cross-checker |

### Test 4

| **Name** | **Company** | **E-mail address** | **Type** |
| --- | --- | --- | --- |
|  |  |  |  |
| Ying-Zhan Xu | Bytedance | [xuyingzhan@bytedance.com](mailto:xuyingzhan@bytedance.com) | Proponent |
| Luong Pham Van | Qualcomm | [lphamvan@qti.qualcomm.com](mailto:lphamvan@qti.qualcomm.com) | Cross-checker |

### Test 5

| **Name** | **Company** | **E-mail address** | **Type** |
| --- | --- | --- | --- |
|  |  |  |  |
| Kyohei Unno | KDDI | [ky-unno@kddi.com](mailto:ky-unno@kddi.com) | Proponent |
| Luong Pham Van | Qualcomm | [lphamvan@qti.qualcomm.com](mailto:lphamvan@qti.qualcomm.com) | Cross-checker |

### Test 6

| **Name** | **Company** | **E-mail address** | **Type** |
| --- | --- | --- | --- |
|  |  |  |  |
| Keng Liang Loi | Panasonic | [kengliang.loi@sg.panasonic.com](mailto:kengliang.loi@sg.panasonic.com) | Proponent |
| Adarsh K. Ramasubramonian | Qualcomm | [aramasub@qti.qualcomm.com](mailto:aramasub@qti.qualcomm.com) | Cross-checker |
| Hyejung Hur | LGE | [hj.hur@lge.com](mailto:hj.hur@lge.com) | Cross-checker |

# Information on proposed tools/tests

## Test 1

In the adoption of the techniques proposed in [3] into Inter-EM version 3.0, the performance of Inter-EM was evaluated with planar mode enabled and angular mode disabled. It was desired to evaluate the performance of Inter-EM when the angular mode (which is set by default in the all intra common test condition) is enabled. In this EE test, the performance of Inter-EM version 3.0 will be investigated with angular mode enabled.

## Test 2

In Inter-EM, global motion is applied to the previous point cloud to create a compensated previous point cloud, and local motion is searched using both previous and compensated point clouds. Since Inter-EM does not apply global motion to points corresponding to roads, the road of the compensated previous point cloud and the original previous point cloud show the same position. If global motion is applied to a road, the road in the corrected previous point cloud and the road in the original previous point cloud will have different position. This method is thought to reduce the compression efficiency, but since the number of samples that can be searched for the local motion increases, the compression efficiency of the local motion increases. In addition, since there is no need to transmit the global threshold matrix to the decoder, a higher compression gain can be obtained. Figure 1 shows the proposed technology [9] as a flow chart.

