Dolby Vision
Color Grading Best Practices Guide

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1 Introduction

The objective of this document is to provide information and clear guidelines for creating the best possible Dolby Vision HDR Master and the Dolby Vision Dynamic Metadata using a color correction system. It is assumed that the source material used for this purpose will be of the highest quality available and the system is running the released Dolby Vision version of software.

The Dolby Vision content creation process involves the following steps. Steps 1, 2 and 4 are required.

1. Create the HDR Master
2. Create Level 1 (L1) Analysis Dolby Vision Metadata
3. Optionally apply creative Level 2 (L2) Trim Metadata
4. Create Deliverables

2 Creating the HDR Master

Creating the HDR master involves using images in the highest quality, coloring on an approved Dolby Vision enabled color corrector and monitoring on a reference grade professional HDR monitor.

2.1 Source Images

Use the highest quality images as the source as the starting point for the Dolby Vision HDR Master. This ensures that the import process into the color corrector does not limit, scale or compress any of the dynamic range and color gamut in the source. Also, remove or modify any LUTs that may be limiting dynamic range and color.

For more information on file formats, refer to the latest version of the *Dolby Vision Source Formats* Document. In general, starting a project with Camera RAW is best, followed by uncompressed 16 or 12 bit, RGB, 444 files so that all the dynamic range and color information is preserved from the original acquisition.

2.2 **Color Grading** (Updated Guidance)

Use a certified Dolby Vision color corrector for Dolby Vision metadata creation. There are many acceptable color pipeline workflows for the timeline/color corrector, but the output color space must be set to ST.2084 (PQ), and either P3D65 or Rec.2020 for monitoring and delivery. Dolby recommends using Full Range levels throughout the HDR grade and Dolby Vision Metadata creation process. Consult your studio spec for further specific guidance. (Also, see section 3.2 for color gamut considerations).

The entire range of tools in the color corrector are available to create the best HDR images according to the creative brief and requirement. Be careful not to clip highlights in the HDR master as these cannot be recovered in the mapped/derived Rec.709 SDR target. The Dolby Vision content mapping algorithms are designed to maintain the look and intent of the HDR master.

A list of approved partner products supporting Dolby Vision can be found at our website: https://www.dolby.com/us/en/technologies/dolby-vision/dolby-vision-for-creative-professionals.html

2.3 Monitoring

Use a professional, reference grade HDR monitor that meets the minimum requirements for Dolby Vision. The requirements can be found on our website: https://www.dolby.com/us/en/technologies/dolby-vision/dolby-vision-for-creative-professionals.html

Monitors with different display technologies may exhibit metameric issues. To avoid metameric issues, it is recommended that the HDR and SDR monitors use the same display technology. For example, if you use the Sony BVM-X300 OLED HDR Master Monitor, do not use an LCD-based or consumer TV for the SDR target display.

In addition to professional monitoring, professional scopes are also strongly recommended. Use professional scopes that can display PQ signal values. Scopes should be used for both the HDR master and the output of the Internal (iCMU) or External (eCMU) to the target display to monitor highlights and black levels.

NOTE: You can also use the same professional HDR monitor as your SDR target display, by using the second input setup as SDR 100 Nits, Rec 709, Gamma 2.4.

3 Creating Global Dolby Vision Metadata

For mastering in Dolby Vision, the color corrector settings need to be setup correctly to work with Dolby Vision. This may differ from system to system but should be straight forward to match these specifications to each system. Refer to the color corrector's documentation for product specific settings and instructions.

3.1 Setting the Dolby Vision Algorithm Version

With the introduction of Dolby Vision Content Mapping version 4 (CMv4) in the fall of 2018, there are now two versions of algorithms supporting Dolby Vision. The previous CM algorithm is version 2.9 (CMv2.9). This is the version that has been used since the introduction of Dolby Vision.

CMv4 is backwards compatible with CMv2.9 and contains many enhancements for mapping and artistic trims. See section, Overview of the Dolby Vision Mastering Metadata

Projects started or created in one version cannot be converted to another version within the color corrector.

IMPORTANT NOTE: Check with your studio and customer - users should select CMv2.9 for new projects unless otherwise stated from your studio during the transition phase to CMv4 ecosystem adoption.

3.2 Setting Up the Output Color Space (Updated Guidance)

There are many acceptable color pipeline workflows for the timeline/color corrector, but the output color space must be set to either a P3D65 or Rec.2020^ color gamut for monitoring and delivery**.** Consult your studio spec for guidance on which color gamut to use.

^Guidance on Output Color Space Workflows: Some studios request P3 deliveries and some request Rec 2020 deliveries. Dolby recommends using Reference Grade Mastering Monitors that can accurately represent 100% of P3 color gamut. However, these same monitors cannot yet reach 100% of the Rec 2020 color gamut. So, there are several recommended best practice options for delivering an accurate Rec 2020 Dolby Vision master:

1. Color Grade the project in P3, Output P3 to the HDR Monitor (which is set to P3), Grade and Export a P3 file. Then, apply color conversion to this file from P3 to Rec 2020 – this maintains the P3 color primaries in a Rec 2020 container. You must also modify and update the color encoding section Dolby Vision XML from P3 to Rec 2020, (using either Metafier or a 3rd party mastering tool).
2. Set the Project and HDR Monitor to Rec 2020 and inside the color corrector, chose to limit the color space to either P3 (in the rec 2020 container) or with a 3D LUT to the native primaries of the mastering display. This workflow will not require updating the Dolby Vision XML.

IMPORTANT NOTE: The XML color gamut not matching the video file is a common error that QC houses and studios see.

3.3 Using iCMU or eCMU

With the rollout of Dolby Vision CMv4, systems supporting the integrated CMU are also starting to become available. Traditionally, a color corrector would need to be connected to an external CMU which contained all the mapping algorithms and video I/O to the target display. With the new CMv4 rollout, color correctors have the option to include these algorithms within their platform and eliminates the need for an eCMU.

When configuring Dolby Vision with iCMU functionality, you now will need to select whether to use iCMU for internal processing or eCMU to be compatible with the Dolby Vision CMU. This setting can be changed throughout the project based on your needs.

Refer to the eCMU user manual and the color grading system's documentation for CM algorithm support.

3.4 Selecting a Dolby Vision Mastering Display

Select the Mastering Monitor to the specification of the HDR monitor used. This setting is used to create Level 0 (L0) metadata that is essential to Dolby Vision. All the mapping algorithms are based on the mastering display –it is crucial to select the proper master display nit value. (i.e. Sony BVM X300 is 1000-nits). Dolby Vision supports multiple Mastering Monitors that the colorist can choose from.

If the mastering is done on multiple systems, the mastering display for all systems for the deliverable must be set to the same mastering display.

3.4.1 CMv2.9 Mastering Displays

In CMv2.9, the mastering display is a pre-defined list of displays. Select the one that best matches the reference monitor being used.

3.4.2 CMv4 Mastering Displays

In CMv4, the mastering display is also a pre-defined list of displays with the ability to support a custom mastering display if the color corrector has support for custom mastering displays (refer to the color corrector's feature list and/or documentation for supporting this feature).

When using a custom mastering display, all the fields are required to setup the mastering display.

3.5 Setting the Active Image Area (Output Blanking)

Set the aspect ratio for the project. The aspect ratio should be set to limit the analysis area to the active picture area (excluding letterboxes). This step is crucial to get the proper L1 values that are not analyzing the black levels of the Letterbox Region. If this is not set correctly, the 'L1Min' values will read 0.000 for all shots.

If the project contains multiple aspect ratios, set the global aspect ratio (L0) to the most commonly used ratio for the project. Some color correctors can set a per-clip aspect ratio for shots that differ from the global aspect ratio. This should be set for all shots that are different from the global aspect ratio and is saved as per-shot (L5) metadata.

Some systems require this to be set as letterbox left, right, top and bottom. Once set, this will be converted to ratio and stored in the XML. This can be performed by setting the letterbox metadata in pixels (left, right, top, bottom) and recording the aspect ratios in the XML metadata.

