

“New” Extended-gamut Color Space for Video Applications; xvYCC(IEC61966-2-4)



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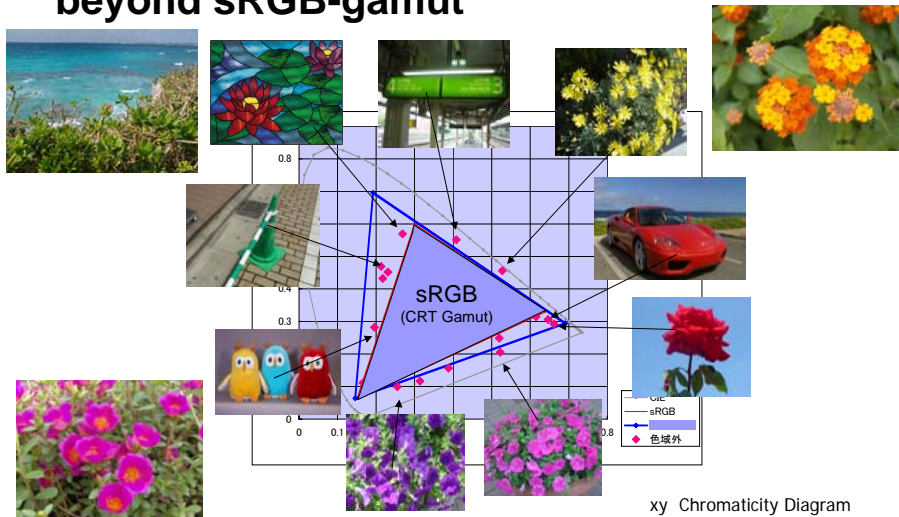
2007/01/31 @The Westin Mission Hills Resort & Spa

Extended-gamut YCC colour space for video applications - xvYCC

- The need for extended-gamut color space
 - Output: Display Devices
 - Intermediate: Standard (cf. Still Images)
 - Input: Capturing Devices
- Color Space Standardization in IEC
 - xvYCC – IEC61966-2-4
- Comparison of Color Spaces
 - Media Gamut Cover Ratio
- Expected Advantages
- Adoption by other standards (MPEG, HDMI)

* Most of today's slide contents are excerpted from JEITA's presentation:
JEITA <http://www.jeita.or.jp/japanese/hot/2006/0830/0830.pdf>

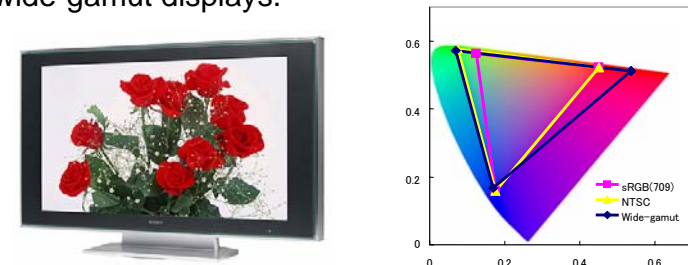
Examples of Object Surface Colors beyond sRGB-gamut



These colors cannot be reproduced by conventional TV signals, based on CRT. 3

Need for the Extended Color Space I

- Various kind of extended-gamut TVs are emerging, that are based on new technologies other than CRT.
- However, most of the current video contents are color-rendered for conventional CRT (ie sRGB-gamut limited) displays.
- Consequently, users are NOT receiving the benefit of wide-gamut displays.