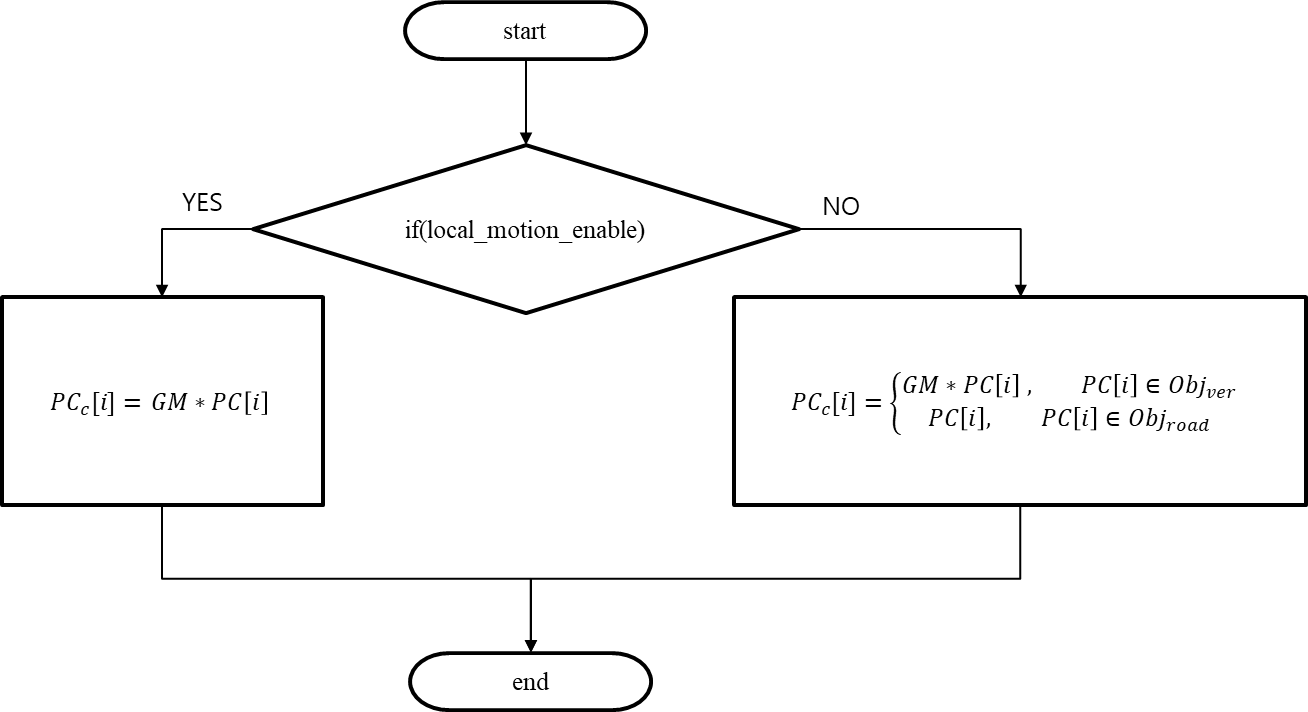


Figure : Flowchart of the proposed technology

As shown in Figure 1, in the compression condition where local motion is used, global motion () is applied to all points in the previous point cloud (). If local motion is not used, global motion is applied to the point corresponding to the vertically placed object (), and not to the point corresponding to the road ().

## Test 3

In the current Inter-EM, points are classified into road and objects with two thresholds derived based on the histogram of the height of points, and global motion estimation and compensation is performed with points classified as objects.

The proposed tool [5] introduces vertical segmentation that extends road and object classification mechanism. Global motion is estimated with all points. To compensate global motion, points are partitioned into blocks based on z value. Each block has a flag to indicate whether global motion compensation is applied based on RDO. The flag for the global motion compensation for each block is signaled in the GPS.

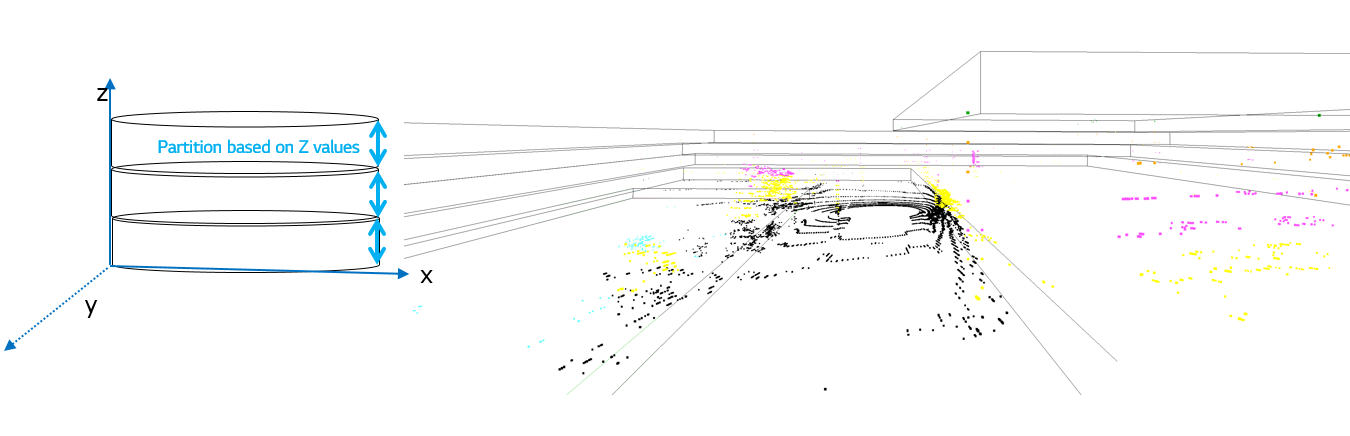


Figure : Example of the proposed vertical segmentation

## Test 4

In Inter-EM, the points are classified into road points and object points to perform global motion estimation. The encoder scans cubic block one-by-one to generate the object points cluster. In [6], it was proposed to use planar region instead of cubic block as the processing unit of the classification process.

