

CODEC COMPARISON FOR THE DIGITAL PRESERVATION OF ANALOG VIDEO

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INTRODUCTION

Dance Heritage Coalition, Washington, D.C., is an alliance of major dance collections, formed to document and preserve American dance. Their membership includes libraries, dance festivals, museums, and universities. They wanted a way to digitize and share their collections. They wanted to be able to do something akin to an inter-library loan without having to ship tapes around the country. Because the member organizations did not have rights to all of the pieces in their collections, it was not possible to simply put the video online for everyone to see. And for these reasons they called it the Secure Media Network. In 2008, Dance Heritage Coalition and Bay Area Video Coalition (BAVC), San Francisco, California, began planning for the Secure Media Network.

The Secure Media Network requires archival quality digital files to be stored in a digital repository as well as streaming video to be viewed within the walls of the member organizations. In the spring of 2009, in preparation for this undertaking, BAVC performed this study to evaluate current commonly used codecs for the reformatting of analog videotape. Nine participants were selected for this study. The participants included video professionals, colorists, archivists, and a dancer. In addition to informing our decisions regarding codecs for the Secure Media Network, BAVC hopes that this study will provide an additional data point for archives and other organizations to consider when planning their inevitable migration to digital files.

BACKGROUND: WHY STUDY LOSSY COMPRESSION SCHEMES?

The act of transferring analog video from one format to another introduces a change of some sort, no matter to which format you migrate. If the target is analog, such as Betacam SP, there will be generation loss. If the target is digital, there may be compression and in any case the new master will not be exactly identical to the original even if it is of a very high quality.

The ideal format for the preservation of videotape to digital file is uncompressed or lossless compression. Budget constraints may prevent archives from choosing the ideal format. Migrating to Digital Betacam has for years been considered a best practice. Digital Betacam is a robust digital tape format and has not lost its integrity over time. For example, Digital Betacam tapes that BAVC sees that are well over a decade old play back without many problems. However, Digital Betacam playback equipment is quite expensive and there is a risk of catastrophic data loss should tapes become damaged or suffer from chemical breakdown (Murphy 1997). Digital Betacam is also nearing the end of its life, due to increased chance of obsolescence of playback equipment and tape stock. While Sony has built in backwards compatibility for playback of Digital Betacam tapes into many of their HDCAM, IMX, and other video tape recorders, these too are quite expensive and out of the reach of many archives, libraries, and museums. Digital Betacam is compressed at a ratio of 1.6:1 using a proprietary hardware based codec. In a sense, most uncompressed standard definition digital formats are compressed in the area of color reproduction, known as chroma subsampling (Poynton 2003 and Wilt 1999). Complete chroma subsampling in digital capture would be 4:4:4 but this is considered to be excessive for standard definition video, therefore 4:2:2 is most commonly used. 4:2:2 chroma subsampling is used in Digital Betacam, DV50, uncompressed codecs, some versions of MPEG-2 and other codecs.

For many of these reasons, some of BAVC's preservation clients have requested transfers to less expensive

and more fragile formats like DVCAM. Often they already had playback equipment for DVCAM or could afford to purchase it. DVCAM is compressed at a ratio of 5:1 and uses 4:1:1 chroma subsampling (see table 1), less than higher-end digital formats, the tape itself is smaller and more fragile than Digital Betacam and catastrophic loss of data is more likely to occur with this format.

The advantages of video files are numerous. Playback equipment is significantly less expensive than for videotape formats such as Digital Betacam. Files can be automatically checked for data integrity. Files can be migrated easily to new media or file types faster than real time and this process can be automated. Derivative files for access can also be automatically generated. All of this freedom comes at a price. No permanent data storage media exists, so it is recommended that an active management program be implemented in order to protect the digital assets, which can be expensive. Redundancy is also recommended for storage and this can also be expensive. Media such as hard drives are regularly dropping in price, but cost is still a factor, especially when one factors in overhead such as servers, RAID (redundant array of independent disks) controllers, and so on. Digital archiving of moving images is, by definition (at least at this moment in its development), a very active process, so there must be staff time and migration costs allocated because of the lack of a standard file format in the field, development of new playback software, operating systems, and so on.

