



Mastering HDR content with Dolby Vision in Nucoda

Dolby CMU 2.5.2 Firmware

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Dolby Vision Mastering Workflow

A Dolby Vision Master has an HDR grade plus scene by scene metadata to optimise playback on displays of different brightness. It uses the ST2084 PQ curve but requires a display with Dolby Vision licensed firmware to play back correctly. LG and Visio currently offer Dolby Vision licensed consumer displays.

The workflow entails the grading of the master HDR version on the brightest display available, then creating scene by scene metadata. The scene based metadata is used to create additional versions of the content that are suited to different displays. This process requires operator input using a limited set of tools that were defined by Dolby.

A monitor capable of displaying material with the ST2084 PQ EOTF is required to grade Dolby Vision Master and deliverables.

Currently the list of approved mastering monitors are:

- Dolby Pulsar 4000 nits - not commercially available, but can be provided by Dolby on request
- Dolby Maui 2000 nits - not commercially available, but can be provided by Dolby on request
- Sony BVM X300 1000 nits - available from Sony
- Dolby PRM - available from Dolby - *this monitor is only capable of 600 nits but it is possible to create the master project at 600 and then make the trim passes on a brighter display.*

The output of an Dolby Vision grading session consists of two parts. The first part is the image sequence encoded and exported as Tiff or EXR files. The files are created with the PQ curve as part of the rendered images.

The other component is the Dolby Vision XML file that contains metadata about the project, the image analysis and trim data for every additional target display.

This XML is used to create different masters and also dynamically map the content on Dolby Vision enabled displays based on the additional target display trim data.

Dolby Vision in Nucoda

Nucoda has support for Dolby Vision and when licensed and activated, additional UI elements are available when a suitable **Dolby Content Mapping unit (CMU)** is connected to the system.

Contact Dolby directly for information on how to obtain CMU for use with Nucoda. Dolby also provide a full manual for the CMU hardware itself.

The CMU is an external processing unit provided by Dolby that enables the following Dolby Vision functionality in Nucoda.

- Image analysis and metadata generation for trim passes
- Controls for Dolby Vision tools in Nucoda
- Access to the database of supported mastering Monitors and output Target Displays
- Real-time Content Mapping (CM) processing to target display

The CMU performs the content mapping function from content with embedded Dolby Vision metadata over a SDI interface for a selected target display.

In the Nucoda interface there are two buttons added in the Library :

Config Dolby CM: Allows access to the CMU setup menu

Export Dolby CM: Export the XML Metadata file

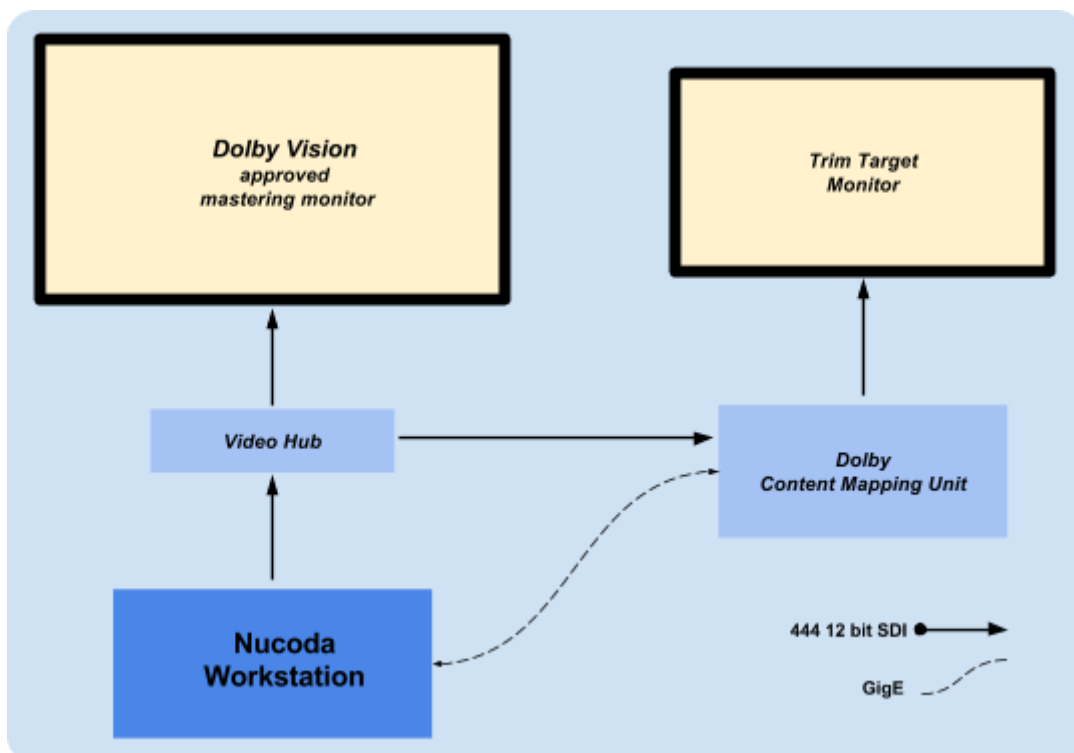
In the grading tool stack an additional layer called “Content mapping” has been added after the Master Layer, this is where analysis and trim functions are available. The trim tools are also available on the Precision control panel.

