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Video Standards

Signals, Formats and Interfaces

Part 12

HDR – Opportunities, Guidelines, Pitfalls

www.videoq.com

Multi-format Content Assets – Automated Monetization

When you launch a **new HDR project** you have to ask yourself one important question:

Q: Which grade first?
A1: **HDR first**. Why? Most exciting version first then SDR grades from the HDR version; *PQ or HLG? For a live outdoor coverage it must be HLG.*
A2: **SDR first**. Why? Do the money-making (**now**!) version first, then make HDR 're-using' the LOG master files (*OK for HLG, but hard for PQ*).
A3: **HDR and SDR** graded independently from a master media. Why? You'll get the highest quality for both versions, *but it is slow and expensive*. *Some colorists find it difficult to grade both HDR and SDR; it's like swimming after riding the bicycle – body movements are too different.*
Amazingly enough **all 3** answers are **wrong**, though they have been formulated by the knowledgeable industry experts.

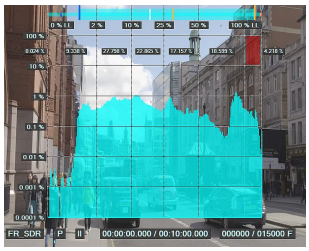
Correct answer:
A4: **HDR-PQ** *or* **HDR-HLG** graded first (*PQ or HLG depending on the program type),* thus producing a **future-proven content asset**, then **automated cross-conversion** to other flavors of HDR and **automated down-conversion** to SDR (you'll need a good **Converter**), then **automated QA/QC** of the resulting files and final quick checks/adjustments **by a human operator** – *only if necessary*.

For such cost-effective semi-automatic workflows VideoQ has created **VQPT** – suite of software tools providing for **robot assisted human decisions.**

3840x2160 **UHD** 1,000 nit **HDR-PQ manually graded** original converted to anamorphic 16:9 720x576 **SD SDR** via **manual tone-mapping**.

Resulting SDR version exhibits severely clipped cloud gradations, de-saturated sky color and unnaturally light tarmac tone.

See next slide for more details …



Video images – courtesy of newsbyte.co.uk

Content Conversion – Manual, Semi-Automatic, Automated

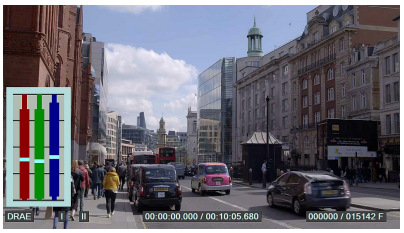
Mixed HD/UHD and SDR/HDR environment requires software and hardware engines for auto-enhancement, up-, down- and cross- conversion within and/or between all formats:
SD SDR, **HD SDR**, **HD HDR**, **UHD SDR** and **UHD HDR** (*and don't forget various flavors of HDR*).

Rendition of HDR images by HDR displays relies on the corresponding metadata;
in fact, without such metadata proper rendition of HDR images is not possible.

In this situation software and hardware tools calculating / measuring actual content light levels statistics, normalizing / mapping image gradations, checking, adjusting and editing metadata, are vitally important.

Such tools are required for R&D, product verification, content production, post-production and distribution.

HDR-PQ to SDR by the **VideoQ Adaptive LUT**



Good for living room, full contrast, no clipping

HDR-PQ 1,000 nit as by the **HDR10** metadata

Good for home theater, too dark for living room

Manual SDR color grading

Image too bright, reduced saturation, white crush

Limited to 500 nit as by the **HDR10+** metadata

Good compromise, but still a bit too dark

Video images – courtesy of newsbyte.co.uk

HDR-PQ Metadata & HDR Display

There are two extreme cases of the interaction between HDR-PQ content metadata and HDR display (*e.g. two **HDR10** modes of operation*)

1. Dictatorship:
- Metadata tell the display what to do and do not offer **any options**. So-to-say "one way street" or "master-slave relations".
- Pro: Simple scheme, display **must** render any content **as instructed**.
- Contra: Not enough **flexibility**, any **discrepancy** between declared content parameters and display features **is a problem**.