As we move into the era of high definition video, development of standard definition video technology has virtually ended. Most research and development that is being done is directed toward access. H.264/MPEG-4 AVC, for instance, is a codec that yields very high quality video at very small file sizes. This is ideal for delivery of television over the Internet. Satellite and cable TV apply heavy compression to their transmissions. Digital artifacts such as blockiness or blurring and missed frames plague these broadcasts. Since we are concerned with

archival storage, we must choose from file formats that are already available.

The vast majority of widely used codecs are based upon lossy compression schemes, meaning some data is discarded in order to reduce file size. While some losslessly compressed codecs for standard definition video exist, they are not supported by most post-production software or hardware and are not widely used in the industry. For this reason, it may be risky from a support standpoint or expensive from an equipment standpoint to use some of these codecs. Interoperability is an important hedge against obsolescence. Most of the codecs examined in this study are playable on Apple or Microsoft Windows-based computers and can be captured and played back with relatively inexpensive hardware made by different manufacturers.

We intended to include JPEG2000 in this study (Media Matters 2004), but there is a lack of standardization among software and hardware implementations of this codec. Some of the hardware encoded files may not be readable without the appropriate hardware installed. A company called T-VIPS recently announced a new product that supports JPEG2000 encoded video files. When asked about whether they use the lossless mode and whether interoperability exists between their system and those of other manufacturers, the company replied that it does support lossless compression but playback of their files requires their hardware and is not compatible with other implementations of JPEG2000. Grass Valley also makes an editing system with JPEG2000 support, but it does not support lossless compression. For this reason, we used software encoders to create the test files from uncompressed video files. Unfortunately, we were unable to decode them back to a compatible uncompressed file format that would play back over Serial digital interface through the AJA Video Systems, Kona 3 video capture card that we used for this test. Other lossless video compression schemes exist, such as HuffYUV (Wikipedia, 2011b), FFV1 (Vatolin and Smirnov 2009),

lossless H.264 and SheerVideo (Wikipedia, 2010) but they are not widely supported and were not examined in this study. One can assume that, being lossless they are equivalent to uncompressed. This is a worthwhile area to explore but is outside of the scope of this study.

As stated before, uncompressed video files are ideal. 10-bit uncompressed video can be around 95 gigabytes (GB) per hour, 8-bit files can be about 85 GB per hour. Compare this to digital video's (DV) 13 GB or DV50's 25 GB per hour. Lossless JPEG2000 can be around 30 GB per hour. For a small collection, uncompressed is not prohibitively expensive. In fact, the pricing of storage compares favorably with the price of Digital Betacam tape. However, if you have hundreds or thousands of tapes to be digitized in your collection or if the video is of a poorly lit lecture on a marginal format, such as Video8 or VHS it may be prudent to consider compression. When you compare the lines of resolution, video bandwidth, and so forth, even the highly compressed DV outperforms these formats (Vitale and Messier 2007).

Because formats such as DV, DV50, and uncompressed video are so widely supported by various software and hardware, it is very inexpensive to create a digitizing station using "off the shelf" technology that will create high quality video files. It is even less expensive to create a viewing station. Files may be played on a computer with no additional hardware or through a proper NTSC monitor with the appropriate hardware installed. These file formats are supported on Apple and Microsoft Windows platforms. One major shortcoming of 10-bit uncompressed video files is the lack of a truly generic codec. Each manufacturer of digitizing hardware (capture card) has their own codec, which must be installed in order to play back the files. Fortunately, this is usually available as a free download and is usually cross platform. BAVC includes this software in file folder packages for clients as a part of delivery of files. We do not anticipate the creation of a video equivalent of broadcast WAV files, which

are widely used in audio-only reformatting as a standard for preservation-quality files (IASA 2009).