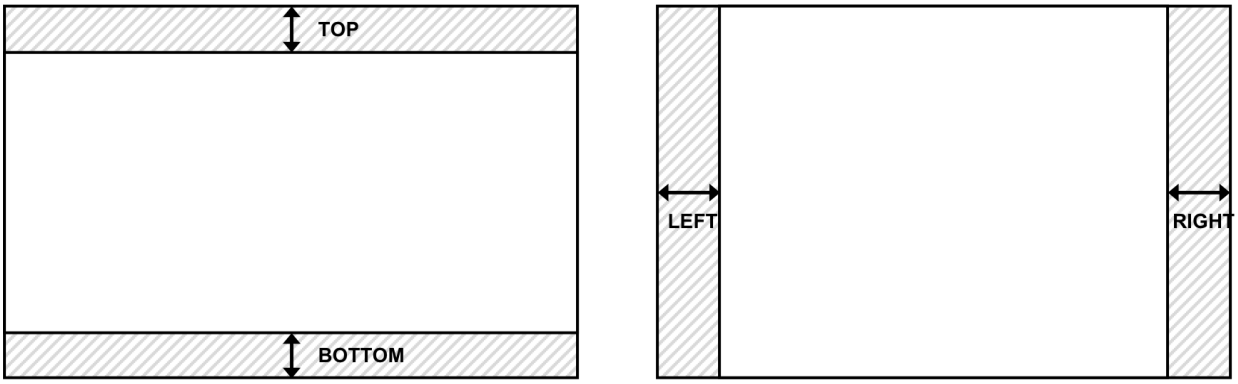

Figure 1: Specifying letterbox coordinates

4 Creating Dynamic Dolby Vision Metadata

Once grading is completed for the HDR master, the first step is to analyze all the shots to create Level 1 Analysis Metadata for Dolby Vision. Shots can be analyzed after each shot has been graded, at the end of a scene or at the very end of HDR mastering.

The timeline must be accurately cut into individual shots and Analysis to generate L1 metadata should be performed on a per-shot bases. If the timeline is not accurately cut into shots, there will be issues with luminance consistency and will exhibit artifacts during playback such as flashing and flickering. Using an EDL is the best method for cutting the timeline into individual shots. An alternative method is using shot detection to create the cuts on the timeline and checked for accuracy.

The Dolby Vision system analyzes all frames in the shot and then combines the L1 Min, Mid and Max values from all frames to create one set of L1 values that represents the entire shot. After Analysis, the Dolby Vision creative trims can be used to make additional adjustments to the mapped image. These values are also applied to all frames within the shot. This process is repeated for every shot on the timeline.

Figure 2: Example of per-shot metadata

4.1 Setting the Target Display

Select a target display for Content Mapping and creative trims. Set the target display to the Rec.709, 100-nit target display first. Make sure you are using Full Range settings on your target display.

IMPORTANT NOTE: If applying trims to any shot on the timeline, the SDR 100-nit, Rec.709 trim is required to establish the foundation for trim interpolation.

4.1.1 CMv2.9 Target Displays

In CMv2.9, the target display is a pre-defined list of displays. Select the one that matches the target monitor being used.

4.1.2 CMv4 Target Displays

In CMv4, the target display is also a pre-defined list of displays with the ability to support a custom target display if the color corrector has support for custom target displays (refer to the color corrector's feature list and/or documentation for supporting this feature).

When using a custom target display, all the fields are required to setup the display. Only one custom target display can be defined per project.

4.2 Creating L1 Analysis Metadata

Select the shot or shots on the timeline and execute the analysis algorithm. L1 metadata is automatically created for each shot. L1 metadata consists of three values to describe the tonal range of the shot and stored as L1Min, L1Mid and L1Max. Once the L1 values are applied, this creates the first level of Dolby Vision Content Mapping.

The L1 values are not editable. With CMv4, there is an additional global trim control to shift the mid tones of the image using the global 'Mid Offset'.

4.3 Setting Trim Metadata

Once the target display is selected and Analysis has completed, the color corrector will start content mapping or send L0 and L1 metadata to the eCMU over SDI and the eCMU will start content mapping to the target display. The colorist can now use the Dolby Vision L2/L8 Trim controls to modify the mapped look as needed.

The Dolby Vision Content Mapping algorithms are designed to reflect the creative intent in the HDR master image. The colorist can use the Dolby Vision Trim controls to modify the mapped look as needed. If the default mapping is acceptable, the colorist can skip that shot and move to the next shot on the timeline.

IMPORTANT NOTE 1: It is REQUIRED that the colorist set the target display to map the HDR grade to an SDR Rec.709, 100-nit target and check the mapping for all the shots across the entire timeline. This is required irrespective of whether you intend to use the resulting metadata to create an SDR Rec.709, 100-nit deliverable for distribution.

IMPORTANT NOTE 2: Copying and Pasting L1 & L2/L8: It is not acceptable to override the Dolby Vision analysis and paste the same L1 information across the entire reel or movie. It is acceptable to copy and paste L1 and or L2/L8 values to similar shots in the same scene.

IMPORTANT NOTE 3: Avoid using positive values **over 0.025** on the **LIFT** trim control for letterboxed content. (Negative Lift values are acceptable on all versions). The current implementation on Ultra HD Blu-ray devices apply the Trims to the entire image area, including the letterbox blanking area, to allow subtitles to appear over them. If the scene contains positive Lift values over 0.025, this may cause the letterboxed area to have elevated black levels during playback. An alternate way to achieve the desired result is to use a combination of GAIN and GAMMA trims more aggressively as these controls are manipulating the tone curve to achieve a more lifted black effect without using Lift. You can also choose to go back and modify your original HDR content to lift the blacks slightly and then re-analyze and trim without the need to have a positive value on the Lift trim over 0.025. If the active image area matches the canvas aspect ratio, (i.e. there is no letterbox), positive Lift can be used.

Setting Additional Target Trims

Always complete the SDR Rec.709, 100-nit Target Trim first. In addition to this target trim, the colorist has the option to create additional trims for other targets to refine the Dolby Vision Content Mapping algorithms. These additional trims are not required for Dolby Vision but may be requested by the client or studio. If additional trims are required, be sure to perform a full pass and not use the same values for the entire timeline. Once the Rec.709, 100-nit trim has been created, the additional trims should not be drastic and very quick to achieve. In general, only a few shots per reel may require trimming.

- For a 4000-nit Dolby Vision HDR Master, the colorist may add an optional target trim at 1000-nits to check the mapping at 1000 nits for the HDR10 deliverable.
- For a 1000-nit Dolby Vision HDR Master, the colorist may add an optional target trim at 600-nits to check the mapping at the average peak luminance level of current consumer HDR televisions.

Colorists may choose to add both 600-nit and 1000-nit additional trims for a 2000-nit or 4000-nit master HDR grade. Dolby Vision supports up to 4 target trims per deliverable. Each additional trim pass only requires minimal adjustments due to the previous trims at surrounding targets.

4.3.1 CMv2.9 L2 Trim Controls

For CMv2.9, there are six controls that can be used to modify the mapped image. These values are stored as Level 2 metadata.

Lift, Gamma and Gain are the most common controls used to modify the shadows, mid tones and highlights of the image. In CMv2.9, these controls do not function exactly like the traditional lift, gamma and gain controls. Instead, these three controls are essentially adjusting the tone mapping curve.

Note: Tone Detail Trim is disabled for the Rec.709, 100-nit trim.

PRIMARY TRIMS	Value Range	Default Value
Lift*	(-1,1)	0
Gain	(-1,1)	0
Gamma	(-1,1)	0
Chroma Weight	(-1,1)	0
Saturation	(-1,1)	0
Tone Detail	(-1,1)	0

Table 1: CMv2.9 Trim Controls

*see above note on using the Lift trim

4.3.2 CMv4 L8 Trim Controls

For CMv4, there are a total of 21 trim controls that can be used to modify the mapped image. The trim controls are in the table below and stored as Level 8 metadata. Lift, Gamma and Gain trim controls have been improved in CMv4 and are very similar to traditional Lift, Gamma, Gain controls that colorists are used to.

The extended toolset of trim controls in Cmv4 lets colorists refine and modify the metadata with increased precision and flexibility.

