WHAT IS HDR?
(And why should I care?)

MARK TURNER
Agenda

• What qualifies as HDR? How does it fall in order of UltraHD priorities?
• What type of infrastructure is required?
• What is the intersection with color space (eg. REC 2020)
• When will you be transmitting HDR?
• What different file formats will you need to deal with?
• SMPTE, MPEG, ATSC and UHD Alliance standards
• Live and Non-Live Workflows
Technicolor By The Numbers…

- **Creatives**: >5000
- **Operationals**: >7000
- **Researchers & Engineers**: >1700
- **Revenues**: >€5Bn

**Regional Headquarters**
- London, UK
- Los Angeles, United States
- Paris, France
- Rennes, France
- Los Altos, United States
- Vancouver, Canada
- Guadalajara, Mexico
- Toronto, Canada
- Montpellier, France
- Istanbul, Turkey
- Tel Aviv, Israel
- Bangalore, India
- Shanghai, China
- Sydney, Australia
- Beijing, China

**AMERICAS**
- Appr. 8,000 employees

**EMEA**
- Appr. 4,000 employees

**APAC**
- 1,800 employees

**Others**
- Manaus, Brazil
- Hanover, Germany
- Edegem, Belgium
- Piaseczno, Poland

*2015 revenues pro forma for Cisco Connected Devices and The Mill acquisitions.*
Why Technicolor & HDR?

**TECHNOLOGY**

80%+ of **ALL** CE Manufacturers integrate our IP

A **leader** in patent, technology and trademark licensing with over 40K patents

250 scientists & researchers around the globe focused on immersive media, context-aware entertainment and digital life services

**ENTERTAINMENT SERVICES**

#1 and #2 worldwide provider of pre & post production services to major Hollywood studios.

70% of Hollywood blockbusters serviced by Technicolor

World’s largest independent manufacturer of consumer packaged media products – 5 million products shipped daily.

Over **1 billion discs** manufactured and shipped every year.

**CONNECTED HOME**

1st in Home Gateways

2nd largest Set Top Box leader

Innovation leader in key mobile technologies

350 million digital home devices shipped to date.

250 Operators as clients worldwide

A company wide commitment to next-generation imaging
Why Technicolor & HDR?

TECHNOLOGY

2 licensed products:

1) Intelligent Tone Management
   - HDR Up Conversion
   - Post, Broadcast and on device

2) HDR Delivery System
   - Joint product with Philips
   - Backwards compatible to SDR

ENTERTAINMENT SERVICES

HDR Grading & VFX

1) Episodic TV
2) Theatrical Movies
3) Home Video Releases
4) Remastering

- Defined HDR workflows
- Color science team optimizing
- Establishing reference pro and consumer displays

CONNECTED HOME

HDR Set Top Boxes

1) HDR 10 & PQ
2) Technicolor HDR delivery system
3) Technicolor ITM up conversion
4) Support for HDMI 2.0a

Actively working on deployments for Q4 2016 and Q1 2017

A company wide commitment to next-generation imaging
HDR 101
5 Key Dimensions of Video Quality

- **Image Size** (Spatial Resolution)
  - 4k
  - 720/1080p
  - 480p

- **Frame Rate** (Temporal Resolution)
  - 24/30
  - 60
  - 120

- **Color Precision** (Bit Depth)
  - 10 bit
  - 8 bit
  - 6 bit

- **Color Volume** (Color Space)
  - RGB/709
  - D65/P3
  - REC 2020

- **Dynamic Range & Luminance** (Contrast Ratio)
  - SDR
  - HDR

- **Cathode Ray Tubes**
HD Standard Dynamic Range

Image Size
(Spatial Resolution)

Frame Rate
(Temporal Resolution)

Color Precision
(Bit Depth)

Color Volume
(Color Space)

Dynamic Range & Luminance
(Contrast Ratio)
UHD Phase 1

**Image Size**
(Spatial Resolution)

- 480p
- 720/1080p
- 4k

**Color Precision**
(Bit Depth)

- 6 bit
- 8 bit
- 10 bit

**Color Volume**
(Color Space)

- RGB/709
- D65/P3
- REC 2020

**Frame Rate**
(Temporal Resolution)

- 24/30
- 60
- 120

**Dynamic Range & Luminance**
(Contrast Ratio)

- SDR
- HDR

- Cathode Ray Tubes

UHD SDR
(Est. 2014)
Higher Dynamic Range 101

- Arri Alexa
- Sony F55
- Sony F65
- Film

F STOPS

ACTIVE CONTRAST RATIO

CURRENT DELIVERY SPECIFICATION

HIGHER DYNAMIC RANGE

HIGHEST DYNAMIC RANGE
Our HDR Manifesto

1. It’s about LIGHT and SHADOW
   - True HDR requires high contrast, deep blacks & bright whites
   - When telling a story, shadows are often more important than highlights
   - Delivering the ‘creative intent’ is key
   - Simply making the scene brighter can skew the intent

