|  |  |
| --- | --- |
| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11**  23rd Meeting: San Diego, USA, 19–26 February 2016 | Document: JCTVC-W1004 |

|  |  |  |  |
| --- | --- | --- | --- |
| *Title:* | **SHVC verification test report** | | |
| *Status:* | Output Document Approved by JCT-VC | | |
| *Purpose:* | Final test report | | |
| *Author(s) or Contact(s):* | Yan Ye  Vittorio Baroncini  Ye-Kui Wang | Email: | [Yan.Ye@InterDigital.com](mailto:Yan.Ye@InterDigital.com)  [vittorio@fub.it](mailto:vittorio@fub.it)  [yekuiw@qti.qualcomm.com](mailto:yekuiw@qti.qualcomm.com) |
| *Source:* | Editors | | |

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# Executive summary

SHVC, the scalable form of HEVC, codes video data of different qualities into *layers*, and allows subsets of the layers of video data to be extracted and used on their own. The verification tests of SHVC were conducted to evaluate the amount of savings that can be achieved by SHVC compared to HEVC simulcast, where video data of different qualities are separately coded into independent bitstreams using HEVC. This document reports the results for the verification testing of SHVC compression performance.

A subjective evaluation was conducted to compare the SHVC Scalable Main and Scalable Main 10 profiles to HEVC *simulcast* using the HEVC Main and Main 10 profiles, respectively, based on the compression performance of reference software developed as part of the SHVC development process. The tests covered a range of video resolutions from 540p to 4K, and various scalability cases, including spatial scalability with 1.5x ratio, spatial scalability with 2x ratio, SNR scalability, and colour gamut scalability (CGS).

The tests were performed according to the previously established test plan [1] and as summarized in this report. The results confirmed that the tested encodings using the SHVC Scalable Main and Scalable Main 10 profiles achieve the same subjective quality as the HEVC simulcast encodings using the Main and Main 10 profiles, respectively, while requiring on average approximately 40~60% less bitrate as shown in Figure 1. For each individual scalability case, the average bitrate savings are 39.5%, 48.4%, 59.3%, and 53.2% for spatial 2x, spatial 1.5x, SNR, and CGS scalability, respectively.

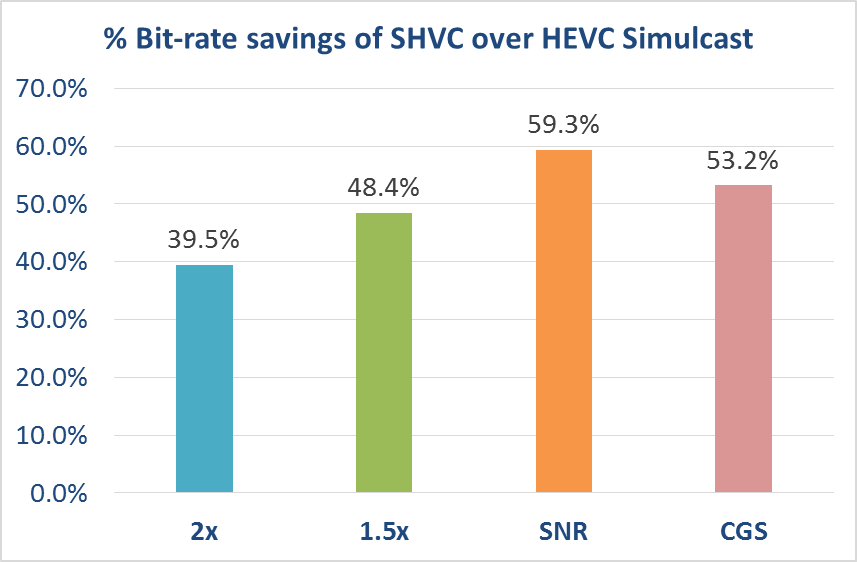


Figure : Average bitrate savings of SHVC vs. HEVC simulcast

# Test sequences and conditions

## Test sequences

The sequences used in the SHVC verification tests are listed in Table 2‑1, Table 2‑2, Table 2‑3, and Table 2‑4 for spatial 2x, spatial 1.5x, SNR, and CGS scalability, respectively. Also provided in the tables are the sequence characteristics, including the sequence name, sequence source, base layer (BL) and enhancement layer (EL) resolutions, BL and EL colour space and dynamic range, frame rate, sequence length, and the prediction structure used to encode each sequence. The two tested prediction structures are referred to as the Random Access (RA) and Low Delay (LD) configurations. All sequences used in the spatial 2x, spatial 1.5x, and SNR cases were 8-bit sequences coded using the Scalable Main profile or the Main profile; and all sequences used in the CGS case were 10-bit sequences coded using the Scalable Main 10 profile or the Main 10 profile.

Table ‑ Test sequences used for the spatial 2x scalability

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sequence | Source [Copyright] | EL  resolution | BL resolution | Frame rate (fps) | Length (frames) | RA / LD |
| ElFuente\_12000\_12600\_Crop | Netflix/NTIA [C4] | 3840x2160 | 1920x1080 | 60 | 600 | RA |
| ElFuente\_14900\_15500\_Crop | Netflix/NTIA [C4] | 3840x2160 | 1920x1080 | 60 | 600 | RA |
| Vidyo6 | Vidyo[C3] | 1920x1080 | 960x540 | 30 | 300 | LD |

Table ‑ Test sequences used for the spatial 1.5x scalability testing

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sequence | Source [Copyright] | EL resolution | BL resolution | Frame rate (fps) | Length (frames) | RA / LD |
| ElFuente\_12000\_12600\_Crop | Netflix/NTIA [C4] | 3840x2160 | 2560x1440 | 60 | 600 | RA |
| Vidyo5 | Vidyo[C3] | 1920x1080 | 1280x720 | 30 | 300 | LD |
| Bbscorecheer | NTIA[C4] | 1920x1080 | 1290x720 | 30 | 300 | RA |

Table ‑ Test sequences used for the SNR scalability testing

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sequence | Source [Copyright] | EL resolution | BL resolution | Frame rate (fps) | Length (frames) | RA / LD |
| ElFuente\_14900\_15500\_Crop | Netflix/NTIA[C4] | 3840x2160 | 3840x2160 | 60 | 600 | RA |
| UnderBoat1 | NTIA[C4] | 1920x1080 | 1920x1080 | 30 | 300 | RA |

Table ‑ Test sequences used for the CGS scalability testing

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sequence | Source [Copyright] | EL colour space/ dynamic range | BL colour space/ dynamic range | Frame rate (fps) | Length (frames) | RA/LD |
| BirthdayLucy | Technicolor [C1] | BT.2020 | BT.709 | 60 | 600 | RA |
| Parakeets | Technicolor [C1] | BT.2020 | BT.709 | 60 | 600 | RA |
| Market | Technicolor [C1] | BT.2020/ HDR | BT.709/ SDR | 50 | 500 | RA |
| BalloonFestival | CableLabs [C2] | BT.2020/ HDR | BT.709/ SDR | 24 | 240 | RA |

## Test conditions

The SHVC performance was compared to HEVC simulcast performance for a wide range of bitrates that cover a wide range of subjective qualities.

In HEVC and its SHVC extensions, as in most international standards for video coding, the encoding method is left outside the scope of the video coding standard. Only the format of the bitstream syntax and the decoding process are standardized. (Encoder pre-processing, decoder post-processing, display adaptation, and recovery from data losses and corruption are also left outside the scope of the standard.) This particularly allows encoder designers the freedom to develop their own encoding algorithms, while ensuring that *interoperability* for decoding is maintained. Nevertheless, when trying to assess the compression capability of a standard, it is necessary for some particular encoding algorithm(s) to be selected to reasonably represent its capability. Moreover, when comparing different coding schemes under well-controlled circumstances, it is generally helpful to use comparable encoding techniques and configurations for the coding schemes that will be compared. In this instance, a recent version of the reference software known as the SHM (scalable HEVC model) [2], developed as part of the work on developing the SHVC standard itself, was used for this verification test. The SHM software encoder is capable of operating either as an SHVC layered encoder or as a "single-layer" ordinary HEVC encoder, and can apply similar encoder decision-making processes in both contexts.

Both the SHVC and HEVC simulcast encodings were performed using the SHM 10.0 reference software, which provides the functionality to produce either SHVC multi-layer or HEVC single-layer *simulcast* encodings. For SHVC, the encoding of each test sequence was configured to satisfy an additional condition, that is, the bitrate ratio between the EL and the BL was kept within a predefined range that depends on the scalability case (2x, 1.5x, SNR, or CGS). The predefined range of EL/BL bitrate ratio was selected for each of the scalability cases, as shown in Table 2‑5. Each sequence was encoded at four bitrates. For each video test sequence and each bitrate point, encoding was performed using the constant-QP configuration as defined in the well-established SHVC common test conditions [3]. For SHVC, the EL and BL QP values were selected such that the predefined range of bitrate ratios (in Table 2‑5) were satisfied. For HEVC simulcast, the same EL and BL QP values as used in the corresponding SHVC encodings were used. Further information on the detailed coding configurations can be found in Annex B.

Table ‑ SHVC EL/BL bitrate ratio for each scalability case

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Spatial 2x | Spatial 1.5x | SNR | CGS |
| SHVC EL/BL bitrate ratio | 80%~110% | 40%~60% | 30%~45% | 10%-20% |
| BL/EL spatial resolutions | 960x540/ 1920x1080  1920x1080/ 3840x2160 | 1280x720/ 1920x1080  2560x1440/ 3840x2160 | 1920x1080/1920x1080  3840x2160/3840x2160 | 1920x1080/ 1920x1080 |

# Test environment and methodology

The test procedure for the formal subjective evaluation considered two main requirements:

* to be as reliable and effective as possible in verifying the performance in terms of subjective quality (and therefore adhering to the existing recommendations on assessment methods for the testing of subjective video quality for multimedia applications [4]);
* to take into account the evolution of technology and laboratory set-up requirements oriented to the adoption of appropriate Flat Panel Display (FPD) and video server systems as video recording and playing equipment.

Therefore, one of the test methods described in [4], specifically the Degradation Category Rating (DCR) method, was used. Some modifications were applied, in relation to the kind of displays and the video recording and play-back equipment. Further information on the DCR method can be found in Annex A.

In subjective viewing sessions, two test cases were compared: the HEVC simulcast coded higher quality video (labelled as P01) and the SHVC coded higher quality video (labelled as P02). The higher quality video corresponding to the enhancement layer video was displayed as the “coded” video in Figure 4 in Annex A; the lower quality video corresponding to the base layer video was not viewed and compared, as they were identical between the SHVC and HEVC simulcast test cases. The subjective viewing sessions were arranged by grouping together video sequences with the same characteristics such as spatial resolution, colour space, and dynamic range into one session. Four sessions were arranged for viewing. Table 3‑1 shows the video resolution, colour gamut, dynamic range, and bit depth for each session, as well as the test equipment (e.g., display) used for the sessions. Further information about the test laboratory set-up can be found in Annex A.

The video test sequences for each of the four scalability cases were renamed and regrouped according to the viewing session to which they belong, as shown in Table 3‑2. The sequences were renamed as “P0xS0xCnRn” using the following convention:

* P0x identifies the test case, with P01 being the HEVC simulcast test case and P02 being the SHVC test case.
* S0x identifies the sequence number, from S01 to S12.
* Cn identifies the scalability type, with C1 being Spatial 2x, C2 being Spatial 1.5x, C3 being SNR, and C4 being CGS.
* Rn identifies the coded rate, four rates, R1 to R4, were used to identify rates from the highest to the lowest.