Since most research is devoted to detecting the lowest acceptable quality for the average viewer, using pristine source video, we intend to provide guidance to cash-strapped archives, libraries, museums, etc., as they try to navigate cost vs. quality. Are any or all of these production quality codecs too compressed for archival purposes? While the numbers compare favorably on paper, how do these codecs compare to 10-bit uncompressed files when the source is inherently lower quality? Are differences detectable by the naked eye? If so, are there circumstances where their use may be justified?

METHODOLOGY

Study participants were asked to visually compare video files in order to determine the lowest acceptable quality. The files were created from videotapes that were contributed by the Museum of Performance and Design, San Francisco, California; The New York Public Library for the Performing Arts, Jerome Robbins Dance Division, New York City; Jacob's Pillow Dance Festival, Becket, Massachusetts; and the American Dance Festival, Durham, North Carolina.

These videotapes were preserved by BAVC to 10-bit uncompressed (4:2:2 chroma subsampling) Quicktime files (except in the case of DV and DVCPRO tapes which were kept in their native DV codec) using an AJA Io external video capture device, an Apple Mac Pro computer, and Apple Final Cut Pro software. A Digital Betacam and DVD access copy were provided to each organization for their archives. From these tapes five were selected for the compression study based on their original format excluding already compressed formats such as DV. We selected tapes that originated on ½ in. open reel, ¾ in. Umatic cassettes, Hi-8 and Betacam SP.

Using Apple's Compressor software, samples of these 10-bit uncompressed files were transcoded to the follow-

ing file types:

- 8-bit uncompressed (4:2:2 chroma subsampling)
- DV25 (25 mbps 4:1:1 chroma subsampling)
- DV50 (50 mbps 4:2:2 chroma subsampling)
- IMX (50 mbps 4:2:2 chroma subsampling)
- H.264 for Apple Devices
 - Frame rate: (100% of source)
 - Frame Controls: Automatically selected: Off
 - Codec Type: H.264
 - Multi-pass: On, frame reorder: Off
 - Pixel depth: 24
 - Spatial quality: 50
 - Min. Spatial quality: 50
 - Key frame interval: 120
 - Temporal quality: 50
 - Min. temporal quality: 50
 - Average data rate: 1.5 (Mbps)
 - Maximum data rate: 4 (Mbps)

These file types were selected because they have native support in many hardware and software products and are widely used in video production. In addition, the 10-bit uncompressed files were recorded to Digital Betacam (10-bit 4:2:2 chroma subsampling) and recaptured as 10-bit uncompressed files. Digital Betacam was included because it is widely used as a preservation format but is compressed. H.264 was included to gauge the participants' capacity to perceive compression artifacts.

Two Apple Mac Pro computers with AJA Kona 3 video capture cards and AJA's VTR Xchange software were used to play the files via serial digital interface to a Sony BVM-20F1U monitor using the 1 and 2 inputs. One clip was always 10-bit uncompressed (the control) and the other clip was one of the other codecs. The participants had a switch to change between the 1 and 2 inputs. The operator of the study was responsible for loading the files into the player application for comparison and playing them. This level of abstraction concealed the file type being viewed and ensured an unbiased examination of

the video signal. We considered using a split screen but did not want to introduce additional hardware that may affect the signal. We also considered using two identical monitors, but even calibrated monitors may have subtle differences. While imperfect, we chose to use an A/B comparison for this test.

Nine people participated in the study. They included technical experts, archivists and dance professionals. Each participant spent about two hours comparing video clips.

The participants were asked to note the following:

1. Visual difference between clips. Was any difference noticed?
2. Compression artifacts observed. Compression artifacts include blockiness, blurring, etc. Because these codecs are considered to be production quality, these artifacts were expected to be minimal.
3. Chroma reproduction. Were there any shifts in hue or chroma level from one clip to the next?
4. Luminance reproduction. Were there any differences in luminance from one clip to the next?
5. Any other artifacts. Were other differences noticed?

