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# TD 215 R1 (WP3/16)

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**Title:** Report of Question 6/16 "Visual coding"

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# 1 Results

## 1.1 Summary

### 1.1.1 Recommendations for Approval

No documents were considered under TAP approval at this meeting.

### 1.1.2 Recommendations proposed for Consent in accordance with Rec. A.8.

The following Recommendations were proposed by Q6/16 for Consent by SG16:

| Description | Documents | Question |
|---|---|---|
| ITU-T H.264 (V10) "*Advanced video coding for generic audiovisual services*" (Rev.) | TD 429/Plen | 6/16 |
| ITU-T H.264.1 (V6) "*Conformance specification for ITU-T H.264 advanced video coding*" (Rev.) | TD 430/Plen | 6/16 |
| ITU-T H.264.2 (V6) "*Reference software for ITU-T H.264 advanced video coding*" (Rev.) | TD 431/Plen | 6/16 |
| ITU-T H.265.2 (V2) "*Reference software for ITU-T H.265 high efficiency video coding*" (Rev.) | TD 432/Plen | 6/16 |
| ITU-T T.800 (V2) "*Information technology — JPEG 2000 image coding system: Core coding system*" (Rev.) | TD 443/Plen (TD 192/WP3) | 6/16 |

**Note to TSB:** The texts for Q6/16 may be subject to additional editorial refinement before Last Call. Thus, the TSB is requested to delay posting of these until confirmation of delivery final text by the Rapporteur (to occur within six weeks following the SG16 meeting)

### 1.1.3 Other documents for Approval

No Appendices, Supplements, Implementors' Guides or Technical Papers were proposed by Q6/16 for approval at this meeting.

### 1.1.4 Question 6/16 summary

The primary goals for Question 6/16 at this meeting of SG16 were to review the progress of Q6/16, JCT-VC, JCT-3V, and JPEG work, and reach AAP Consent on revised Recs. H.264 (V10), H.264.1 (V6), H.264.2 (V6), and T.800 (V2). A substantial portion of the image coding work of Question 6/16 has been conducted jointly with ISO/IEC JTC 1/SC 29/WG 1 (JPEG/JBIG). A substantial portion of the video coding work of Question 6/16 is currently being conducted jointly with ISO/IEC JTC 1/SC 29/WG 11 (MPEG) in two organizations, known as the Joint Collaborative Team (JCT) on Video Coding (JCT-VC) and the Joint Collaborative Team (JCT) on 3D Video Coding (JCT-3V). Meetings of the JCT-VC and JCT-3V were held in a collocated fashion with this meeting of SG16 under its auspices. The JCT-VC is tasked with development of extensions to High Efficiency Video Coding (HEVC). The JCT-3V is tasked with development of 3D video coding extensions. A meeting of MPEG was also held in a nearby hotel during the current meeting of SG 16. Q6/16 is planning to hold one Rapporteur meeting, one JCT-VC meeting, and one JCT-3V meeting before the next SG16 meeting in June 2016 and also to hold a meeting of the JCT-VC and of the JCT-3V in a collocated fashion with the next SG16 meeting in June 2016 under its auspices. The Question prepared five outgoing Liaison Statements. A proposed revision of the text description for Question 6 was also produced for consideration for the next study period, including a merging of some responsibilities formerly in the domain of Question 7.

## 1.2 Question 6/16 – Visual coding

Question 6/16 was addressed in twelve sessions during the SG16 meeting under the chairmanship of Gary Sullivan (Microsoft, USA) with the assistance of Jill Boyce (Vidyo, USA) and Thomas Wiegand (Fraunhofer HHI, Germany). The group adopted the agenda in TD 185/WP3.

The objectives for this meeting were:

– Consider proposals for new enhancements and maintenance of Recs. H.26x, H.271, T.8xx video and image coding standards.

– Coordinate the work on "High Efficiency Video Coding" (HEVC, Rec. ITU-T H.265), including coordination with ISO/IEC JTC 1/SC 29/WG 11 (MPEG) and oversight of Joint Collaborative Team on Video Coding (JCT-VC), particularly including the work on development of the screen content coding extensions and the development of a conformance test suite and reference software for the format range, scalability, and screen content coding extensions.

– Coordinate the work on 3D video coding extension development, including coordination with ISO/IEC JTC 1/SC 29/WG 11 (MPEG) and oversight of Joint Collaborative Team on 3D Video Coding Extension Development (JCT-3V), particularly including the work on development of combined 3D depth and texture coding extensions of HEVC, and multi-resolution frame compatible with depth (MFC+D) extension of "Advanced Video Coding" (AVC, Rec. ITU-T H.264), and associated conformance test suites and reference software.

– Consider and coordinate with ISO/IEC JTC 1/SC 29/WG 11 (MPEG) regarding the potential need for further extensions of video coding standards in the domain of Question 6.

– Consider and progress the status of work on twin text standardization of H.STI "coding independent code point" specification of video signal type identifiers, which could potentially reach Consent at the current meeting.

– Coordinate the work on T.8xx image coding Recommendations, including coordination with ISO/IEC JTC 1/SC 29/WG 1 (JPEG / JBIG)

– Review, plan and coordinate the future work of Q6/16, particularly including potential needs for next-generation video coding beyond the current capabilities of HEVC.

– Study and coordinate on issues relating to the use of video and image coding in systems.

– Coordinate and communicate with other organizations on video and image coding related topics of Q6/16, JVT, JCT-VC and JCT-3V, particularly including coordination with ISO/IEC MPEG and JPEG / JBIG.

### 1.2.1 Documentation

The following documents were examined:

– Contributions: 886, 890, 908, 966, 983, 988, 992, 998, 1016, 1023, 1025, 1027, 1028, 1029, 1030, 1031, 1032, 1044, 1045, 1046

– TD/Plen: 429, 430, 431, 432, 443;

– TD/Gen: 289, 291, 315, 328, 331, 335, 339, 344

– TD/WP3: 185, 186, 190, 191, 192, 208, 210, 211, 212, 213, 214

### 1.2.2 Report of interim activities

Since the last SG16 plenary meeting, Question 6/16 held one Rapporteur meeting, in June 2015. The report of that Rapporteur meeting (TD 191/WP3) was approved at this SG16 meeting.

The JCT-VC held a meeting in a collocated fashion under the auspices of the previous meeting of SG16, and also held a meeting in June 2015 prior to this SG16 meeting. The reports of these meetings (TD 190/WP3 and TD 191/WP3) were approved at this meeting.

The JCT-3V held a meeting in a collocated fashion under the auspices of the previous meeting of SG16, and also held a meeting in June 2015 prior to this SG16 meeting. The reports of these meetings (TD 190/WP3 and TD 191/WP3) were approved at this meeting.

The work also progressed by correspondence using the Q6/16 email reflector (vceg-experts@yahoogroups.com) and JVT email reflector (jvt-experts@lists.rwth-aachen.de). Documentation is found in the VCEG archive site http://ftp3.itu.int/av-arch/video-site/, the JVT archive site http://ftp3.itu.int/av-arch/jvt-site, and the two JCT-VC archive sites http://ftp3.itu.int/av-arch/jctvc-site/ and http://phenix.it-sudparis.eu/jct/.