Table ‑ Description of viewing sessions

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Session | Resolution | Colour gamut, dynamic range | Bit depth | Test Equipment | Number of test points |
| Session 1 | 1920x1080 | BT.2020, SDR | 10-bits | EIZO CG 301W display | 2x4x2=16 |
| Session 2 | 1920x1080 | BT.2020, HDR | 10-bits | SIM2 display | 2x4x2=16 |
| Session 3 | 3820x2160 | BT.709, SDR | 8-bits | 4K LCD monitor | 4x4x2=32 |
| Session 4 | 1920x1080 | BT.709, SDR | 8-bits | HD TV monitor | 4x4x2=32 |

Table ‑ Numbering of test sequences according to viewing session

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Session | Sequence no | Sequence name | Frame rate | Frame rate to be displayed | Scalability type | Coding Config. |
| Session 1 | P0xS01C4Rn | BirthdayLucy | 60 fps | 50 fps | CGS | RA |
| P0xS02C4Rn | Parakeets | 60 fps | 50 fps | CGS | RA |
| Session 2 | P0xS03C4Rn | Market | 50 fps | 50 fps | CGS | RA |
| P0xS04C4Rn | BalloonFestival | 24 fps | 25 fps | CGS | RA |
| Session 3 | P0xS05C1Rn | ElFuente\_12000\_12600\_Crop | 60 fps | 50 fps | 2x spatial | RA |
| P0xS06C1Rn | ElFuente\_14900\_15500\_Crop | 60 fps | 50 fps | 2x spatial | RA |
| P0xS07C2Rn | ElFuente\_12000\_12600\_Crop | 60 fps | 50 fps | 1.5x spatial | RA |
| P0xS08C3Rn | ElFuente\_14900\_15500\_Crop | 60 fps | 50 fps | SNR | RA |
| Session 4 | P0xS09C1Rn | Vidyo6 | 30 fps | 25 fps | 2x spatial | LD |
| P0xS10C2Rn | Vidyo5 | 30 fps | 25 fps | 1.5x spatial | LD |
| P0xS11C1Rn | Bbscorecheer | 30 fps | 25 fps | 2x spatial | RA |
| P0xS12C3Rn | UnderBoat1 | 30 fps | 25 fps | SNR | RA |

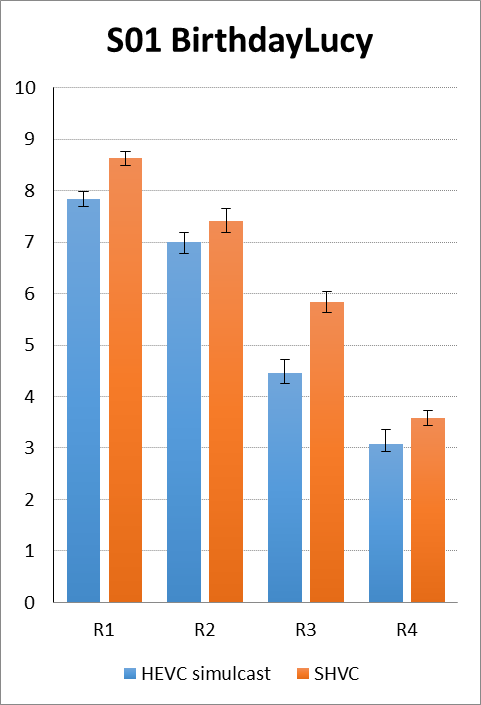
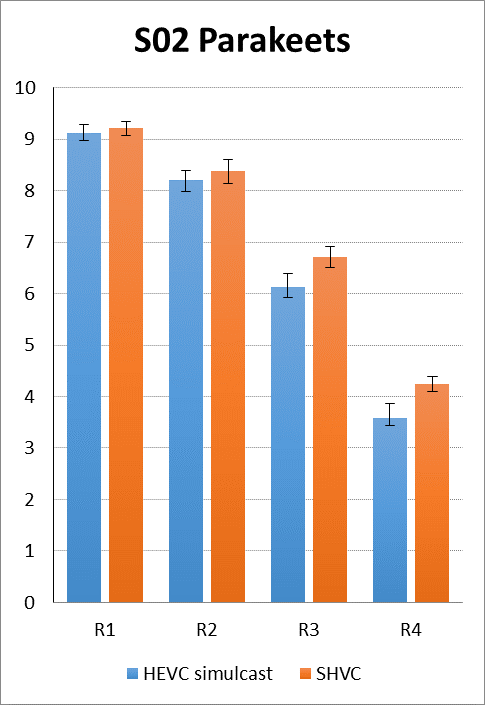
# Test results

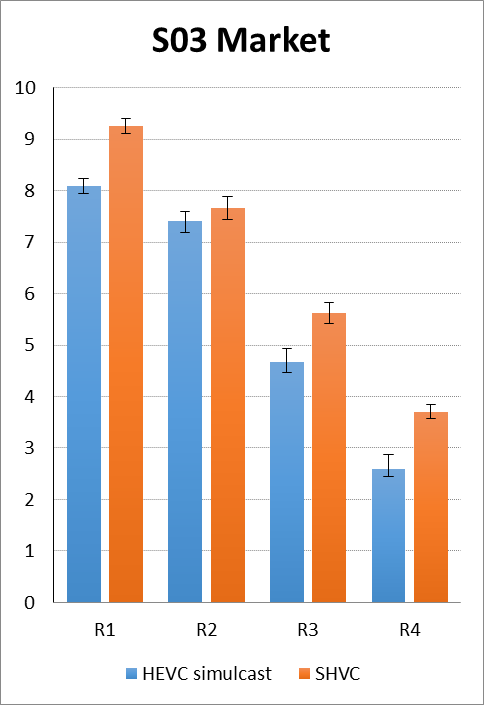
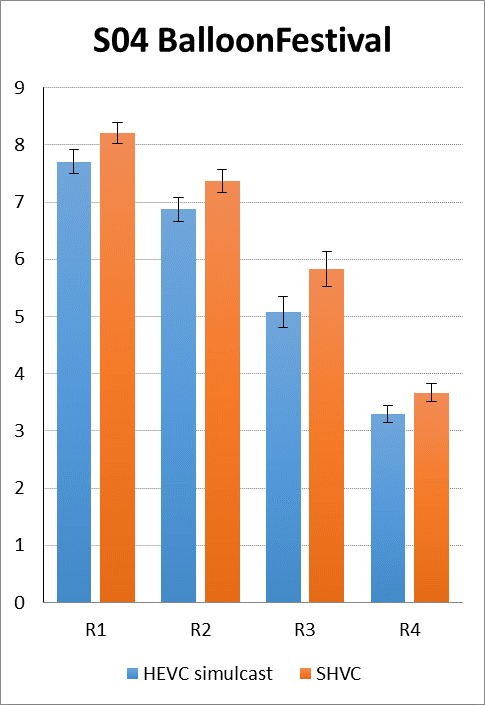
The eleven-grade mean-opinion score (MOS) scale from 0 to 10 was used to plot the figures in this section. They may be interpreted as follows.

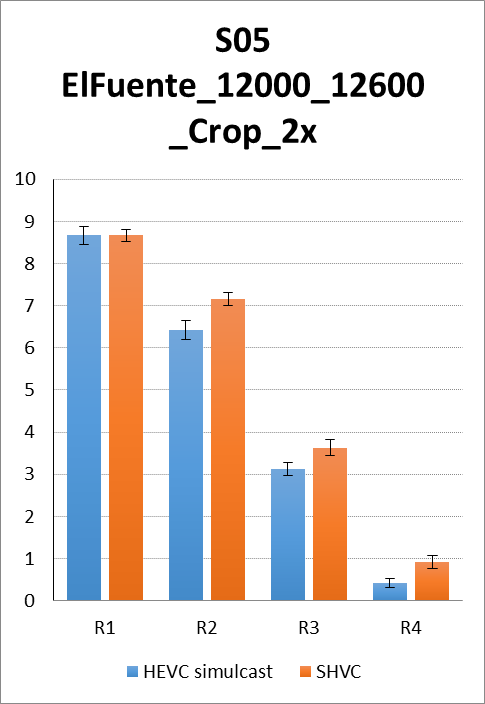
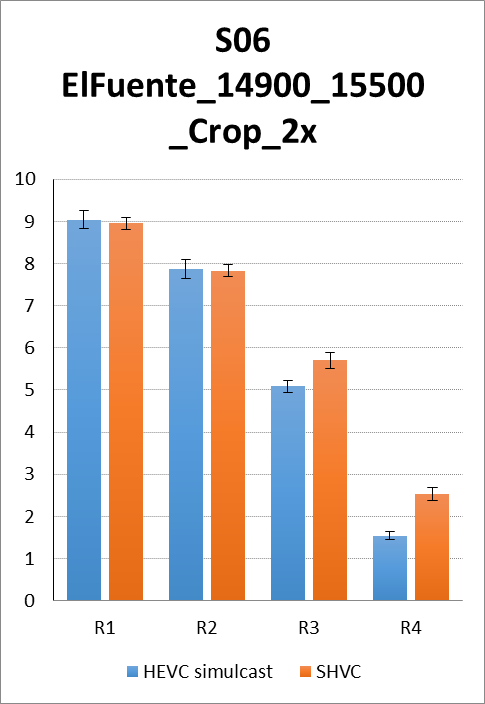
|  |  |
| --- | --- |
| 10 - | The number 10 denotes a quality of reproduction that is perfectly faithful to the original. No further improvement is possible. |
| 9 - | Excellent |
| 8 - |  |
| 7 - | Good |
| 6 - |  |
| 5 - | Fair |
| 4 - |  |
| 3 - | Poor |
| 2 - |  |
| 1 - | Bad |
| 0 - | The number 0 denotes a quality of reproduction that has no similarity to the original. A worse quality cannot be imagined. |

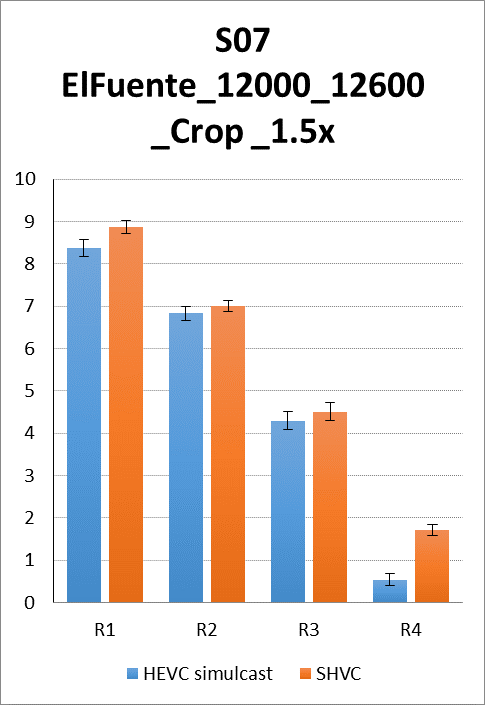
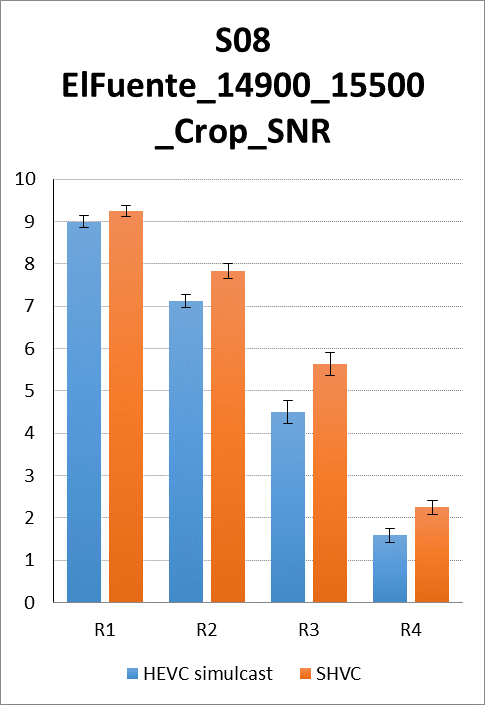
## Subjective viewing results