SID 2005 @ Boston

5 Extended-gamut related papers (from 4 companies)



■ Session 25: Spatial and Temporal Color

- *STColor: Hybrid Spatial-Temporal Color Synthesis for Enhanced Display Image Quality*
 - L. D. Silverstein, [VCD Sciences, Inc.](#), USA
- *A Wide-Gamut-Color High-Aperture-Ratio Mobile Spectrum Sequential LCD*
 - S. Roosendaal, [Philips Research Laboratories](#), The Netherlands
- *Spectrum Sequential LCD*
 - M. Jak, [Philips Research Laboratories](#), The Netherlands
- *Six-Primary-Color 23-in. WXGA LCD Using Six-Color LEDs*
 - H. Sugiura, [Mitsubishi Electric Corp.](#), Japan

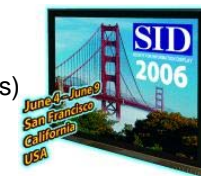
■ Session 31: Novel Displays

- *Development of Six-Primary-Color LCDs*
 - Y-C. Yang, [Samsung Electronics Co.](#), Ltd., Korea

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SID 2006 @ San Francisco

4 Extended-gamut related papers (from 3 companies)



■ Session 19: Applications and Vision (Applications/Applied Vision)

- *Improved Six-Primary-Color 23-in. WXGA LCD Using Six-Color LEDs*
 - Hiroaki Sugiura, [Mitsubishi Electric Corp.](#), Japan
- *xvYCC: A new Standard for Video Systems Using Extended-Gamut YCC Color Space*
 - Tatsuhiko Matsumoto, [Sony Corp.](#), Japan
- *Laser TV: Ultra-Wide Gamut for a New Extended Color-Space Standard, xvYCC*
 - Jun Someya, [Mitsubishi Electric Corp.](#), Japan

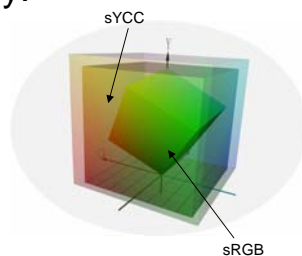
■ Session 25: Color, Luminance, and Contrast (Applied Vision)

- [Invited Paper] *Development of Wide-Color-Gamut Mobile Displays with Four-Primary-Color LCDs*
 - Eiji Chino, [Sanyo Epson Imaging Devices Corp.](#), Japan

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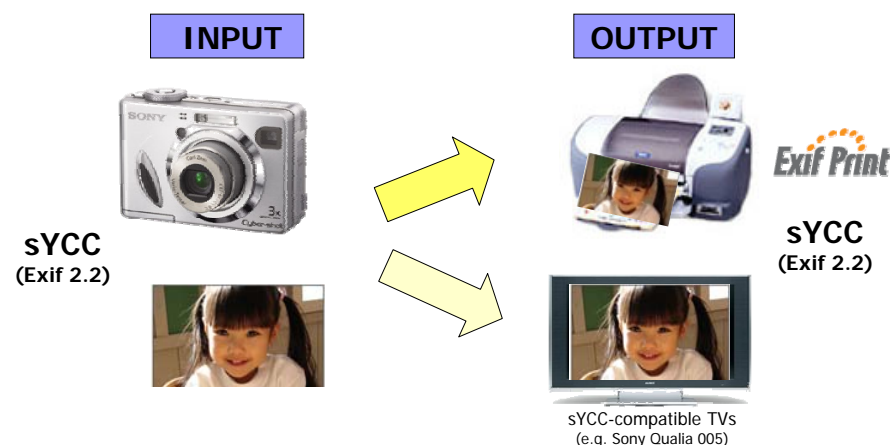
Need for the Extended Color Space II

- On the other hand, in the still image applications, wide-gamut color space: sYCC (IEC61966-2-1AMD) is adopted in the DSC's file format: Exif 2.2 (JEITA CP-3451), and is widely used for interchange color space between DSC and printers.
- Therefore, users are already enjoying wide-gamut still color images, unconsciously.
- Video signals have "similar" unused/undefined regions that could store wide-gamut colors.



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Extended Color Space (sYCC) is already available in Still Image Applications (Exif2.2)

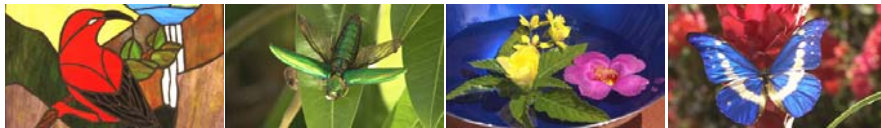


The wide-gamut colors can be transferred from DSCs to Printers, which supports sYCC color space (in Exif 2.2).