2. Unlimited freedom (*aka Anarchy*):
- Metadata tell display about the values of content parameters and don't offer **any instructions**. This is yet another "one way street".
- Smart display should find the **optimal rendering mode** itself, following the **instructions provided by its designers**.
- Pro: Simple scheme, display can render **any content**, but the actual EOTF will be as the **display designers** found appropriate.
- Contra: Content originator should forget about the **intended look**. Display may render HDR images in absolutely unpredictable way.

So, what is the optimal way between two extremities? It make sense to check how **similar problems** been resolved by colleagues.

The IPTV was facing similar problems in attempt to deliver the best possible images via the **unpredictable** Internet connections.
The solution found was to offer the smart player a **menu** of various frame sizes and bitrates – so called **bitrate ladder**.
A player permanently checks current bandwidth status, then select and **request** from the server the **most appropriate** video format on chunk-by-chunk basis.

HDR 10+

This is the **third and optimal way** – Limited freedom.

In this case the HDR content originators are still in control of the **intended look**, though it may split into **few variants**.
The **HDR10+ alliance** is planning to use this approach for LAN / WAN delivery of HDR content to a **variety of displays** with **different** features.

There are little chances that such approach will be used with application to the **broadcast delivery**, where **HLG** is the most appropriate format.

HDR10 & HDR10+

HDR10 metadata provide the **HDR display** with a bizarre mixture of **irrelevant**, **insufficient** and **really useful** values:

HDR 10

Mastering display color primaries:
R:x=(0.708)y=(0.292)
G:x=(0.17)y=(0.797)
B:x=(0.131)y=(0.046)
White point:x=(0.3127)y=(0.329)
Mastering display luminance:
Min:0cd/m2,
Max:1000cd/m2

OK, thank you, now we know that **some colorist** used **this type of monitor** for color grading.
This info was maybe useful for the other team members performing QA/QC or editing,
But, what should a supposedly "smart" **TV** do with this information?
Shall the TV refuse to show this movie if its screen brightness is lower or higher than 1,000 nt?
And what do you do if the display screen is of LCD type, i.e. not capable of rendering 0.001 nit?

Maximum Content Light Level(MaxCLL):800cd/m2
Maximum Frame-Average Light Level(MaxFALL):400cd/m2
Color primaries:Rec. ITU-R BT.2020
Transfer Characteristics:SMPTE ST 2084
Matrix Coefficients:ITU-R BT.2020 non-constant luminance system

At first, this looks like **useful info**. But **MaxCLL** is the light level of the **brightest pixel** within thousands of frames.
Thousands of 800 nt **pixels in all frames** are symptoms of massive clipping, but just **one pixel in** just **one frame** means **nothing**, i.e. MaxCLL should be **ignored**.
MaxCLL value is 800 nt, or it is 10,000 nt – why it should affect the **TV** behavior?

Only these two lines are **really useful** – display must enable **particular** EOTF **LUT** and YUV ⇒ RGB conversion **matrix**.

MaxFALL value **may** serve as a hint or **warning** – "this piece of content contains a number of relatively bright frames with the average level ≈ 400 nt", but the **durations** of bright frames **sequences** are **unknown**, and what shall **TV** do with this warning?

