



# **Dolby Vision**

# **UHD Blu-ray Authoring Workflow Guide**

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# Table of Contents

<b>1</b>	<b>OVERVIEW</b> .....	<b>4</b>
1.1	DOLBY VISION MASTER AND DOLBY VISION MEZZANINE DELIVERABLES .....	4
<b>2</b>	<b>RECOMMENDED HARDWARE FOR TESTING</b> .....	<b>5</b>
<b>3</b>	<b>CONTENT MAPPING (CM)</b> .....	<b>6</b>
3.1	UHD BLU-RAY AUTHORIZING .....	6
<b>4</b>	<b>VERIFYING DOLBY VISION SOURCE DELIVERABLES</b> .....	<b>7</b>
4.1	SOURCE DELIVERABLES TYPES .....	7
4.2	METADATA VALIDATION .....	7
4.2.1	<i>Validating global metadata</i> .....	7
4.2.2	<i>Validating dynamic metadata</i> .....	8
4.2.3	<i>Checking shot boundaries</i> .....	8
<b>5</b>	<b>ENCODING</b> .....	<b>9</b>
5.1	WORKING WITH THE BASE LAYER AND ENHANCEMENT LAYER .....	9
5.2	DOLBY VISION UHD BLU-RAY BITRATE RECOMMENDATIONS .....	11
5.2.1	<i>Bitrate ratio recommendations between base layer and enhancement layer</i> .....	11
5.2.2	<i>Dolby Vision UHD Blu-ray options</i> .....	12
5.3	VALIDATING THE DOLBY VISION VIDEO ELEMENTARY STREAM.....	14
5.4	VISUAL QC FOR DOLBY VISION .....	14
5.4.1	<i>Comparing Dolby Vision video elementary stream to mezzanine</i> .....	14
5.4.2	<i>Dolby Vision specific checks</i> .....	14
<b>6</b>	<b>AUTHORIZING</b> .....	<b>16</b>
6.1	DOLBY VISION GRAPHICS PRIORITY MODE.....	16
6.1.1	<i>Controlling Graphics Priority mode</i> .....	16
6.1.2	<i>Graphics Priority mode testing</i> .....	17
6.1.3	<i>Recommendations for using Dolby Vision Graphics Priority mode</i> .....	18
6.2	DUAL PLAYLIST FOR IMPROVED BACKWARDS COMPATIBILITY .....	18
<b>7</b>	<b>CHECKING THE DIGITAL DISC IMAGE AND PHYSICAL DISC</b> .....	<b>19</b>
7.1	CHECKING THE DISC IMAGE FOR DOLBY VISION SYNTAX.....	19
7.2	CHECKING VISUAL APPEARANCE AND PLAYBACK .....	19

# 1 Overview

This document describes Dolby Vision-related information and testing components to incorporate in standard practices and procedures for Dolby Vision UHD Blu-Ray authoring.

## 1.1 Dolby Vision master and Dolby Vision mezzanine deliverables

Dolby Vision masters and Dolby Vision mezzanines require these components:

- HDR images in SMPTE ST.2084 (Perceptual Quantization or *PQ*)
  - Delivered as high bitrate MXF JPEG2000 image files
  - Rec.2020 or P3D65 color gamut
- Dolby Vision metadata describing several aspects of the content:
  - Mastering Monitor metadata, or Level 0 metadata, describing the mastering monitor; that is color primaries, white point, peak luminance, and minimum luminance.
  - Static metadata:
    - Level 6 – Recommended but optional
      - The MaxCLL element should be the Maximum Clip Light Level specified by CTA 861.3.
      - The MaxFALL element should be the Maximum Frame Average Light Level specified by CTA 861.3.
  - Dynamic, or scene-based metadata:
    - Level 1 - For each shot, the  $\min \leq \text{avg} \leq \text{max}$  values that describes the amount by which the shot must be mapped
    - Level 2 - Recommended but optional
      - You can view the results of the automatic content mapping at targets (for example. Rec.709/1886, HDR10). For each target, you can optionally apply lift, gain, gamma, and saturation adjustments to shots. This lets the colorist control mapping so that any automatic method shortcomings can be corrected during mastering.
    - Level 5 – Recommended but optional
      - Canvas and Image aspect ratios saved as global values and can be overridden per shot if necessary.
      - Ensures that letter/pillar bars are not mapped away from darkest black