Answers to these questions were noted by the operator and are included in this report.

SUMMARY

Overall, most participants noticed major differences only in the H.264 files and the IMX files. Minor color differences were noticed by some participants, even between 8-bit and 10-bit uncompressed files but all stressed that it was very difficult to see these differences and were very subtle. These types of color changes can also be introduced by time base correctors, playback equipment or monitor issues. In general, artifacts such as blockiness, blur or motion artifacts were not seen when comparing 8-bit and 10-bit uncompressed files, but were seen in H.264 files. The artifacts that were seen were subtle

“softening” in varying degrees on certain clips and a reduction in apparent noise, which led some participants to conclude that the compressed file was “better.” Since lower quality analog sources were used, most of these tape formats exhibit signal problems which can be difficult to distinguish from other artifacts that may be introduced by digital compression.

In addition to visual analysis, clips of different codecs were compared in Final Cut Pro using a difference filter (fig. 1). Surprisingly, in some clips the only difference easily seen in some clips was in the H.264 files. Certain other clips showed slight color differences. With the exception of H.264, no temporal differences were seen. In order to really see the differences, stills were exported and the Levels were adjusted in Adobe Photoshop in order to make visible these slight changes in color reproduction (fig. 2).

Based upon these results, BAVC recommends 10-bit uncompressed files for any videotape that is aesthetically important. However, many collections include tapes that are important in terms of the content but visually are less important. For instance, a lecture series recorded in VHS in an auditorium at a distance or an oral history recorded on video 8 in a poorly lit room may be an unwise use of valuable storage space. For these types of materials, DV25 or DV50 appear to be completely acceptable with a comparatively small file size.

See Appendix 2 for specific results for each tape and each participant.



Fig. 1. The difference between each of the codecs and 10-bit uncompressed video, using the difference filter in Apple Final Cut Pro. Screenshot of *Fagaala*, Presented by the New Jersey Performing Arts Center, Alternate Routes: World Festival VII, 2004, original format Beta SP. Courtesy of the New York Public Library for the Performing Arts.

