AMIRA & ALEXA Mini
Color by Numbers

Date: 3rd May 2018

1. Introduction

This document gives an insight into the color processing of AMIRA/ALEXA Mini and describes the creative options available. Originally created for AMIRA, our versatile documentary-style camera, all said for AMIRA (with premium license) likewise applies to ALEXA Mini.

Table of Contents

2. Shooting with the AMIRA/ALEXA Mini

Both cameras use the same Super 35 sensor, that can be found in the regular ARRI ALEXA, ALEXA XT and ALEXA SXT camera series. This enables AMIRA/ALEXA Mini to capture 16:9 HD or 2K QuickTime ProRes clips at up to 200 frames per second (4K UHD up to 60 fps). As with the classic ALEXA, an AMIRA or ALEXA Mini allows you to record your images, encoded as **Log C** or **Rec 709** video. These terms refer to two types of image encoding that are commonly used in today's broadcast and feature productions.

2.1. Rec 709 – "Video" (and Rec 2020/2100)

Rec 709 video is the default video encoding in an HDTV production. Without the time, the budget or the tools to allow color grading, choosing Rec 709 video for recording will produce images that are ready to use for editing or TV broadcast without further conversion. The term **video** refers to images that are encoded for display on a computer, video monitor or digital projector.

Rec 709, short for ITU Recommendation BT.709, defines the primary colors and white point of HDTV displays. In addition to this, the contrast characteristic curve for flat panel displays is defined in ITU Rec. BT.1886.
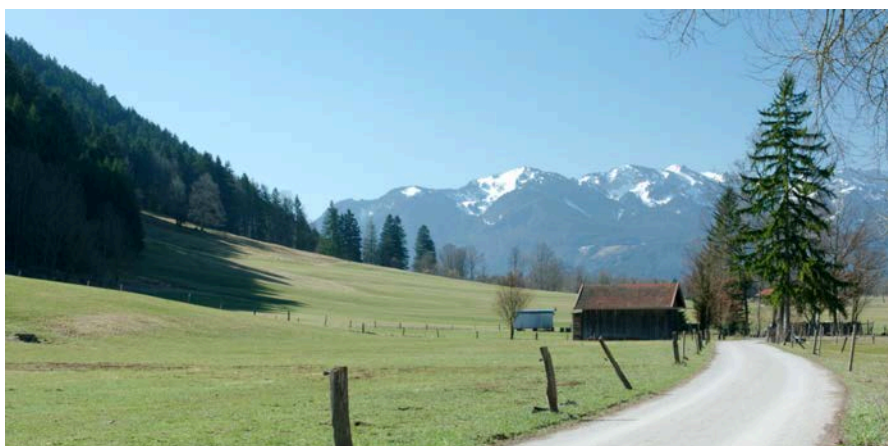
ITU Recommendation BT.2020 or Rec 2020 for short, is a bigger color space definition for UHD. Rec 709 literally lives inside the Rec 2020 specification as you can see below.
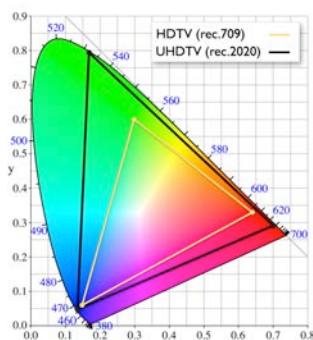
Rec 2100 on the other hand is based on Rec 2020. It "only" adds various aspects of HDR and up to 8K (7680 × 4320) resolution to the specification.

2.2. Log C

If you have access to current editing tools, you can unlock the camera's true potential by recording Log C. The digital numbers in a Log C encoded image are proportional to the exposure measured in stops. This creates a flat "data curve" which provides optimum control over the image information in the top range of the camera's 14-stop latitude. Log C encoding, which is the same basis for all ALEXA and AMIRA camera formats, stores color information in the native camera color space. Therefore Log C is also an ideal acquisition color space for HDR content (HLG or PQ/HDR10) which will be converted to Rec 2020/2100 color space for delivery.