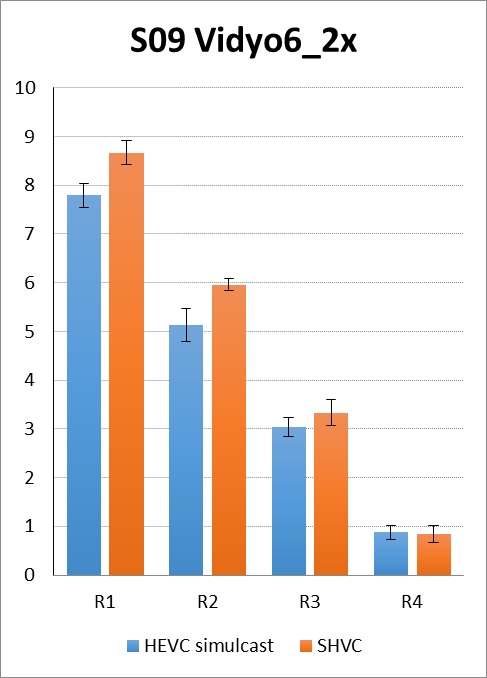
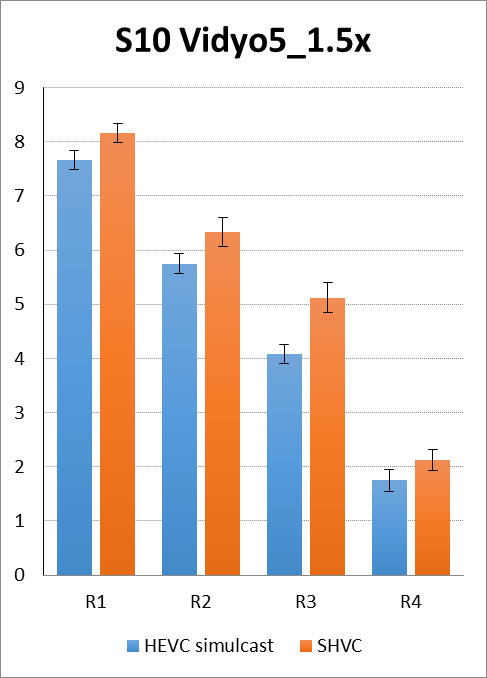
The subjective viewing results were collected and the MOS mean and confidence interval (CI) values for each test point are presented below.

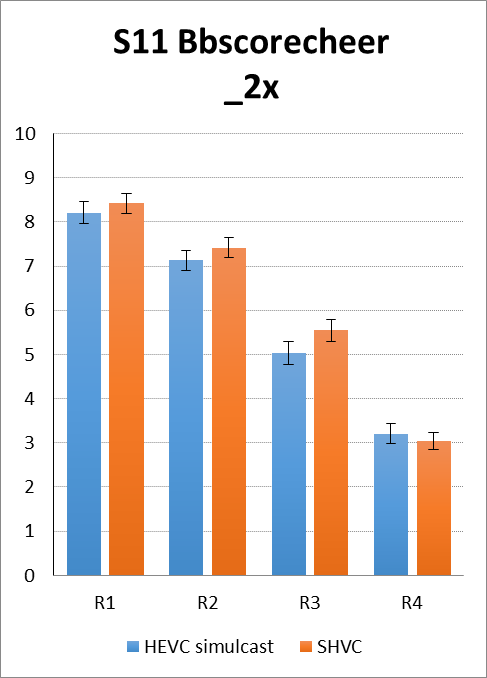
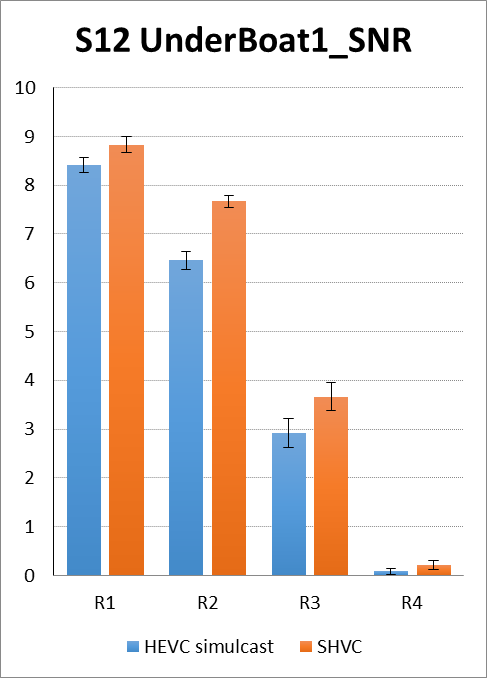
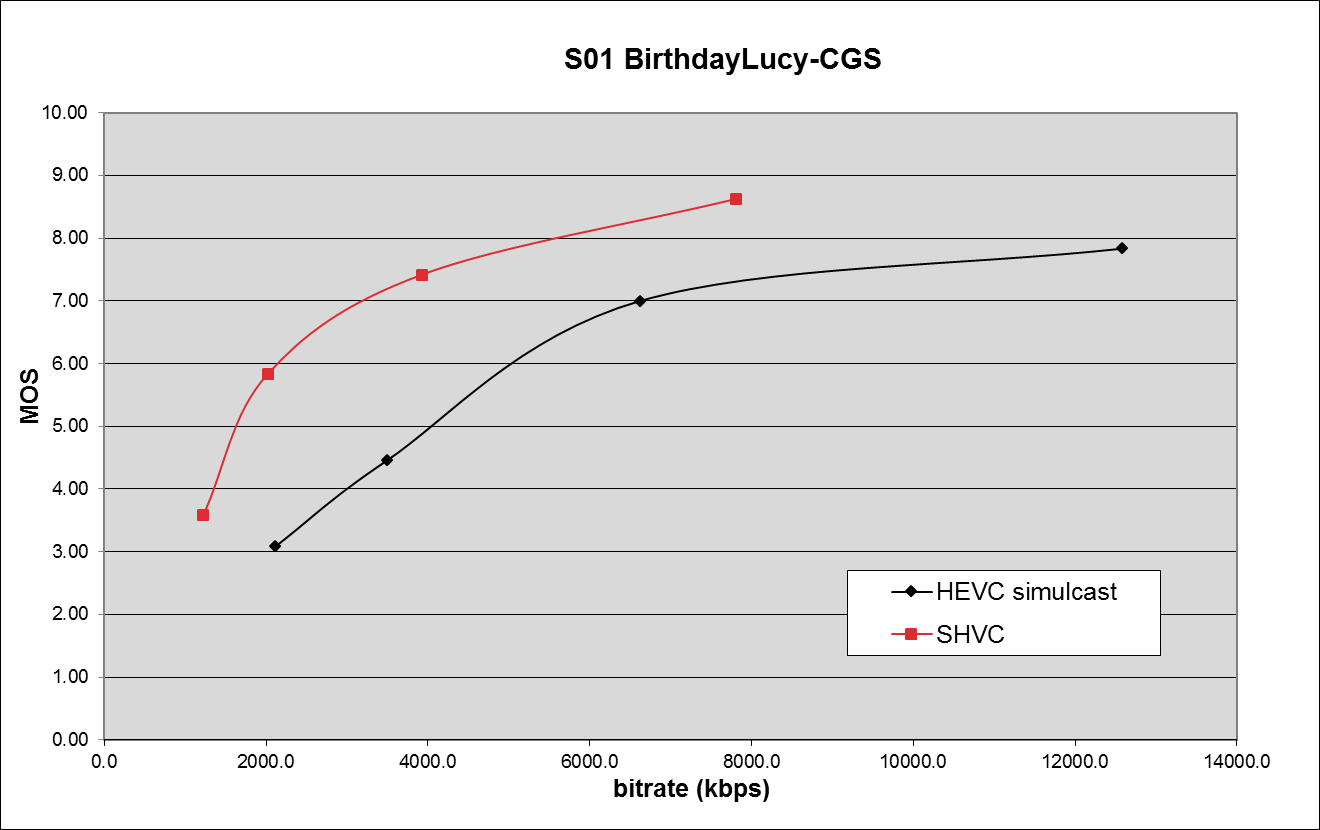
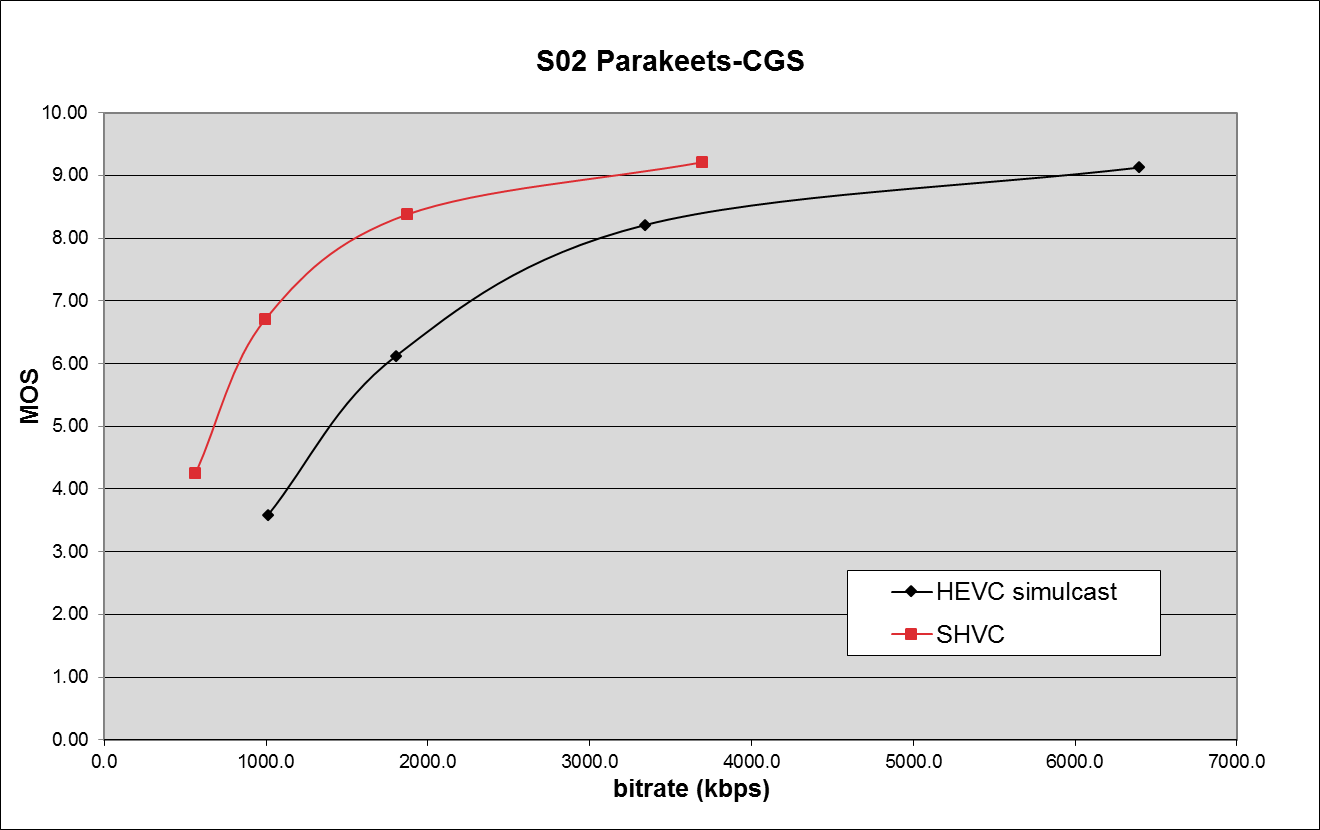
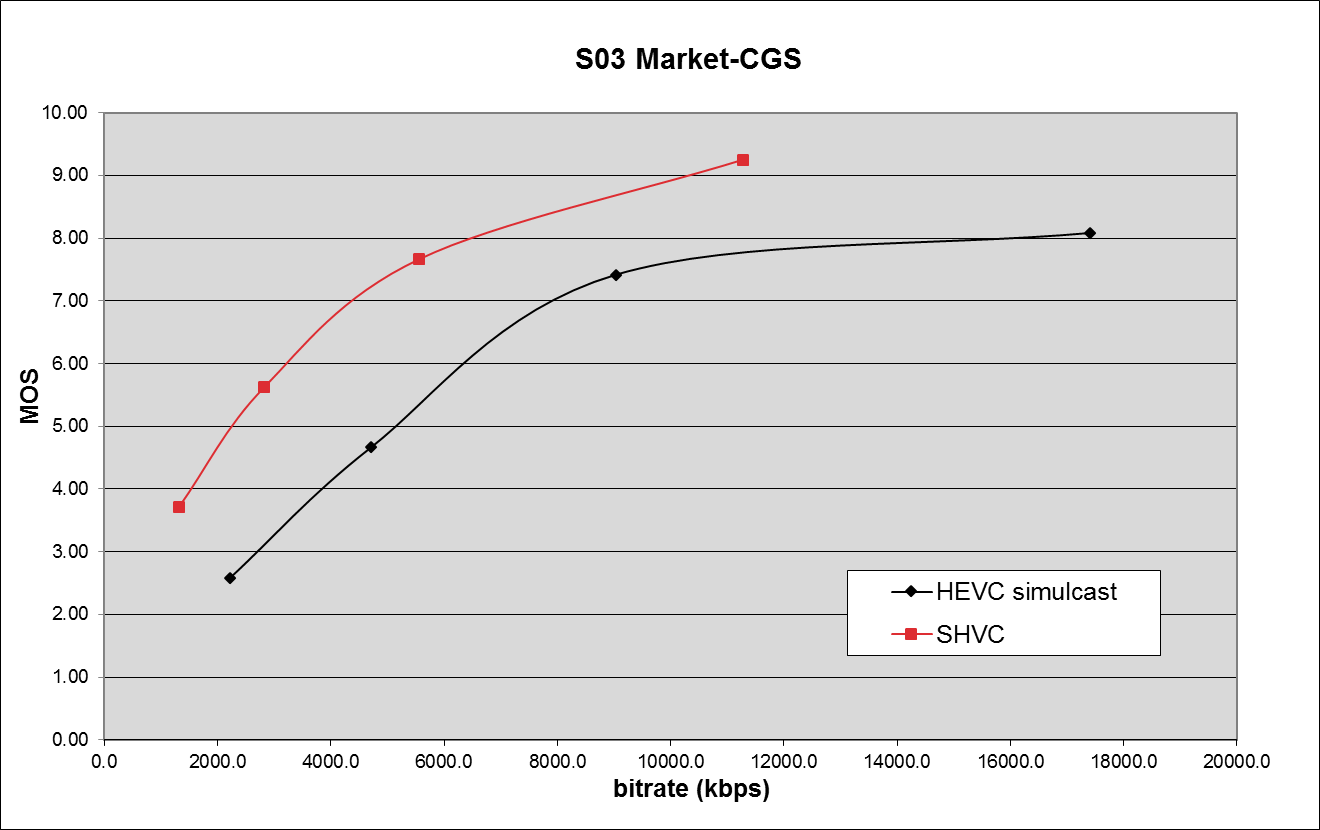
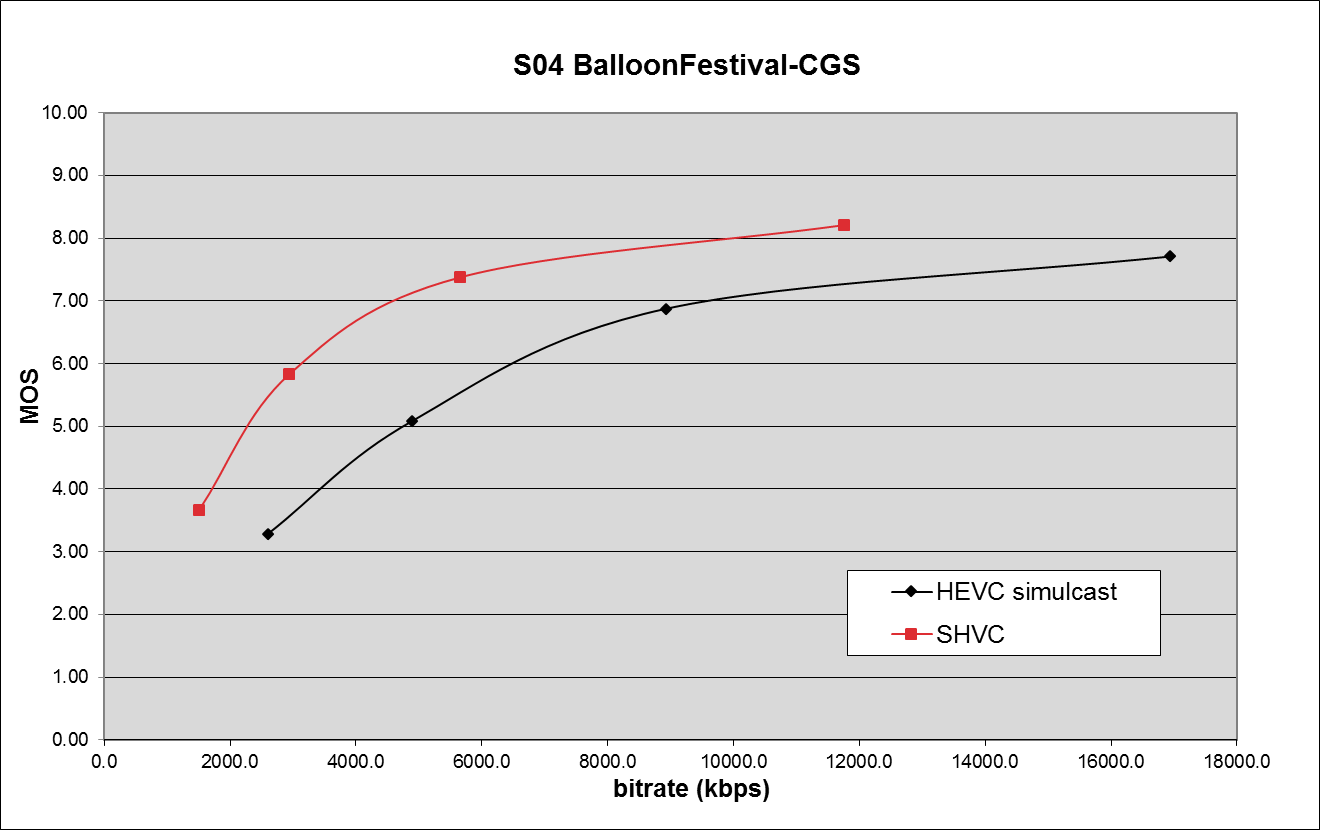
 