## **2 Recommended hardware for testing**

Obtain the following for testing:

- Oppo UDP-203 Dolby Vision compatible Blu-ray player
- LG OLED C7-series or newer Dolby Vision compatible TVs

## **3 Content Mapping (CM)**

The Dolby Vision system uses the same Dolby Vision Content Mapping algorithm in the color suite, the Dolby Vision Professional Encoder, and in Dolby Vision enabled consumer devices. A colorist can adjust the mapping parameters shot-by-shot to ensure the optimal appearance of the Rec709, HDR10, and Dolby Vision versions of a title. On compatible devices, Dolby Vision mapping can interpolate the colorist's adjustments to achieve the best possible mapping, whether on a Rec709 SDR TV, a 500 nit Tablet, today's HDR TVs, or next generation displays.

For UHD Blu-ray, some studios prefer to use HDR10 playback that is a signed-off version that is capped at 1000 nits. Content Mapping creates this base layer on Dolby Vision compatible discs, so that playback on existing displays, which are usually sub-1000 nit, has a less difficult tone-mapping task. In addition to the HDR10 base layer, Dolby Vision discs have an enhancement layer that contains the data to get from the HDR10 to the full pixels of the Dolby Vision master, with 12-bits per color channel. Dolby Vision TVs use this enhancement layer so that mapping is done from the full master range, which may be as high as 4000 nits peak.

### **3.1 UHD Blu-ray authoring**

Because a Dolby Vision master typically represents multiple signed-off content versions that are based on one set of image files, there is more up-front verification and post-encode quality control (QC) required than for traditional single-target formats. This document describes some of the important steps to follow to make sure that Dolby Vision UHD Blu-ray discs are correct for both the HDR10 version and Dolby Vision.

## 4 Verifying Dolby Vision source deliverables

When you receive a Dolby Vision deliverable, perform these basic checks to avoid having to re-encode and perform multiple QC passes later in the process.

### 4.1 Source deliverables types

Dolby Vision sources can be delivered as:

- MXF source with interleaved metadata
- MXF source with sidecar XML metadata
- ProRes source with sidecar XML metadata

### 4.2 Metadata validation

Dolby Vision metadata can be validated in either XML or interleaved MXF. When receiving an interleaved MXF deliverable, the metadata can be edited in a third-party application that is Dolby Vision enabled, such as Rohde & Schwarz Clipster, Colorfront Transkoder, or MTI Cortex. The metadata must be extracted from the MXF to XML before it can be edited. Once editing is finished, it can then be rewrapped back into the original MXF or used as a sidecar.

Use the Dolby Vision Professional Tools kit that can be licensed from Dolby to validate metadata. Specifically, the kit's metafier tool extracts metadata from a MXF, performs a high-level verification of the metadata, and re-wrap the metadata. This tool identifies common issues in the metadata and alerts the user to any issues. Some of these issues can be resolved on-site, while other issues may require the studio to fix and/or redeliver the asset.

For details on the checks performed and instructions on how to use the metafier tool, see the *Dolby Vision Professional Tools User Manual*.

#### 4.2.1 Validating global metadata

Check that the metadata has the correct global metadata values, and that these match what the studio intended. Global metadata include:

- Mastering display
- Frame rate
- Global aspect ratios
- Color encoding information

For MXF with interleaved metadata, run the metafier tool's validation function on the MXF. However, if any issues are identified, the metadata must be extracted before it can be fixed, and then re-wrapped into the source MXF. Alternatively, the XML can be used as sidecar.

In the case of multiple reels with per-reel XMLs, check that all reels have the same global metadata values.

### 4.2.2 Validating dynamic metadata

The Dolby Vision Professional Tools metafier tool checks L1 and L2 dynamic metadata and validates that the values are within the legal ranges. This check does not guarantee the quality of the output images when mapped.