As shown in Figure 3, a planar region is a cuboid block. The points in a point cloud frame can be clustered into one or multiple planar regions according to their plane coordinates (e.g., x coordinates and y coordinates) and the planar region block size.

卡通人物

低可信度描述已自动生成

Figure : Example of planar regions and cubic blocks

Each planar region in the current frame corresponds to one or zero reference planar regions in the reference frame. The reference planar region is the collocated planar region with an extension in the reference frame.

图标

低可信度描述已自动生成

Figure : Example of reference planar region

For each planar region in the current frame, the points in the planar region will be classified only if there are at least one point in its corresponding reference planar region in the reference frame.

In this EE test, the coding performance of planar regions will be compared with usage of bigger cubic blocks. The block size of bigger cubic block should be larger than the planar region block size.

## Test 5

In the current geometry inter prediction, occupancy prediction is sometimes difficult especially when both the reference point cloud and the current point cloud are sparse (e.g., point cloud captured by LiDAR). To solve this problem, upsampling for a reference point cloud is proposed in [8]. Figure 5 shows an example of the proposed upsampling. The proposed method applies upsampling to each point by the following procedure.

1. The unit vector of a reference point is calculated as . In this step, the calculations of square root and division are done by integer approximation.
2. is upsampled as . Here, is the parameter to control the interval of generated points by the upsampling, and is the parameter to control the number of generated points. Those two parameters are defined in the GPS.

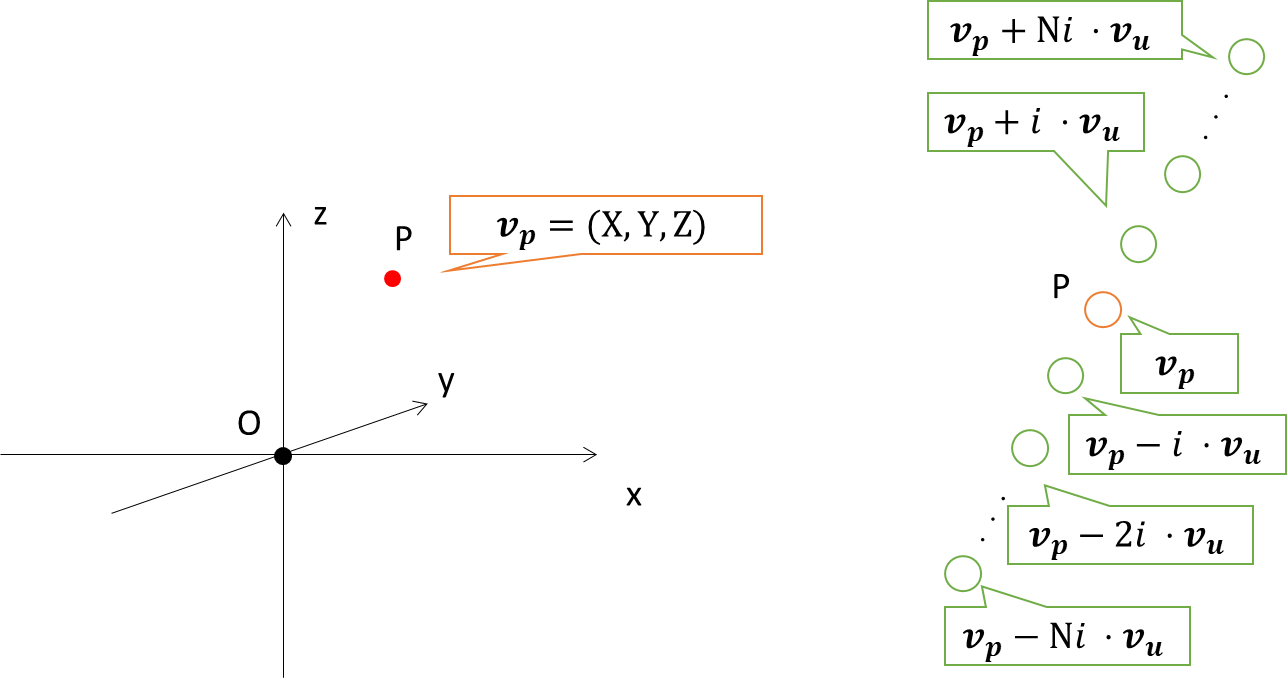


Figure 5: The proposed upsampling.