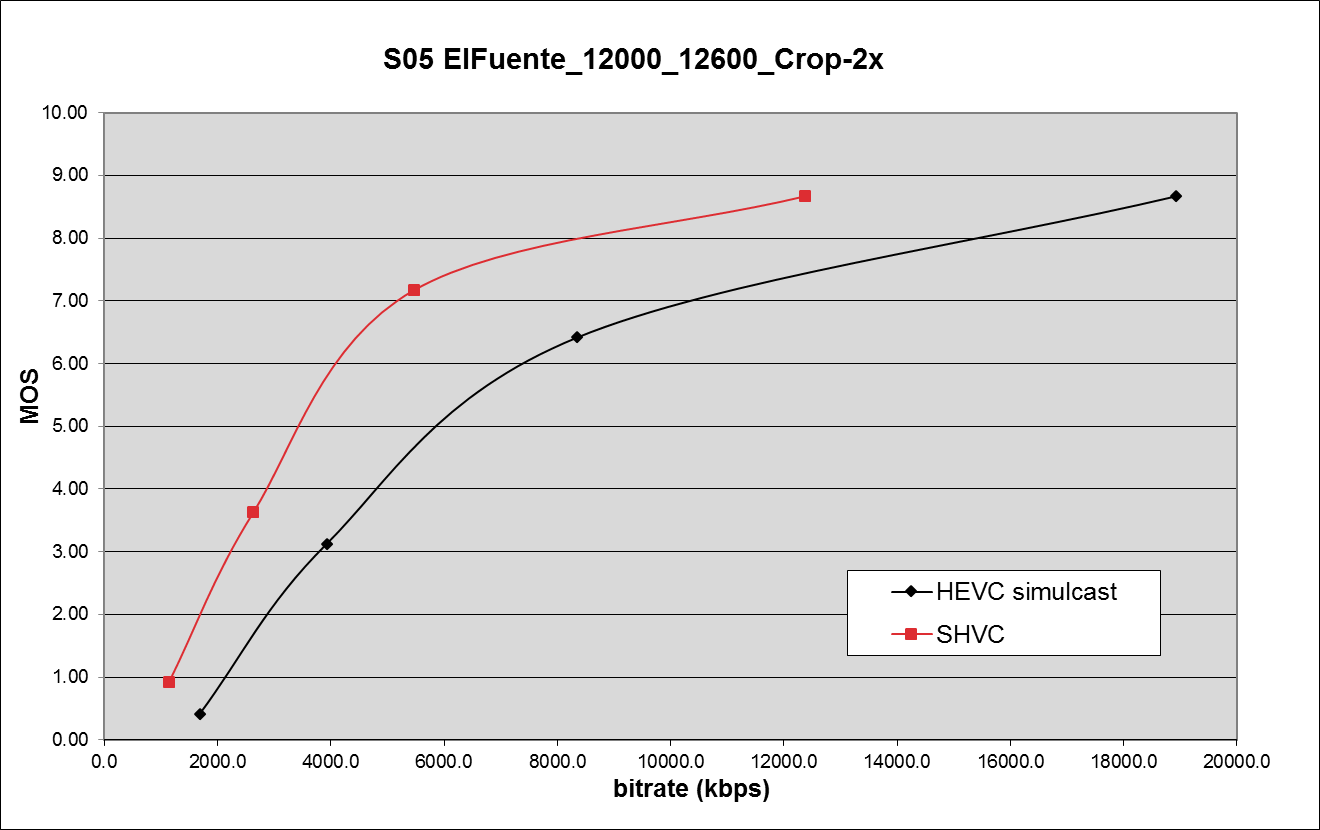
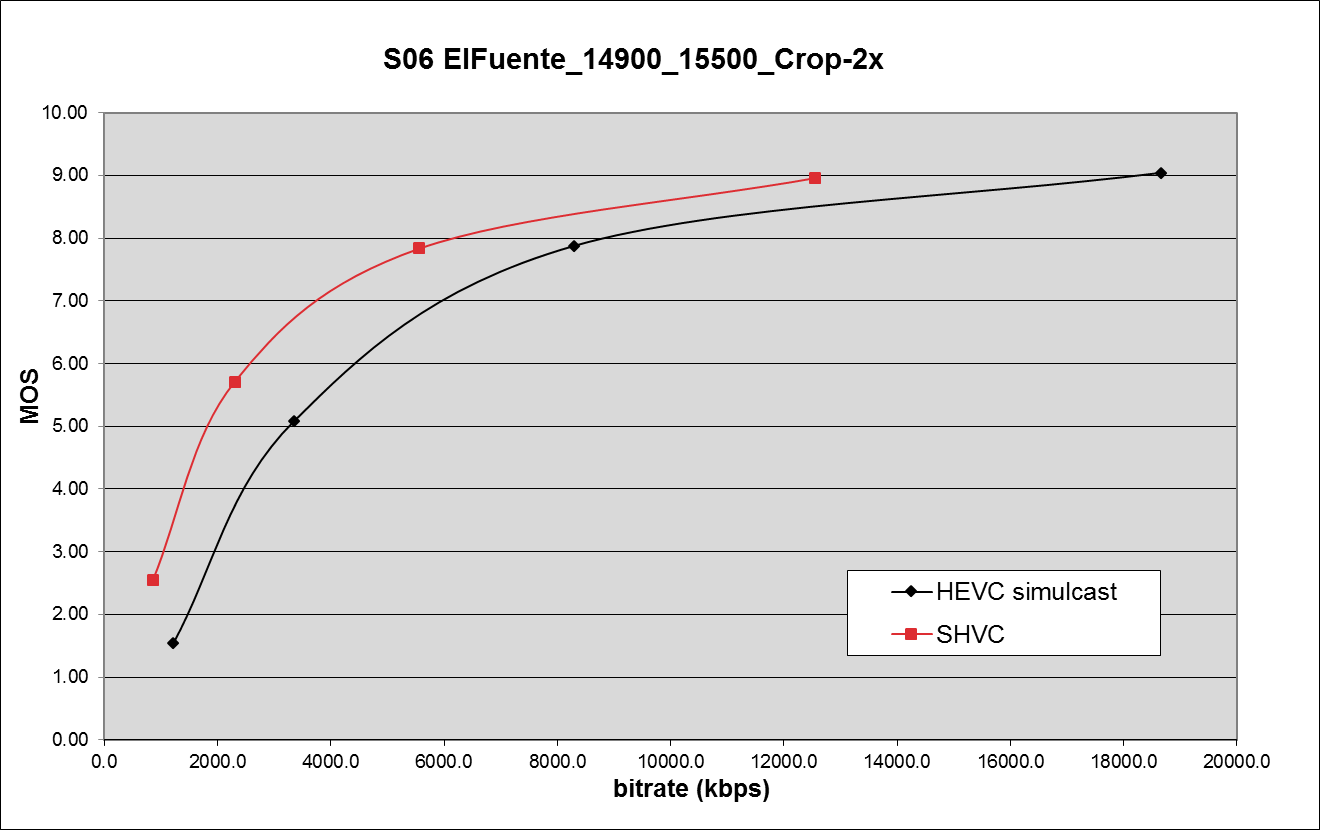
Figure : subjective viewing results for SHVC and HEVC simulcast