### 4.2.3 Checking shot boundaries

While the metafier tool checks for gaps and overlapping shots in the metadata, it does not verify shot boundaries with the image sequence. To verify shot boundaries, perform a manual check as follows:

1. Find a few shot entries in the XML at the start, middle, and end of the file.
2. Find the `<Record><In>` *value* for each entry.
3. Check the image sequence at the same points to make sure that there is a cut between frame number *value* and the preceding frame.

If there is no cut in the image sequence, the metadata is likely out of sync when compared to the image sequence frame numbers. If this occurs, the XML must be re-delivered.



## 5 Encoding

Dolby Vision UHD Blu-ray is supported by the Dolby Vision profile 7 dual layer encoding approach which supports both HDR10 and Dolby Vision compatible devices. Profile 7 complies with UHD Blu-ray Disc HDR specifications. The HDR10 compatible layer (or base layer) allows non-Dolby Vision HDR10 decoders to decode and playback a Dolby Vision signal in HDR10.

- The base layer essence is a 10-bit video bitstream of the full picture element with HDR10 standards that enables compatibility with HDR10 devices.
- The enhancement layer essence is a 10-bit video bitstream that carries the residual between the mezzanine source and the base layer and the dynamic metadata for Dolby Vision.
  - An enhancement layer that carries a residual signal equal to zero, that is, the decoder does not need to process the residual signal, is called minimum enhancement layer (MEL).
  - If the enhancement layer carries a residual signal not equal to zero, it is called full enhancement layer (FEL).

Dolby Vision UHD Blu-ray options include:

- **No Mapping with MEL** - No content mapping is applied to the HDR10 base layer.
- **No Mapping with FEL** - No content mapping is applied to the HDR10 base layer.
- **Mapping to 1000 nits with FEL** - Maps the HDR10 base layer to 1000 nits.

**NOTE:** Do not use Mapping to 1000 nits if the master is graded using a 1000 nit mastering display.

- **Mapping to 1000 nits for UHD content at 50fps or higher** - Maps the HDR10 base layer to 1000 nits. For UHD at 50 fps or higher content, the enhancement layer must use a minimal enhancement layer (MEL) to provide performance efficiency.

**NOTE:** Do not use Mapping to 1000 nits if the master is graded using a 1000 nit mastering display.

- **Mapping to 600 nits with FEL** - Maps the HDR10 base layer to 600 nits.

### 5.1 Working with the base layer and enhancement layer

Confirm whether the base layer is the master image or if the studio requires mapping to a specific target; for example, No Mapping with MEL or Mapping to 1000 nits with FEL.

- Ateme Titan File (v3.9.2.0 and newer) can support one of the following options:
  - **No Mapping with MEL**
  - **No Mapping with FEL**
  - **Mapping to 1000 nits** – Ateme Titan File automatically uses FEL unless the Dolby Vision master is greater than 50 fps, in which MEL is used. In this case, user does not need to select FEL or MEL because Ateme Titan File handles it internally.
  - **Mapping to 600 nits with FEL**



- If mapping the base layer is desired, make sure the HDR10 base layer has the correct ST.2086 metadata:
  - By default, the encoder should populate the mastering display peak brightness field with the mapping target display peak brightness value.
  - Level 6 metadata - MaxFALL and MaxCLL should either be specified by the studio without re-calculation after the mapping, or the encoder can recalculate these values from the mapped base layer.

## 5.2 Dolby Vision UHD Blu-ray bitrate recommendations

The following bitrate recommendations are based on maximum video bitrates defined in *System Description Blu-ray Disc Read-Only Format, Part 3: Audio Visual Basic Specifications, Version 3.0*. The total bitrate for UHD Blu-ray can be 100 Mbps or 50 Mbps per this spec.

Dolby Vision UHD Blu-ray bitrate recommendations are mainly based on MEL or FEL regardless of whether the base layer is mapped or not mapped.

### 5.2.1 Bitrate ratio recommendations between base layer and enhancement layer

The overall total bitrate allocation should consider account overhead, such as watermarking and metadata carriage, for the bitrate ratio between the base layer and enhancement layer.

#### 5.2.1.1 MEL recommendations

In the following base layer and MEL bitrate allocation recommendations, the ratio between base layer and MEL are fixed and scaled linearly based on the total bitrate target.