### 1.2.3 Discussions

#### 1.2.3.1 Incoming liaison statements

Liaison statements of particular relevance to Q6/16 included the following:

- TD 289/Gen from MPEG on HDR and WCG (which had been discussed and responded to at the interim meeting of Q6/16 in June 2015)
- TD 291/Gen from ITU-R SG6 on extended image dynamic range for television (EIDRTV) (which had been discussed and responded to at the interim meeting of Q6/16 in June 2015)
- TD 315/Gen from IETF IESG on call for comments on an IETF WG on Internet Video Codec (netvc) (which had been discussed at the interim meeting of Q6/16 in June 2015)
- TD 328/Gen from MPEG on video coding collaboration
- TD 331/Gen from ITU-T SG9 on the initiation of draft new Recommendation ITU-T J.4kstb
- TD 335/Gen from DVB TM-AVC on ETSI TS 101 154 and HEVC
- TD 339/Gen from ITU-R WP6C on 4:2:0 chroma positioning for Recommendation ITU-R BT.2020
- TD 344/Gen ARIB on ARIB standard on high dynamic range television system parameters

Question 6 prepared five outgoing liaison statements, replying to MPEG, ITU-T SG9, DVB TM-AVC, ITU-R WP6C, and ARIB. These generally thanked the senders for the information they provided and encouraged further future exchange of information on matters of mutual interest. The OLS to MPEG contained two topics of significant substance – confirming the collaboration arrangements for two areas of work in Q6/16, which are high-dynamic-range (HDR) / wide colour gamut (WCG) video coding and exploration studies for future video coding.

#### 1.2.3.2 Updated text of Question 6/16

Question 6 prepared an updated text of its Question, as recorded in TD 211/WP3. This included merger with the video-related responsibilities previously allocated to Question 7.

#### 1.2.3.3 Ad hoc group activities for Question 6/16

Reports of interim activities of *ad hoc* groups for Q6/16 were provided in TD 208/WP3. These ad hoc groups included the following:

- AHG1: Coding Efficiency Improvements [M. Karczewicz, M. Budagavi]
- AHG2: Measurement of Subjective Distortion in Video Coding Development [T. K. Tan]
- AHG3: Future Applications, Devices, and Formats [T. Wiegand, K. Kawamura, R. Sjoberg]

– AHG4: Test Sequence Selection [T. Suzuki, J. Boyce, A. Norkin]

– AHG5: HDR Video Coding [J. Boyce, J. Samuelsson, E. Alshina]

– AHG6: KTA Software Development [K. Suehring, X. Li]

No report was submitted for AHG3, and it was verbally reported that no specifically coordinated activity on that topic had occurred (although some relevant contributions were noted to have been submitted).

For coordination and encouragement of further work in the upcoming interim period, these ad hoc groups were continued, with coordinators and mandates established as follows:

– AHG1 on Coding Efficiency Improvements
  - Chair(s): M. Karczewicz, M. Budagavi
  - Mandates:
    - Evaluate existing tools regarding coding efficiency
    - Collect new methods for improved video coding
    - Optimize HM encoding methods

– AHG2 on Measurement of Subjective Distortion in Video Coding Development
  - Chair(s): T. K. Tan
  - Mandates:
    - Re-assess the viability of MSE/PSNR for video coding encoder optimization and distortion measurement
    - Study how to pool video quality measurements across different pictures, test sequences and categories
    - Identify existing distortion/quality measures for use in video coding development
    - Identify expedited methods for subjective video coding quality measurement
    - Propose new methods

– AHG3 on Future Applications, Devices, and Formats
  - Chair(s): T. Wiegand, K. Kawamura and R. Sjoberg
  - Mandates:
    - Identify trends in the evolution of formats
    - Identify new applications for digital video and their requirements
    - Estimate development of device and computing evolution
    - Study network transport issues
    - AHG discussions are to be held for all three AHGs on the main VCEG reflector.

– AHG4 on Test Sequence Selection
  - Chair(s): T. Suzuki, J. Boyce, A. Norkin
  - Mandates:
    - Identify test sequences available for video coding technology testing

   - Particularly seek useful source material for non-4:2:0 colour formats, high bit depth, high frame rate, high dynamic range and wide colour gamut
   - Select suggested subsets for conducting experiments

– AHG5 on High Dynamic Range Video Coding

  o Chair(s): J. Boyce, J. Samuelsson, E. Alshina

  o Mandates:

   - Study the potential impact of emerging HDR video services on video coding technology
   - Study the possibility of using a codec-neutral approach to HDR video coding outside the core codec
   - Study the need for minor additions to video coding standards, such as additional VUI/SEI or other relatively small modifications at the slice header level or above, to facilitate indication and/or control of HDR video coding
   - Study best practices techniques for pre-processing, encoding, post-processing, and metadata for handling HDR video content using the existing HEVC standard, and collect such information toward documenting such practices in a technical paper or supplement
   - Develop and contribute software for investigation of proposed best-practices techniques for use with existing coding technology and investigation of other proposed HDR coding technology
   - Study and suggest HDR video test content and test conditions, including displays, in coordination with AHG 4 on Test Sequence Selection

– AHG6 on Software Development for Future Video Coding Investigation

  o Chair(s): K. Suehring, X. Li

  o Mandates:

   - Coordinate the development and availability of the "Joint Exploration Model" (JEM) software for future video coding investigation
   - Update the software as necessary for bug fixes and new adoptions
   - Coordinate with AHG1 on analysis of the behaviour and capabilities of the new proposed features that are integrated into this software

#### 1.2.3.4 General status of work in JCT-VC and JCT-3V

The work under way in the JCT-VC and JCT-3V was considered to be going well, and had been generally active, although most of the work allocated to JCT-3V had been completed and thus its level of activity had been declining. At their collocated meetings hosted under the auspices of the SG16 meeting, the JCT-VC had about 80 documents and 200 participants, and the JCT-3V had about 10 documents and 15 participants. The reports of these two meetings will be submitted for review and approval at the next SG16 meeting. The primary work of the JCT-VC was on extensions to HEVC (Rec. H.265) and associated conformance and reference software:

– Screen content coding extensions of HEVC (SCC), adding improved coding efficiency for non-camera generated content

– Specification of additional profiles and levels of HEVC based on combinations of existing technology already specified therein

– Development of supplemental enhancement information and video usability information metadata for HEVC

– Development of reference software and conformance specifications for HEVC and its various non-3D extensions

– Conducting verification testing of the capabilities of HEVC and its extensions

At this meeting an agreement was reached with MPEG to move new work on high-dynamic-range (HDR) video coding for HEVC into the JCT-VC, effective at the next JCT-VC meeting. This brings new activity into the JCT-VC, whereas much of the current work of JCT-VC was anticipated to be completed by the next meeting of SG16.

The remaining topics for work in JCT-3V were on the development of the following extensions relating to 3D video coding:

– Development of supplemental enhancement information metadata for 3D extensions of AVC and HEVC

– Development of reference software and conformance specifications for 3D extensions of AVC and HEVC

– Conducting verification testing of the capabilities of 3D extensions of AVC and HEVC

Other work that had been in the domain of JCT-3V had generally been completed, and the level of activity in JCT-3V was anticipated to be relatively low in the foreseeable future as its remaining work is completed.

#### 1.2.3.5 Coordination with MPEG during the SG16 meeting

A joint discussion session for Q6/16 joint discussion with ISO/IEC JTC 1/SC 29/WG 11 (MPEG) was held during the SG16 meeting-primarily to discuss the status of specific topics under development in the JCT-VC and JCT-3V, potential new work on high-dynamic-range video coding, and potential new work on future video coding technology beyond the capabilities of HEVC and its extensions. The record of various specific items in those areas will be reported in the meeting reports of the JCT-VC and JCT-3V.

Additional discussions of the joint meeting that were not directly bearing on the current work of the JCT-VC and JCT-3V were as follows:

– New work in the area of high-dynamic range (HDR) and wide colour gamut (WCG) video coding for HEVC was agreed to be allocated to the JCT-VC for development of potential HEVC extensions and best practices guidelines, effective at the next meeting of the JCT-VC. Any significant decisions made at the current meetings of Q6/16 or MPEG on the topic, such as the creation of a working draft for standardization (although the creation of a working draft was not expected to occur when the matter was discussed) would need to be confirmed jointly at that time. Contributions to the next meeting on HDR video coding are to be submitted as JCT-VC input documents. The development of a technical report for best practices for HDR video usage with existing compression standards would also take place in the JCT-VC.