CMU connection

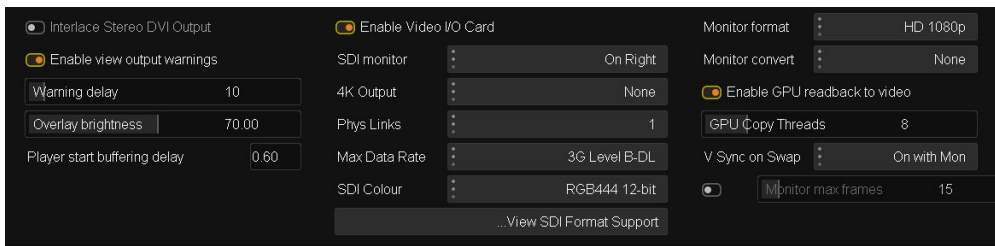
The CMU is designed to be a “headless” box, meaning it is designed to sit in a rack in the server room with no GUI explicitly running. The current CMU OS is Linux.

Not having a monitor connected is normally only an issue when the network has not been configured to work for the environment it is being installed in. As such, it is usually advisable to initially set up the machine with a VGA monitor and USB keyboard. The following steps should be followed for initial connectivity:

- Unbox the CMU and connect power, making sure there is sufficient ventilation top and bottom
- Locate the included mini-SDI to SDI cable harness. This is used to connect the CMU to the SDI output of the Nucoda system (from the AJA Kona 4 card). This can be done using either dual-link HDSDI or single-link 37G SDI.
- The SDI signal from the Nucoda must be split - one output to the Mastering monitor and the other to the CMU. The signal must be 444 12 Bit and can be Dual or Single link using the Kona 4
- Connect a network cable to the first port and connect it to the Nucoda workstation.
- If instead of connecting directly you choose to route through a network then ensure that no ports are blocked.
- Complete networking information should be obtained from the Dolby Vision CMU User Manual
- The default setup for the CMU is DHCP
- Plug a USB keyboard into a usb slot. There is no need for a mouse, as there is no graphical user interface
- Connect a monitor to the VGA port. **Do NOT connect the monitor to the graphics card on the CMU**
- Turn on the machine – all the services will start automatically