- Bitrate ratio: (98% base layer and 2% MEL) to (99.5% base layer and 0.5% MEL)
- Recommended defaults for a total 100 Mbps:
  - Base layer: 99.5 Mbps
  - MEL: 0.5 Mbps
- Recommended defaults for a total 50 Mbps:
  - Base layer: 49.75 Mbps
  - MEL: 0.25 Mbps

### 5.2.1.2 FEL recommendation

In the following base layer and FEL bitrate allocation recommendations, the ratio between base layer and FEL are fixed and scaled linearly based on the total bitrate target.

- Bitrate ratio: (80% base layer and 20% FEL) to (95% base layer and 5% FEL)
- Recommended defaults for a total 100 Mbps:
  - Base layer: 85 Mbps
  - FEL: 15 Mbps
- Recommended defaults for a total 50 Mbps:
  - Base layer: 42 Mbps
  - FEL: 8 Mbps

## 5.2.2 Dolby Vision UHD Blu-ray options

### 5.2.2.1 Choosing FEL or MEL

Both FEL and MEL will contain approved target trims for SDR, 1000-nit, 4000-nit in metadata.

- Content mastered on a 4000-nit mastering display
  - For a base layer with lower peak luminance, such as 1000 nits, FEL is required for reconstruction of 12-bit signal.
  - To keep the base layer at 4000 nits, Dolby recommends using MEL.
- Content mastered on a 1000-nit mastering display

Dolby recommends using MEL since a base layer of 1000 nits can carry the full mastering peak luminance

	Pros	Cons
MEL	Faster processing time to produce good video quality and less disc space required	Not for studios who are concerned about losing any information from 12-bit master Can't recreate the 12-bit signal Can't recreate the 4000-nit signal from the 1000-nit mapped base layer
FEL	Better video quality Can recreate the 12-bit signal* Can recreate the 4000-nit signal from the 1000-nit base layer	Longer processing time to produce and more disc space required

\* 12-bit performance varies depending on the base layer resolution, content type, enhancement layer bit rate, and the scene information.

### 5.2.2.2 Choosing No Mapping or Mapping

	<b>Pros</b>	<b>Cons</b>
No Mapping	Future proof solution to get full video quality from the 4000 nits or 1000 nits master despite capability of HDR displays today	Limited to the capability of current HDR displays. Therefore, consumers may not see the full benefit of no mapping
Mapping	Include the capability of current HDR displays (most less than 1000 nits)	Does not provide future proof the quality is not as good as no mapping on displays beyond 1000 nits and those future displays

## 5.3 Validating the Dolby Vision Video Elementary Stream

For Dolby Vision UHD Blu-ray authoring, the input always contains separate base layer and enhancement layer with interleaved Reference Processing Unit (RPU) files. The RPU is the container for Dolby Vision metadata for display management.

Use can run the Dolby Vision Bitstream Verifier tool, specifying both the base layer and enhancement layer with RPU files as input. This tool performs comprehensive syntax and metadata checks of the base layer, enhancement layer and RPU to avoid potential issues.

You can obtain the Dolby Vision Verification Toolkit that includes the Dolby Vision Bitstream Verifier and Dolby Vision Blu-ray Verifier from <https://developer.dolby.com/dolby-professional/professional-products/dolby-vision-verification-toolkit/>

See the *Dolby Vision Bitstream Verifier User Manual* for details about the checks performed, options, and instructions on using the Dolby Vision Bitstream Verifier tool.

## 5.4 Visual QC for Dolby Vision

### 5.4.1 Comparing Dolby Vision video elementary stream to mezzanine

Use one of the following tools to perform a side-by-side comparison of Dolby Vision video elementary stream and mezzanine: Resolve, Transkoder, Cortex, Clipster or Fraunhofer EasyDCPPlayer connected to an optional Dolby Vision eCMU and reference display over SDI.

Select the source target to the closest target display for the Dolby Vision TV used to check the encoded file.

This results in a near comparison as the Dolby Vision eCMU target may not exactly match the TV specifications and the reference monitor may not be using the same display technology.