2. HDR for all content types and budgets
   - Different types of content (theatrical, live sports, local news) will benefit from different content creation approaches
   - Creating content in HDR provides greater flexibility

3. An open approach will benefit the entire industry
   - Promotes continued innovation by solution providers
   - Allows differentiation by the CE manufacturers
   - Builds a broad base of solutions to meet different needs
Wider Color Gamuts

**REC. 709 Color Space**
- Broadcast TV, Blu-ray, OTT

**DCI-P3 Color Space**
- Digital Cinema, coming to TVs

**Rec. 2020 Color Space**
- New standard for UltraHD TVs
- Only currently available on laser projectors
Preservation of correct color is VITAL to telling the story…

Correct

Narrow Gamut Displays

Display with Incorrect Gamut

Displays with Incorrect White Point
Impending fragmentation of Devices and Content

SDR Content library
- REC 709
- 100nit peak luminance

HDR Content library
- 4000nit P3 PQ
- 1000nit, 709 S-LOG
- 1000nit, REC 2020 HLG

SDR Displays
- REC 709
- 300-400nits

Next-Gen Displays
Eg.
400nits P3 colors
1000nits 709 colors
800nits xx% of 2020
State of the Standards
The HDR Standards Ecosystem

CONTENT CREATION
- Advanced Imaging Society
- The UHD Forum
- The Guilds
- SMPTE

CONTENT DISTRIBUTION
- DVB
- ATSC
- Consumer Electronics Assoc.
- HDMI
- SCSA and UltraViolet (DECE)
- Blu-ray Disc Association
- DEG
- MPEG
- ITU-R
- ETSI

CONTENT RENDERING
- UHD Alliance
- Digital Cinema Initiatives (DCI)
SMPTE HDR Work Status

Published Documents:

- ST 2084:2014 HDR EOTF of Mastering Reference Display [the “PQ” curve]
- ST 2086:2014 Mastering Display Color Volume Metadata...
  - Describes the monitor used to grade a particular content

In Process: the ST 2094 suite for dynamic color transform metadata

- 2094-1 – the core definitions document
- 2094-10 – [Dolby] metadata for a tone mapping based on the source content characteristics and colorist adjustments.
- 2094-20 – [Philips] metadata for a color transform based on a creatively set tone mapping curve and a luminance dependent saturation gain curve.
- 2094-40 – [Samsung] metadata for tone mapping and color saturation based on mastering and target displays peak luminances and content characteristics.
The UHD Alliance

- Alliance to support an **open standard** for production, distribution and display of UHD & High Dynamic Range video
- Minimum specifications for video quality and metadata
- Room for licensors to innovate on top ensures competition
- Certification scheme to ensure compliance
- Logo program for content and devices
Initiatives to help clarify the HDR offers

- The CTA— the consumer electronics industry's trade association initiative; “HDR Compatible” defines a TV that can play HDR content but is not necessary an HDR display. Potentially confusing consumers.

- The UHD Alliance initiative: has set criteria to define a premium home entertainment experience and unveiled consumer-facing “ULTRA HD PREMIUM” logo at CES 2016 in order to reduce consumer confusion and help ensure consistency of both buyer expectations and the delivery of the end experience.
  - 30 TVs devices from 3 manufacturers announced for the Premium Ultra HD logo at CES.
  - Content, Distribution and Devices can all carry the logo.
  - Just expanded to UltraHD Blu-ray players
  - Other devices/categories under consideration
Ultra HD Premium Movie Content

- **Image resolution**: 3840x2160
- **Color gamut**: minimum of 100% P3
- **EOTF**: ST.2084
- **Peak Brightness**: 1000 nits or more
- **Black Level**: 0.03 nits or less
- **Contrast**: 33,333:1 or higher

Source: http://www.uhdalliance.org/uhd-alliance-press-releasejanuary-4-2016/
What about Live Production?