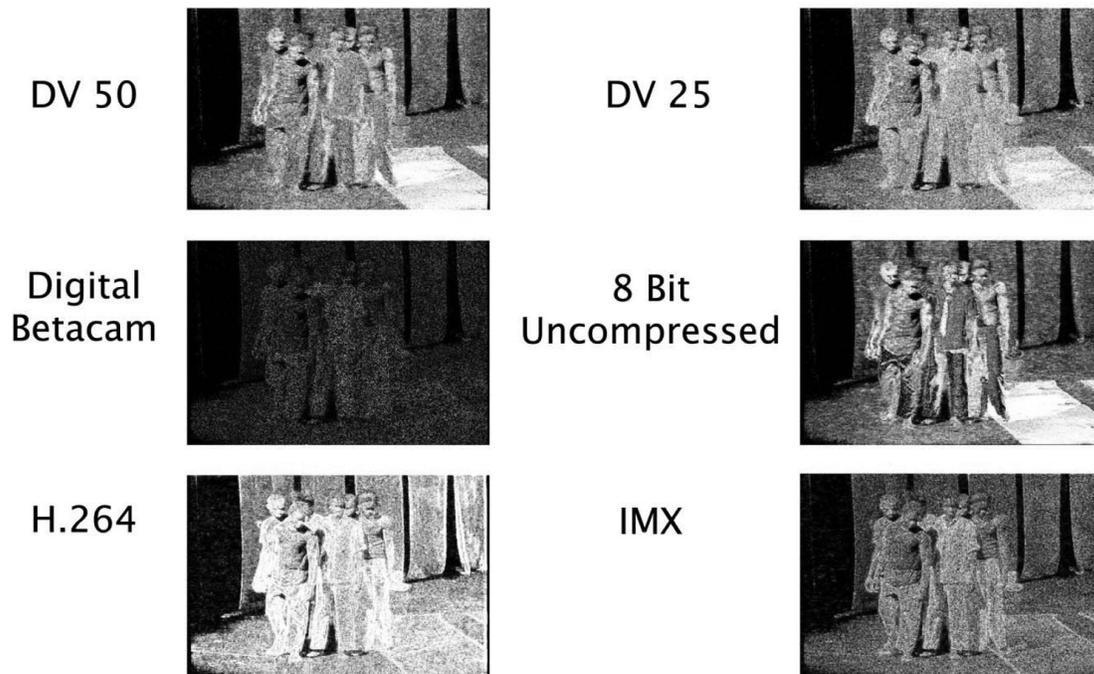


Fig. 2. The difference between each of the codecs and 10-bit uncompressed video, using the difference filter in Apple Final Cut Pro and a Levels adjustment to enhance the perception of subtle differences. Screenshot of *Fagaala*, Presented by the New Jersey Performing Arts Center, Alternate Routes: World Festival VII, 2004, original format Beta SP. Courtesy of the New York Public Library for the Performing Arts.

TAPE SAMPLE DESCRIPTIONS

American Dance Festival

Connecticut College Dance Festival, Program 1

Choreographers: Nora Guthrie, Bill Evans, Ed de Soto, Chuck Davis, Mel Wong

Date: July 11, 1976

Format: Umatic

Name in study: ADF 1

This tape was recorded on ¾ in. Umatic tape. It appears to be a two-camera shoot and there is an offset line on the left hand side of one of the cameras. There is a fair amount of noise visible in the background and the image is generally soft.

Jacob's Pillow Dance Festival

Joanna Haigood's INVISIBLE WINGS: A Documentary 1998

A documentary by Núria Olivé-Bellés on the inspiration and performance of Joanna Haigood's site-specific work, Invisible Wings. Includes footage with storyteller Diane Ferlatte and interviews with Haigood and composer/choir director Linda Tillery.

Date: 1998

Format: Beta SP

Name in study: JP 1

This tape is an edited piece with many fast cuts and both motion and color effects. The video appears to be from a number of different sources, including Hi8. Most participants had difficulty with this clip due to all of these factors.

New York Public Library for the Performing Arts

Fagaala

Presented by New Jersey Performing Arts Center's Alternate Routes: World Festival VII ; Jant-Bi ; artistic direction by Germaine Acogny ; choreography by Germaine Acogny and Kota Yamazaki ; music by Fabrice Bouillon-Laforest and Jean-Yves Gratius.

Date: 2004

Format: Beta SP

Name in study: NYPL 1

This tape is from a two-camera shoot of a stage performance. It may have been recorded directly to Beta SP. The scene is very dark and one of the cameras appears to have the gain on, which adds a great deal of noise to the image. Some participants were able to distinguish striking differences in color reproduction based upon red clothing against the black background.

Museum of Performance and Design

Soledad Prison

Anna Halprin's Dancers' Workshop, D.W. Soledad Prison, May 1971

Date: 1971

Format: Beta SP previously transferred from ½ in. open reel

Name in study: MPAD 1

This tape originated as black and white EIAJ ½ in. open reel and had been preserved by BAVC previously to Beta SP tape, which is how it came to us this time. EIAJ is fairly crude and unstable and there are many errors in the signal including jitter, flagging, dropout and head switching. Some of these can be perceived as motion artifacts. This was shot with one camera and there are no edits.

Museum of Performance and Design

20th Century Anniversary Home Season

Alonzo Kings's Lines Ballet

Alonzo King, choreographer and artistic director; Axel Morgenthaler, lighting design; Robert Rosenwasser and Axel Morgenthaler, set design; Robert Rosenwasser, Sandra Woodall, Cari Borja and Colleen Queen, costume design.

Videotaped at the Yerba Buena Center for the Arts, San Francisco, CA, October 18, 2002.