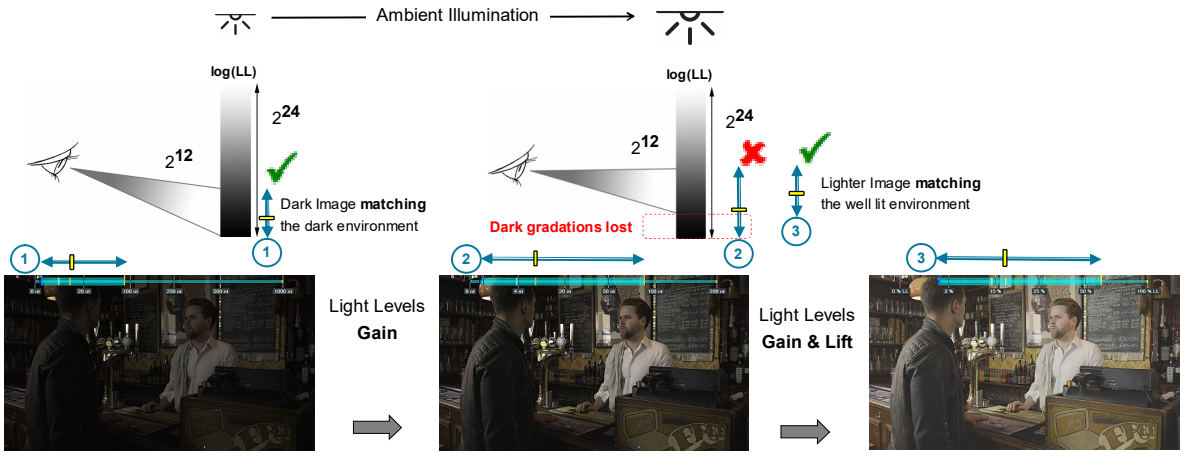
HDR10 is "optimized" only for the **brightest scene** – this is the so called **Static Tone Mapping**.
HDR10+ is a **backward compatible extension** of HDR10.

HDR 10+

SMPTE ST 2094 standard defines **D**ynamic **M**etadata for **C**olor **V**olume **T**ransforms (**DMCVT**) format *for* HDR10+ *and other HDR flavors*
DMCVT provides for optimization of **each scene** by **suggested modification of the EOTF in the display**, *but this is easier to say that to do.*
The ST 2094 standard does not define the methodology or algorithm of **DMCVT metadata derivation**; this is up to the content originators.
Content encoded in HDR10+ will also play back on **HDR10 devices**. The HDR10+ dynamic metadata will be **ignored**.

Ambient Illumination & Video Image Dynamic Range

When the **ambient illumination light level** goes up, the **logarithmic range of visible gradations** does not increase nor decrease, it **moves upwards**.
Therefore, to provide the best **viewing comfort** all gradations of the **rendered video image** must also go up, **following the visible range**.
It is relatively easy to fit the smart TV with the **ambient illumination sensors**.
The challenge is to find the optimal light levels **re-mapping algorithm**, i.e. to provide **ambient light adaptive EOTF** functionality.



Video images – courtesy of newsbyte.co.uk

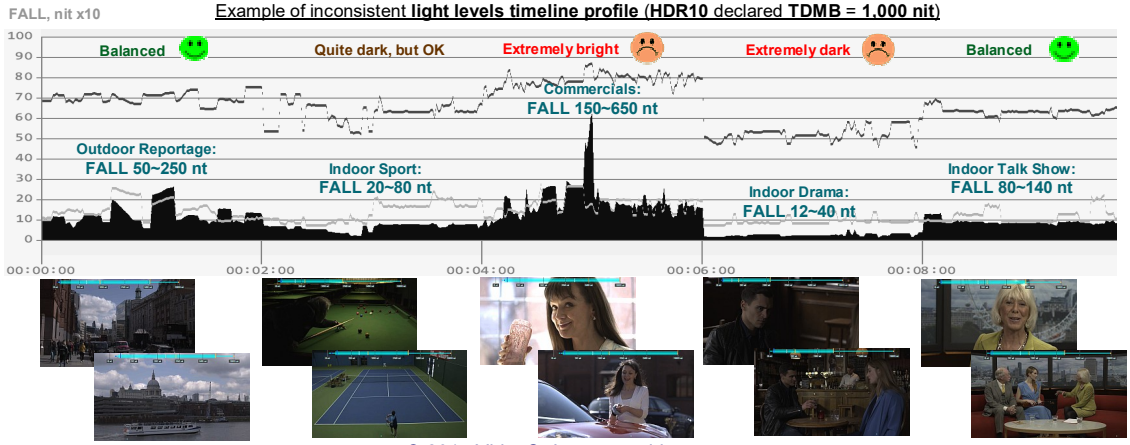
HDR Content Viewing Comfort

Whilst we think about the maximum viewing comfort, called **QoE** or **Q**uality **o**f **E**xperience, we should be guided by two slogans:

1. Consistency is more important than performance. I.e. a **consistent** '4' quality mark all the time is better than '5','3','5' up-down-up variation.
E.g. in the DC industry **sweetening** means adjustments for **consistent** colors, voice pitches, loudness, etc. – all movie segments from start to finish.

2. A Happy Viewer is the only measure of success.

For the **HDR-PQ** content the list of parameters for consistency checks should include the **F**rame **A**verage **L**ight **L**evel (**FALL**).



Video images – courtesy of newsbyte.co.uk

HDR Displays & HDR Content Safety

SDR content could be good or bad, but, except the special case of periodic red flashes, it was never thought to be **dangerous**.

With the arrival of new bright screens the **excessive brightness** may become a global problem similar to the **excessive audio content loudness**, which was put under control only few years ago. Whilst displaying SDR or HDR-HLG content on HDR screen the **average absolute** brightness is **unspecified** and **unlimited**; For the HDR-PQ it is specified, but not restricted. *So far, in terms of standardization or regulations this is a "Gray Zone".*

Without appropriate **control** and **restrictions** HDR content may be dangerous in several aspects:
- High brightness and high contrast cause **eye fatigue** – quite strong in case of short viewing distances and large angles of view (UHD!)
- Long high brightness segments significantly increase **power consumption** of UHD HDR TVs and **battery discharge** of mobile devices
- Long high contrast segments and large areas of saturated colors may cause HDR LCD screens **overheating**

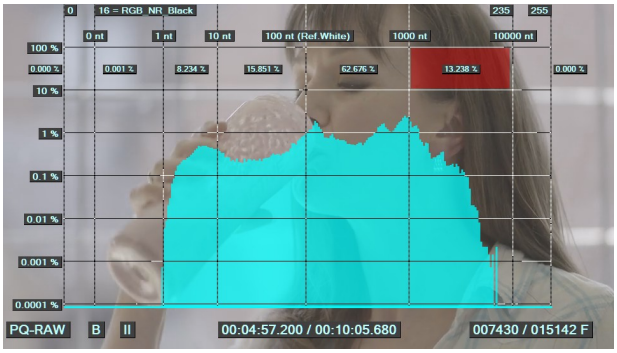
This HDR-PQ content example (commercial advertisement) shows what may happen in absence of any rules.

Frame Average Light Level = **650 nit**, i.e. extremely high.

More than 13% of video frame pixels are brighter than **1,000 nit**.

The 10 percent of the screen area brighter than 1,000 nit is often quoted as the *de-facto* **safety threshold** of modern displays.

Of course, the TVs manufacturers already designed the **overload and overheat protection schemes**, but this safety measures bring us back to the issue of **unpredictable** display behavior, so the content originators may forget about the **intended look**.



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About This Presentation

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"Video Standards: Signals, Formats and Interfaces" by Victor Steinberg
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For further reading we recommend wikipedia.org

About VideoQ

Company History

- Founded in 2005
- Formed by an Engineering Awards winning team sharing between them decades of global video technology.
- VideoQ is a renowned player in calibration and benchmarking of video processors, transcoders and displays, providing tools and technologies instantly revealing artifacts, problems and deficiencies, thus raising the bar in productivity and video quality experience.
- VideoQ products and services cover all aspects of video processing and quality assurance - from visual picture quality estimation and quality control to fully automated processing, utilizing advanced VideoQ algorithms and robotic video quality analyzers, including latest UHD and HDR developments.

Operations

- Headquarters in Sunnyvale, CA, USA
- Software developers in Silicon Valley and worldwide
- Distributors and partners in several countries
- Sales & support offices in USA, UK