– A new collaboration agreement was established to jointly conduct exploration activity toward the potential development of standards or HEVC extensions for future video coding technology beyond the current capabilities of HEVC, according to the mutually agreed collaboration working method described in TD 210/WP3. This somewhat-informal collaboration team arrangement (with the tentative nickname of "Joint Video Exploration Team" – JVET) took effect immediately at the current meeting, and a new email reflector and web site document archive devoted to this is planned to be set up shortly after the current meeting and announced on the Q6/16 email reflector.

– A proposal COM16-C.992 / WG 11 m37069 was considered, suggesting to add various profile definitions in AVC (ITU-T H.264), not including support for frame/field adaptive coding, with considerations for 4:4:4 8 bit video, 4:2:0 10 bit video, still picture coding, and predictive lossless mode. In the discussion, some interest was expressed by other experts for the "Progressive High 10" and "Progressive High 4:4:4 8" parts of the proposal. Further study of this topic was encouraged for potential future action.

– A generalized form of signalling to indicate, in video coding standards, a luma/chroma "colour matrix" transformation based on colour primaries chromaticity coordinates (proposed in JCTVC-V0035). Support for this was agreed to be added to the AVC and HEVC and "coding-independent code points" specifications.

An outgoing liaison letter was later also prepared by Q6/16 to send to MPEG (see also §1.2.3.1).

#### 1.2.3.6 Preparation of H.264 (V10), H.264.1 (V6), H.264.2 (V6), and H.265 (V2) for Consent

Draft text for video coding specifications under development primarily in JCT-VC and JCT-3V was prepared and recommended for Consent by Q6/16.

The revision to H.264 adds support for the combination of multiresolution frame-compatible (MFC) video coding with depth maps in an additional profile called the MFC High profile. H.264.1 (V6), H.264.2 (V6), and H.265 (V2) add support for additional extended features of AVC and HEVC into reference software and conformance specifications for these standards.

#### 1.2.3.7 Preparation of T.800 (V2) for Consent

Draft text for a revised Rec. ITU-T T.800 "Information technology — JPEG 2000 image coding system: Core coding system" (common text with ISO/IEC 15444-1) was forwarded for approval from the JPEG working group in ISO/IEC. This is a revision to bring together the previously approved corrigenda and amendments and make minor updates, corrections, and editorial refinements. This development was welcomed and the text was recommended for Consent by Q6/16.

#### 1.2.3.8 Status of work on H.STI signal type identifiers for image and video signals

The drafting and stabilization of text for H.STI signal type identifiers for image and video signals remained in need of further work at the time of the SG16 meeting, so the development plan for this new Recommendation was deferred; Consent at the next meeting of SG16 in June 2016 is expected. Although this has been postponed several times previously, Q6/16 confirms its plan to complete this work.

#### 1.2.3.9 Discussions of high dynamic range video coding using HEVC

The coding of video content with high dynamic range and wide colour gamut has been a major area of interest to the industry in recent months, and has begun to be a more active subject in Q6/16 and MPEG (see also §1.2.3.5 regarding the agreement reached at this meeting to move work on this topic into the JCT-VC).

Contribution COM16-C.1031 (from Ericsson) proposed to establish a new work item related to HDR. This contribution proposes to initiate work on creating a Recommendation for procedures and values for high dynamic range and wide colour gamut in multimedia systems. It is proposed that the recommendation would contain a clear and well-defined description of how to operate high dynamic range video in a format compatible with what is sometimes referred to as "HDR 10", meaning that the representation format is 10 bit 4:2:0 non-constant luminance Y'CbCr using the SMPTE ST 2084 EOTF, ITU-R BT.2020 colour primaries matrix coefficients and, when compressed, is using the Main10 Profile of HEVC (ITU-T H.265, ISO/IEC 23008-2). This configuration is already used in commercial systems and products but it was asserted that there has been no complete, publicly available recommendation or specification describing best-practices processing steps and parameters for this configuration. It was proposed that the proposed Recommendation should not make any changes to the processes in H.265 or introduce any new syntax but should include descriptions of how to perform conversion to and from the format.

The contributor clarified that this proposed work was not necessarily in conflict with other proposals to specify new video coding technology for HEVC for HDR – rather, it was said that both topics could be pursued in parallel and be complementary.

The suggested new Recommendation was suggested to describe conversion prior to encode and after decode. It would describe practices for the processing chain involving starting from authored linear light through RGB and YCbCr, chroma subsampling, quantization to 10 bits, HEVC Main 10 encoding, output post-processing, chroma upsampling, and metadata practices for this workflow. Various options could be considered, e.g., in regard to potentially describing the use of AVC as well as HEVC, potentially using other transfer characteristics than SMPTE 2084, or 12 bit encoding rather than 10 bits.

The proponent suggested that accompanying reference software also be developed.

In the discussion, it was clarified that this new text would not necessarily have conformance requirements – rather, it could be more of a "best practice" example. Possibly the result could become a technical report or supplement rather than a Recommendation.

It was remarked that we should coordinate with other organizations (e.g., ITU-R) to confirm that this should be done in Q6/16 and is not already being sufficiently addressed elsewhere.

The spirit of this was to produce a document providing guidance on how to do a good job with existing technology.

The concept of this was supported, pending appropriate input to develop such a technical report with sufficient substance and validity. Further study to formally launch a work item on this topic was highly encouraged. In the joint discussion with MPEG, this view was also embraced on the MPEG side and it was agreed that the work to develop such a document should be conducted in the JCT-VC.

In the discussion, it was suggested to consider the prior JCT-VC contribution JCTVC-U0045 and the follow-up contribution JCTVC-V0052 (on HDR10 practices) in the work to develop such a report.

Contribution COM16-C.1028 (from Ericsson) describes a method to calculate an improved luma component value that is called "luma adjustment". It is claimed that the method avoids luminance artefacts that may result from traditional processing of HDR material in the Y'CbCr domain when a highly non-linear EOTF is used in combination with 4:2:0 subsampling. The contribution claims gains up to 20 dB in non-compressed material using the tPSNR-Y distortion measurement metric, and up to 6% bit rate savings for equivalent tPSNR-Y in compressed material. No change to the decoder is necessary to support the proposed scheme.

Because of the 4:2:0 conversion, substantial artefacts are reportedly introduced when using ordinary format conversion practices. The described technique, applied as input processing, adjusts the Y values with consideration of the original 4:4:4 input and the distortion introduced in the chroma components by the downsampling and upsampling that is applied for conversion to and from 4:2:0. The technique was reported to work well for higher bit rates, and has no effect on the decoder (although it would help to know what the decoder is using for its post-decoding conversion processing).

It was noted that this issue is not really specific to HDR in principle, and can be applied to any video that involves 4:2:0 coding of 4:4:4 original content.

The experts found the presentation of this technique quite interesting, and it could be a strong candidate for inclusion in the sort of best-practices guidelines produced as suggested in the accompanying contribution COM16-C.1031.

Contribution COM16-C.1029 (from Ericsson) states that colour quality for HDR10 coding of HDR/WCG video can be significantly improved by reducing the QP individually for Cb and Cr compared to the QP for luma. A chroma component QP offset is derived based on a combination of a linear model of the luma QP which is scaled by a factor that depends on the difference between the capture and encoded colour space with respect to the chroma component. If the capture and encoded colour space is same, the scaling factor is 1; if the captured colour space is a subset of the encoded colour space, it is larger than 1. The concept is applied on top of the luma adjustment presented in the accompanying contribution COM16-C.1028 that removes luminance errors otherwise appearing in non-constant luminance Y'CbCr 4:2:0 HDR10 source video.