Date: 2002

Format: Hi8

Name in study: MPAD 2

This tape is a one-camera shot of a stage performance. The high contrast and constantly changing lighting conditions combined with the low resolution of the recording

media caused the participants some difficulty in seeing the differences.

PARTICIPANTS

Larry Landes

Larry Landes is an engineer who worked in broadcasting for over 30 years at KTVU in Oakland, California. Larry repairs many of BAVC's VTRs and has been an invaluable resource to BAVC's post-production and preservation programs over the years.

Janel Quirante

Janel Quirante has worked as a video technician, closed captioner, and book and paper conservator. A graduate of the University of California, Berkeley and the University of Hawaii, Manoa, she is currently the archivist for visual collections at the Hoover Institution Archives, Stanford University, California.

Dave Cerf

Dave Cerf is a filmmaker, musician, sound designer, and user interface designer currently working in the Professional Applications division at Apple, Inc. Between 1996 and 2003, Dave was an online editor and colorist. Between 2003 and 2006, he wrote the Final Cut Pro 5 and Final Cut Pro 6 User Manuals.

Angela Holm

Angela Holm is the director of production at Big Sound Inc., a company that produced the restoration of the silent film classic, *Pandora's Box* from 1929. She is also Manager of Video Production and Sales at Digital Pickle, a San Francisco media company. Angela studied film preservation at the L. Jeffrey Selznick School for Film Preservation at the George Eastman House, Rochester, New York.

Stephen Parr

Archivist, filmmaker and curator Stephen Parr is the founder of Oddball Film+Video, a stock footage company specializing in offbeat and historical footage for feature

films, documentaries and media projects. Oddball recently provided footage for the 2008 Gus Van Sant film *Milk* and the CNN biopic *Obama Revealed*. He is curator of Oddball Films, an award-winning weekly film series in San Francisco. Parr is also the director of the San Francisco Media Archive, a non-profit organization dedicated to the preservation of and access of culturally significant film and related media.

Kirsten Tanaka

Kirsten Tanaka is the head librarian and archivist at the Museum of Performance & Design. Kirsten holds a B.A. in humanities from California State University, Sacramento and a master of library and information science from the University of California, Berkeley. She started working at the Museum of Performance & Design (then called the San Francisco Performing Arts Library & Museum) in 1991 as an intern and became the head librarian and archivist in 1993.

Timothy Vitale

Timothy Vitale is a conservator in private practice in Emeryville, California, treating works on paper, photographs, and electronic media. With over 35 years of experience, he received an M.S. in art conservation from Winterthur Museum/University of Delaware in 1977 and a dual B.A. in art history and chemistry from San Jose State University in 1974. His current areas of interest include paper, photographs, and electronic media conservation; digital imaging; video preservation and conservation research. Vitale has worked on water and paper interactions including the effects of drying and flattening on surface texture; science of albumen prints, including the Albumen Website; digital migration from still film, audiotape and videotape, including the VideoPreservation Website; and digital surrogates created from artworks and wallpaper. Vitale has published numerous articles and made presentations on the use of digital imaging and printing in conservation. He is a founder of the Book and Paper Specialty Group and Electronic Media Specialty Group of AIC. Vitale held positions at the Pierpont Morgan Library;

Museum of Fine Arts, Boston; Intermuseum Conservation Association; National Archives and Records Administration; Smithsonian Institution Conservation Analytical Laboratory; and the Glasgow School of Art.