Alternatively, visual QC can also be performed using a Dolby Vision TV. Transkoder, Cortex, and Clipster supports the playback of a Mezzanine through HDMI Tunneling that is connected to a Dolby Vision TV. Other tools can connect to the eCMU and use the HDMI Tunneling output of the eCMU. The HDMI Tunneling enables sending full pixel output and metadata to the TV and the TV maps to its capabilities. For more information on HDMI Tunneling, refer to the *Dolby Vision Best Practices Color Grading* guide.

### 5.4.2 Dolby Vision specific checks

Carefully check the following items when checking Dolby Vision:

- **Errors in L5 Active Area (letterbox)**

If the L5 Active Area is incorrect in the RPU, the image can appear as an unprocessed picture; usually as thin bands at top or bottom of active area, or lifted letterbox areas.

- **Out of sync metadata**

Metadata that is out of sync usually results in unexpected brightness changes in the middle of many shots.

- **Out of sync enhancement layer**

An enhancement layer that is out of sync usually results in a ghost image superimposed on the base layer.

## 6 Authoring

### 6.1 Dolby Vision Graphics Priority mode

When graphics are the focus onscreen, it is desirable to program the UHD Blu-ray Disc Player to optimize the picture accordingly. Properties are now available to Blu-ray Disc Java (BD-J) programmers to explicitly switch between these modes.

**Note:** In HDMV mode, graphics priority is the default setting.

To maintain a consistent graphics and brightness level, a disc author can invoke Graphics Priority mode when graphics are present. The video is still rendered well, although certain advanced picture rendering technologies are disabled. Therefore, it is important to keep playback as the default Video Priority mode whenever graphics are not present, as well as for certain kinds of graphics, such as subtitles.

#### 6.1.1 Controlling Graphics Priority mode

Only use Dolby Vision properties when the system is playing Dolby Vision content on a Dolby Vision-compatible television.

1. Verify Dolby Vision compatibility by verifying the following Player Status Registers:
  - PSR25 indicates the UHD Blu-ray Disc on a UHD Blu-ray Disc Player is UHD/HDR compatible.
  - PSR26 indicates the UHD Blu-ray Disc Player is connected to a Dolby Vision television.
  - PSR27 -indicates that HDR Output Preference is set for Dolby Vision.
2. Verify that Graphics Priority mode is available by checking the read-only property.

```
dolbyvision.graphicspriority.available = true
```

This parameter indicates that the UHD Blu-ray Disc Player supports Graphic Priority mode (true) or does not support this mode (false). If the property does not exist, the property returns null, and Graphics Priority mode cannot be invoked.

3. If `dolbyvision.graphicspriority.available` is true, Graphics Priority can be invoked

```
if (System.getProperty("dolbyvision.graphicspriority.available") == "true") {  
    // the property exists, so it can be enabled  
    System.setProperty("dolbyvision.graphicspriority.enabled", "true");  
}
```

4. To return to Video Priority mode, enter:

```
if (System.getProperty("dolbyvision.graphicspriority.available") == "true") {  
    System.setProperty("dolbyvision.graphicspriority.enabled", "false");  
}
```

Because the property is also readable, you can check which mode is active:



```
if (System.getProperty("dolbyvision.graphicspriority.enabled") == "true") {
    // Graphics Priority enabled, so proceed accordingly..
}
if (System.getProperty("dolbyvision.graphicspriority.enabled") == "false") {
    // Video Priority enabled, so proceed accordingly..
}
```

### 6.1.2 Graphics Priority mode testing

These tests verify that the Dolby Vision UHD Blu-ray disc player successfully displays interactive graphics without significant brightness fluctuations during scene transitions.

There should be no major fluctuations in the graphics appearance, even when the underlying video goes through scene changes.

These tests verify that the Dolby Vision UHD Blu-ray Disc Player supports graphics priority mode. They also allow you to check the graphics' appearance when graphics priority mode is enabled.