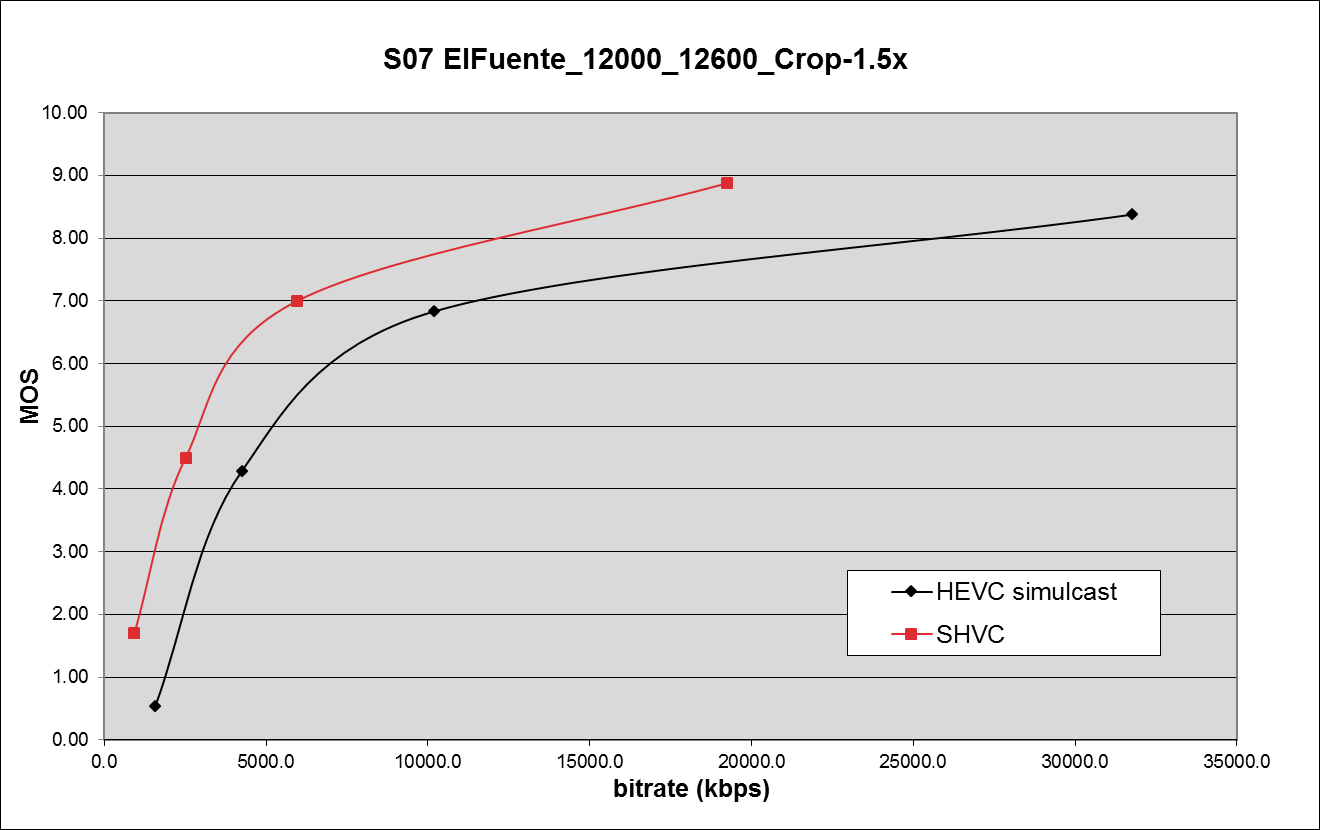
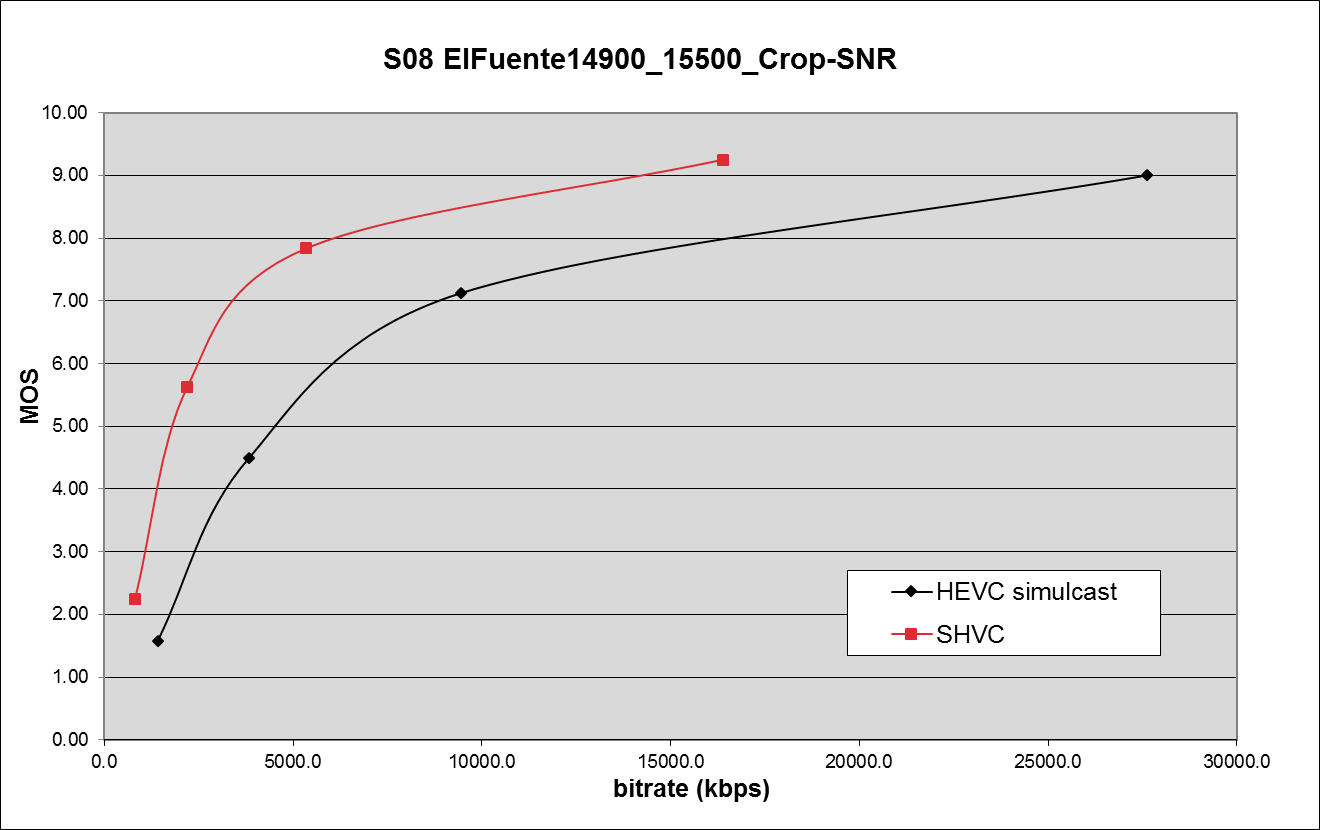
## Plots of MOS vs. bitrates