PRIMARY TRIMS	Value Range	Default Value
Lift*	(-1,1)	0
Gain	(-1,1)	0
Gamma	(-1,1)	0
Chroma Weight	(-1,1)	0
Saturation	(-1,1)	0
Tone Detail	(-1,1)	0
Mid Contrast Bias	(-1,1)	0
Highlight Clipping	(-1,1)	0
SECONDARY TRIMS		
Red Channel Saturation	(-1,1)	0
Yellow Channel Saturation	(-1,1)	0
Green Channel Saturation	(-1,1)	0
Cyan Channel Saturation	(-1,1)	0
Blue Channel Saturation	(-1,1)	0
Magenta Channel Saturation	(-1,1)	0
Red Channel Hue	(-1,1)	0
Yellow Channel Hue	(-1,1)	0
Green Channel Hue	(-1,1)	0
Cyan Channel Hue	(-1,1)	0
Blue Channel Hue	(-1,1)	0
Magenta Channel Hue	(-1,1)	0

Table 2: CMv4 Trim Controls

*see above note on using the Lift trim

4.3.3 CMv4 Trim Controls Improvements

CMv4 introduces a new and improved way to create Dolby Vision content using color correction systems that have been updated to support CMv4.

For additional information about Dolby Vision solutions from our partners, select the **Solutions** tab at https://www.dolby.com/us/en/technologies/dolby-vision/dolby-vision-for-creative-professionals.html]

This section describes the new tools and improvements of CMv4 using the implementation in Blackmagic Resolve v15.x as a reference.

4.3.3.1 CMv4 Global Mid Tone Offset Trim Control Settings

This control is useful for matching the overall exposure of the mapped SDR signal to the HDR master or to an SDR reference. It acts an offset to the L1 mid values and adjusts the image's mid tones without affecting the blacks and highlights. This global offset is per-shot and applies to all targets for the shot.

The changes made to this modifier are recorded as part of L3 metadata for each shot or frame of the project.

The following figure shows the global Mid Tone Offset controls in Resolve.

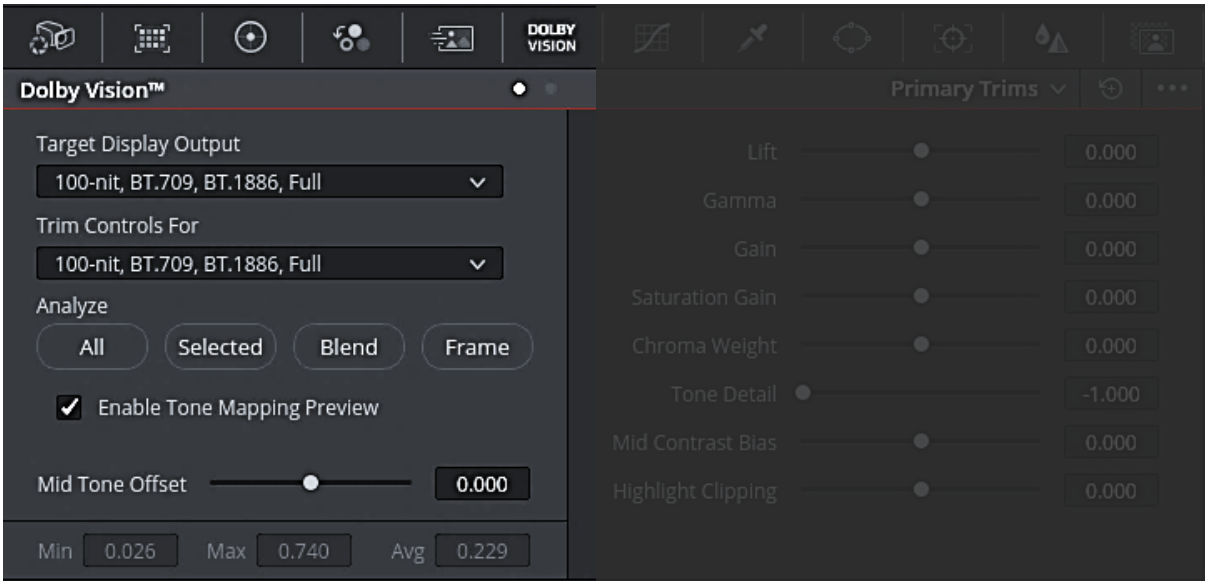

Figure 3 CMv4 Global trim control in Resolve 16.

4.3.3.2 CM4 Primary trim controls

The Primary trim controls are recorded as L8 metadata for each shot or frame of the project.
The following figure shows primary trim controls in Resolve.

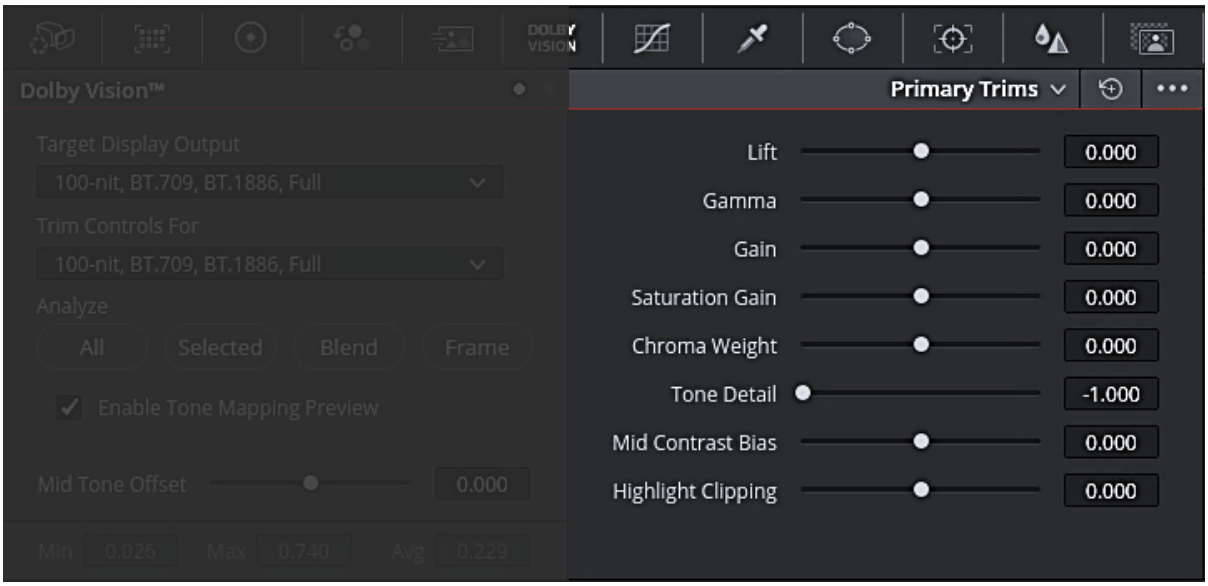

Figure 4 CMv4 Primary trim controls in Resolve 16

4.3.3.2.1 Lift/Gamma/Gain

In CMv4, the feel and response of these controls have been greatly improved over the previous version. These trims are designed to work like traditional lift, gamma and gain controls in the main color correction panel. These three controls modify the shadows, mid tones, and highlight areas of the mapped image.NOTE: The same positive lift guidelines described in Section 4.3 Important Note 3 also applies to Dolby Vision version 4.0.

4.3.3.2.2 Saturation Gain

Saturation Gain trim enables colorists to adjust the overall saturation of the mapped image.

Note: This Saturation Gain affects all colors in the image. To adjust saturation only for certain colors, use the saturation controls in the Secondary Trims panel.

4.3.3.2.3 Chroma Weight

Chroma Weight trim helps preserve color saturation in the upper mid-tones and highlight areas, especially when mapping down from HDR to SDR. This reduces luminance in highly saturated colors, thereby adding detail in those areas.

Chroma Weight ranges from minimum luminance with maximum saturation on one end to maximum luminance with minimum saturation on the other end.

If large **Chroma Weight** adjustments are made at 100 nits, we recommend checking the mapping at 600 nits and adjust **Chroma Weight** as required.

4.3.3.2.4 Tone Detail

Tone Detail trim restores sharpness only in the highlight areas of the mapped image. This works well in SDR by restoring some of the sharpness and details in the highlights that may be lost when mapping down from HDR to SDR.

4.3.3.2.5 Mid Contrast Bias

New to CMv4, the Mid Contrast Bias trim compresses and stretches the image around the mid tone region and can increase or decrease contrast in the mid tones of the mapped image. For more precise results, use **Mid Contrast Bias** adjustments with Lift or Gain.