Nucoda workstation setup



The SDI output from the AJA Kona 4

- The SDI IO Mode in Nucoda must be set to **RGB 444 12 bit** to support the Dolby Vision workflow
- **The SDI output from Nucoda must be connected to both the mastering monitor and the CMU input, it is possible to use a looped output from the monitor to the CMU.**
- **Ensure that the Monitor format is set to HD1080p and convert set to None or Fit**
- You can only send 1080p HD SDI signals to the CMU (see CMU manual for details)
- The CMU will accept :
 - 1.5G dual-link SDI (2 Physical links)
 - 3G Level B-DL (1 Physical link)
- Do NOT set the Max Data Rate to 3G (Auto) - Set to 3G Level B-DL
- The CMU will automatically configure the output SDI interface to match the input SDI interface. If needed, the CMU can be set to force a 3G SDI output, even if the input SDI is dual-link HDSDI
- If possible, it is recommended to use 3G connectivity, if only because of the reduced cabling necessary, but also because there are fewer timing and VPID identification issues.
- Since the Nucoda workstation IP Address is encoded and sent to the CMU via SDI, please ensure that the Nucoda is has an image on the screen or has a composition open to allow discovery of the CMU.

Ethernet connection between Nucoda workstation and the CMU

- Please see the CMU User Manual for setup instructions.
- The ethernet address of the Nucoda is encoded in the SDI video stream to the CMU and the CMU then connects with Nucoda via the ethernet port.
- You may have to add a windows firewall exception for the port communicating with the CMU or turn off the windows firewall completely.
- You are able to control and reset the CMU by loading a web browser and entering the CMU IP address in the browser.
- The default network on the CMU is configured for DHCP.
- With multiple ethernet connections and complex routing being more and more common it is possible that the CMU cannot be discovered when starting Nucoda, even it it can be seen and controlled via the browser application. In cases like this, there is an option in the general.prefs file for Nucoda to enter the IP address of the Nucoda Workstation, to allow the CMU to connect.
 - ForcelPAddress "Nucoda workstation IP"
 - c:\Nucoda\20xx_x\root\Users\All Users\General.prefs

Nucoda project setup:

Option 1: ACES 1.0.3

The benefit of using ACES is that the input transforms required to display material with a 2084 PQ transfer curve is very simple. The ACES workflow is scene referred so it is possible to easily create different masters based on the standardised ACES output transforms, or to save the material as scene referred linear images that can be archived and used to create other masters as required.

Select a resolution and frame rate for the project, formats compatible with the CMU:

- 1920 x 1080p 23.98
- 1920 x 1080p 24
- 1920 x 1080p 25
- 1920 x 1080p 27.97
- 1920 x 1080p 30

Create an additional output format set to the same resolution and frame rate as the main output format.

- In the colour space menu, select *ACES* and select *V1.0*
- Select *ACEScc* as the working colour space

In the CMS/ACES menu select Nucoda ACES OT and then set the output transform that matches your mastering monitor, use the ST2084 transforms. Dolby Vision requires working in P3D65 with PQ 2084 EOTF set in the mastering display,

- P3-D65-ST2084 - 1000n

Apply this transform to both output formats, for the second output format enable the “Apply CMS” button - this will render the transform as part of the output for that output format.

Ensure that you use a transform with “Apply CMS” enable when doing your analysis.

Video Output scaling set to “Scale to SDI Legal”

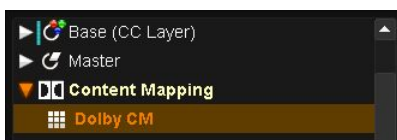
Enable the **Dolby CM** option under the Content Mapping menu



There are 2 new buttons in the Library for controlling **Dolby CM** functions.



You will notice that there is a new layer named **Content Mapping** with a **Dolby CM** tool in the tool stack beneath the Master Layer.



Option 2: Full Range - Half

Mastering material that is supplied as linear images

You may have to create a HDR master and trim versions from an existing feature film master, material is often supplied as images that are already linear. In these cases the typical workflow would involve importing the material, placing the material on the timeline and applying the PQ Matrix to the material, and setting the PQ Matrix to “To PQ” on the input and “none” on the output.

With the monitor set to PQ the images are ready to create the HDR version. Once the HDR version is created, analysis is performed and the other versions are created.

Ensure that the mastering display is set up correctly. The monitor should match the mastering monitor description.

Preparing material for grading - working with Log material

Providing the Master display is correctly set up and the EOTF is set to PQ, normal grading to HDR is possible.

Any form of log source material can be graded using the Nucoda tools to look correct on the master display.