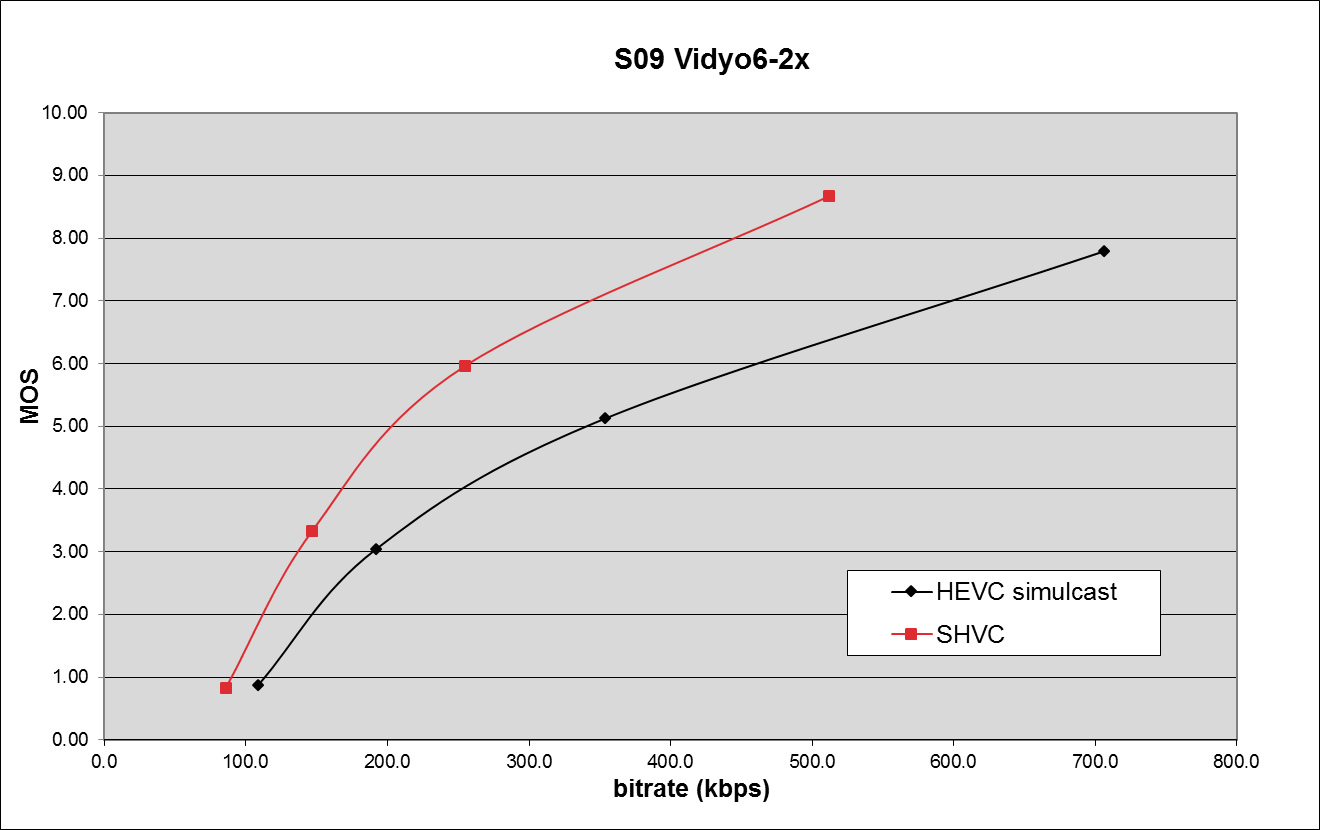
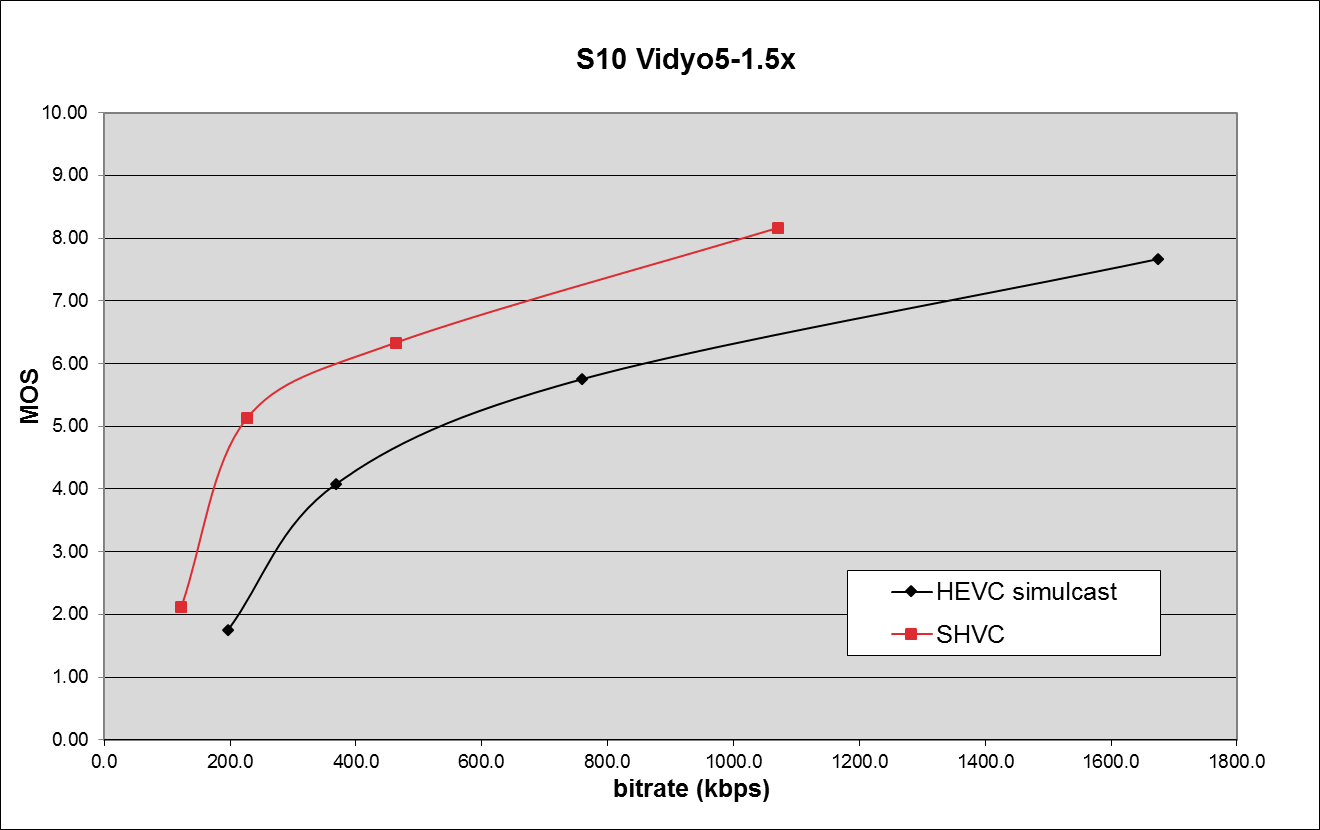
In this section, plots of MOS vs. bitrates are provided in Figure 3 for all test sequences used in the SHVC verification test. All plots show that the bitrate vs. MOS curves of the SHVC test points are located substantially to the left of the corresponding bitrate vs. MOS curves of the HEVC simulcast test points. This confirms that SHVC achieves a substantial bitrate reduction over HEVC simulcast at the same subjective quality.

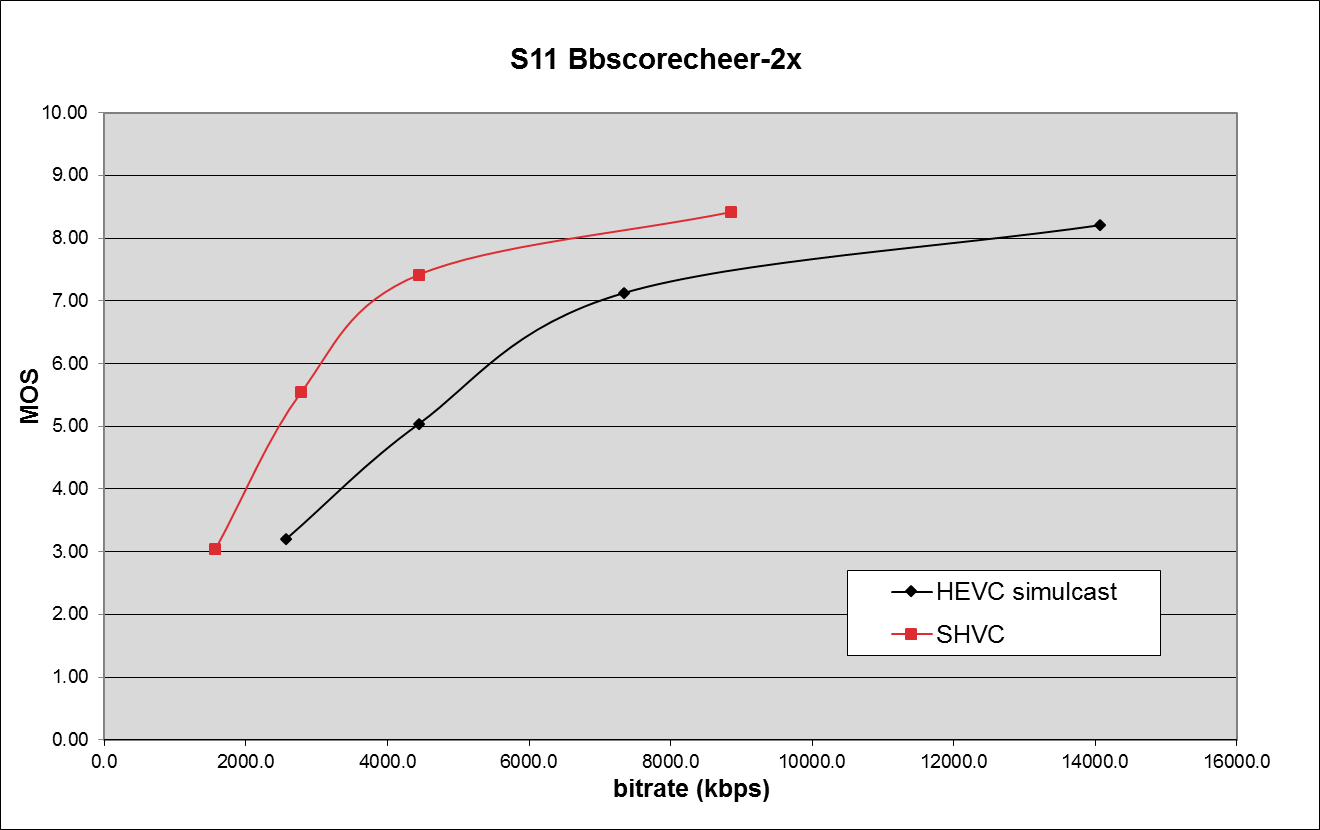
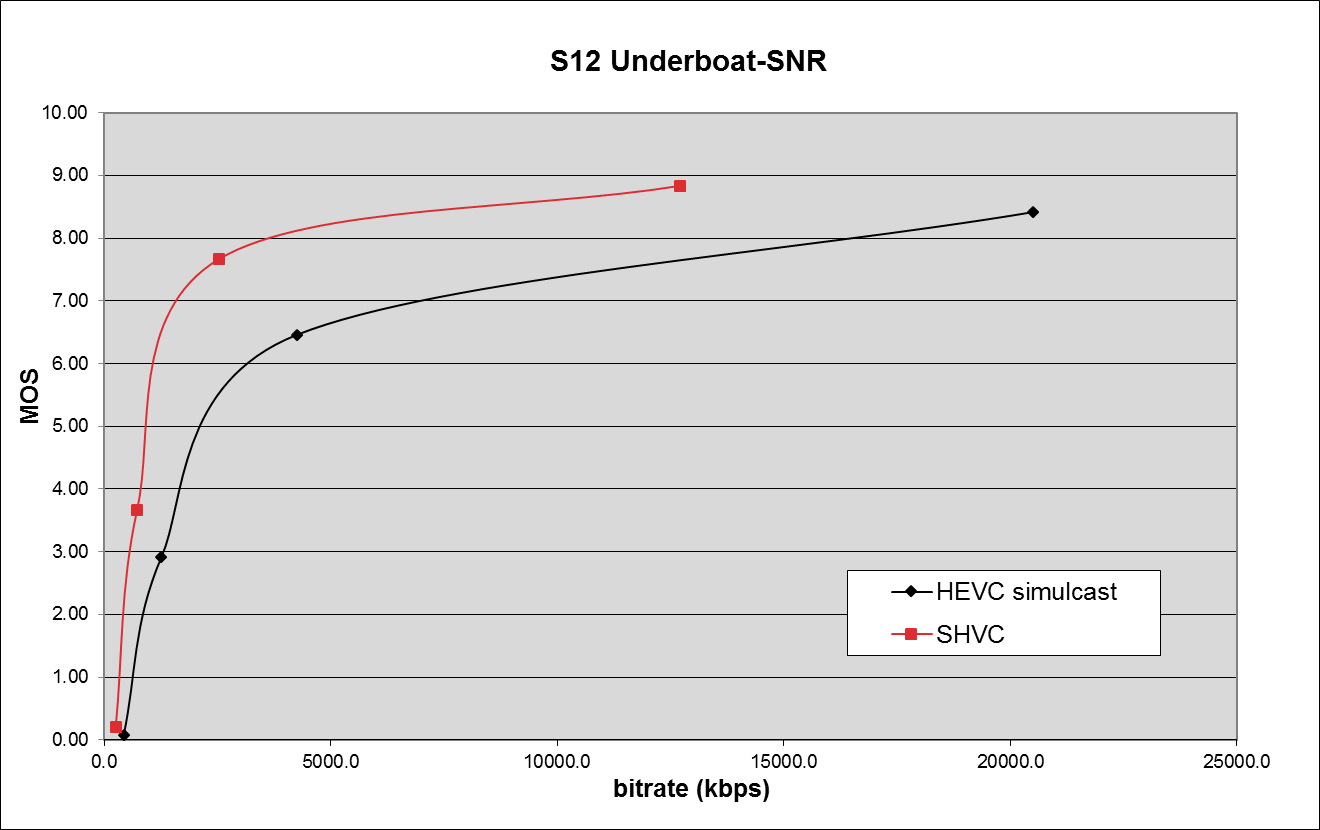
 

Figure : Bitrate vs. MOS curves for all test sequences

The average bitrate savings of SHVC compared to HEVC simulcast for each sequence were computed from the MOS vs. bitrate data to further quantify the savings achieved. Table 4‑1 shows the MOS Bjøntegaard -Delta-rate (BD-rate) for each sequence in all four test categories. BD-rate measures as described in [5] were used with MOS scores taking the place of peak signal-to-noise ratio (PSNR) values, with negative numbers indicating percentage of rate reduction at the same MOS quality. When considering (BL + EL) bitrates, the measured relative bitrate savings achieved by SHVC compared to HEVC simulcast ranged from 34.7% to 59.5%. When considering only the EL bitrates, the measured relative bitrate savings achieved by SHVC compared to HEVC simulcast ranged from 49.1% to 89.2%. In terms of the scalability cases, generally SNR scalability achieves the highest measured bitrate savings, followed (in order) by CGS, spatial 1.5x, and spatial 2x.