4.3.3.2.6 Highlight Clipping

New to CMv4, the Highlight Clipping trim reduces or limits details in the highlights by clipping them as required, especially when the mapped image displays details that are undesirable. The resulting clipping may extend into the upper mid tones and may require some compensation using Gamma or Gain. This trim can be very useful when trying to match the mapped SDR to an existing SDR Reference.

4.3.3.3 CMv4 Secondary Trim Controls

Secondary trim controls are recorded as L8 metadata for each shot or frame of the project and enables per-color channel sat and hue adjustments per target.
The following figure shows secondary trim controls in Resolve.

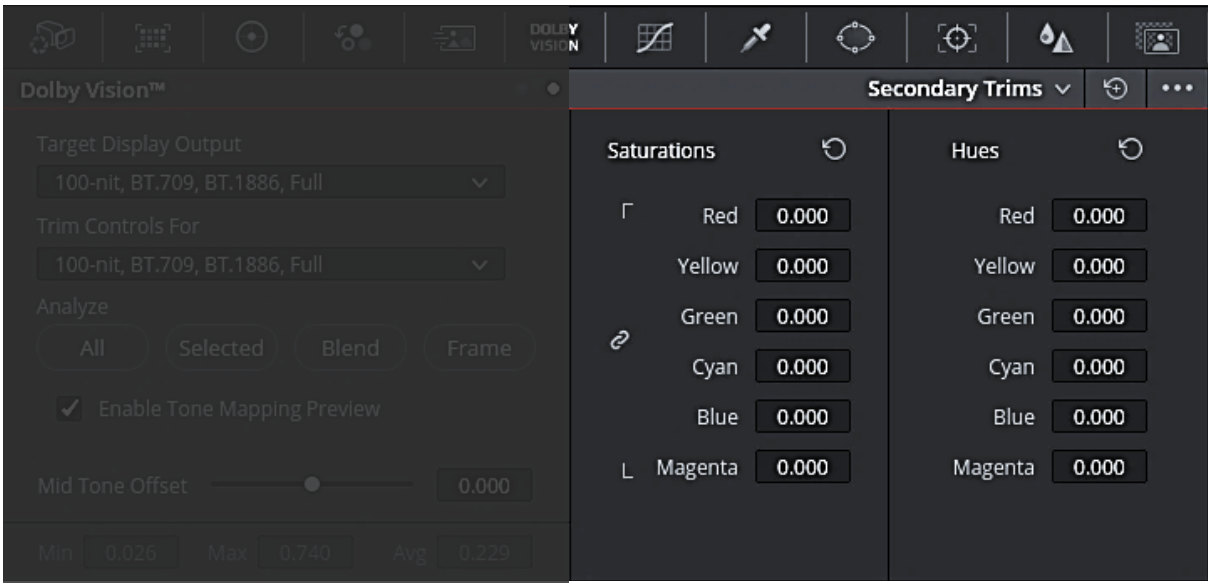

Figure 5 CMv4 Secondary trim controls in Resolve 16

4.3.3.3.1 Secondary 6-Vector Saturation Trim Controls

The six color saturation controls allow colorists to adjust the saturation of the mapped image individually across red, yellow, green, cyan, blue, and magenta, or all colors collectively when linked together.

4.3.3.3.2 Secondary 6-Vector Hue Trim Controls

The six color hue controls allow colorists to offset the hue of the mapped image individually across red, yellow, green, cyan, blue, and magenta. These controls are especially useful when trying to fit/shift the WCG of P3 or Rec 2020 into the limited color gamut of Rec 709/SDR.

NOTE: Secondary Trims are not backwards compatible with version 2.9 and will be ignored for all backwards compatibility.

4.4 CMv4 Backwards Compatibility

A CMv4 XML contains all the necessary metadata for backwards compatibility with version 2.9 devices. It is designed to maintain a good match in the creative intent of the content when it is played back on a version 2.9 device. Currently, content creation partner tools use CMv4 metadata and in real-time calculate the necessary CMv2.9 metadata (in the background).

However, all Dolby Vision partner tools use the 1st generation of this backwards compatible algorithm. Since the launch of CMv4, vast improvements have been made for this algorithm to achieve a closer match between 4.0 & 2.9 derived versions and we now have the 2nd generation of this algorithm. While we wait for partner tools to transition to the new backwards compatible algorithm, metafier V5.0 released 12.17.2019 can update the CMv2.9 metadata in a CMv4 XML.

To update a CMv4 XML with metafier, use this command line string:

```
./metafier --upgrade-cm29-metadata <input_cm4.xml>
```

This will generate a new CMv4 XML with the updated CMv2.9 metadata. To achieve the closest match possible, the new algorithm will generate three new L2 target trims at 100-nit, 600-nit and 1000 nit, regardless of how many CMv4 L8 trims exist.

To identify whether or not a CMv4 XML has been updated, refer to Level 254 <CMVersion> metadata. XMLs that contains <CMVersion>4 0</CMVersion> are XMLs that have the 1st generation algorithm applied. XMLs that contains <CMVersion>4 1</CMVersion> are XMLs that have the 2nd generation algorithm applied.

1st generation backwards compatible algorithm:

Level 254

<CMVersion>**4 0**</CMVersion>

2nd generation backwards compatible algorithm:

Level 254

<CMVersion>**4 1**</CMVersion>

It is strongly recommended that all CMv4 XMLs apply the 2nd generation backwards compatible algorithm before delivering for distribution.

Refer to Appendix B: Updating Backwards Compatible CMv2.9 Metadata in a CMv4 Deliverable and follow the workflow diagram for your deliverable requirements and use case.

4.5 Testing 4.0 to 2.9 Backwards Compatibility

The purpose of the v2.9 backwards compatible metadata is to closely match the look of v4 when played back on a Dolby Vision TV that only supports v2.9. Playback will always be in Dolby Vision and therefore to test v4 to v2.9, it should be compared by mapping to the same HDR target. Since most Dolby Vision TVs have a peak brightness of aproximately 600-nits, it makes sense to create a 600-nit 2.9 and 600-nit 4.0 to be used for comparison.

Steps for compatibility testing:

- Create a test project using CMv4
- Grade and trim the test project in Dolby Vision and export the Dolby Vision Master
- Follow the steps described in the Previous Section to update the metadata for the test project
- Render the test project to 600-nits for CMv4 and also CMv2.9
- Playback CMv4 and CMv2.9 and compare the results

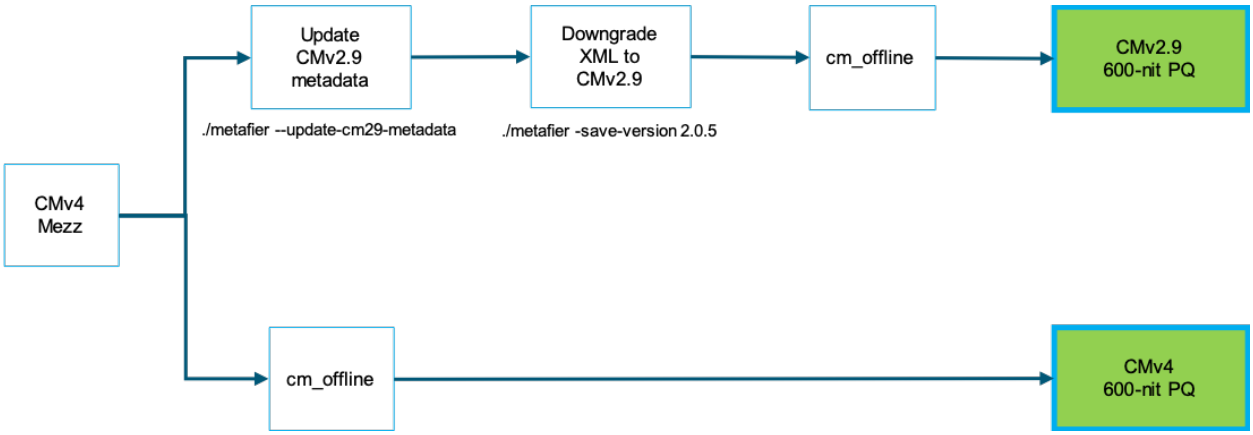

Figure 6 Testing Backwards Compatibility Workflow

5 Previewing the grade on a Dolby Vision TV via HDMI Tunneling

eCMU software version 3 includes a new feature called, 'HDMI Tunneling'. This feature enables the eCMU to output video and metadata to a compatible Dolby Vision TV over HDMI for version 2.9 projects. The eCMU accepts SDI video with Dolby Vision Metadata and outputs to the Dolby Vision TV over HDMI. The TV then performs the content mapping with its on-board processing and displays real-time mapping of the content as a consumer would experience it (minus encoding).