Material that is already Rec.709 or P3 with traditional 2.2 - 2.6 gamma applied must be converted to PQ using the PQ matrix tool or a appropriate LUT.

Project setup

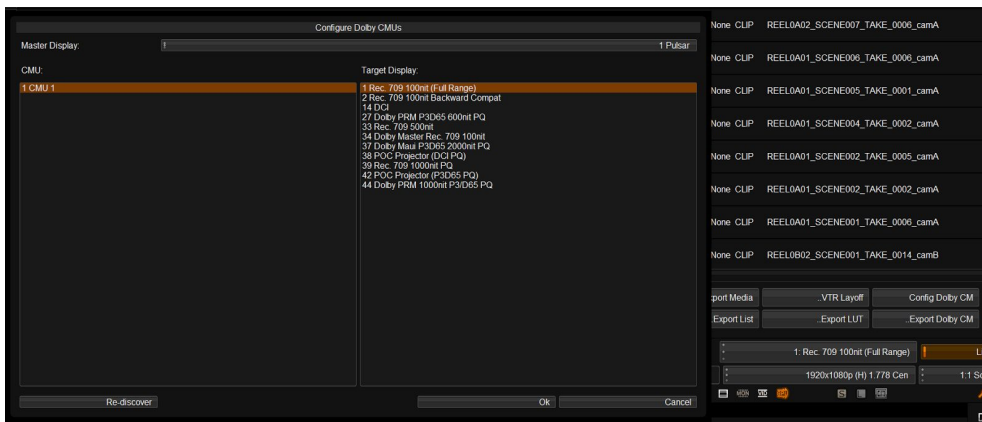
Select a resolution and frame rate for the project, formats compatible with the CMU:

- 1920 x 1080p 23.98
- 1920 x 1080p 24
- 1920 x 1080p 25
- 1920 x 1080p 27.97
- 1920 x 1080p 30

- Bit Depth : Half
- Full Range
- Video Output scaling : Scale to SDI Legal
- Enable the **Dolby CM** option under the Content Mapping menu

You will notice that there is a new layer named **Content Mapping with a Dolby CM** tool in the tool stack beneath the Master Layer.

Setting up the Mastering display in Nucoda



In the library view there are two new options available, the first is “Config Dolby CM”

... Config Dolby CM

- This will open a new panel called Configure Dolby CMU
- When a CMU is connected the CMU name will be displayed in the left column
Note: It is possible to have multiple CMUs connected
- The Master Display dropdown has a list of mastering monitors currently supported - options will change as the product is updated by Dolby.
 - **Current options (November 2016) include:**
 - Dolby Pulsar - 4000 nit
 - Dolby PRM32HFD - 2000 nit
 - Sony BVM X300 - 1000 nit
- Use this selection to select the mastering monitor for the HDR version.
- Select a Target Display in the right column. This is to select the trim target monitor connected to the CMU. The list includes displays that are commonly used.
- These target display list is dynamic - they are sent from the CMU and available targets will depend on the version of CMU software being run.

Note: There will be no displayed targets if a CMU is not connected

There is also a “Re-discover” button for reconnecting to the CMU if it disconnects for some reason.

- Finally there is an “OK button for finalising your selections, or a Cancel button if you decide to make no change at this time to a previous selection.
- The Web interface that is available for the CMU via the browser and the CMU Ip address is a very useful source of information.
- Remember to check the CMU web interface for error messages if something does not seem to be working as expected.

Image Analysis

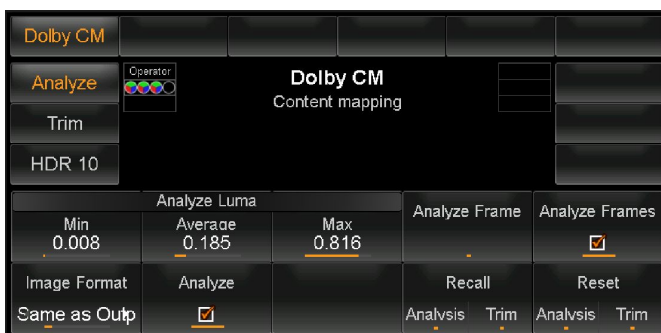
Once the HDR grade has been completed, the graded content must be prepared for the trim pass to create the other required deliverables.