Table ‑ MOS BD-rate savings measurements

|  |  |  |  |
| --- | --- | --- | --- |
| Scalability type | Test sequences | BD-rate using MOS (BL+EL) | BD-rate using MOS (EL only) |
| Spatial 2x | ElFuente\_12000\_12600\_Crop | −43.2% | −58.8% |
| ElFuente\_14900\_15500\_Crop | −40.6% | −55.2% |
| vidyo6 | −34.7% | −49.1% |
| Spatial 1.5x | ElFuente\_12000\_12600\_Crop | −48.0% | −72.3% |
| BbScoreCheer | −44.0% | −67.7% |
| vidyo5 | −53.2% | −74.9% |
| SNR | ElFuente\_14900\_15500\_Crop | −59.1% | −82.4% |
| UnderBoat | −59.5% | −81.4% |
| CGS | BirthdayLucy | −56.8% | −89.2% |
| BalloonFestival | −52.5% | −87.4% |
| Market | −52.3% | −86.7% |
| Parakeets | −51.3% | −86.7% |

# Conclusion

The subjective test results show that SHVC and HEVC simulcast have similar subjective quality (that is, with overlapping confidence intervals) for approximately half of the test points. For the remaining half of the test points, SHVC provides better subjective quality. For all test points, the SHVC bitrates are substantially lower than the HEVC simulcast bitrates.

By applying the MOS BD-rate measurement on the results of the subjective test, it is estimated that SHVC achieves the same subjective quality as HEVC simulcast while requiring on average 40~60% less bitrate, depending on the scalability scenario.

Therefore, it is concluded that the project objective of achieving a substantial bitrate reduction over HEVC simulcast has been met by SHVC.

# Acknowledgements

The JCT-VC wishes to thank all the organizations and individuals who contributed to the SHVC verification test, including:

* Cable Television Laboratories, Netflix, NTIA (The National Telecommunications and Information Administration), Technicolor, and Vidyo for providing the test sequences.
* InterDigital Communications Inc., Microsoft Corporation, Nokia Corporation, Qualcomm Inc., Technicolor, and Vidyo for providing financial support for this activity.
* InterDigital Communications Inc. and Qualcomm Inc. for providing the resources to prepare the test material.
* Giacomo Baroncini of GBTech for conducting the subjective test.
* Dr. Vittorio Baroncini (MPEG Test Chairman) for his guidance and coordination of the subjective test.

# References

1. [JCTVC-V1004](http://phenix.it-sudparis.eu/jct/doc_end_user/current_document.php?id=10310), “SHVC verification test plan,” Oct. 2015.
2. JCTVC SHM10.0 reference software, available at <https://hevc.hhi.fraunhofer.de/svn/svn_SHVCSoftware/tags/SHM-10.0>.

1. [JCTVC-Q1009](http://phenix.it-sudparis.eu/jct/doc_end_user/current_document.php?id=9106), “Common SHM test conditions and software reference configurations,” April 2014.
2. International Telecommunication Union – Telecommunication Standardization Sector; [Recommendation ITU-T P.910](http://www.itu.int/rec/T-REC-P.910) *Subjective video quality assessment methods for multimedia applications*.
3. Gisle Bjøntegaard, "Improvements of the BD-PSNR model", ITU-T SG16/Q6, 35th VCEG meeting document [VCEG-AI11](http://wftp3.itu.int/av-arch/video-site/0807_Ber/VCEG-AI11.zip), Berlin, Germany, July, 2008.

### Annex A

### *Testing procedure*

*Test method*

The test method adopted for this evaluation was DCR (Degradation Category Rating) [4].

*Degradation category rating (DCR)*

This test method is commonly adopted when the material to be evaluated shows a range of visual quality that well distributes across all quality scales.

This method is used under the schema of evaluation of the quality (and not of the impairment); for this reason, a quality rating scale made of 11 levels was adopted, ranging from "0" (lowest quality) to "10" (highest quality).

All the video material used for these tests consisted of video clips of 10 seconds duration.

The structure of the Basic Test Cell (BTC) of DCR method was made by using two consecutive presentations of the video clip under test; at first the original version of the video clip was displayed, immediately afterwards the coded version of the video clip was presented; then a message was displayed for 5 seconds asking the viewers to vote (see Figure 4).



Figure : DCR BTC

The presentation of the video clips was preceded by a mid-grey screen displaying for one second.

*How to express the visual quality opinion with DCR*

The viewers were asked to express their vote by putting a mark on a scoring sheet.

The scoring sheet for a DCR test was made of a section for each BTC; each section was made of a column of 11 vertically arranged boxes, each associated with a number from 0 to 10 (see Figure 5).

The viewers were required to put a check mark on one of the 11 boxes; checking the box "10" if the subject expresses an opinion of "best" quality, while checking the box "0" if the subject expresses an opinion of the "worst” quality.

The vote was written when the message "Vote N" appeared on the screen. The number "N" was a numerical progressive indication on the screen, aiming to help the viewing subjects to use the appropriate box of the scoring sheet.

Scoring sheet Class C IVC english

Figure : Example of DCR test method scoring sheet

*Training and stabilization phase*

The outcome of a test is highly dependent on the proper training of the test subjects.

For this purpose, each subject was trained by means of a short practice (training) session.

As a testing principle, the video material used for the training session was required to be different from those of the test, but the impairments introduced by the coding were kept, as much as possible, similar to those in the test.

The stabilization phase used the test material of a test session; three BTCs, containing one sample of best quality, one of the worst quality and one of medium quality, were duplicated at the beginning of the test session. By this way, the test subjects had an immediate impression of the quality range they were expected to evaluate during that session.

The scores of the stabilization phase were discarded. Consistency of the behaviour of the subjects was checked by inserting in the session a BTC in which the original is compared to the original.

*The laboratory set-up*

The laboratory for a subjective assessment was set up according to [4], except for the selection of the display and the video play-out server.

For 4K video clips, high quality LCD monitors were used with diagonal size equal to or higher than 56'' and able to accept resolutions of up to 3840x2160. Play-out of 3840x2048 video clips was done at the native resolution using the central area of the screen; the remaining part of the screen was set to a mid grey level (128 in 0-255 range)". In the case where the width of the sequence exceeded 3840, the left and right sides of the picture were cropped and only the centre 3840 pixels were shown.

For other resolutions, High quality LCD monitors (or TV set) were used, having a diagonal size equal or higher of 40” and capable to accept resolution equal to 1920 x 1080. When using TV sets, all the local colour and contrast features were disabled (where applicable).

For sequences with wide colour gamut (WCG) and standard dynamic range (SDR), the EIZO display was used. For sequences with high dynamic range (HDR), a SIM2 display was used.

The video play server, or the PC, used to play video was be able to support the display of 4K, and 1080p video formats. For video sequences with 24 and 30 frames per second, they were displayed at 25 frames per second. For video sequences at 50 and 60 frames per second, they were displayed at 50 f frames per second. The frame rate at which each of the S01 to S12 test sequences was displayed is provided in Table 3‑2.

*Viewing distance*

The viewing distance varies according to the physical dimensions of the active part of the video; this led to a viewing distance varying from 1.5H to 4H, where H is equal to the height of the active part of the screen, depending on the size of the active part of the screen and its native resolution.

The number of subjects seating in front of the monitor is a function of the monitor size and of the selected viewing distance.

*Viewing environment*

The test laboratory was carefully protected from any external visual or audio pollution.

Internal general light was kep low (just enough to allow the viewing subjects to fill out the scoring sheets) and a uniform light was placed behind the monitor, in a way that no direct light would hit the viewing subjects seated in front of the screen; the light behind the monitor was dimmed to an intensity as specified in Table 4 of Recommendation ITU-T P.911 (“Typical viewing and listening conditions as used in audio-visual quality assessment”) [A1]. No other light source was admitted, and in particular any light source directed to the screen or creating reflections; ceiling, floor and walls of the laboratory was required to be made of non-reflecting material (e.g. carpet or velvet) and to have a colour tuned as close as possible to mid grey.

*Overall test effort and subjects’ involvement*

The duration of the test depended on the number sequences tested in each category / resolution assigned to the test laboratory; in any case each viewing session did run for more than 20 minutes and the same viewing subject did not participate in the test run for more than six hours in total. The same subject was also required not to be enrolled for two consecutive days. Young human subjects, equally distributed in gender, between the age of 18 to 30, and highly preferably among university students of scientific faculties, were hired. Viewing subjects were compensated for their participation in the testing activities (with compensation in money or services).

*Statistical analysis and presentation of the results*

The data collected from the score sheets, filled out by the viewing subjects, was stored in Excel spreadsheets.

For each coding condition the Mean Opinion Score (MOS) and associated Confidence Interval (CI) values were computed in the spreadsheets.

The MOS and CI values were used to draw graphs. The graphs were drawn grouping the results for each video test sequence. No graph grouping results from different video sequences was considered.

From the “raw” data, subject reliability was calculated, and the method used to assess subject used criteria for subjective reliability as given in [A2] and [A3].

As an example, the reliability of a subject could be determined by computing the correlation index between each score provided by a subject to the general MOS value assigned for that test point; in this regard a correlation index equal or superior to 0.75 (computed making the mean of all the correlation values) could be considered as valid for the acceptance of the subject.

*References*

1. International Telecommunication Union Standardization Sector; Recommendation ITU-T P.910 “Subjective video quality assessment methods for multimedia applications”
2. Pseudo Isochromatic Plates, engraved and printed by The Beck Engraving Co., Inc., Philadelphia and New York, United States.
3. Kirk, R.E., Experimental Design – Procedures for the Behavioural Sciences, 2nd Editions, Brooks/Cole Publishing Co., California, 1982.

### Annex B

### *Additional information on encoding configurations*

The following encoding configuration parameters are used:

* Fixed QP
  1. 4 bitrate points per sequence covering the whole MOS range as much as possible
* Bit depth
  1. 8 bits for spatial 1.5x, 2x and SNR scalabilities
  2. 10 bits for CGS
* Coding structure
  1. Random access (RA)
     1. IRAP picture period at approximately 0.5 second
     2. Hierarchical B coding structure
  2. Low delay (LD)
     1. Only the first picture in the bitstream is IRAP picture
     2. Without picture reordering
* Other settings are set the same as the following configuration files found in the cfg/ subdirectory of the SHM 10.0 software [2]:
  1. layers.cfg, encoder\_lowdelay\_scalable.cfg and encoder\_randomaccess\_scalable.cfg for spatial 1.5x, 2x and SNR scalability;
  2. encoder\_randomaccess\_scalable10.cfg for CGS.

### Annex C

### *Copyright licenses of test sequences*

1. ***Technicolor R&D***

This copyright document relates to the following video content:

BT709\_BirthdayLucy\_1920x1080\_60\_10bit\_zerophase\_0.9pi.yuv

BT2020\_BirthdayLucy\_3840x2160\_60\_10bit.yuv

BT709\_Parakeets\_1920x1080\_50\_10bit\_zerophase\_0.9pi.yuv

BT2020\_P3\_Parakeets\_3840x2160\_50\_10bit.yuv

Market3Clip4000r2\_AG\_1920x1080p\_50\_10\_709\_420.yuv

Market3Clip4000r2\_1920x1080p\_50\_hf\_709\_ct2020\_444\_xxx.exr

This video content (“Content”) may only be used for the purpose of developing, testing and promulgating technology standards developed by the MPEG, VCEG or JCT-VC standardization groups (“Purpose”), under Technicolor R&D France SNC (“Technicolor”) owned or controlled copyrights, by individual(s) or organization(s) that participates, contributes or is part of such standardization groups (“User(s)”).

RESTRICTIONS: No license whatsoever is implied except from this expressed limited personal, non-sublicensable, non-transferrable authorization. In particular no right under any patent of Technicolor or its affiliates is granted. Any other use is strictly prohibited. This Content cannot be distributed or otherwise disposed of or made available (via internet or otherwise), broadcasted, disclosed to third parties (except to other User(s) who agreed with the present terms and conditions), used for providing any services to third parties or for any commercial use, nor copied (except as technically necessary for the Purpose), modified, adapted, translated, exchanged, publicly performed (even for demonstration or educational purposes), integrated, without limitation. This Content and all intellectual property rights, titles and interests therein, are and remain the exclusive property of Technicolor or its affiliates.