This feature should only be used as a final check, real-time QC pass or client monitor. This feature is NOT intended to replace a reference display for color grading or to directly set trims. Using a consumer display will likely cause image issues in the deliverable and during playback on different devices.

It is important to follow the below steps to ensure this feature will function properly and the displayed image is correct:

1. Break in the TV before proceeding. LG recommends a burn in time of 100 hours of HDR content for the most consistent pixel response.
2. Set the TV picture mode to 'Dolby Vision Cinema' to best match the reference monitor.
3. Calibrate the TV with at least a full 20-point calibration using SpectraCal's CalMAN software (version 2017 or newer) using the 'Custom Dolby Vision Workflow' with a professional measurement probe.
    a. NOTE: Custom Dolby Vision calibration is currently only available on LG display models from 2017 or newer.
4. Complete all Trims (Rec.709, 100-nits plus any optional trims) on the reference grade target display.
5. View content on the TV. If changes are desired, only make decisions based on viewing both the reference target monitor and TV. Never make creative decisions by viewing the images on the TV alone.

5.1 Recommended Dolby Vision TVs

The below Dolby Vision TVs are compatible and recommended for using the HDMI Tunneling feature:

- Calibrated LG C9, C8 and C7 Series

NOTE: Only certain Dolby Vision TVs are compatible with the HDMI Tunneling feature. It is highly recommended that the TVs listed above are used with this feature.

Sony and Panasonic Dolby Vision TVs are not compatible with the eCMU's HDMI Tunneling feature.

6 Deliverables

After completing the Dolby Vision HDR Master grade and creating the Dolby Vision Metadata, the project can be delivered.

6.1 Dolby Vision Master

A Dolby Vision Master consists of the master HDR images saved in the highest image quality, typically in an uncompressed, 16-bit RGB format like TIFF or OpenEXR and the XML metadata file. The Dolby Vision Master can also be the Archival Master and is the deliverable in which all other deliverables are derived from.

- Render the Dolby Vision HDR Master as:
    - 16-bit TIFF image sequence
    - ProRes 4444XQ .mov file (for iTunes)
    - ProRes 4444 .mov file
- Export the Dolby Vision Metadata as a separate XML file

6.2 Dolby Vision Mezzanine

A Dolby Vision Mezzanine also contains the HDR images and Metadata, similar to the Dolby Vision Master, but saved in a compressed format.

There are two common types of a Dolby Vision Mezzanine:

- Dolby Vision MXF
    - Suitable for an IMF deliverable. A Dolby Vision MXF contains the HDR images with interleaved metadata in a single MXF deliverable. This deliverable does not require a separate XML deliverable.
- ProRes 4444/4444XQ with sidecar XML metadata file
    - Suitable for non-IMF delivery. This contains HDR images saved in ProRes and a separate sidecar XML file that is frame-synced to the images.

Some systems allow to render directly to a Dolby Vision MXF deliverable. A Dolby Vision MXF deliverable is a J2K-MXF video track with interleaved Dolby Vision metadata and does not require a separate XML file as the metadata is contained in the single MXF deliverable.

6.3 Making Legal Range Deliverables

As stated earlier, Dolby Vision HDR master images and deliverables should be created using Full/Data Range Video levels. If a studio requests for Legal Range deliverables, like an SDR version, you should derive that from the Full Range Master, taking care to scale the image correctly during the conversion and avoid any clipping or loss of detail in the highlights and shadows. (You can refer to the document **Dolby Vision Legal Range Workflows for Home Distribution** on the Dolby website, for further information).

7 Working with Dolby Vision in Blackmagic Resolve Studio

This section highlights cases that are specific to Resolve Studio for creating Dolby Vision content. Always refer to the manufacturer's user manual for specific instructions.

7.1 Dolby Vision Feature Support

It is recommended to use Resolve Studio v16.1 or at minimum, v15.3.1, for creating new Dolby Vision projects.

Resolve Studio supports many new features of Dolby Vision:

- Dolby Vision CMv2.9 Algorithms and Trims
- Dolby Vision CMv4 Algorithms and Trims
- Both iCMU and eCMU support
- Dolby Vision IMF Deliverables
- Rendering directly to HDR10 and SDR
- New Dolby Vision licensing

7.2 Setting Dolby Vision CM Version in Resolve Studio

Resolve Studio supports both Dolby Vision CMv2.9 and CMv4. This setting is configured in **PROJECT SETTINGS → COLOR MANAGEMENT → DOLBY VISION**

This setting applies to both iCMU and eCMU configurations.

It is important to properly setup the correct Dolby Vision version before creating Dolby Vision metadata. Once the project has started with Dolby Vision metadata creation, it is not possible to switch to a different Dolby Vision version and keep the metadata that has already been created.

7.3 Creating Dolby Vision Metadata in Resolve Studio

7.3.1 Timeline Layout

In Resolve Studio, it is recommended that the graded HDR material should be flattened and placed on the first video layer (V1) before Analysis.

If multi-track support is necessary, shots on the additional tracks should not be overlapping shots on the primary (V1) track.

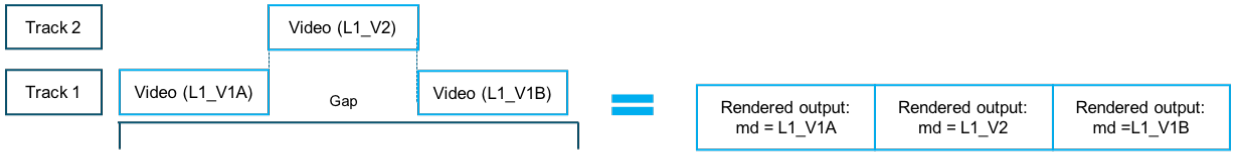

Figure 7: Examples of multi-track workflows

7.3.2 Active Area (Output Blanking)

The Output Blanking must be set before Analysis so that the Analysis metadata applies only to the active area of the image. If this not set or set incorrectly, the Analysis will include the letterbox region and on the L1Min values will result in zero and will be incorrect.

Set the Global Output Blanking under **TIMELINE → OUTPUT BLANKING**

Set per-clip Output Blanking under **COLOR TAB → SIZING → OUTPUT SIZING → BLANKING → SHOW BLANKING CLIP OVERRIDE → CLIP**

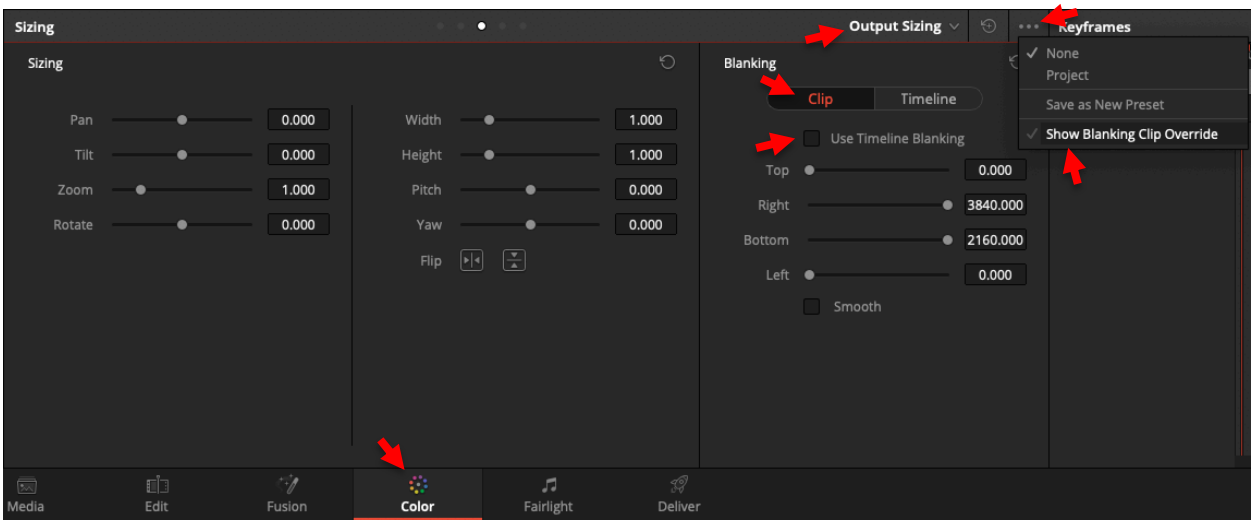

Figure 8: Resolve Per-Clip Output Blanking

7.4 Using the eCMU

For new projects using the eCMU, the Mastering and Target monitor settings under **PROJECT SETTINGS → COLOR MANAGEMENT → DOLBY VISION** is only active when:

- the connection to the eCMU over SDI and Ethernet has been established
- at least one shot on the timeline has been analyzed and the play head is on the analyzed shot, so the image and metadata are being sent to the eCMU

7.5 Using the iCMU

Resolve Studio version 15 includes fully integrated Dolby Vision processing and does not require the eCMU.

The Resolve system must have the following SDI hardware installed:

- Decklink 8K Pro PCIe card
- Decklink 4K Extreme 12G PCIe card
- UltraStudio 4K Extreme 3

NOTE: The Decklink 4K Extreme 12G and UltraStudio 4K Extreme 3 only supports HD resolutions using dual output on SDI. For UHD resolution support, the Decklink 8K Pro is required.

To use dual monitoring, this selection must be checked in **PROJECT SETTINGS → MASTER SETTINGS → VIDEO MONITORING → USE DUAL OUTPUT ON SDI**

This setting enables SDI A to output the Master HDR image and SDI B to output the Dolby Vision mapped target display image.

7.6 IMF Deliverable with Dolby Vision

IMF Deliverables with a Dolby Vision MXF is now supported. This deliverable includes the Dolby Vision MXF (with interleaved metadata). To export a Dolby Vision IMF, configure the following render settings to the following:

- Set FORMAT to IMF
- Set CODEC to Kakadu JPEG 2000
- Choose TYPE to Dolby Vision HD, 2K, UHD or 4K, depending on the export resolution
- Configure all other IMF settings as desired

7.7 HDR10 and SDR Deliverable from a Dolby Vision Master

A standalone HDR10 and/or SDR deliverable from a Dolby Vision project can be delivered directly from Resolve's render engine. This provides the same functionality as the 'cm_offline' tool in the Dolby Vision Professional Tools kit.

To render a standalone deliverable, expand the Advanced Settings and set Tone Mapping for Dolby Vision in **ADVANCED SETTINGS → TONE MAPPING → DOLBY VISION** and choose the target in which to render. For example, to render a standalone SDR, choose the 100-nit, BT.709, BT.1886, Full target.

8 Filmlight Baselight

This section highlights cases that are specific to Baselight for creating Dolby Vision content. Always refer to the manufacturer's user manual for specific instructions.

8.1 Dolby Vision Feature Support

It is recommended to use Baselight 5.2 or higher for creating new Dolby Vision projects.

Baselight supports many features of Dolby Vision:

- Dolby Vision CMv2.9 Algorithms and Trims
- Dolby Vision CMv4 Algorithms and Trims
- Both iCMU and eCMU support
- Rendering directly to HDR10 and SDR
- New Dolby Vision licensing

8.2 Creating Dolby Vision Metadata in Baselight

Setup Baselight for a Dolby Vision PQ project.

1. Set the Mastering Color Space for Dolby Vision in **VIEWS → SCENE SETTINGS → FORMAT & COLOR → ADVANCED → MASTERING COLOR SPACE**, select an appropriate Dolby Vision PQ color space
2. Set the Content Mapping and Mastering display for Dolby Vision in **VIEWS → SCENE SETTINGS → FORMAT & COLOR → DOLBY VISION** to the following settings:
    - Content Mapping: Software CMU (v2.9) or Hardware CMU (vX.X)
    - Dolby Mastering Display: choose any display marked with DOLBY
3. Set the viewing color space to the same-spec viewing space as the 'Dolby Vision Mastering Display' selected above in **VIEWS → CURSORS → VIEWING COLOR SPACE**

The trimming operation can be accomplished in two ways:

- Set the Viewing Color Space to the intended target's color space.
- Set the Secondary Output in Dual Color Spaces Layout mode to the intended target color space displayed.

If there are multiple target layers, you must change to the intended target color space in the cursor area to trim that target.

8.2.1 Timeline Layout

In Baselight, the Analysis and Trim strips are now separated. Each shot requires 1) Analysis strip and; 2) optional Trim strip.

1. Set a target display In **CURSORS → VIEWING COLOR SPACE** and select a target display, i.e. 'Rec.1886, 2.4 Gamma /Rec.709'.
2. Add a Dolby Vision Analysis layer by selecting all stack bottoms and insert a Dolby Vision Analysis layer in **INSERT → MISCELLANEOUS → DOLBY VISION ANALYSIS**. This adds a Dolby Vision strip under each shot and will default to the target display selected above.
3. Add a Dolby Vision Trim layer by selecting all the stack bottoms and insert a Dolby Vision Trim layer in **INSERT → MISCELLANEOUS → DOLBY VISION TRIM**
4. Adjust the Trim layer as needed.
5. Repeat steps 2-4 for all shots on the timeline.

8.2.2 Active Area (Mask)

The Mask must be set before Analysis so that the Analysis metadata applies only to the active area of the image. If this not set or set incorrectly, the Analysis will include the letterbox region and on the L1Min values will result in zero and will be incorrect.

Set the Mask in **CURSORS → MASK**.

8.2.3 Dissolves

Handling dissolves starting in Baselight v5.1 has changed. A Dolby Vision Analysis layer must be added to the Dissolve layer and then a Dolby Vision Trim layer as outlined above.

The Dissolve trim layer now has a function button labeled 'Set Animated Trim Across Dissolve'. This allows the dissolve to function properly. See the transition by highlighting the trim layer and adjust from the 'A' to 'B' side of the dissolve.

NOTE: Changing the Dolby Vision trim on either the 'A' or 'B' shot will cause the dissolve to 'bump'. The only solution to fixing this is to remove the Dolby Vision Trim layer from the dissolve and re-insert the layer. You must then click on the 'Set Animated Trim Across Dissolve' button to fix the problem. All separate display targets require a separate trim layer for a dissolve.

8.3 Using the eCMU

Configure the eCMU by setting 'Content Mapping' to 'Hardware CMU' under **VIEWS → SCENE SETTINGS → FORMAT & COLOR → DOLBY VISION → CONTENT MAPPING**.

As before with the eCMU, to place a trim layer you pick a Display Type from the Views/Dolby Vision window and then add a Dolby Vision Trim from the Insert tab. The Display Type must match the target in the layer you are attempting to trim.

To control the Target Display of the eCMU, open the Dolby Vision window in **VIEWS → DOLBY VISION**.

8.4 Using the iCMU

Baselight includes fully integrated Dolby Vision processing and does not require the eCMU. The iCMU mode requires unique steps.

1. Set the Viewing Color Space to a color space with a Dolby double-D logo.
2. Set the Dolby Vision Trim layer's Viewing Color Space to the appropriate target color space that has the Dolby double-D logo.

Once the settings are configured, the operation and output the target image will start working.

NOTE: Even if the Dual Color Spaces Layout in the Display pulldown has a target specified in the Secondary Output in the cursor area, without having the target specified in the Viewing Color Space, a trim layer cannot be added.

8.5 HDR10 and SDR Deliverable from a Dolby Vision Master

A standalone HDR10 and/or SDR deliverable from a Dolby Vision project can be delivered directly from Base light's render engine. This provides the same functionality as the 'cm_offline' tool in the Dolby Vision Professional Tools kit.

To render a standalone HDR10 or SDR deliverable, set **RENDER → RENDER COLOR SPACE** to the appropriate Dolby Vision target display, marked with the double-D symbol.