**Image resolution**: 3840x2160, or is 1080p with a high frame rate more important?

**Color gamut**: minimum of 100% P3?

**EOTF**: ST.2084? HLG? S-Log? Other camera optimized curves?

**Peak Brightness**: 1000 nits or more?

**Black Level**: 0.03 nits or less?

**Contrast**: 33,333:1 or higher?
Additional HDR Broadcast Requirements

1. One production
2. Budget, Time, and Footprint constraints
3. Same production tools must be available
4. No dynamic metadata in production
5. SDR Elements: Archive material, Interstitials, and Graphics
6. Support for higher frame rates
CONSUMER DISPLAYS
HDR TV offer will boost end-user demand

All major TV manufacturers have demonstrated High Dynamic Range (HDR) TVs at CES 2016

- Samsung
- LG
- Sony
- Skyworth
- Sharp
- Hisense
- Toshiba
- TCL
- Vizio
- Panasonic
- RCA
CEA regarding the U.S. market

4M WERE UHD TV’S LARGER THAN 40”

34.8M TOTAL TV’S SHIPPED IN 2015

► This represents only 11.5% of the total TVs sold

► In 2019 UHD TVs will represent 34% of the U.S. Market

Source: CEA, IHS
What does this all add up to?

NEW TVs sold in the U.S. in 2019

〜34.8M TOTAL TVS

〜3.8M units (10.9%)

UHD HDR TV

〜8M units (23.0%)

UHD SDR TV

〜23M units (66.1%)

Other TVs

34% WILL BE UHD

32% OF THOSE WILL BE HDR

Source: CEA, IHS
Different types of HDR content

Movie and Television Content has already started to be created to the UHD Alliance specifications and is being distributed.

Live Events and Sports workflows are in the testing phase.

Source: CEA, IHS
Technicolor view on phased rollout of HDR

- Movies
- Live events & sports
- Premium network & broadcast content
- Basic channel content

Content Volume

Now  End 2015  End 2016  End 2017
Pending adoption of ATSC 3.0

Source: CEA 2015
Moving to Live TV – Plugging the gaps until HDR content is ubiquitous

An example network with mixed content, ads and some new and old content

Ecosystem (consumers, cable networks, programmers) don’t want to wait until they can fill 100% of network with HDR content but:

- A partial network will create consumer confusion and support calls as some shows will look good (HDR) and some dull and flat (SDR)
- An ad-load mixed with HDR and SDR content will create an inconsistent experience and
- Unlike SD to HD conversion TVs do not upscale SDR to HDR well or consistently
- Ads with different brightness levels could introduce government issued CALM style legislation again

HDR (Eg. 1000nit, P3 Colors)

- HDR Live Sports Event (Produced in Sony S-Log EOTF)
- HDR Episodic TV show (Produced in PQ EOTF)
- SDR Catalog TV Show

SDR (100nit, 709)

- SDR Ad Block
- Mixed HDR & SDR Ad Block
- Ads & Interstitials
Solution – Use ITM and Prime to deliver one network to all consumers

Using Technicolor ITM and Prime in the broadcast chain so all users can benefit from all networks being HDR:

- ITM+Prime simplifies the broadcast stream by taking in SDR and multiple HDR EOTFs and normalizing for a single SDR compatible delivery:
  
- ITM will ‘fill in the gaps’ so HDR users see all content as HDR, even those not originally created that way

- ‘Prime’ ensures SDR users see only SDR content but require no truck roll or CPE change if they want to upgrade to HDR packages

- Ads & content that are too bright are automatically tone mapped down to maintain a consistent network ‘look’
LIVE AND NON-LIVE WORKFLOWS
HOME HDR REFERENCE

- 1000 nits or greater
- D65 P3
- ST 2084

MASTER HDR FILE
Movie and television HDR workflow

HOME HDR REFERENCE

- 1000 nits or greater
- D65 P3
- ST 2084
## Home Masters

<table>
<thead>
<tr>
<th></th>
<th>SDR Reference Screen</th>
<th>Dolby Pulsar</th>
<th>Sony X300</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Local Contrast</strong></td>
<td>1000:1</td>
<td>&gt;133,000:1</td>
<td>&gt;10,000,000:1</td>
</tr>
<tr>
<td><strong>Peak White Level</strong></td>
<td>100 nits</td>
<td>4000 nits</td>
<td>1000 nits</td>
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<tr>
<td><strong>Resolution</strong></td>
<td>1080</td>
<td>1080</td>
<td>4k</td>
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<tr>
<td><strong>Black Level</strong></td>
<td>~0.1 nits</td>
<td>&lt;0.03 nits</td>
<td>&lt;0.0000 nits</td>
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<tr>
<td><strong>Color Gamut</strong></td>
<td>Rec.709</td>
<td>P3</td>
<td>P3</td>
</tr>
<tr>
<td><strong>White Point</strong></td>
<td>D65</td>
<td>D65</td>
<td>D65</td>
</tr>
<tr>
<td><strong>Open/Proprietary</strong></td>
<td>Open Standards Based</td>
<td>Dolby Proprietary</td>
<td>Open Standards Based</td>
</tr>
<tr>
<td><strong>Target Monitor for:</strong></td>
<td>All SDR Content</td>
<td>Approved/Sponsored Projects Only</td>
<td>All Open HDR Content (exceeds the UHDA specifications for both consumer parameter sets)</td>
</tr>
<tr>
<td><strong>Availability</strong></td>
<td>General</td>
<td>Limited</td>
<td>General</td>
</tr>
</tbody>
</table>
SDR Distribution Workflow