NO WARRANTY: This Content is supplied "as is" and without any warranty of any kind, expressed or implied, including but not limited to any warranty for accuracy or performance, fitness for a general or particular purposes, or any warranty arising by statute or by law, or non-infringement of any third parties’ rights. In no event will Technicolor be liable for damages of any kind, including without limitation, any special, indirect, incidental, or consequential damages even if Technicolor has been advised of the possibility of such damages.

This authorization is effective as of the date of use of the Content and shall expire on January, 1, 2020. Technicolor may nevertheless terminate it at any time for any reason upon notice to User(s). It is governed by the laws of France without regard to conflict of laws. It shall be exclusively submitted to the first instance civil court of Paris, France (TGI) in the event of a dispute not settled amicably.

BY USING THIS CONTENT USER(S) AGREES AND ACCEPTS THE ABOVE MENTIONED TERMS AND CONDITIONS. IF USER(S) DOES NOT AGREE TO THESE TERMS AND CONDITIONS, IT SHALL NOT ACCESS OR OTHERWISE USE THIS CONTENT. DO NOT REMOVE OR MODIFY TECHNICOLOR OR ITS AFFILIATES’ NAMES, SIGNS, LOGOS, NOTICES OF/IN THE CONTENT.

Copyright © 2012-2014 – Technicolor R&D France, SNC

All Rights Reserved

1. ***Cable Television Laboratories***

**Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International Public License**

By exercising the Licensed Rights (defined below), You accept and agree to be bound by the terms and conditions of this Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International Public License ("Public License"). To the extent this Public License may be interpreted as a contract, You are granted the Licensed Rights in consideration of Your acceptance of these terms and conditions, and the Licensor grants You such rights in consideration of benefits the Licensor receives from making the Licensed Material available under these terms and conditions.

**Section 1 – Definitions.**

a **Adapted Material** means material subject to Copyright and Similar Rights that is derived from or based upon the Licensed Material and in which the Licensed Material is translated, altered, arranged, transformed, or otherwise modified in a manner requiring permission under the Copyright and Similar Rights held by the Licensor. For purposes of this Public License, where the Licensed Material is a musical work, performance, or sound recording, Adapted Material is always produced where the Licensed Material is synched in timed relation with a moving image.

b **Copyright and Similar Rights** means copyright and/or similar rights closely related to copyright including, without limitation, performance, broadcast, sound recording, and Sui Generis Database Rights, without regard to how the rights are labeled or categorized. For purposes of this Public License, the rights specified in Section 2(b)(1)-(2) are not Copyright and Similar Rights.

c **Effective Technological Measures** means those measures that, in the absence of proper authority, may not be circumvented under laws fulfilling obligations under Article 11 of the WIPO Copyright Treaty adopted on December 20, 1996, and/or similar international agreements.

d **Exceptions and Limitations** means fair use, fair dealing, and/or any other exception or limitation to Copyright and Similar Rights that applies to Your use of the Licensed Material.

e **Licensed Material** means the artistic or literary work, database, or other material to which the Licensor applied this Public License.

f **Licensed Rights** means the rights granted to You subject to the terms and conditions of this Public License, which are limited to all Copyright and Similar Rights that apply to Your use of the Licensed

Material and that the Licensor has authority to license.

g **Licensor** means the individual(s) or entity(ies) granting rights under this Public License.

h **NonCommercial** means not primarily intended for or directed towards commercial advantage or monetary compensation. For purposes of this Public License, the exchange of the Licensed Material for other material subject to Copyright and Similar Rights by digital file-sharing or similar means is NonCommercial provided there is no payment of monetary compensation in connection with the exchange.

i **Share** means to provide material to the public by any means or process that requires permission under the Licensed Rights, such as reproduction, public display, public performance, distribution, dissemination, communication, or importation, and to make material available to the public including in ways that members of the public may access the material from a place and at a time individually chosen by them.

j **Sui Generis Database Rights** means rights other than copyright resulting from Directive 96/9/EC of the European Parliament and of the Council of 11 March 1996 on the legal protection of databases, as amended and/or succeeded, as well as other essentially equivalent rights anywhere in the world.

k **You** means the individual or entity exercising the Licensed Rights under this Public License. **Your** has a corresponding meaning.

**Section 2 – Scope.**

a **License grant**.

1 Subject to the terms and conditions of this Public License, the Licensor hereby grants You a worldwide, royalty-free, nonsublicensable, non-exclusive, irrevocable license to exercise the Licensed Rights in the Licensed Material to:

A reproduce and Share the Licensed Material, in whole or in part, for NonCommercial purposes only; and

B produce and reproduce, but not Share, Adapted Material for NonCommercial purposes only.

2 Exceptions and Limitations. For the avoidance of doubt, where Exceptions and Limitations apply to Your use, this Public License does not apply, and You do not need to comply with its terms and conditions.

3 Term. The term of this Public License is specified in Section 6(a).

4 Media and formats; technical modifications allowed. The Licensor authorizes You to exercise the Licensed Rights in all media and formats whether now known or hereafter created, and to make technical modifications necessary to do so. The Licensor waives and/or agrees not to assert any right or authority to forbid You from making technical modifications necessary to exercise the Licensed Rights, including technical modifications necessary to circumvent Effective Technological Measures. For purposes of this Public License, simply making modifications authorized by this Section 2(a)(4) never produces Adapted Material.

5 Downstream recipients.

A Offer from the Licensor – Licensed Material. Every recipient of the Licensed Material automatically receives an offer from the Licensor to exercise the Licensed Rights under the terms and conditions of this Public License.

B No downstream restrictions. You may not offer or impose any additional or different terms or conditions on, or apply any Effective Technological Measures to, the Licensed Material if doing so restricts exercise of the Licensed Rights by any recipient of the Licensed Material.

6

7 No endorsement. Nothing in this Public License constitutes or may be construed as permission to assert or imply that You are, or that Your use of the Licensed Material is, connected with, or sponsored, endorsed, or granted official status by, the Licensor or others designated to receive attribution as provided in Section 3(a)(1)(A)(i).

b **Other rights**.

1 Moral rights, such as the right of integrity, are not licensed under this Public License, nor are publicity, privacy, and/or other similar personality rights; however, to the extent possible, the Licensor waives and/or agrees not to assert any such rights held by the Licensor to the limited extent necessary to allow You to exercise the Licensed Rights, but not otherwise.

2 Patent and trademark rights are not licensed under this Public License.

3 To the extent possible, the Licensor waives any right to collect royalties from You for the exercise of the Licensed Rights, whether directly or through a collecting society under any voluntary or waivable statutory or compulsory licensing scheme. In all other cases the Licensor expressly reserves any right to collect such royalties, including when the Licensed Material is used other than for NonCommercial purposes.

**Section 3 – License Conditions.**

Your exercise of the Licensed Rights is expressly made subject to the following conditions.

a **Attribution**.

1 If You Share the Licensed Material, You must:

A retain the following if it is supplied by the Licensor with the Licensed Material:

i identification of the creator(s) of the Licensed Material and any others designated to receive attribution, in any reasonable manner requested by the Licensor (including by pseudonym if designated);

ii a copyright notice;

iii a notice that refers to this Public License;

iv a notice that refers to the disclaimer of warranties;

v a URI or hyperlink to the Licensed Material to the extent reasonably practicable;

B indicate if You modified the Licensed Material and retain an indication of any previous modifications; and

C indicate the Licensed Material is licensed under this Public License, and include the text of, or the URI or hyperlink to, this Public License.

2 For the avoidance of doubt, You do not have permission under this Public License to Share Adapted Material.

3 You may satisfy the conditions in Section 3(a)(1) in any reasonable manner based on the medium, means, and context in which You Share the Licensed Material. For example, it may be reasonable to satisfy the conditions by providing a URI or hyperlink to a resource that includes the required information.

4 If requested by the Licensor, You must remove any of the information required by Section 3(a)(1)(A) to the extent reasonably practicable.

**Section 4 – Sui Generis Database Rights.**

Where the Licensed Rights include Sui Generis Database Rights that apply to Your use of the Licensed Material:

a for the avoidance of doubt, Section 2(a)(1) grants You the right to extract, reuse, reproduce, and Share all or a substantial portion of the contents of the database for NonCommercial purposes only and provided You do not Share Adapted Material;

b if You include all or a substantial portion of the database contents in a database in which You have Sui Generis Database Rights, then the database in which You have Sui Generis Database Rights (but not its individual contents) is Adapted Material; and

c You must comply with the conditions in Section 3(a) if You Share all or a substantial portion of the contents of the database. For the avoidance of doubt, this Section 4 supplements and does not replace Your obligations under this Public License where the Licensed Rights include other Copyright and Similar Rights.

**Section 5 – Disclaimer of Warranties and Limitation of Liability.**

**a Unless otherwise separately undertaken by the Licensor, to the extent possible, the Licensor offers the Licensed Material as-is and as-available, and makes no representations or warranties of any kind concerning the Licensed Material, whether express, implied, statutory, or other. This includes, without limitation, warranties of title, merchantability, fitness for a particular purpose, non-infringement, absence of latent or other defects, accuracy, or the presence or absence of errors, whether or not known or discoverable. Where disclaimers of warranties are not allowed in full or in part, this disclaimer may not apply to You.**

**b To the extent possible, in no event will the Licensor be liable to You on any legal theory (including, without limitation, negligence) or otherwise for any direct, special, indirect, incidental, consequential, punitive, exemplary, or other losses, costs, expenses, or damages arising out of this Public License or use of the Licensed Material, even if the Licensor has been advised of the possibility of such losses, costs, expenses, or damages. Where a limitation of liability is not allowed in full or in part, this limitation may not apply to You.**

c The disclaimer of warranties and limitation of liability provided above shall be interpreted in a manner that, to the extent possible, most closely approximates an absolute disclaimer and waiver of all liability.

**Section 6 – Term and Termination.**

a This Public License applies for the term of the Copyright and Similar Rights licensed here. However, if You fail to comply with this Public License, then Your rights under this Public License terminate automatically.

b Where Your right to use the Licensed Material has terminated under Section 6(a), it reinstates:

1 automatically as of the date the violation is cured, provided it is cured within 30 days of Your discovery of the violation; or

2 upon express reinstatement by the Licensor.

c For the avoidance of doubt, this Section 6(b) does not affect any right the Licensor may have to seek remedies for Your violations of this Public License.

d For the avoidance of doubt, the Licensor may also offer the Licensed Material under separate terms or conditions or stop distributing the Licensed Material at any time; however, doing so will not terminate this Public License.

e Sections 1, 5, 6, 7, and 8 survive termination of this Public License.

**Section 7 – Other Terms and Conditions.**

a The Licensor shall not be bound by any additional or different terms or conditions communicated by You unless expressly agreed.

b Any arrangements, understandings, or agreements regarding the Licensed Material not stated herein are separate from and independent of the terms and conditions of this Public License.

**Section 8 – Interpretation.**

a For the avoidance of doubt, this Public License does not, and shall not be interpreted to, reduce, limit, restrict, or impose conditions on any use of the Licensed Material that could lawfully be made without permission under this Public License.

b To the extent possible, if any provision of this Public License is deemed unenforceable, it shall be automatically reformed to the minimum extent necessary to make it enforceable. If the provision cannot be reformed, it shall be severed from this Public License without affecting the enforceability of the remaining terms and conditions.

c No term or condition of this Public License will be waived and no failure to comply consented to unless expressly agreed to by the Licensor. Nothing in this Public License constitutes or may be interpreted as a limitation upon, or waiver of, any privileges and immunities that apply to the Licensor or You, including from the legal processes of any jurisdiction or authority.

1. ***Vidyo, Inc.***

Vidyo donates the sequences to the public domain.

1. ***The National Telecommunications and Information Administration (NTIA)***

<http://www.its.bldrdoc.gov/resources/video-quality-research/video-footage.aspx>

Standards committees can use CDVL R&D content within subjective tests to validate objective video quality models (e.g., ATIS, VQEG, ITU).