9 Digital Vision Nucoda

This section highlights cases that are specific to Nucoda for creating Dolby Vision content. Always refer to the manufacturer's user manual for specific instructions.

9.1 Dolby Vision Feature Support

It is recommended to use Nucoda version 2019 for creating new Dolby Vision projects.

Nucoda supports many features of Dolby Vision:

- Dolby Vision CMv2.9 Algorithms and Trims
- Dolby Vision CMv4 Algorithms and Trims
- Both iCMU and eCMU support (Note, eCMU v4 will be available in the future)
- Rendering directly to HDR10 and SDR
- New Dolby Vision licensing

9.2 Setting Dolby Vision CM Version in Nucoda

Starting in Nucoda version 2018.3, both Dolby Vision CMv2.9 and CMv4 are supported. This setting applies to both iCMU and (CMv2.9) eCMU configurations. The CM version is set on the Project Settings panel in the Content Mapping dropdown.

This setting applies to both iCMU and eCMU configurations.

9.3 Creating Dolby Vision Metadata in Nucoda

The mastering display should be set before analysis in **LIBRARY → CONFIG DOLBY CM**.

9.3.1 Timeline Layout

There should be no gaps in the timeline, with all graded HDR material placed end-to-end. Video can be placed on any track for analysis, with the clip on the higher track overriding any shot below it, but it is always better to flatten your timeline.

9.3.2 Active Area (Output Blanking)

The Output Blanking must be set before Analysis so that the Analysis metadata applies only to the active area of the image. If this not set or set incorrectly, the Analysis will include the letterbox region and on the L1Min values will result in zero and will be incorrect.

The Image Format can be found in the dropdown menu in **DOLBY VISION EFFECTS PANEL → ANALYZE**.

9.3.3 Keyframes

Nucoda allows for keyframing of all CM 2.9 trims, and just Lift, Gamma, Gain for CM 4.0. Refer to Nucoda's user manual for how to keyframe color settings, as it works the same way.

9.4 Using the eCMU

The eCMU can be activated for a 2.9 project under **LIBRARY → CONFIG DOLBY CM.** This is also where the mastering and target displays can be set. Unlike for the internal CMU, selecting the target display for trim controls in the 'Dolby Vision Effects' panel will not change the target display for the eCMU. For the eCMU, the target display must be set in the 'Config Panel as well as the 'Dolby Vision Effects Panel'.

The eCMU can be selected from a list of currently active eCMU's or a list of all eCMU's that have been used on this project. The eCMU will only appear as an active option when:

- the connection to the eCMU over SDI and Ethernet has been established
- at least one shot on the timeline has been analyzed and the play head is on the analyzed shot, so the image and metadata are being sent to the eCMU
- the Library panel is closed so there is an active image on the UI screen

9.5 Using the iCMU

Nucoda includes fully integrated Dolby Vision processing and does not require the eCMU. Under **LIBRARY → CONFIG DOLBY CM**, select 'Integrated CMU' in the top left corner.

For dual SDI outputs, go to **PREFERENCES → MONITORING/VIDEO IO** and turn on 'Dual Dolby Output.' Monitor format should be set for 1080p, and the video card settings to 1 link, RGB444.

NOTE: Systems with Kona 4 card:

- SDI 3 = Mapped Video Output
- SDI 4 = HDR output

9.5.1 Multiple L2 Target Trims

In addition to the SDR Rec.709 100-nit trim, when adding additional L2 Target Trims, it is required to use the 'Interpolate' function for each additional trim. The interpolate function automatically calculates the correct interpolated metadata values for that trim, based from the existing trim(s). Once it is interpolated, manual adjustments for the target trim can now be made, if needed.

9.6 HDR10 and SDR Deliverable from a Dolby Vision Master

A standalone HDR10 and/or SDR deliverable from a Dolby Vision project can be delivered directly from Nucoda's render engine. This provides the same functionality as the 'cm_offline' tool in the Dolby Vision Professional Tools kit.

In the Dolby Vision panel under the Trim tab, select the desired target display for the render by switching to it under the Trim Target dropdown. Then under **LIBRARY → EXPORT MEDIA**, choose your export settings, making sure that the 'Dolby CM' button is turned on.

10 XML Metadata Validation

The XML Metadata should be checked (QC) for quality and integrity before leaving the color suite. The Dolby ‘metafier’ command line metadata utility tool that is part of the Dolby Vision Professional Tools checks the Dolby Vision XML metadata and does not need the image sequence. It can be used to quickly check and validate the Dolby Vision XML as well as to modify it, if required.

Example CLI:

```
./metafier --validate <file.xml>
```

For v4.0.2 XML, ‘metafier’ includes a separate validation for XML schema

```
./metafier --validate-schema 4.0.2 <file.xml>
```

For detailed information on metadata validation, errors and warnings, refer to the, “Dolby Vision Professional Tools User Manual”.

11 Appendix A: Overview of the Dolby Vision Mastering Metadata

The Dolby Vision Mastering Metadata comprises global type, track type, shot type and frame-based structures. Global and track type metadata are static metadata and applied to the entire deliverable while shot-based and frame-based metadata are dynamic and applied on a per-shot, per-frame basis.

As there are two versions of Dolby Vision CM algorithms, there are also two versions of XML to support each CM version. While there is built-in backwards compatibility in the metadata, the XMLs themselves are not backwards compatible.

The following tools also needs to be updated to support CMv4:

- Dolby Vision Professional Tools, version 4.0 and higher
    - Metafier
    - Cm_offline
    - Mezzinator
    - Cm_analyze
- eCMU, version 5.0 and higher
- Pro Encoder SIDK, version 4.2.1 and higher (version 5.4 is strongly recommended)

11.1 Metadata Version 2.0.5 XML for CMv2.9

Metadata Level/Field	Description
LEVEL 0	**GLOBAL METADATA (STATIC)**
Mastering Display	Describes the characteristics of the mastering display used for the project
Global Aspect Ratio	Ratio of canvas and image (active area)
Frame Rate	Frame Rate
Target Display	Describes the characteristics of each target display used for L2 trim metadata
Color Encoding	Describes the image container deliverable
Algorithm/Trim Version	CM algorithm version and Trim version
LEVEL 1	**ANALYSIS METADATA (DYNAMIC)**
L1 Min, Mid, Max	Three floating point values that characterizes the dynamic range of the shot or frame Shot-based L1 metadata is created by analyzing each frame contained in a shot in LMS color space and combined to describe the entire shot as L1Min, L1Mid, L1Max
LEVEL 2	**PER-TARGET TRIM METADATA (DYNAMIC)**
Reserved1, Rerserved2, Reserved3, Lift, Gain,	User defined image controls to adjust the content-mapped images on a per-target basis.

Gamma, Saturation, Chroma and Tone Detail	
LEVEL 5	**PER-SHOT ASPECT RATIO (DYNAMIC)**
Canvas,Image	Used for defining shots that have different aspect ratios than the global L0 aspect ratio
LEVEL 6	**OPTIONAL HDR10 METADATA (STATIC)**
MaxFALL, MaxCLL	Metadata for HDR10 MaxCLL - Maximum Content Light Level MaxFALL - Maximum Frame Average Light Level

11.2 Metadata Version 4.0.2 XML for CMv4

Metadata Level/Field	Description
LEVEL 0	**GLOBAL METADATA (STATIC)**
Mastering Display	Describes the characteristics of the mastering display used for the project
Global Aspect Ratio	Ratio of canvas and image (active area)
Frame Rate	Frame Rate
Target Display	Describes the characteristics of each target display used for L2 trim metadata
Color Encoding	Describes the image container deliverable
Algorithm/Trim Version	CM algorithm version and Trim version
LEVEL 1	**ANALYSIS METADATA (DYNAMIC)**
L1 Min, Mid, Max	Three floating point values that characterizes the dynamic range of the shot or frame Shot-based L1 metadata is created by analyzing each frame contained in a shot in LMS color space and combined to describe the entire shot as L1Min, L1Mid, L1Max Stored as LMS(CMv2.9) and L3 Offsets
LEVEL 3	**OFFSETS TO L1 (DYNAMIC)**
L1 Min, Mid, Max	Three floating point values that are offsets to L1 Analysis metadata as L3Min, L3Mid, L3Max L3Mid is a global user defined trim control L1 is stored as CMv2.9 computed values, CMv4 reconstructs RGB values with L1 + L3
LEVEL 2	**BACKWARDS COMPATIBLE PER-TARGET TRIM METADATA (DYNAMIC)**
Reserved1, Rerserved2, Reserved3, Lift, Gain, Gamma, Saturation, Chroma and Tone Detail	Automatically computed from L1, L3 and L8 (lift, gain, gamma, saturation, chroma, tone detail) metadata for backwards compatibility with CMv2.9

