
Matthew Goldman
Senior Vice President, TV Compression Technology
Ericsson
Resolution Revolution
Resolution Revolution
Resolution Revolution
In context of broadcast television, “4KTV” is UHDTV Level 1 or 4K UHDTV.

4KTV = UHDTV-1

- UHDTV as a standard
  SMPTE 2036-1 & ITU-R BT.1769 define
  - UHDTV Level 1 = 3840 x 2160
  - UHDTV Level 2 = 7680 x 4320

- Consumer Electronics Association (CEA) October 2012
  “Ultra High Definition” or “Ultra HD”
  - >8 million active pixels
  - At least 3840 (H) x 2160 (V)
  - At least 16:9 aspect ratio
  - At least 1 digital input capable of carrying and displaying native 3840x2160 resolution without relying on up-conversion
Can UHDTV Resolution Really Be “Seen” in the Home?

• Human vision studies have theorized that the average person can resolve resolution up to 30 cycles per degree
  – Human Resolution Theory - Snellen Chart (1862)
  – Equivalent to 60 pixels/degree

• Using 30 cpd, 20/20 vision matches to 1080-line resolution for an ~ 70” screen @ 9’ viewing distance
  – 9’ = Median Lechner distance for TV viewing in home

• This is equivalent to 2160-line resolution for ~ 140” screen @ 9’

• So, not for most homes, right?

• Except …

Panasonic 150” (3.8m) plasma UHDTV-1 at 2008 CES
• The human eye can resolve edges beyond 20/20
  – Most people can distinguish 3 eye chart lines below 20/20

• From April 2008 SMPTE *Motion Imaging Journal*, NHK’s “Research on Human Factors in UHDTV”
  – It is possible to distinguish between 78 and 156 cpd
    • 156 cpd is more than five times the 20/20 criterion
  – “Realness” is a function of image detail
    • Rises rapidly to 50 cpd
    • Continues rising through 156 cpd

• At CES 2012, observations of 60”+ UHDTVs demonstrated that higher resolution is discernable at recommended viewing distances

*Courtesy of Mark Schubin, HPA Technology Retreat 2012*
1 arc minute

UHDTV-1 = 2x horizontal & 2x vertical resolution of HDTV
... but spatial resolution is not the entire story ...
Visual Quality - Immersive Experience

Central field of vision - 90°
Visual Quality - Immersive Experience

Central field of vision - 90°
UHD is More Immersive

- HDTV field-of-view ~30º
- 4K UHDTV field-of-view ~60º

Proper viewing distance
- HD ~= 3H
- 4K UHD ~= 1.5H
Increased Motion Sensitivity …

… increases perceived Motion Blur or …

Wider viewing angle = more immersive viewing experience

Images courtesy of BBC
Motion Judder*

*simulated for illustration purposes by a strobing effect

Images courtesy of Dolby Laboratories

Higher frame rates are needed to compensate
50/60 fps minimum (100/120 fps being vetted)
Sample Bit Depth: 8 is Not Enough

10-bit DTH, 10-bit/12-bit Contribution

- Banding (posterization) with 8b, especially in plain areas
  - Sky, backgrounds, graphics, logo
  - More noticeable with slow changes, such as fades

8-bit

10-bit

10-bit operation does not cost bitrate
Color Gamut

**Expanded color space for more realistic presentations**

- UHDTV can offer more realism via color
  - But, we need technology with the right color space
- Quantization of levels
  - With more colors to represent, higher bit sample rates (10-bit) are critical

**UHD Color Space per ITU-R Rec. BT.2020**

**HD Color Space per ITU-R Rec. BT.709**
Color Distribution of Objects on X-Y Chromaticity Coordinates

From Report
ITU-R BT.2246-1
Inner triangle: HDTV primaries
Outer triangle: UHDTV primaries
High Dynamic Range

Clipping at 40% Luminance reduction

Displayed at 100% luminance

Images courtesy of Dolby Laboratories
Standard Dynamic Range - Lowlight

Images courtesy of Dolby Laboratories
Standard Dynamic Range - Highlight

Images courtesy of Dolby Laboratories
High Dynamic Range

Images courtesy of Dolby Laboratories
UHDTV Summary

• Spatial resolution is not the key factor for immersive TV viewing experience
  – *Not all 4K UHDTV solutions are “true” Ultra HD*
  – For an immersive experience in “Phase 1”,
    • At least 50-60 fps required for sports and other complex motion content
    • At least 10-bit depth data values required to avoid contouring quantization artifacts

• Will 4K UHDTV’s adoption be more like 3DTV or HDTV?*
  – Depends on how we in the industry present it!
  – *Can be transformative if the experience is immersive*

• Implementation & standardization efforts continue
  – When will consumer displays implement 10-bit / 12-bit sample data values?
  – When will consumer displays implement expanded color space?
  – The high frame rate (HFR) debate continues
    • 100 fps, 120 fps, higher? Fractional HFR (e.g., 120/1.001 fps) or integer only?
  – High dynamic range (HDR), including peak white levels, fact finding and calls for proposed technologies just starting