To support the technique, four new parameters for the HM are proposed to control the offsets.

The offsets are fixed, based on the luma QP. In the discussion, there was support for adding this functionality into the HM test model for HEVC, pending confirmation by the JCT-VC, which maintains that software. One participant commented that it would be nice to add the ability to control this at the slice level instead of the whole-picture (PPS) level.

Contribution COM16-C.998 (from Qualcomm) proposed using the colour remapping information SEI message for range adjustment for HDR/WCG video compression.

In the discussion, it was noted that there may be some issues with the clarity of the existing specification of this SEI message. It was suggested to take action to clarify the meaning of "may be applied to the decoded samples, …" and to clarify (or prohibit) what might be indicated when there is more than one message for the same gamut mapping.

It was commented that rather than adding new functionality into a bug of underspecified semantics for the prior SEI message, it would be better to prohibit a potentially overlooked possibility for the existing message. Perhaps providing another new SEI message to explicitly enable the new functionality would be preferable. This topic was also discussed later in the JCT-VC, and further study was requested. Some action is needed, at least for the errata issue.

Contribution COM16-C.1027 (from Qualcomm) proposes a new SEI message to be added to HEVC for carriage of metadata for use in post-processing stages of HEVC-based HDR/WCG content delivery. Depending on the configuration, it was asserted that HDR/WCG video coding system employing the proposed SEI message would be capable to provide either 1) an SDR backward compatible bitstream or 2) a non-backward compatible configuration with non-compromised quality of HDR/WCG video coding. It was asserted that this flexibility could give service providers the capability of an easier transition from an SDR (standard dynamic range) legacy devices installed base towards a next generation HDR/WCG devices without changes of equipment and utilized technology. Some simulation results for selected implementations of proposed technology were reported.

It was suggested that current "HDR 10" solutions are adequate for high bit rates but are not optimized for lower ones (<4 Mbps), and that HDR 10 does not provide SDR compatibility.

The contributor suggested, for example, the encoding of BT.709 content in a BT.2020 HDR "container" representation (see also the discussions of COM16-C.1029 and COM16-C.1030). Merely because the encoding colour space has the capability of supporting HDR video does not imply that the actual signal content being carried exercises the full capability of the higher dynamic range – the content may merely be SDR content. Such a use results in a different bit rate balance for chroma relative to luma than when using an ordinary SDR "container" – having narrower range of chroma signal values.

It was reported that SMPTE 2084 devotes 21% of its representation range to values with a brightness of less than 3 cd/m$^2$, and 30% of its values to brightnesses less than 10 cd/m$^2$ – which are levels of emitted light that may not even be perceived by viewers if the average brightness of the image or the viewing environment (i.e., room lighting) is moderately high. It was further reported that this causes a causing non-uniform allocation of quantization noise in the compression coding.

The contribution proposes the use of an adaptive transfer function involving a dynamic range adjustment (DRA) – supporting a scaling and offset per part of the range of signal values.

Another participant commented that quantization step size (QP) control can be used to do something like this, based on spatial regions rather than using a dynamic transfer function warping (see also contribution COM16-C.1030). The contributor provided the analogy of pixel-level QP control, and noted the overhead needed for the spatial region QP control that was discussed as an alternative to the DRA approach. The technique adjusts, based on brightness / amplitude of individual sample values, the effective bit allocation.

It was commented that changing the mapping from one frame to another would affect prediction effectiveness.

The proposal is to normatively specify the decoder-side processing stages. Regarding the precise signal processing steps to be applied at the decoding side as post-processing, there could hypothetically be different degrees of quality of processing at the decoder side. If one method is needed for conformance, a particular precision would be selected. The proposal suggested having multiple modes of quality for this.

Further study of this was encouraged.

Contribution COM16-C.1030 (from Sharp) describes an investigation of coding video with the SMPTE ST-2084 transfer function and BT.2020 colour primaries. One element of the investigation is the reported development of a model that enables a video codec operating with SMPTE ST-2084 and BT.2020 formatted data to maintain the same quantization characteristics as a video codec operating with BT.1886 and BT.709 formatted data. The investigation begins with the current VCEG test sequences, which are asserted to be well studied and understood by the video coding community. These sequences are then converted to the ST-2084 and BT.2020 container, and both data analysis and coding simulations are performed. Data analysis results in a model relating quantization noise in the original data to quantization noise in the ST-2084 and BT.2020 representation. The model is asserted to be simple and to provide the desired method for maintained the same quantization characteristics between the two containers. Simulations are also performed, and results are asserted to support the model. As an outcome of the study, changes to the VCEG-KTA software are proposed to improve performance when coding data stored in a ST-2084 and BT.2020 container.

The contribution considers that services may use a single "container" to carry SDR content as well as HDR content. It suggests to try to adjust for that so approximately the same encoding quality and bit allocation results despite the remapping.

The concept is to derive a quantization parameter (QP) in the BT.2020 space to correspond to the QP used in the BT.709 space. The contribution suggests that the QP should change based on the luma value, using an offset of 12 in the brighter areas, and 0 in darker regions.

Using a fixed QP in BT.2020 reportedly creates a shift of bits to darker areas of the picture.

The contribution suggests performing CU-based QP adjustment based on the local luma value, and asserts that after adjustment for the luma level, the offset for chroma can be relatively constant.

The contributor also suggested making available BT.2020 container representations of our BT.709 content for experiments.

Further study was encouraged, and it was agreed to encourage software development in AHG work on HDR video. New practices and software should consider application in other future video coding work as well as shorter term efforts specifically for HDR.

COM16-C.886 (from Apple) provides a copy of the "HDRTools" software package, originally developed for use in the MPEG community in the HDR/WCG exploration, to the Q6/16 VCEG community and its members. The package is made available for analysing existing and developing future video coding standards and technologies. (For other uses, the contributors would appreciate being contacted.)

This software package currently includes a variety of tools for video processing and filtering, format conversion, as well as video distortion analysis. More specifically, the following tools are currently supported:

– HDRConvert: A format conversion package supporting a variety of input and output formats including RAW/YUV and limited support for EXR, TIFF, and AVI files.

– HDRMontage: A simple montage/video concatenation tool

– HDRMetrics: A video distortion analysis package

– ChromaConvert: A basic chroma format conversion package (with interlace support).

The project is currently available on "Gitlab" and can be downloaded using a git client using the following command:

git clone https://ituvceg@gitlab.com/vceg/HDRTools.git

The login and password for the account are *ituvceg* and *VcegHDRTools2015!* respectively.

An initial version of the software was also provided attached with the contribution document.

The software has a substantial number of processing features that could be useful for experiments for our work.

The potential for formal publication of this (e.g. in the ITU-T media tools signal processing package) was suggested, and could be considered, depending on the level of interest.

An Ericsson representative commented that they would be happy to allow public access and usage for their contributions to this software.

The contribution was much appreciated.

JCT-VC contributions relevant to Q6/16 work on HDR video coding were noted and briefly surveyed as follows:

– JCTVC-V0052 HDR-10 update [C. Fogg (MovieLabs)], a clarification errata to prior contribution JCTVC-U0045, which can be considered as input to technical report development.

– JCTVC-V0053 Best HDR/WCG video coding practices for Blu-Ray 3.0 [C. Fogg (MovieLabs)], an update to a workflow description and discussion of coding tools, which includes comments on QP control and resampling filters.

– JCTVC-V0055 Comments on Hybrid-Log-Gamma (HLG) video transfer functions [C. Fogg (MovieLabs)], which discusses "hybrid log gamma" transfer characteristics, of which the ARIB STD B67 scheme is a special case. It asserts that some additional data is needed for interpretation and display of video that uses such a transfer function with a scene-referred definition of light from the camera-capture perspective.