The first stage of the trim pass is analysis. The analysis pass works by processing each frame of the content, using the project timeline to generate metadata for each shot. At this point, the metadata consists of just three numbers, a minimum, maximum, and average brightness for each shot.

The analysis has to process every frame in the sequence, and might take some time, our tests we have found that for a typical Nucoda system the analysis runs at about real time.

The metadata that is generated by the analysis is stored within Nucoda as parameters and are available the CMU process layer.

- Ensure that the Image Format setting matches the content being analysed, the setting should match the picture content and exclude any black bars. There is a user editable file called `DolbyOutputFormats.prefs` in `C:\Nucoda\2016_1\root\Presets\Users` that can be customised
- The image format setting will also be used to correctly mask the image when using the CMU, preventing the masked areas of the image from being processed.
- If you are in an ACES project, ensure that your output format is set to apply CMS, the analysis must be done using an output with PQ 2084 function.
- To only analyse certain clips, select a clip (or multiple clips) on the timeline (Ctrl click or drag select)
- Press the Analyse button, this will analyse all selected clips
- Single or multiple clips can be selected, reset and re-analysed
- The option exists to analyse a single frame using the Analyse Single Frame button. (the result will be used for the entire clip)



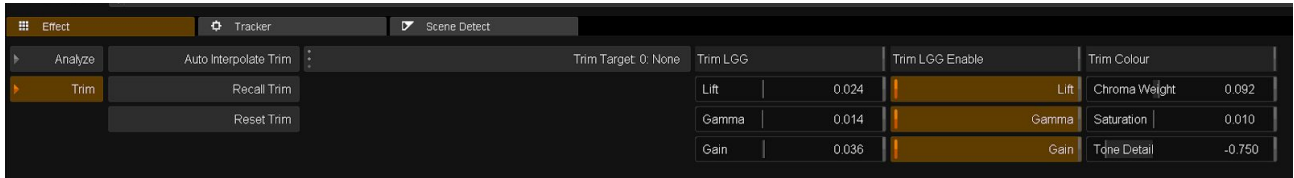
Precision analysis controls

As a clip is analysed the render status indicator bar will turn purple. After analysis is complete the render status will no longer display purple.

The Analyse Luma column will contain the results of the analysis. The MaxFall/MaxCLL data is also calculated but is not required for Dolby Vision - it is included for future format compatibility.

Creating trim versions for other displays using the Trim tools

After analysis, select the trim target - make sure the required monitor is connected to the CMU



At this point the colourist will take a view as to whether or not the resultant image is the best representation of his image on the Trim target monitor.

If it is considered that enhancements could be made then there are specific trim tools available in the tool to do this. Remember, the changes made using the trim tools are created by using the trim data to affect the CMU signal. No actual changes are made to the master. Changes are made by the CMU and applied to the image on the connected monitor.

- There will be a few frames delay due to the processing in the CMU.
- It is possible to copy and paste Trim and Analysis values between clips the same as normal grading - note: Using the normal Recall button will recall Trim and Analysis data. Please use the buttons on the tool screen in the Precision or use the Turbine button - press to recall and long press to reset.
- In cases where there are two clips composited over each other using the Composite effect on the top clip, the Dolby Analysis effect will be on the bottom clip

The option also exists to interpolate new trim targets based on previously created trim.