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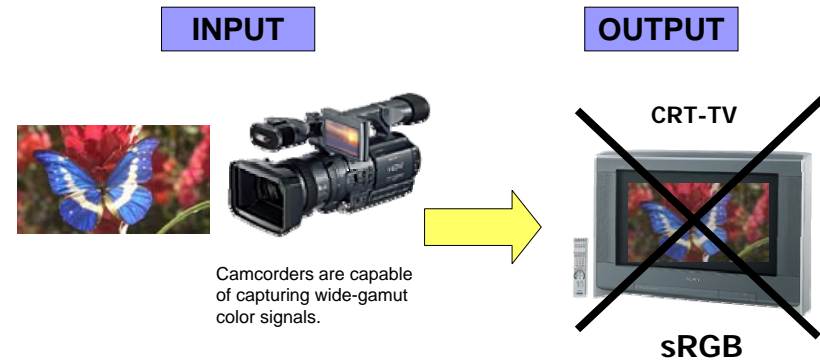
Need for the Extended Color Space III

- There already exist some cases that capturing devices (CAMs) are storing extended-gamut color signals (unintentionally).
- However, since most of current display are sRGB-limited, CAM designers render images on CRT displays, with an assumption that wide-gamut colors will be clipped.
- If extended color space will be defined, those wide-gamut colors are rendered as defined (intentionally).



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How about Video Applications?



We cannot enjoy wide-gamut images, since current video standard is limited to sRGB-gamut, which is based on CRT phosphor characteristics.

⇒ We need the "new" standard for video signal that can store and transmit extended-gamut colors!

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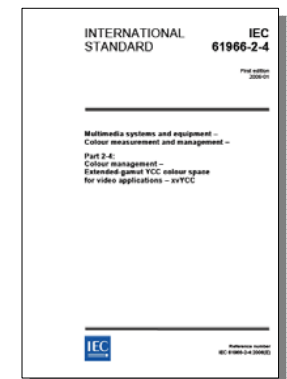
xvYCC Colour Space

- IEC 61966-2-4: Extended-gamut YCC colour space for video applications – xvYCC
- IEC/TC100/ PT 61966-2-4:
<http://www.iec.ch/cgi-bin/procgi.pl/www/iecwww.p?wwwlang=E&wwwprog=dirwg.p&progrdb=db1&ctnum=2770>
 - Multimedia systems and equipment - Colour measurement and management - Part 2-x: Colour management - Extended-gamut YCC colour space for video applications - xvYCC (TA2)
 - 9 PT members from US, NL, KR, JP

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xvYCC Colour Space

- International Standard developed at IEC
<http://webstore.iec.ch/webstore/webstore.nsf/artnum/035442>
- Official Name:
 IEC 61966-2-4 (First Edition 2006-01)
**Multimedia systems and equipment –
 Colour measurement and management –
 Part 2-4: Colour management –
 Extended-gamut YCC colour space
 for video applications - xvYCC**
- Discussed at IEC/TC100/TA2
 - Project Leader: Naoya Katoh, Sony
 - 9 Intl' Experts from JP, KR, NL, US
- Published at Jan. 17, 2006
 - Part of IEC61966-2 series, which contains "color management" standard (incl. sRGB, etc)



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xvYCC Standardization Schedule

- '04/9/14: JEITA/Color Management Std. Committee
 - The first proposal by Sony.
 - Approved to bring this proposal to IEC as JNC.
- '04/10/1: JEITA/IEC61966-2sRGB Committee
 - Technical Discussions in this committee
- '04/10/17-22: IEC General Meeting (Seoul, Korea)
 - NP approved as IEC61966-2-4 at IEC/TC100/TA2 meeting.
 - Project Team: **PT61966-2-4** was formed.
 - Approved to proceed as "**Fast Procedure**" by AGM, considering its industrial importance for the next-generation video signal.