## Test 6

The proposed tool [7] introduces an additional inter predictor point that is obtained by finding the first point that has azimuth greater than the inter predictor point obtained using tools presented in [4] as shown in Figure 6.

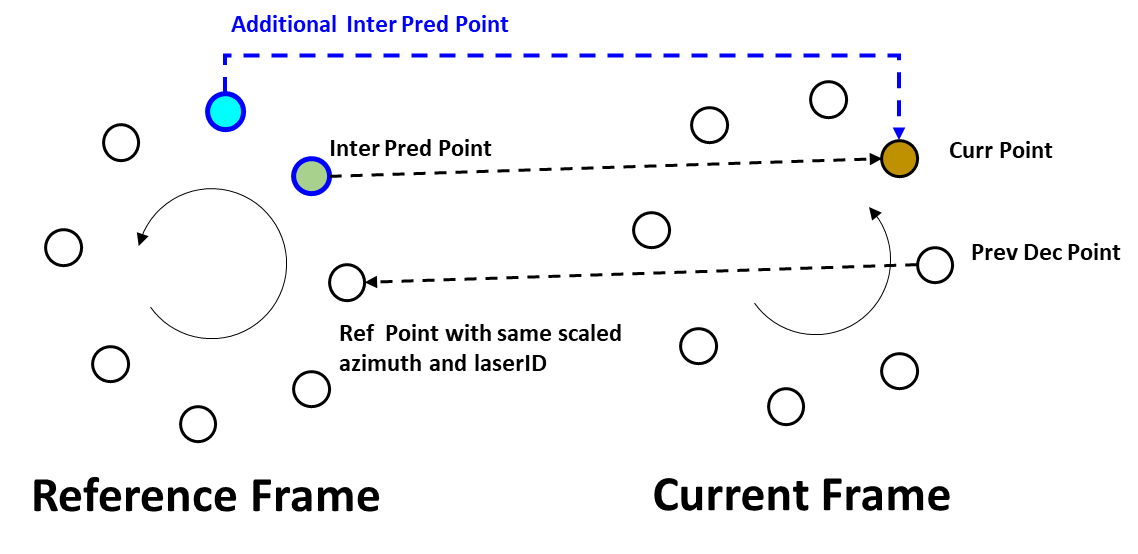


Figure : Additional Inter Predictor Point obtained from the first point that has azimuth greater than the Inter Predictor Point

Additional signalling is used to indicate which of the predictors is selected if inter coding has been applied. The proposed method will be investigated in terms of coding gain and complexity.

# Information for conducting tests

The latest software of Inter-EM-v3.0 (based on TMC13-v14.0) will be released in the MPEG Gitlab repository (link to be shared in the 3DG reflector). Proposed tools should be added on top of this software.

## Test 1

The EE test will be conducted on top of the latest software of Inter-EM v3.0 which based on TMC13 version 14.0. The “category 3-frame” sequences including Ford and QNX sequences will be tested under C2 lossy-lossy and CW lossless-lossless configurations.

## Test 2

The tests will be evaluated on top of the software of octree tools (also will be used as the anchor for the tests): Inter-EM-v3.0 based on TMC13-v14. The following sub-tests will be conducted for Test 2 described in Section 3.2.

In the simulations, the Ford and QNX sequences are tested under lossy-lossy and lossless-lossless configurations. The following tests will be carried out:

* Test 2.1: Inter-EM using only global motion for inter prediction.
  + Test 2.1.1: The global motion is estimated using the external ICP method of Inter-EM with road/object classification.
  + Test 2.1.2: The global motion is estimated using the internal ICP method of Inter-EM with road/object classification.
* Test 2.2: Inter-EM using both global and local motion for inter prediction.
  + Test 2.2.1: The global motion is estimated using the external ICP method of Inter-EM with road/object classification.
  + Test 2.2.2: The global motion is estimated using the internal ICP method of Inter-EM with road/object classification.

## Test 3

The test will be conducted on top of latest the Inter-EM v3.0 software. Ford and QNX sequences will be tested under C2-lossy geom. lossy attribute and CW-lossless geom. lossless attribute. The test will include two different motion block sizes: 4096 and 8192.