#### Preconditions

Setup 1: Dolby Vision UHD Blu-ray Disc Player with two HDMI outputs

- Obtain two HDMI cables, and connect the main HDMI port of the Blu-ray player to any of the HDMI ports on the Dolby Vision TV.
- Using the second HDMI, connect the audio output port of the Blu-ray player to any of the input ports on the Dolby Vision-compatible sound bar or AVR.

Setup 2: Dolby Vision UHD Blu-ray Disc Player with one HDMI output

- Obtain two HDMI cables, and connect the HDMI output of the Blu-ray player to the input of the Dolby Vision-compatible AVR.
- Using the second HDMI, connect the Dolby Vision-compatible AVR's HDMI output to a Dolby Vision HDMI input.

#### Test Procedure

1. Insert the appropriate test disc into the UHD Blu-ray Disc player under test. The Top Menu appears with a list of test suites.
2. Navigate to the test clips listed in the Test Suite table and play that clip.

## Expected Results

1. The `dolbyvision.graphicspriority.available = "true"` displays on the test disc, indicating that the Dolby Vision UHD Blu-ray Disc Player supports graphics priority mode.
2. The `dolbyvision.graphicspriority.enabled = "true"` displays when you toggle the player with the remote, indicating that graphics priority mode is enabled or disabled.
  - When a BD-J application sets the property to **true**, the Dolby Vision UHD Blu-ray Disc Player goes into graphics priority mode.
  - When a BD-J application sets the property to **false**, the Dolby Vision UHD Blu-ray Disc Player goes into video priority mode.
  - When graphic priority mode is enabled, there should be a change in the colors of the graphic bar displayed on the screen.
  - The graphics should display without artifacts.

### 6.1.3 Recommendations for using Dolby Vision Graphics Priority mode

Before working with Graphics Priority mode, make sure that the Blu-ray player is Dolby Vision capable. If not, do not use Graphics Priority mode. If the Blu-ray player is Dolby Vision capable, additionally check whether it supports Graphics Priority mode. If not, do not use Graphics Priority mode.

Some Blu-ray players contain old firmware that does not support Graphics Priority mode. By default, do NOT invoke Graphics Priority mode (in other words, reset the Java property for disc loading, playback or beginning of main movie.). This is important as Java properties can get stored in persistent memory and stay with the player upon reboot otherwise.

- When not displaying graphics, do not invoke Graphics Priority mode.
- If the only display graphic is a subtitle, do not invoke Graphics Priority mode (Though not obvious, this is important).
- Invoke Graphics Priority mode for large graphics, such as the pop-up menu or main menu.
- Always reset to Video Priority mode when the large graphics go away, such as when the user exits the pop-up menu.

## 6.2 Dual playlist for improved backwards compatibility

Dolby highly recommends that Dolby Vision UHD Blu-Ray discs are authored with a dual playlist, so that non-Dolby Vision Blu-ray disc players can bypass the enhancement layer for HDR10 playback. Device firmware versions vary and dual playlist provides the most player compatibility.

A dual playlist includes:

- One playlist for Dolby Vision
- One playlist for non-Dolby Vision HDR10 players

## 7 Checking the digital disc image and physical disc

### 7.1 Checking the disc image for Dolby Vision syntax

Use the Dolby Vision Blu-ray Verifier (available from <https://developer.dolby.com/dolby-professional/professional-products/dolby-vision-verification-toolkit/>) to test a disc image for Dolby Vision syntax and elements conformance. .

In addition, you can optionally verify that the included streams are Dolby Vision Profile 7 (UHD BDA) compliant as described in [Validating the Dolby Vision Video Elementary Stream](#).

See the *Dolby Vision Blu-ray Verifier User Guide* for more information on using the tool.

### 7.2 Checking visual appearance and playback

In addition to standard practices for Blu-ray QC, additional perform testing in the beginning for Dolby Vision UHD Blu-ray discs.

Thoroughly test the deliverable with Dolby Vision UHD Blu-ray disc players and non-Dolby Vision UHD Blu-ray disc players for backwards compatibility until there is confidence that there are no playback issues from the established workflow.

We recommend that titles go through visual QC in their entirety for:

- Playback smoothness
- A/V sync
- System menus, pop-up menus, and graphical overlays
- Fast forward, rewind, and chapter skip
- Multi angle features (if present)