Several International Meetings in 2005;

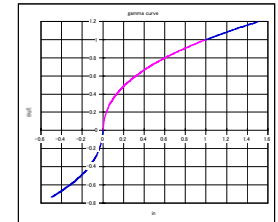
- '05/3/28-4/15: Int'l Virtual (e-mail) Meeting
- '05/9/28: PT meeting at San Jose, CA, USA
- '05/10/7: Voting closed for 100/967/CDV
 - **Unanimous approval (17 P-member approvals)**
 - Will proceed to direct "IS" publication (within 2 months)
- '06/1/17: IS document published
 - **IEC61966-2-4** (xvYCC) standard was published
 - Awarded as "**IEC1906 Award**"



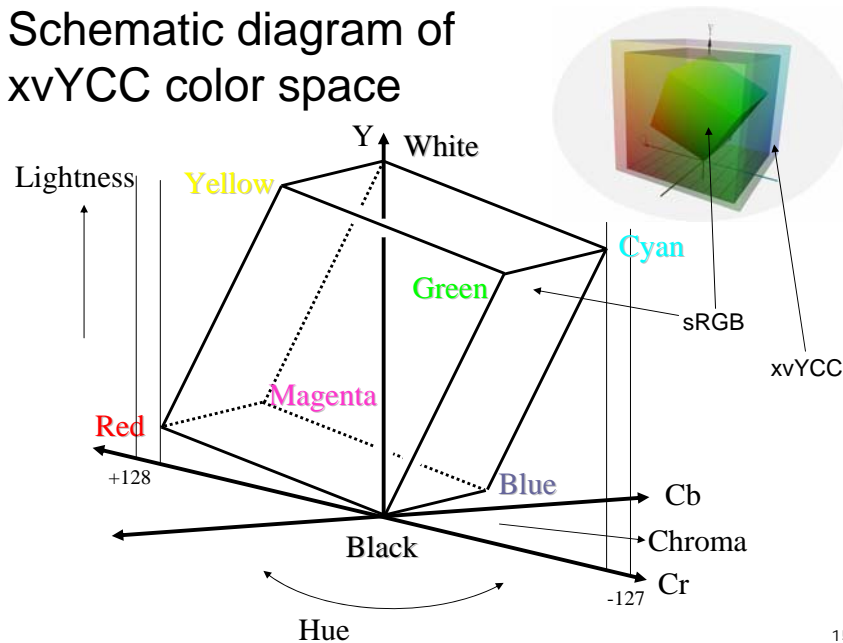
Detail of xvYCC Color Space



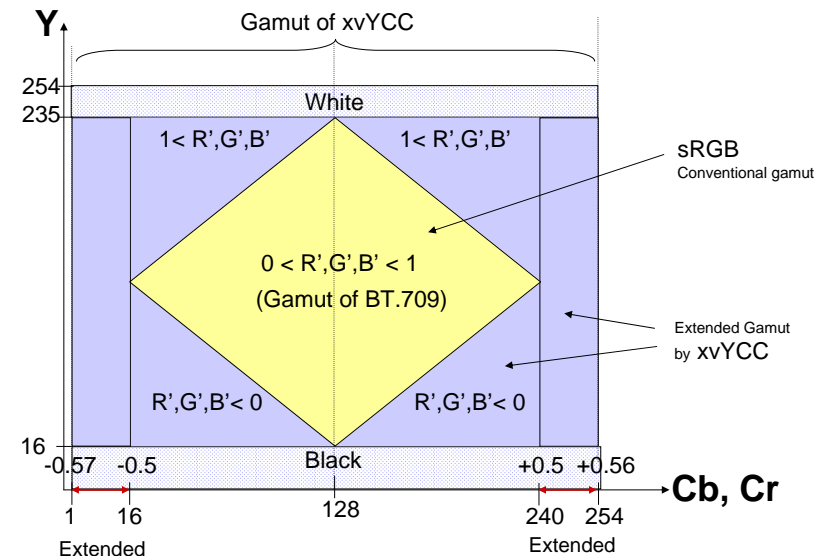
- RGB/Primary and White Point **[Unchanged]**
 - RGB (ITU-R BT.709) + W.P (D65)
- Opto-electronic transfer characteristics **[Extended]**
 - Extended ITU-R BT.709 tone curve by defining over-ranged values.
 - Unchanged for inside the "0-1" range.
- Encoding Matrix (RGB-YCC) **[Unchanged]**
 - For SD: Matrix defined in the ITU-R BT.601
 - For HD: Matrix defined in the ITU-R BT.709
- Quantization (N-bit compliant) **[Unchanged]**
 - The range 0-1 will be quantized as 16-235 for Y, and as 16-240 for Cb/Cr.
 - 1-15 and 241-254 will be used for gamut-extension in Cb/Cr.