**WORKFLOW**

SDR reference screen

**MASTERS**

SDR Master

**DISTRIBUTION**

- All colorist tools available
- Can use any SDR reference screen
- Available for any SDR project
- Masters will work on any SDR device

SDR Video
UHDA Home Workflow (Single HDR Master)

**WORKFLOW**

- Sony X300

**MASTERS**

- UHDA Master
- HDR10
  - Technicolor Single Stream
  - SDR

**DISTRIBUTION**

- All colorist tools available
- Can use any HDR reference screen
- HDR masters will work on any UHDA premium device
- SDR derived signal for the millions of current customers
- Best local contrast providing the highest dynamic range master
- Optimizes content for both consumer LCD and OLED television technology
UHDA Home Workflow (Dual Master)

WORKFLOW

Sony X300

Trim Pass

SDR reference screen

MASTERS

UHDA Master

HDR10

Technicolor Single Stream

SDR Master

SDR

DISTRIBUTION

► All colorist tools available for HDR and SDR
► Can use any HDR or SDR reference screen
► HDR Masters will work on any UHDA premium device
► Best possible SDR for the millions of current customers
► Best local contrast providing the highest dynamic range master
► Optimizes content for both consumer LCD and OLED television technology
LIVE EVENTS AND SPORTS
Live events and sports HDR workflow

HDR CAMERA  \hspace{1cm} DISTRIBUTION \hspace{1cm} HDR TV
Live events and sports HDR workflow
Live events and sports HDR workflow

HDR CAMERA x40

HDR TRUCK

HDR DISTRIBUTION

HDR TV

SDR CAMERA x40

SDR TRUCK

SDR DISTRIBUTION

SDR TV
Live events and sports HDR workflow

- HDR TRUCK
- HDR DISTRIBUTION
- SDR DISTRIBUTION
- Convert HDR>SDR
- HDR TV
- SDR TV

HDR CAMERA x40

$ $ $ $
Long Term Vision – All HDR Production

Option 1 = $$$$
Near Term Vision – Hybrid HDR Production

- **Near Term Vision – Hybrid HDR Production**

- **HDR** and **SDR**

- **SINGLE DISTRIBUTION** (SDR Video + Metadata)

- **PRODUCTION TRUCK**

- **HDR TV**

- **SDR TV**

- **Convert SDR > HDR**

- **Option 2 = $ $ $**
Available Today – 2016 HDR Production

Convert SDR>HDR

HDR and SDR SINGLE DISTRIBUTION (SDR Video + Metadata)

Option 3 = $
ATSC 3.0 - Distribute to everyone

HDR and SDR
SINGLE DISTRIBUTION
(SDR Video + Metadata)
BACKUPS
Technicolor @ IBC 2015

Live capture of 4K, High Frame Rate (60p) video

Real-Time up conversion to HDR using ITM

Encoding to HEVC with Technicolor Single Stream HEVC distribution system

Playback of 4K, 60p, HDR

Simultaneous playback of 4K, 60p, standard dynamic range from same signal

Live capture of 4K, High Frame Rate (60p) video
Technicolor Prime – Delivers all HDR content

Content Production

Live Content Capture
(eg. S-Log EOTF @1000nits REC-709)

Studio Masters
(eg. PQ EOTF, SMPTE 2086 metadata, @1000nits D65-P3)

Dolby Masters
(eg. PQ EOTF, SMPTE 2086 metadata, @4000nits D65-P3)

Licensed Broadcast Masters
(eg. HLG, @1000nits REC2020)

Legacy SDR Material
(eg. 100nits REC-709)

Content Distribution

CMS

Playout Server

technicolor PRIME Encoder

Distribution Systems
(QAM, IP, 4G/5G, OTT)

technicolor PRIME Decoder

Consumption

Dynamic metadata (MPEG SEI standard message) created and consumed only for delivery

Requires no mandatory metadata at content creation or rendering stage
Millions of hours of SDR Content Created

Expand the dynamic range of SDR content to improve visual experience while preserving artistic intent

*simulated images
Tone Mapping & Inverse Tone Mapping

Digital Intermediate/Color Grading/Tone Mapping

Inverse Tone Mapping

Horizontally

Luminance

Luminance

Color Space

Color Space

SDR Deliverables

Eg. REC-709 100 nits for Blu-ray

Raw capture and created video elements

Higher Dynamic Range Deliverables
Eg. P3 @ 1000 nits