Heather Weaver

Heather Lyon Weaver has been working as an online video editor and colorist for over 12 years. She specializes in independent documentary programs, but has worked on a wide variety of projects including narrative, experimental, animation, and video art. Heather is an expert in the field of video preservation and restoration. In 2000, she devised the methodology for the reconstruction of the 1976 *The Eternal Frame*, by the art collectives Ant Farm and T.R. Uthco. She worked with artists Chip Lord and Doug Hall to perform all restoration on the piece. She regularly participates on panels and conferences, where she shares her preservation, restoration knowledge, and expertise. Heather has been a student of independent video art, history, and theory since 1990. She received a bachelor of arts degree from Hampshire College in 1994 and began working professionally in video immediately thereafter. Theory and practice converged in 1995 when she began working with Kate Horsfield and Maria Troy on Video Data Bank's *Surveying the First Decade: Video Art and Alternative Media in the United States*, a 17 hour compilation of excerpted video pieces originating on ½ in. open reel and ¾ in. tape.

Muriel Maffre

Born in Enghien-les Bains, France, Muriel Maffre received her ballet training from the Paris Opéra Ballet School and Paris National Conservatory of Music from which she graduated with a Premier Prix with honors. Prior to joining the San Francisco Ballet as a principal dancer in 1990, Muriel danced with the Hamburg Ballet and Monte-Carlo Ballet. Muriel is Chevalier in the French order of arts and letters. She is a gold medalist from the Paris 1st International Ballet Competition, and the recipient of two Isadora Duncan Awards for Outstanding Achievement in Individual Performance for both 1990

and 2002 repertory season performances with the San Francisco Ballet. Muriel performed leading roles in the romantic, classical, and contemporary repertory. She also created roles in ballets by major present-day choreographers. She toured extensively and made guest appearances in eminent theaters in the United States, Europe, Russia and Asia. Muriel holds a B.A. in performing arts from St Mary's College of California. Muriel retired from the San Francisco Ballet with a farewell gala on May 6, 2007. Since 2007, she has been involved in dance education and public humanities.

ACKNOWLEDGEMENTS

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APPENDIX 1

Since this was a heterogeneous group of people, there was no common vocabulary to describe what participants were seeing. For instance, one participant repeatedly described certain clips as "brighter." After a while it became clear that she was referring to chroma and not luminance. We have included the language used by each participant placed into the proper category for clarification. While some focused on noise, others were more tuned into color or motion problems. In some cases clips were described as having "blur" when it may have been soft or noise may have been described as "grain." Some degree of interpretation was required (in consultation with the participants) in order to correlate verbal descriptions with specific artifacts.

Some participants found the use of an A/B switch with a single monitor problematic. Some participants were distracted by the poor quality of the source material, being more accustomed to dealing with pristine sources.

Timothy Vitale was able to spot many color differences, but not all. Tim has gotten very high scores on color perception tests such as the Online Color Challenge by X-Rite available at www.xrite.com/custom_page.aspx?PageID=77. This is what he had to say:

I've been thinking about why this so called "color imaging person" didn't see the color issues in the compression exemplars you showed. This is what I have come up with...

Humans adjust to white balance (reference white) almost instantaneously. Video color is based on white a reference white (often set by device) and there are very well established equations for the transfer in and out of RGB and YCbCr. The YCbCr color space is a variant of CIE Lab-type color space, where there is a neutral lightness and darkness axis (Y), so that black and white always stay neutral, and opposing-color components Cb/Cr are not pure tones so a slight shift is never a shift in pure color, such as RGB or CMY, but a slight hue shift (that is, plus and minus in 224 steps, out of 256 in 8-bit space, of greenish blue or reddish cyan). All this leads to a very forgiving color space well inside the limits of the system. Just the way clever engineers would set up "color" if you had to dumb color down for use in off-the-shelf color TV sets, using content created by TV stations from NYC to Rural Alaska.

Therefore, the comparison protocol of A and B shift will not reveal color "hue" errors, it will hide them.

Video color compression protocols, 4:4:4, 4:2:2, 4:1:1 and 4:0:0, are all spatial compression, rather than hue compression. Note that the lightness value, Y, the 4 is never compressed, because humans are very sensitive to that. The compression the color is in the region of the "pix-

el" group being compressed. The errors will show up along a hard edges between regions with large color differences.

I was not looking for that type of error, sorry.