Schematic diagram of xvYCC color space



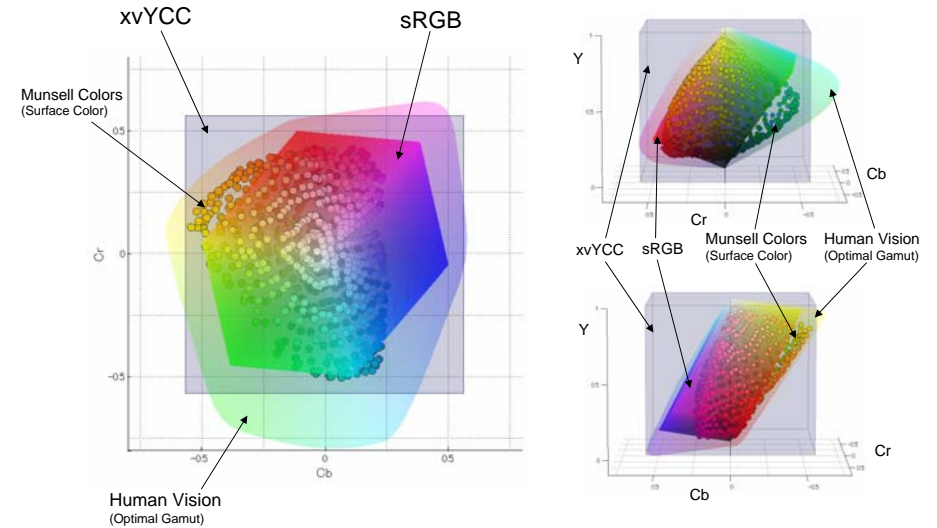
Two-dimensional View of xvYCC



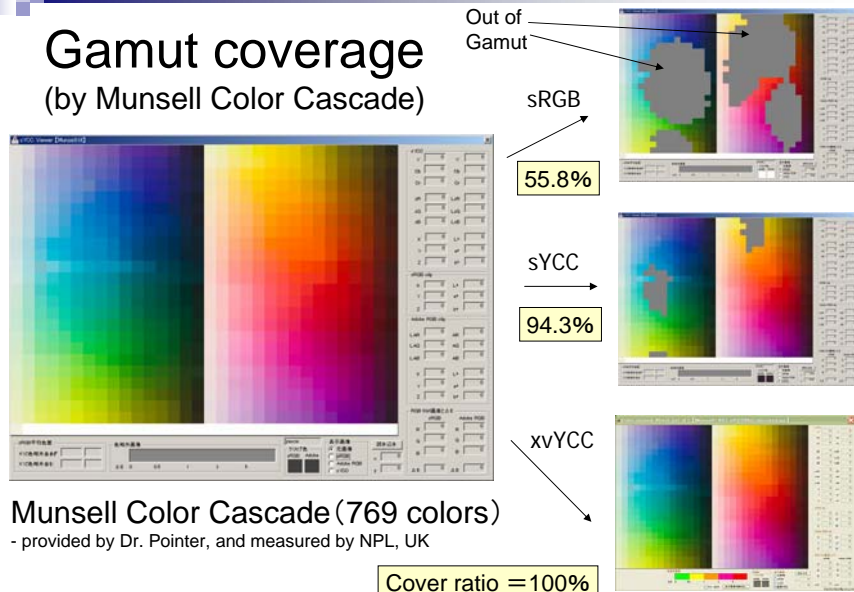
Merits of xvYCC Color Space

- Compatible with currently-used video signals.
 - Same definition for inside of the sRGB-gamut. (No change is necessary for conventional contents.)
 - Added an unambiguous definition to the currently-undefined (out-of-sRGB-gamut) regions.
- Most of the surface colors can be stored.
 - 55% coverage by sRGB, and 100% coverage by xvYCC
- Suitable for image processing/compression
 - Luminance-chrominance separated color space

3-dimensional View of Color Spaces

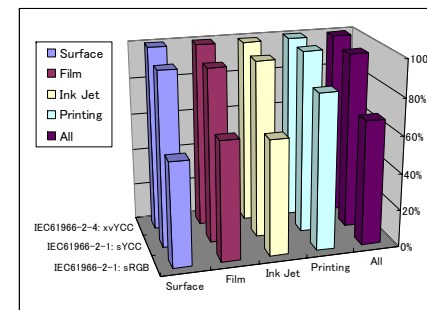


Gamut coverage (by Munsell Color Cascade)



Color Space Comparison

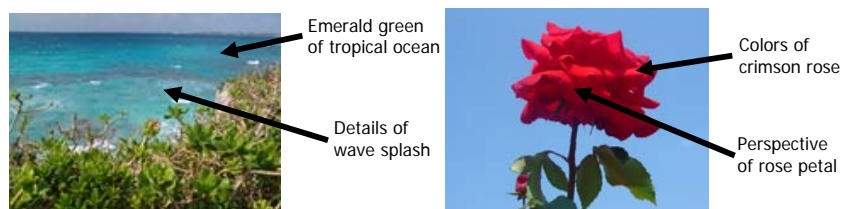
Color Space	Media Gamut Cover Ratio				
	Surface	Film	Ink Jet	Printing	All