– JCTVC-V0085 Comments on contribution JCTVC-V0055 [M. Naccari, A. Cotton (BBC)], which responds to the comments in JCTVC-V0055.

– JCTVC-V0063 Information on HDR bitstream generation for Samsung SUHD TV(JS9500) [E. Alshina, Y. Park (Samsung)], which reports on an asserted bug in the HM reference software relating to the mastering display colour volume (MDCV) SEI message

– JCTVC-V0064 Clarifications on the semantics of CRI SEI message and its usage for HDR/WCG video compression [A. K. Ramasubramonian, J. Sole, D. Rusanovskyy, D. Bugdayci, S. Lee, M. Karczewicz (Qualcomm)], which contains similar remarks on the colour remapping information (CRI) SEI message as found in COM16-C.998

– JCTVC-V0038 Effective Colour Volume SEI message [A. Tourapis, Y. Su, D. Singer (Apple)], which proposes a new SEI message to identify the colour volume covering video source content

#### 1.2.3.10 Investigation of developments for future video coding technology

At recent meetings of Q6/16, there was substantial and growing interest in investigation of future application requirements and the potential availability of new technology developments that could enable the use of compression technology substantially beyond the capabilities of HEVC and its current extensions. At the previous meeting of SG16, new "Key Technology Area" (KTA) studies were launched to create a coordinated exploration of the proposed advances in technology. This topic remains of strong and growing interest to Q6/16.

The AHG report in TD 208/WP3 summarized the current state of the KTA work, including a study of its coding efficiency relative to the Main 10 profile of HEVC, as shown in the table below (where a negative number indicates a bit rate reduction in percentage terms for equivalent PSNR distortion). The results showed that there is some substantial improvement illustrated by the proposed technologies.

| | **KTA 2.0 Bit Rate Impact Random Access (10 bit per sample)** | | |
|---|---|---|---|
| **Class** | **Y** | **U** | **V** |
| Class A | −19.47% | −41.15% | −36.64% |
| Class B | −18.82% | −26.71% | −23.23% |
| Class C | −18.11% | −23.85% | −26.36% |
| Class D | −18.17% | −19.83% | −21.08% |
| Class F | −11.9% | −16.5% | −18.9% |
| Overall | −17.8% | −26.6% | −25.6% |

One feature (proposed by Microsoft) had not been included in this analysis, as it was in a separate branch of the software and simulations for it take more encoding time. Tests for that feature were still running, with results expected to arrive during or soon after the meeting. The additional gains from that feature were expected to be significant (probably putting the overall gain of all tools combined above 20% for luma, with more for chroma as shown in the table above).

A bug tracker had been set up for the software work (with the same login as the JCT-VC bug tracker).

In the discussion, it was agreed that we should produce an algorithm description document for the candidate features being evaluated (see the discussion below of the "Joint Exploration Model").

It was also agreed that we should establish "Common Test Conditions" (CTC) for the work.

As an action item for the CTC, it was suggested that the gain should be equalized between luma and chroma (using chroma QP offsets and lambda adjustment) so that the measurements do not show an imbalance of gain between luma and chroma). It was commented that offsetting the chroma QP by a delta of 1 should suffice for initial purposes.

COM16-C.1023 (from KDDI) describes requirements for a future application over a mobile network. A 5G network may include high bandwidth and low latency compared with a typical video bit rate and a video frame duration. The total delay of both the transmission of an access unit and network latency becomes much less than one frame duration on the same base station. An edge computer on a base station will enable the total delay reduction on mixed network. End-to-end mobile video communication like screen and camera sharing will provide synchronization experience because of sub-one frame delay. Three requirements are then derived: error resilience functionality on an encoder, an improvement of an intra-coding performance for an equalization of access unit sizes, and transcoding on an edge computer.

For the 5G-only network usage, the channel bit rate may be much higher than the average video bit rate. A possible feedback channel (with some signalling similar to H.271) and avoidance of references to lost frames can be performed. Mixed environments were also discussed in the contribution. Frame rates may be varying, with some frames discarded. Some of this gets into the domain of system-level interaction.

"Lightweight transcoding" by frame dropping / temporal scalability was discussed.

It was remarked that HEVC basically has the syntax capability for some of the requested functionality (depending on how it is used).

It was remarked that "gradual decoder refresh" is another form of loss resilience that can also be used and considered.

In the discussion, it was mentioned that other aspects that are not purely coding efficiency techniques, such as high-throughput techniques like wavefronts and dependent slices, are also worth considering.

The support for the requested functionality is not fundamentally missing in our prior designs, but further study should be done to determine whether some different approach is needed.

COM16-C.988 (from Vidyo) discussed the requirements studies ongoing in both Q6/16 and MPEG towards a future Recommendation on video coding, possibly H.266, and alternatively referred to as "Future Video Coding" or FVC. In this contribution, it is argued that spatial scalability should be a closely integrated technology in FVC, and should be standardized in the first version of FVC.

A transmission model was described in which a "middle box" called a selective forwarding unit (SFU) selects which data to forward from a source to a destination. Some form of loss protection was also suggested to be applied selectively within the system.

The contribution recommends to study a codec design that incorporates spatial scalability features for error control in heterogeneous receiver populations.

One technical design that is suggested is the approach taken in scalable VP9: In addition to supporting temporal scalability, it also includes reference picture resampling and dynamic resolution changes akin to H.263 Annex P (as also has been proposed by Cisco and others in the JCT-VC). The contribution suggests that the notion of spatial layers in the high layer syntax be kept for system design reasons; ideally in the normative syntax. Following this approach, the low level codec can be viewed as a single-layer design, but it is asserted that the benefits of spatial scalability can be harvested.

In the discussion, it was clarified that part of what is really requested in the contribution is spatial adaptivity rather than "spatial scalability" in the traditional sense.

Prefiltering was mentioned as a way that some form of resolution adaptivity can be achieved.

Also, the quadtree type of hierarchy found in HEVC was mentioned as somewhat along the lines of support for adaptive resolution.

A prior MPEG contribution M36440 was mentioned as relevant regarding the resolution impact on quality and compression.

It was suggested to break down the request into the fundamental characteristics that are requested rather than using a broad term like "scalability" to refer to it.

Further study is needed to clarify the expressed requirements and determine their impact.

COM16-C.1032 (from Apple) provides some comments and suggestions on how to improve our testing and analysis methodologies for any future video codec development. It is asserted that fixing QP parameters and coding structures, as is currently performed in our tests, may not be adequate, whereas it is also suggested that performing time series analysis on the various measurements, instead of only looking at averages is highly recommended.

For example, a time series analysis may reveal that proportionally more bits are being allocated to I frames in one case than in another, which is ignored in an average PSNR measure. The subjective phenomenon of "beating effects" can also be annoying visually in cases where there is excessive fluctuation in quality due to bit allocation among different frame types.

The bit allocation to the first picture in a sequence and the bit allocation of bits in an early part of a scene versus later in the video content cause similar phenomena.

It was suggested to avoid excessive use of averaged measures and strive to create fair tests and study per-picture allocation effects. Iterative coding to meet a bit rate target was suggested as one way to ensure similar bit allocation per picture. Considering chroma was also suggested as important. The phenomena of blocking, banding, ringing, colour accuracy, motion coherence, etc., were also emphasized in the contribution.

The per-frame bit allocation issue was highlighted in the discussion as a very useful way to study what is happening when comparing two different encodings.

Suggestions in the discussion included considering averages per layer and min & max PSNR measurements.

Providing the log files along with test results was suggested as a way to enable further analysis of test results by others.

COM16-C.1046 (from Qualcomm) This contribution proposes an extension to HEVC intra prediction that combines values predicted using the nonfiltered and filtered (smoothed) references depending on the predictor mode, and block size. With the proposed method, the coding performance of HMKTA-2.0 is reportedly improved by 0.9%, 0.3% and 0.1% on average for all intra (AI), random access (RA), and low-delay configurations, respectively.