LEVEL 5	**PER-SHOT ASPECT RATIO (DYNAMIC)**
Canvas,Image	Used for defining shots that have different aspect ratios than the global L0 aspect ratio
LEVEL 6	**OPTIONAL HDR10 METADATA (STATIC)**
MaxFALL, MaxCLL	Metadata for HDR10 MaxCLL - Maximum Content Light Level MaxFALL - Maximum Frame Average Light Level
LEVEL 8	**PER-TARGET TRIM METADATA (DYNAMIC)**
Lift, Gain, Gamma, Saturation, Chroma, Tone Detail, Mid Contrast Bias, Highlight Clipping 6-vector (R,Y,G,C,B,M) saturation and 6-vector (R,Y,G,C,B,M) hue trims	User defined image controls to adjust the CMv4 algorithms per target with secondary color controls
LEVEL 9	**PER-SHOT SOURCE CONTENT PRIMARIES (DYNAMIC)**
Rxy, Gxy, Bxy, WPxy	Stores the mastering display color primaries and white point as per-shot metadata

11.3 Mapping of CMv2.9 Vs. CMv4 Metadata

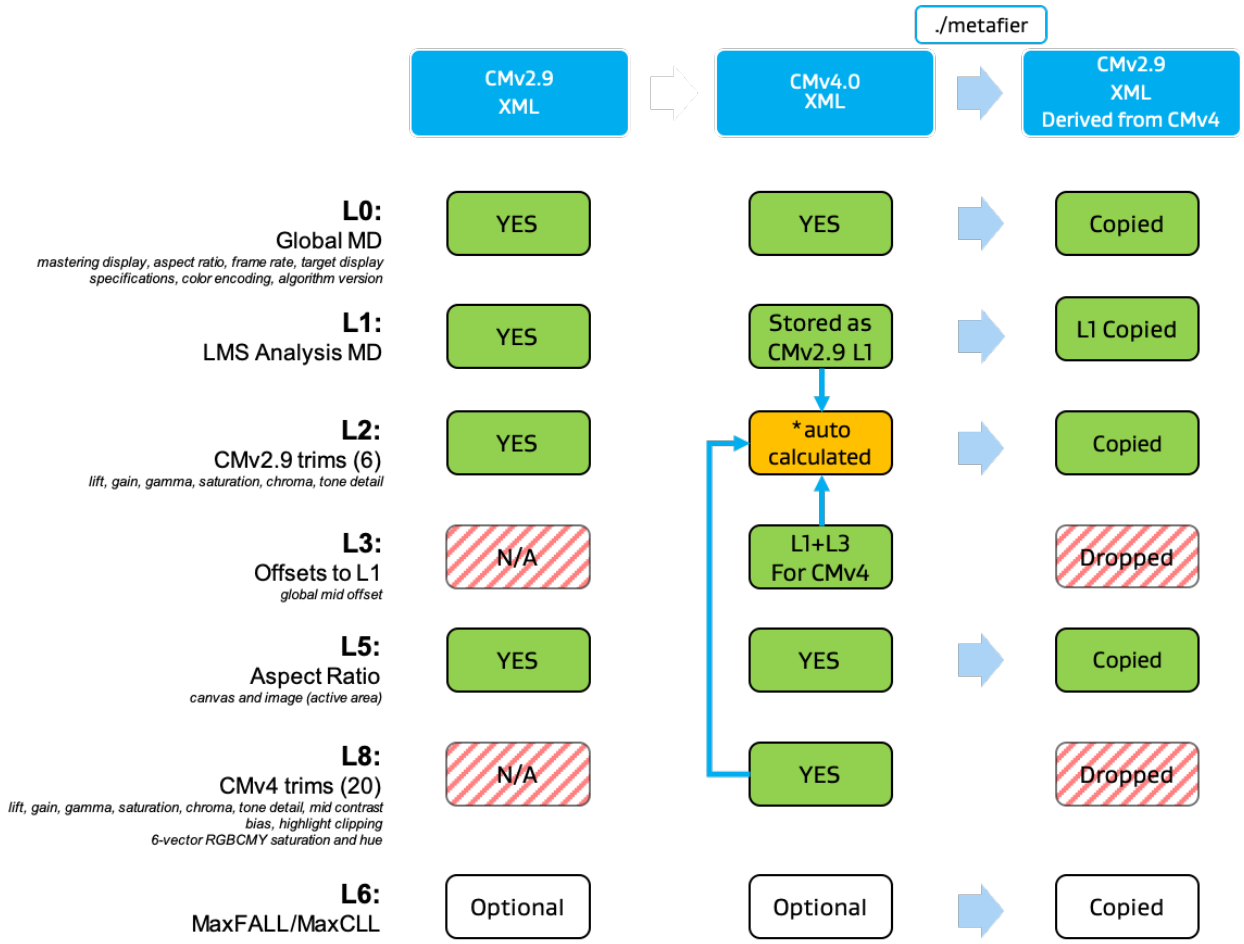

Figure 9: Dolby Vision XML Metadata Comparison Chart

12 Appendix B: Updating Backwards Compatible CMv2.9 Metadata in a CMv4 Deliverable

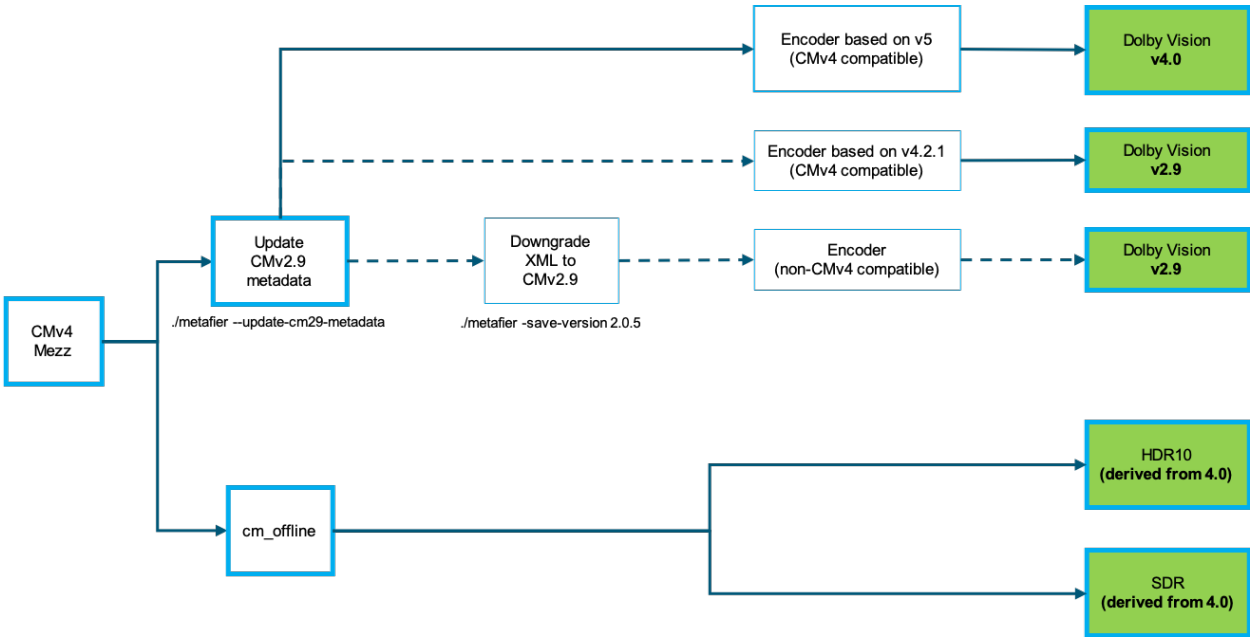

Figure 10: Workflow for updating backwards compatible metadata in CMv4