IEC61966-2-1: sRGB	55.8%	64.2%	62.4%	83.9%	67.5%
IEC61966-2-1: sYCC	94.3%	93.6%	95.5%	98.7%	95.7%
IEC61966-2-4: xvYCC	100.0%	99.9%	99.3%	100.0%	99.8%



- Insufficient coverage for any media by sRGB
- More than 90% coverage by sYCC
- Almost 100% coverage by xvYCC

Expected advantages by xvYCC (1)

- ◆ Colors that were NOT reproduced correctly by the conventional TVs, such as vivid colors of various flowers (Red, Orange, Yellow, Violet), and the beautiful color of “Emerald-blue” of tropical ocean, can now be reproduced as it is.
- ◆ The details of vivid color object will truthfully be reproduced with xvYCC signal which can express extended color gamut, while those details were sometimes lost with the conventional TV signals.

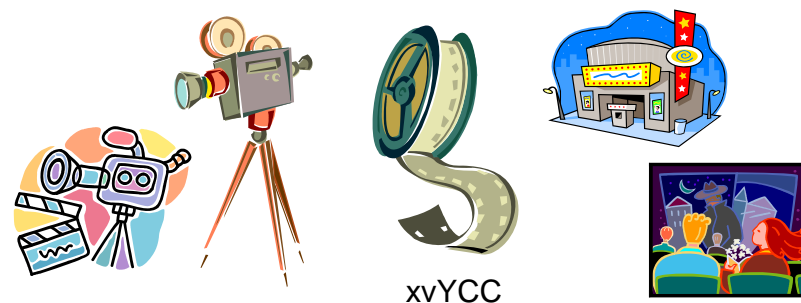


Once you experience the wide-gamut color images with xvYCC, you will NEVER want to go back to the conventional sRGB-limited color images!