- Select the required new trim target.
- Select the Auto interpolate button - Nucoda will calculate the new settings based on the current available trims.
- You are able to recall trim data or analysis data from other clips to one or multiple selected clips on the timeline.
- Analysis of dissolves and dynamics are performed automatically



Precision trim controls

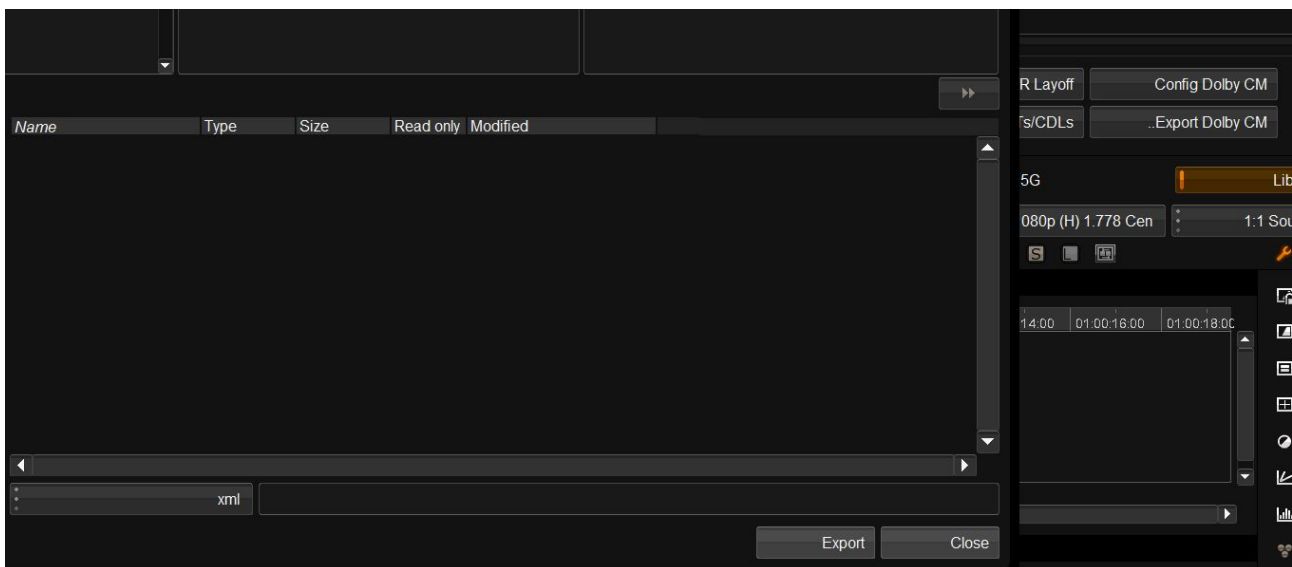
Image comparison when doing the trim pass (Thank you Adam)

Comparisons between the HDR and original SDR master is very useful, however, since the CMU alters the SDI signals it makes using traditional comparisons impossible at this point. It is only possible to use Cut as a compare tool at this point.

The way to work around this issue in Nucoda is simple

1. Import the comparison media and place on a track below the master that is being graded.
2. Make sure that analysis is turned OFF for the comparison image. This means there is no trim data for the CMU to base any trims on.
3. To do a cut compare, between the HDR and the master, use the Page UP / Page Down keys to cut between the two tracks.

Creating the Dolby Vision XML



Using the ...export data option in the library, select a destination and name for the XML file that is being exported. Very important, please ensure that after creating the XML, no additional trims or changes are made to the master or the trim targets.

For reference. the XML contains information about the Nucoda software version, project and composition.

```
<RevisionHistory>
  <Revision>
    <DateTime>2016-09-23T12:13:23+01:00</DateTime>
    <Author>Digital Vision</Author>
    <Software>Nucoda</Software>
    <SoftwareVersion>2016.1.034</SoftwareVersion>
    <Comment>Project: Dolby Test V3, Composition: Blood Simple</Comment>
  </Revision>
</RevisionHistory>
```

File delivery

When exporting the images for mastering - do NOT apply any kind of colour space conversion or image scaling to the masters. The XML contains the information about the mastering monitor and also the image that is being exported. Changing the image colour space or format will create problems during creation of the trim masters.

The images must be exported as 16 bit TIFF or Uncompressed EXR files - if you have used the ACES workflow, make sure the output format is burned into the image.

Using the ACES workflow outputting the images without an output transform will export material encoded as ACES ST2065-1 in the EXR.