The MPI (multi-parameter intra prediction) scheme uses a recursive filtering method, whereas this one is not, and this one provides additional gain. However, it was remarked that the position dependence creates a need for more customized position-dependent operations, which is not friendly to SIMD implementation architectures.

The recursiveness of MPI seems like a problem. It was asked whether high bit rates perform differently from low bit rates. The gains were seen primarily for higher-resolution content.

It was suggested to perform the calculations in higher precision and to move and consolidate the right shifts at the end of the process.

Decision: Adopt into KTA exploration work; further study of the higher-precision rounding suggestion was encouraged.

COM16-C.983 (from Huawei) proposes two sets of low-pass filters for reference sample smoothing. These sets are selected subject to the intra prediction mode and block size. A final decision of what filter to take is signalled using a "data hiding" procedure. For the HMKTA common test conditions, it reportedly achieves 1.1%, 0.5% and 0.5% for luma in the AI, RA, and LDB main 10 profile configurations, respectively. Some subjective benefit was also asserted.

There is reportedly somewhat more (but not much more) coding gain for low bit rates than for high ones. The technique is not applied to chroma.

There was some questioning of the use of data hiding rather than an explicit coded flag, which could be at the TU level or a higher level such as the CU level. The proponent said that the hiding technique helped to reduce overhead. Under some circumstances, when it is difficult to hide the flag, the filtering used ordinarily in HEVC is applied so that no signal is needed. It was asked whether it is possible to measure the effect of the data hiding versus having a signalled flag.

It was noted that the encoder must jointly optimize the prediction generation decision together with the residual signal information, which is undesirable. However, the encoder could choose not to use it, of course.

It was suggested that some gain could be achieved, without any change of syntax or decoding process, by just having the encoder check more modes with joint rate-distortion optimized decision making. However, it was remarked that this would not provide as much gain.

Decision: Adopt into KTA exploration work. Further study the hiding technique.

COM16-C.1045 (from Qualcomm) proposed a modified combination of BIO (Bi-directional optical flow), IC (illumination compensation) and FRUC (merge mode based on frame rate up-conversion). BIO is further extended to low-delay cases. Simulations reportedly show that 0.3% and 0.2% luma BD-rate reduction can be achieved for RA and LDB cases, respectively. Up to 1.0% luma BD-rate reduction was reportedly obtained for HDR sequences with illumination changes.

One aspect is to disable BIO when IC is enabled (on a block-by-block basis). This was suggested to be a bug fix. Decision: Adopted this aspect into KTA exploration work.

In the current scheme, BIO is disabled when FRUC is enabled. It was commented that this was a complexity optimization, but is unnecessary if gain can be obtained by removing that restriction, so removing the restriction was proposed. Decision: Adopted this aspect into KTA exploration work.

MV consistency is proposed to be checked in a generalized way without an assumption of "bi-directionality" for the biprediction. Decision: Adopted this aspect into KTA exploration work.

It was noted that weighted prediction (WP) is disabled in our testing so far, and that improvement of WP has recently occurred, for release in a future version of the HM test model for HEVC. It was commented that we should test that, and see if it affects the gain seen in tests.

COM16-C.1044 (from Qualcomm) proposes a mode-dependent non-separable secondary transform (NSST). The NSST further improves the intra coding efficiency of the secondary transform by applying non-separable transforms to each 4x4 transform coefficient block instead of rotational transforms (ROT). The transforms are derived by off-line training, and different transforms may be applied for different luma intra prediction modes. With the proposed NSST, the coding performance of HMKTA-2.0 is reportedly improved by 1.0% and 0.5% on average for the all intra (AI) and random access (RA) configurations, respectively. 12*3 = 36 of these nonseparable 4x4 transforms were proposed.

Decision: Adopt into KTA exploration work.

A potential interaction with the Microsoft transform was noted, but it was agreed to not let this stop us from including this feature.

Further study was suggested to reduce encoding complexity for the search. Perhaps the check does not need to be exhaustive. Checking the number of transforms to use is also desired.

COM16-C.1025 (from Intel, prepared with LG) reports on an implementation of short-distance intra prediction (SDIP) in KTA 2.0. First, non-square PUs of sizes 2N×hN or hN×2N are introduced in addition to the PUs of sizes 2N×2N and N×N in each coding unit (CU). Next, the non-square transform kernels of the corresponding sizes are provided for all candidate transform types that are present in KTA 2.0. Finally, transform coefficient scanning methods for the non-square blocks of different sizes are defined. In the current implementation, it achieves a BD-rate savings of 0.9% over VCEG HM KTA-2.0 under the AI (All Intra) configuration with the encoding and decoding time increases of 30% and 6%, respectively.

In this contribution, Intel was presenting work done by LG.

The SDIP is only applied to luma.

It was remarked that our CTC is all 4:4:4.

The proposed height or width is as small as 1 sample.

Due to the hierarchical nature of the split, only the following possibilities are considered (and their 90 degree rotations): 16x1, 8x2 and 32x2 (not 16x2), 16x4 and 64x4, 32x8, and 64x16.

Changes are involved that have interactions with lots of aspects of other features.

Most of the gain is at lower resolutions. It was remarked that we would primarily like to emphasize higher resolutions.

The encoding time was not increased as much as some expected. About a 35% increase in encoding time was reported (for all-intra).

It was remarked that there may be some interaction with C.966.

Further study was encouraged.

COM16-C.966 (from MediaTek) In this contribution, a quadtree plus binary tree (QTBT) block partitioning structure is proposed to partition the coding tree block (CTB) into coding blocks (CBs). A CTB is firstly partitioned using a quadtree structure. The quadtree leaf nodes are further partitioned using a binary tree structure. The binary tree leaf nodes are namely CBs used for prediction and transform without any further partitioning. For P and B slices the luma and chroma CTBs in one coding tree unit (CTU) share the same QTBT structure. While for I slice the luma CTB is partitioned into CBs by a QTBT structure, and two chroma CTBs are partitioned into chroma CBs by another QTBT structure. The proposed QTBT structure reportedly achieves around 6% BD-rate gain for luma and 15% BD-rate gain for chroma compared to the HM-13 under RA, LB, LP configurations.

The gain is reported relative to HM 13, not relative to KTA.

A leaf of the quadtree becomes a root for a binary tree (up to 4 levels of splitting). PU and TU are not split from the CU. There is only one tree (as tested). Transforms are often not square. The max transform size is 128x128. For intra, the luma and chroma trees are separated (not for inter). Some new transforms are included (i.e. 64x64, 128x128). No 4x4 inter-predicted blocks are used. Intra/Inter can switch as small as 4x8 / 8x4 in granularity.

It was commented that some gain could also be obtained by more elaborate encoder searches only to optimize the segmentation (with merging) jointly. How much gain could be achieved that way is not known.

Some speedup tricks were used by the contributor.

For intra, the encoding time is increased by about 7 times.

It was commented that some of the gain is from simply increasing the maximum sizes (and search effects). The KTA has been using 256x256 max CTU size.

If the maximum size were reduced, the encoding time would be reduced.

Some results were reported for different maximum sizes.

Some interest was expressed in experimenting with this, but it would be a separate codebase that does not have the same tool set.

Decision: Adopt into KTA exploration work, but in a separate branch of the software, as it has a substantial impact on the coding structure.

COM16-C.1016 (from Huawei) proposed a simplified affine transform prediction tool that is asserted to work especially well for zooming in/out or rotating moving test sequences. In HMKTA common test sequences, it can achieve 0.9%, 1.79% and 1.69% in RA, LDB and LDP, respectively, relative to the 10 bit KTA 2.0 operation.