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Expected advantages by xvYCC (2)

- ◆ A part of colors in movie contents that were shot by “film” were NOT reproduced correctly with conventional TV signal. With the xvYCC signal, those colors will be reproduced correctly, and can be viewed on the wide-gamut TVs at home.



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xvYCC adoption in MPEG

- MPEG: ISO/IEC JTC1/SC29/WG11 
- Jan. 2005: Hong Kong meeting
 - Introduction of xvYCC to the MPEG community, which has just started the discussion at IEC.
- Oct. 2005: Nice (FR) meeting
 - The decision was made that MPEG-2, MPEG-4, MPEG-4 AVC standard will refer to the new extended color spaces incl. xvYCC, and the documentation process has started.
- Standardization Status
 - FDAM voting closed
 - 2006/10: FDIS published (No technical modification allowed)
 - 2007/01: Voting close (Yes/No voting) -> **Approved!**
 - 2007/1H: IS (Intl. Standard) will be published

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xvYCC adoption in HDMI

- HDMI: 
 - High-Definition Multimedia Interface
 - 7C: Hitachi, Panasonic, Philips, Silicon Image, Sony, Thomson, Toshiba
- Jun. 2005: HDMI 7CT Paris (FR) meeting
 - Ver1.3 discussion started & introduction of xvYCC
- Oct. 2005: HDMI 7CT Osaka (JP) meeting
 - Proposal for “gamut-extension” by xvYCC
- Dec. 2005: HDMI 7CT San Diego (US) meeting
 - xvYCC description and demonstration
- Jun. 22, 2006:
 - “HDMI Ver1.3” officially published
- Jul. 20, 2006: CEA (Consumer Electronics Association)
 - “CEA-861-D” officially published

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xvYCC-related Press Releases (1)

- Jan. 5, 2006: Sony Corp.
<http://www.sony.co.jp/SonyInfo/News/Press/200601/06-002/index.html>
 - 82 inch LCD TV demonstration at CES 2006, that has xvYCC-compliant signal processing technology inside.
- Feb. 15, 2006: Mitsubishi Electric Corp.
<http://www.mitsubishielectric.co.jp/news/2006/0215-a.htm>
 - Development of xvYCC-compliant laser projection TV.
- Aug. 30, 2006: JEITA
(Japan Electronics and Information Technology Industries Association)
<http://www.jeita.or.jp/japanese/hot/2006/0830/>
<http://www.jeita.or.jp/japanese/hot/2006/0830/0830.pdf>
 - "xvYCC standardization" explanation for media (journalists).
- Sep. 26, 2006: Epson Corp.
http://www.epson.jp/osirase/2006/060926_4.htm
 - xvYCC-compliant photo storage device: "P-5000"

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xvYCC-related Press Releases (2)

- Aug. 31, 2006: Sony Marketing, Japan
<http://www.sony.jp/CorporateCruise/Press/200608/06-0830B/>
 - Bravia X-2500: First consumer TV which is xvYCC-compliant.
 - Jan. 5, 2007: Sony Corp.
<http://www.sony.co.jp/SonyInfo/News/Press/200701/07-001/>
<http://www.sony.net/SonyInfo/News/Press/200701/07-001E/>
 - "x.v.Color/x.v.Colour" **industry-joint-promotion** announcement.
-  **x.v.Color**  **x.v.Colour**
- Jan. 18, 2007: Sony Marketing, Japan
<http://www.sony.jp/CorporateCruise/Press/200701/07-0118/>
 - "x.v.Color"-compliant digital video cameras (HDR-UX7/5, HDR-HC7)

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Thank you very much
for your kind attention.

Any questions?

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