When I judge color I use side-by-side comparison; that is the only way humans can judge color accurately. Color memory is notoriously bad in humans. Oh, they can see differences of saturation (intensity) in Kodak yellow, but the actual hue (color) can shift around and still seem correct as long as intensity stays consistent. We go to great lengths to get the color temperature of the viewing light established. If I want a client to accept a difficult match, I separate the two samples so that their memory allows for the "errors" rather than one sitting examples next to the other, under the same lighting.

APPENDIX 2

Name of File	Format	Difference?	Blockiness	Blur	Chroma Difference	Luma Difference	Motion Artifacts	Other Artifacts
ADF 1A	IMX	Yes, uncompressed is better, but now it seems like imx might look better			Looks brighter			Less crisp?
ADF 1B	H.264 Apple devices	Yes		Less sharp			Yes	
ADF 1C	10-bit uncompressed							
ADF 1D	DV 25	Might look a little better, but hard to tell			Uncompressed bleeds less (reds)			Might be sharper?
ADF 1E	8-bit uncompressed	Looks better				More crisp and contrasty		
ADF 1F	Digibeta	Yes, uncompressed is better						Looks more "live"
ADF 1G	DV 50	Yes, uncompressed is better, but now it seems like DV50 is better.						Looks a little grainier in the background but it looks almost the same. possibly edges are less problematic on uncompressed.
JP 1A	10-bit uncompressed							
JP 1B	IMX	10-bit looks better, but it is really close						
JP 1C	H.264 Apple devices	10-bit looks better					Yes	Looks less "live"
JP 1D	DV 25	10-bit looks better						Looks less "live"
JP 1E	DV50	10-bit looks better			Color looks brighter			Less sharp? almost impossible to tell...
JP 1F	8-bit uncompressed	Don't know how you would decide. Maybe (8-bit uncompressed)						
JP 1G	Digibeta	Thinking (digibeta) but looks pretty close, sometimes I think uncompressed						
MPAD 1A	H.264 Apple devices	Definitely 10-bit...	Yes				Yes	
MPAD 1B	IMX	10-bit looks better, but now IMX looks better.				Worse contrast or blacks	Movement seems better on 10-bit	
MPAD 1C	DV 25	I'd say DV is better, actually 2 looks better...ultimately DV is better						
MPAD 1D	10-bit uncompressed							
MPAD 1E	Digibeta	10-bit looks better				Uncompressed looked brighter, contrast more expansive		
MPAD 1F	DV 50	Maybe 10-bit is better, really can't tell						
MPAD 1G	8-bit uncompressed	Don't notice that much of difference but 8-bit looks better.						
MPAD 2A	10-bit uncompressed							
MPAD 2B	H.264 Apple devices	10-bit is better, pretty easy		Doesn't look as blocky				
MPAD 2C	IMX	I think IMX is better						
MPAD 2D	8-bit uncompressed	I think 8-bit						
MPAD 2E	DV 25	I think DV...						
MPAD 2F	DV50	Maybe 10-bit is better						
MPAD 2G	Digibeta	10-bit looks a little better						Interlacing looks a little smaller in one section
NYPL 1A	H.264 Apple devices	Looks a little better			Less red			
NYPL 1B	10-bit uncompressed							
NYPL 1C	DV 25	10-bit, but hard to tell						
NYPL1D	IMX	10-bit looks better			10-bit looks better in skin tones			In wide shot, IMX grain seems to move less
NYPL 1E	8-bit uncompressed	Yes			10-bit looks brighter (reds)			
NYPL 1F	Digibeta	10-bit looks better			10-bit color looks brighter	10-bit more contrast		
NYPL 1G	DV50	10-bit looks a little better			More reds			

NOTES

1 A codec is a device or computer program capable of encoding, decoding, or both, a digital data stream or signal. The word codec is a contraction of “compressor-decompressor” or, most commonly, “coder-decoder” (Wikipedia, 2011a).

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