For a different set of test sequences (among well known ones) selected for exhibiting the desired motion characteristics (cut to 100 frames in length in the part where this works well), it can reportedly achieve 13.4%, 29.5%, and 27.0% in RA, LDB and LDP with 10 bit KTA 2.0, respectively.

To determine the affine motion parameters, a gradient-based search is performed.

Size and angle can vary, but not the shape, which remains square. As tested, it is applied only to square blocks. Four parameters are used, representing the MVs of the upper-left and upper-right corners. The tap length is the same as in the current design. The tap bit depth is increased to 8 bits. The contributor said that they believed a 16 bit depth was sufficient for the MC operation.

The motion compensation is performed on a 4×4 translational basis, not on a sample-by-sample basis with warping. The MV resolution is 1/64 pel in the luma domain.

Deblocking is not affected, so the 4x4 boundaries of MC regions within a PB are not deblocked.

Only spatial MV prediction is considered.

Decoding time is actually decreased (on non-CTC sequences). Encoding time is increased by about 10%.

The gain seems to be less for high resolution and random access.

It was commented that the conditions for which this is designed to work well are difficult conditions. Even if the average savings on a typical test set may not be so large, if it helps under difficult conditions, then it could be valuable.

It was remarked that we should consider motion complexity in our CTC sequence selections (the new El Fuente sequence may be helpful for this).

Decision: Adopt into KTA exploration work.

COM16-C.890 (from Sony) offered comments on some new video test sequence material – the "El Fuente" sequence made available by Netflix. See below for a discussion of the consideration of video test sequences.

COM16-C.908 (from Qualcomm) contained suggestions on adding new sequences to common test conditions for experiments. See below for a discussion of the consideration of video test sequences.

Two "Joint Video Exploration Team" (JVET) meeting sessions were held at the meeting (on Monday afternoon and Tuesday afternoon).

It was noted that all but one technical algorithm inputs for this meeting were submitted either just to Q6/16 or to both Q6/16 and MPEG. The remaining contribution (M37043) from Samsung includes a mode-dependent secondary transform – and Samsung acknowledged that a Qualcomm submission has a similar effect, so M37043 did not need to be considered in detail (at least at this time). There was no objection to considering the earlier decisions established for KTA in Q6/16 as the starting basis of JVET work.

The "Joint Exploration Model" (JEM) algorithm description document was reviewed in draft form, and submitted as TD 213/WP3. In subsequent work, the test model will be referred to as the “JEM” rather than “KTA” software.

Two proposed features were further discussed to determine whether to include them in the JEM or not. These were SDIP and QTBT.

It was commented that SDIP has a large impact on the code, and was integrated with an older version of the HM (version 14). The contributor did not provide a commitment to integrate, the feature seemed not so effective on high resolutions, and the gain is limited, so although further study was encouraged, it was agreed not to integrate that into the JEM. QTBT uses a new block partitioning which requires major restructuring for many tools, but gives interesting gain, so it was agreed to adopt this as a separate branch of the software for further study.

The branches to be used in JEM study were summarized as follows:

– Main branch (HM 16.6 based) "JEM 1.0" including all new tools from this meeting

– Mediatek QTBT block partitioning branch: Currently based on HM 13, not integrated with other tools (which seems OK for now).

– Microsoft signal-dependent transform, currently based on HM 14 – this stays a separate branch – to be updated to the HM 16.6 main branch basis after the other recently-included tools are integrated, to become "JEM 1.1"

An issue raised was whether to integrate with the screen content model (SCM). It was agreed not to do this at this time, as that would disrupt the work and the SCM remains under active other development.

For planning of how to analyse the behaviour of the JEM, including on a tool-by-tool basis, it was agreed to plan the following types of testing:

– Everything on versus HM as-is

– Collect data for all features on and then each one turned off individually

– Collect data for all features off except expanded block sizes and then each one turned on individually

A number of video test sequences were noted to have been made available for use in experiments.

A "Break-out Group" (BoG) side activity was established to study these (coordinated by Jianle Chen and Teruhiko Suzuki), with the following activities requested:

– Select sequences for which results are already available, to arrange viewing and make pre-selection of interesting cases
– Calculate amount of storage that is necessary for the new material download
– Set up work plan for performing encodings of new sequences towards the next meeting
– Prepare viewing

In discussion of the draft BoG report, the following was noted:

– 17 test sequences were identified as candidates for further study, but would not be considered mandatory for JEM experimentation for the time being
– The time duration of the test sequences is an issue for experiment difficulty
– For older sequences, we will plan to test with the full duration that we have been using in the past
– Five seconds duration seems generally adequate for subjective testing
– For new high frame rate (greater than 30 fps), high resolution (higher than 4K) test sequences, rather than using a full 10 second duration, it was agreed to adjust the duration of the test sequence so that the number of frames to be encoded is kept the same (and therefore the time duration of the test sequences is shortened), to prevent excessing encoding times
– Although it had been suggested to consider using very short durations (e.g., 1 second) for some types of testing, this was not agreed.

The BoG report, as refined in the discussion, was submitted as TD 212/WP3. Further study of test sequences was planned in side activity on the evening of Tuesday and more viewing was expected to take place after the meeting in AHG work.

For common test conditions, the following was agreed:

– Basing the conditions on the prior well-known JCTVC-L1100 conditions and test material for initial coding efficiency experiments
– Only 10 bit encoding is necessary to be performed
– Low-delay P coding is required as well as low-delay B coding

(See notes above for chroma QP offset, for which the recorded outcome did not seem especially clear, but the chroma QP offset by 1 relative to HM usage seemed reasonable.)

### 1.2.4 Intellectual property statements

Several IPR statements (selecting option 2) relevant to Q6/16 Recommendations were noted to have been recorded in TD 361/Plen for H.264 and H.265. No verbal IPR statements were received at this meeting.

### 1.2.5 Outgoing liaison statements

The following LSs were prepared by the Question:

– TD 214/WP3: Reply LS to MPEG on video coding collaboration
– TD 214/WP3: Reply LS to ITU-T SG9 on initiation of draft new Recommendation ITU-T J.4kstb
– TD 214/WP3: Reply LS to DVB TM-AVC on ETSI TS 101 154 and HEVC

– TD 214/WP3: Reply LS ITU-R WP6C on 4:2:0 chroma positioning for Recommendation ITU-R BT.2020

– TD 214/WP3: Reply LS to ARIB on ARIB standard on high dynamic range television system parameters

### 1.2.6 Work programme

#### 1.2.6.1 Future work

Question 6/16 will continue its work by correspondence (via the Q6/16 email reflector vceg-experts@yahoogroups.com) and during its one planned interim meetings (proposed meeting plans are given below) especially on the following items:

– Consideration of AAP comments on Consented texts (if any)

– Organizational preparation and technical exploration studies on a possible future video project (in coordination with MPEG)

– Coordination of work with MPEG, JPEG, JCT-VC, and JCT-3V

The JCT-VC will continue its work by correspondence (via the JCT-VC email reflector jctvc-experts@lists.rwth-aachen.de) and during its three planned meeting (proposed meeting plans are given below) especially on the following items:

– Development of screen content coding extensions of HEVC

– Consideration toward development of high dynamic range extensions of HEVC

– Consideration toward development of best practices guidelines for handling high dynamic range video using the existing HEVC standard

– Specification of additional profiles and levels of HEVC based on combinations of existing technology already specified therein

– Development of reference software and conformance specifications for HEVC and its extensions

– Conducting verification testing of the capabilities of HEVC and its extensions

The JCT-3V will continue its work by correspondence (via the JCT-3V email reflector jct3v-experts@lists.rwth-aachen.de) and during its three planned meeting (proposed meeting plans are given below) especially on the following items:

– Development of supplemental enhancement information for 3D video

– Development of reference software and conformance specifications for 3D extensions of video coding standards

Those wishing to subscribe or unsubscribe to these email reflectors should contact the Q6/16 Rapporteur for information.

