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Poynton's Vector 8 Wide gamut and wild gamut: xvYCC for HD

It's a complex topic, but I'd like to summarize – in two pages, without cheating the type size or the margins – the situation of wide gamut colour in consumer electronics, and specifically, xvYCC (x.v.Colour).

First, some history: The colour gamut of HD was agreed upon in 1990 in the standard (and therefore, colour space) now called BT.709.

In Poynton's Vector 7, I described the disconnect between colour-space in content creation and colourspace in content presentation.

The colour gamut for digital cinema, agreed upon in 2006, is called DCI P3 RGB. The P3 gamut approximates the gamut of cinema film; it's wider than BT.709. Movies today are typically mastered in P3 gamut. When transferred to HD, a remastering step is undertaken, with "colour correction" performed by a skilled colourist who is sensitive to the creative intent of the movie and who is under the supervision of the director and/or cinematographer. Once the movie is mastered for HD, the creative intent is embedded in BT.709 colour-space. To be faithful to that intent, the movie (in HD) must be presented in BT.709 space. No consumer has access today – and no consumer is likely to have access anytime soon – to the P3 material.

NTSC and PAL video was negative-polarity amplitude modulated onto the RF carrier. The 120% limitation was to avoid undermodulation – you could call it "underloading."

Now, some deep background: In the old days of analog NTSC and PAL, video engineers limited *R'G'B'* values to the [0, 1] "colour cube." For 100% bars, the corresponding composite NTSC/PAL video limit is 133.33%. Transmitter power was set a little lower, to the equivalent of a composite limit of 120%. Video engineers came to use 75% colour-bars so as to avoid exceeding the 120% transmitter limit. In the U.S., NTSC transmitters are now shut off. Analog transmission will soon cease in other countries. These limits are no longer relevant. (Certain broadcasters, post-production houses, and quality control outfits are creatures of habit; for no good reason, they still use "gamut alarms" and "legalizers" to clamp to the historical limits.)

That the BT.709 and sRGB gamuts are identical is no accident: Following agreement on BT.709, computer vendors quickly realized the benefits of adopting a single *RGB* coding worldwide. They incorporated the BT.709 primaries into the sRGB standard.

Fast forward to today: RGB LEDs are practical for use as backlights for LCD panels. They have colours close to the spectral locus of the CIE chart, so they enable wide-gamut displays. RGB LED backlights are commercially available in specialized displays for graphics arts, in some computer displays, and in some consumer television receivers ("LED TVs"). The question is: How should wide-gamut content be encoded and displayed? Clearly, sRGB content doesn't extend outside the sRGB colour gamut, and today's BT.709 content doesn't extend outside the 709 gamut.

One way to encode wide gamut colour is to adopt new primary chromaticities outside the current ones. That approach was taken with the Adobe RGB industry standard used in graphics arts. Many years

ago studio HD engineers realized that another way to represent wide gamut – having a better compatibility story – was to leave the primary reference points fixed, and to allow negative signal excursions with respect to those primaries. That approach was documented for HD in 1998 in ITU-T BT.1361, but BT.1361 was never commercialized. A few years ago, the BT.1361 approach was resurrected in a somewhat modified form, and adopted in 2006 as IEC 61966-2-4, a sister specification to IEC 61966-2-1 (sRGB). That scheme is entitled *xvYCC* – xv for extended video, YCC for $Y'C_BC_R$. Sony trademarked *x.v.Colour* as its marketing term for xvYCC; when *x.v.Colour* is used for advertising, it is with Sony's permission.

The pitch from the xvYCC proponents in consumer electronics is this: At production, turn off the legalizers and gamut alarms. Convey wide-gamut through today's $Y'C_BC_R$ pipeline (digital broadcasting, DVD, Blu-ray, etc.), and we'll deliver wide-gamut colour to consumers.

No so fast. Consider little Nemo the fish. In the cinema, he exceeds BT.709 gamut. If the content producer were to take *Finding Nemo* in P3 RGB and simply use textbook xvYCC encoding for delivery to consumers, and if that xvYCC data is decoded and displayed by legacy consumer equipment, Nemo will clip. His scales will be lost. He will look like a blob of plastic instead of a cute cartoon character. Taking wide-gamut content to a legacy display presents a big problem.

On the other hand, consider legacy content on a new wide-gamut display. Upon introducing wide-gamut displays, marketers were not content to present legacy BT.709 content faithfully. Instead, they elected to "warp" legacy content to create new, saturated colours that they thought would entice consumers, but which content producers never experienced upon mastering the material. I call this *wild gamut.* The mapping can be defeated in various poorly documented ways – for example, by setting FILM, MOVIE, or THEATRE mode – but most consumers are unaware of these modes or don't understand them.

HDMI 1.3 endorsed xvYCC, and in addition included provisions that seem at first glance capable of conveying colour gamut boundary data (GBD) across the HDMI interface. However, a gamut boundary does not define a colour mapping. What is needed is a way for content producers to have control over – or at the very least, have knowledge of – colour mapping that will be applied to their content when it encounters wide-gamut displays. Imagine a CE design engineer excitedly asking a cinematographer, "How could I map your colours so as to improve your movie?" The cinematographer would in all likelihood answer something like, "Get your grubby hands off my movie!"

At the moment, content producers viewing legacy displays see their BT.709 material displayed reasonably faithfully. However, viewed on new, wide-gamut displays, their carefully chosen colours are being screwed up. CE manufacturers are meanwhile effect saying, in effect, "Please give us your cinema-grade, P3 wide-gamut images!" Content creators reply, "Why, so you can screw *them* up, too?"

Resolution to the problem won't be soon in coming. Development of technology to maintain creative intent, and availability of wide-gamut content, are perhaps 3 or 5 years away. If you're a home theatre calibrator, endeavour to disable colour mapping for now, and hold out until things settle down. And watch this space!