## Test 4

The tests will be evaluated on top of the latest software of Inter-EM v3.0 (based on TMC13-v14.0). The following sub-tests will be conducted for Test 4 described in Section 3.4.

In the simulations, the Ford and QNX sequences will be tested under C2 lossy-lossy and CW lossless-lossless configurations. The proposed tests will be conducted under the condition of geometry octree coding. The following tests will be carried out:

* Test 4.1: Inter-EM using only global motion for inter prediction. The global motion is estimated by the estimation method of inter-EM with road/object classification using planar region as the process unit. The planar region block size is the same as the cubic block size in inter-EM.
* Test 4.2: Inter-EM using only global motion for inter prediction. The global motion is estimated by the estimation method of inter-EM with road/object classification using bigger cubic block as the process unit:

1. Test 4.2.1: The bigger block size will be calculated for each sequence so that the volume of a bigger cubic block is the same as that of a planar region in test 4.1.
2. Test 4.2.2: The maximum value of bigger block size will be set to 8192, 16384, 32768 and 65536 respectively.

## Test 5

The test will be evaluated on top of the software of octree tools: Inter-EM v3.0 based on TMC13-v14.0. Ford and QNX sequences will be tested under the conditions of C2 (lossy geom. - lossy attribute) and CW (lossless geom. - lossless attribute). Parameters for the proposed upsampling are set as shown in Table 1.

Table 1: Parameter settings

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **r01** | **r02** | **r03** | **r04** | **r05** | **r06** | **Lossless** |
| **upsampling interval *I*** | 0 | 0 | 1 | 1 | 1 | 2 | 8 |
| **number of generated points (div2) *N*** | 0 | 0 | 1 | 2 | 8 | 8 | 8 |

## Test 6

The test is set to predictive geometry coding to be conducted on top of latest Inter-EM software where Ford and QNX sequences will be tested under the conditions of C2-lossy geom. lossy attribute and CW-lossless geom. lossless attribute.

# Timeline

* **2021-08-06**: Expected date for release of finalized EE description;
* **2021-08-27**: Expected date for release of InterEM-v3.0 with octree and predictive geometry coding tools;
* **2021-09-20:** Deliver source code and results for cross-check;
* **2021-09-27:** Deliver cross-check results;
* **2021-10-04**: MPEG document upload deadline\* (refer to updates from 3DG for document upload deadline).

# References

1. WG 07 MPEG 3D Graphics coding, EE4FE 13.2 on inter prediction, ISO/IEC JTC1/SC29/WG7 MDS20356\_WG07\_N00104, April 2021.
2. Y. Park, H. Hur, EE13.2 Test 3: Report on dependent entropy frame coding, ISO/IEC JTC1/SC29/WG7 m57116, July 2021.
3. L. Pham Van, G. Van der Auwera, A. K. Ramasubramonian, M. Karczewicz, EE13.2 Test 1: InterEM with Planar mode enabled, ISO/IEC JTC1/SC29/WG7 m57286, July 2021.
4. A. K. Ramasubramonian, L. Pham Van, G. Van der Auwera, M. Karczewicz, Improvements to inter prediction using predictive geometry, ISO/IEC JTC1/SC29/WG7 m57299, July 2021.
5. H. Hur, On Global Motion Estimation and Compensation, ISO/IEC JTC1/SC29/WG7 m57316, July 2021.
6. Y.-Z. Xu, L. Zhang, K. Zhang, Encoding complexity reduction for Inter-EM, ISO/IEC JTC1/SC29/WG7 m57320, July 2021.
7. K. L. Loi, T. Nishi, T. Sugio, Inter Prediction for Improved Quantization of Azimuthal Angle in Predictive Geometry Coding, ISO/IEC JTC1/SC29/WG7 m57351, July 2021.
8. K. Unno, K. Matsuzaki, K. Kawamura, Reference point cloud upsampling for geometry inter prediction, ISO/IEC JTC1/SC29/WG7 m57369, July 2021.
9. J. Kim, K. Kim, Y. Lee, H. Kwon, J. Seo, A method of applying the global motion matrix according to the compression condition, ISO/IEC JTC1/SC29/WG7 m57484, July 2021.
10. J. Kim, K. Kim, Y. Lee, H. Kwon, J. Seo, Report on EE13.2 on inter prediction Test 2, ISO/IEC JTC1/SC29/WG7 m57485, July 2021.