Rapporteur group documentation can be found in the external FTP server for Q6/16 located at http://ftp3.itu.int/av-arch/video-site, the JCT-VC sites at http://ftp3.itu.int/av-arch/jctvc-site and http://phenix.it-sudparis.eu/jct/, and the JCT-3V sites at http://ftp3.itu.int/av-arch/jct3v-site/ and http://phenix.it-sudparis.eu/jct3v/.

The Question did not start any new work items at this meeting.

A work item from Question 7 was reallocated to Question 6, on updating the media coding toolbox for IPTV in order to improve its video and image coding aspects (HSTP-MCTB).

The currently open work items for Q6/16 are as follows:

| Acronym | Title | Editor | Consent / Approval | Reference |
|---|---|---|---|---|
| H.264 (V10) | Advanced video coding for generic audiovisual services (with specification of additional levels and a profile for multi-resolution frame compatible coding with depth) (Rev.) | Peng Yin, Takanori Senoh, Ying Chen, Miska Hannuksela, Jens-Rainer Ohm, Gary Sullivan | 2015-10 | TD 429/Plen (2015-10) |
| H.264 (V11) | Advanced video coding (with support for additional levels and SEI messages) (Rev.) | Alexis Tourapis, Felix Fernandes, Gary Sullivan, Takanori Senoh, Ying Chen | 2016-06 | |
| H.264.1 (V6) | Conformance specification for ITU-T H.264 advanced video coding (with support for additional extensions) (Rev.) | Dmytro Rusanovsky, Teruhiko Suzuki, Dong Tian, Peng Yin | 2015-10 | TD 430/Plen (2015-10) |
| H.264.2 (V6) | Reference software for ITU-T H.264 advanced video coding (with support for additional extensions) (Rev.) | Dmytro Rusanovsky, Dong Tian, Teruhiko Suzuki, Peng Yin | 2015-10 | TD 431/Plen (2015-10) |
| H.265 (V4) | High efficiency video coding (with extensions for screen content coding) (Rev.) | Rajan Joshi, Shan Liu, Jizheng Xu, Yan Ye | 2016-06 | |
| H.265.1 (V2) | Conformance for HEVC V2 (RExt, SHVC, MV-HEVC) (Rev.) | Jill Boyce, Ying Chen, Kimihiko Kazui, Adarsh Krishnan Ramasubramonian, Shinya Shimizu, Teruhiko Suzuki, Ikai Tomohiro | 2016-06 | |
| H.265.2 (V2) | Reference software for HEVC V2 (RExt, MV-HEVC) (Rev.) | David Flynn, Yong He, Chris Rosewarne, Vadim Seregin, Karl Sharman, Gerhard Tech | 2015-10 | TD 432/Plen (2015-10) |
| H.265.1 (V3) | Conformance for HEVC V3 (3D-HEVC) (Rev.) | Ying Chen, Shinya Shimizu, Teruhiko Suzuki, Ikai Tomohiro | 2016-06 | |
| H.265.2 (V3) | Reference software for HEVC V3 (SHVC, 3D-HEVC) (Rev.) | Vadim Seregin, Gerhard Tech, Yuwen He | 2016-06 | |
| H.265.1 (V4) | Conformance for HEVC V4 (SCC) (Rev.) | Teruhiko Suzuki | 2017-02 | |

| Acronym | Title | Editor | Consent / Approval | Reference |
|---|---|---|---|---|
| H.265.2 (V4) | Reference software for HEVC V4 (SCC) (Rev.) | Bin Li, Krishna Rapaka | 2017-02 | |
| H.STI | Signal type identifiers for image and video signals | Teruhiko Suzuki, Gary Sullivan | 2016-06 | |
| T.800 (V2) | JPEG 2000 image coding (Rev.) | Gary Sullivan, Joachim Keinert | 2015-10 | TD 443/Plen (2015-10) |
| T.832 (V3) | JPEG XR image coding – revision to define a media type code (Rev.) | Gary Sullivan | 2016-06 | |
| T.835 (V3) | JPEG XR revised reference software (Rev.) | Thomas Richter, Gary Sullivan | 2016-06 | |
| HSTP-MCTB (V3) | Media coding toolbox for IPTV (Rev.) | Gary Sullivan | 2016-06 | TD 55-WP3 (2009-07) |

### 1.2.6.2 Future meetings

Q6/16, JCT-VC, and JCT-3V are each planning to hold one interim meeting before the next SG16 meeting in May/June 2016. The planned meetings are to be held during in San Diego, US, 19–26 Feb. 2016 and will be hosted by ISO/IEC JTC 1/SC 29/WG 11 (MPEG) and the local MPEG meeting host.

Additionally, meetings of the JCT-VC and JCT-3V are planned be held during 26 May – 1 June 2016 in a collocated fashion under the auspices of the next meeting of SG16.

We also note that a meeting of ISO/IEC JTC 1/SC 29/WG 1 (JPEG, JBIG), within which many image coding Recommendations in the domain of Q6/16 are developed, is also planned to be collocated with the next MPEG meeting and the video-related joint collaborative teams that will be meeting under its auspices at that time.

## 2 Summary of liaison activity

The following is a summary of the outgoing Liaison Statements prepared by Q6/16.

| Title | Destination | Purpose | Document | Source |
|---|---|---|---|---|
| Reply LS to MPEG on video coding collaboration | MPEG and SC29 | Reply and action | TD 214/WP3 | 6/16 |
| Reply LS to ITU-T SG9 on initiation of draft new Recommendation ITU-T J.4kstb | ITU-T SG9 | Reply | TD 214/WP3 | 6/16 |
| Reply LS to DVB TM-AVC on ETSI TS 101 154 and HEVC | DVB TM-AVC | Reply | TD 214/WP3 | 6/16 |
| Reply LS ITU-R WP6C on 4:2:0 chroma positioning for Recommendation ITU-R BT.2020 | ITU-R WP6C | Reply | TD 214/WP3 | 6/16 |
| Reply LS to ARIB on ARIB standard on high dynamic range television system parameters | ARIB | Reply | TD 214/WP3 | 6/16 |

## 3 Workplan

The updated work programme for Recommendations that are the responsibility of WP3/16 is on the SG16 web page at http://itu.int/ITU-T/workprog/wp_search.aspx?wp=3/16.

## 4 Summary of interim Rapporteur group meetings

The following is a summary of the interim Rapporteur meetings proposed by Q6/16.

**Question 6/16**

| Tentative Dates | Tentative Host/Place | Question | Objectives |
|---|---|---|---|
| 19–26 Feb. 2016 | ISO/IEC JTC 1/ SC 29/WG 11 /<br>San Diego, US | 6/16 & JCT-VC & JCT-3V | – Progress the work on development of the HEVC screen content coding extensions<br>– Progress the work on 3D extensions of HEVC and other video coding standards including Rec. H.264 and possibly Rec. H.262.<br>– Progress the work on development of reference software and conformance tests for Q6/16 video and image coding Recommendations<br>– Address maintenance needs and proposed enhancements for Q6/16 video and image coding Recommendations<br>– Progress the work on specification of code point identifiers for video and image signal types in video and image coding specifications<br>– Address any AAP comments submitted in the approval process of texts for Q6/16<br>– Collect verification testing data and non-normative information for assisting in the use and deployment of Recommendations in the domain of Q6/16<br>– Coordinate and communicate with MPEG, JPEG, and other organizations regarding image and video coding and the work of Q6/16, JCT-VC, and JCT-3V<br>– Plan for future work of Q6/16, JCT-VC, and JCT-3V |

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