To properly view the footage on a monitor, it has to be converted to the color space of the viewing device (e.g. Rec 709 video for an HD or UHDTV; Wait *UHDTV*? Yes that's possible, since Rec 2020 houses Rec 709 it is backwards compatible).

2.3. Processing Chain

After an exposed image is read from the sensor, the camera applies a white balance and then encodes the sensor-linear to a Log C image, which can be recorded.
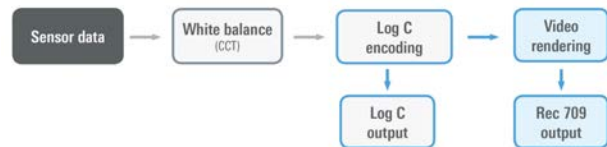
The default video output option, or default look of the AMIRA/ALEXA Mini is Rec 709 video ("ARRI 709"). If you set the camera to deliver Rec 709, the camera renders the video output based on the Log C encoded input image.

2.4. Capturing Images with Looks

Using the LOOK Config menu, you can choose between Look and Log C output for **Recording**, **SDI**, and **EVF/Monitor** (the viewfinder and its external display). While you typically want the look to be visible in the viewfinder and over the SDI outputs, you may prefer to keep the recorded image in Log C, unless you have to deliver Rec 709 files straight out of the camera.

Recording processing: Look

Selecting **Look** for the recorded image means that it will be transformed with the look. The active look becomes inseparable from the image ("burn-in").

If the look, for example, produces a black and white image, you will not be able to remove the look in order to get the colors back.

Recording processing: Log C

Selecting **Log C** for the recorded image means that the look is registered only as metadata, embedded in the camera footage. Since the look can be applied, or simply discarded, recording Log C with look metadata is a non-destructive operation.


Video image with look

Log C image with look in metadata

3. Look Controls

Next to the default Rec 709 video look, the AMIRA/ALEXA Mini's Look menu offers a few look options, to deliver, for example, a softer transition into highlights (Low Contrast Curve look, short: LCC), or more vivid images. Depending on the camera license of AMIRA – Eco, Advanced, or Premium – the look menu allows you to create your own look by modifying one of the presets, or to manage (add, duplicate, modify, export and delete) a look or to bring in a 3D LUT that was created with a color grading tool and use that as the look via ARRI Color Tool.

An ARRI Look File 2 can be put together from two sets of control parameters. The first part are ASC CDL parameters, that will be applied to the Log C encoded image. Second, a rendering 3D LUT, which controls the transformation of Log C data to the output color space.

This 3D LUT can be:
    a) the default ARRI 3D LUT ("ARRI 709"), providing a Rec 709 video output.
    b) a customized version of the 3D LUT with a tone map curve and/or color transformations that have been modified with the Video Look Parameters (see below).
    c) an imported custom 3D LUT, that was generated in a color grading tool. VLP controls are not available when an imported 3D LUT is used.
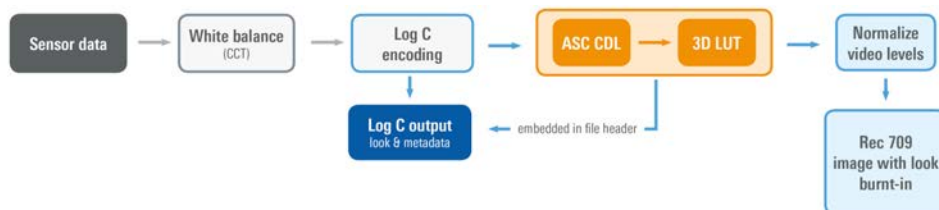
With the basic feature set, the AMIRA offers only the Video Look Parameters for look adjustments. The Advanced license adds ASC CDL controls and support for external look files. The AMIRA Premium license as well as ALEXA Mini enable all look options, including the use of custom 3D LUTs in the look files.

3.1. Why use Looks?

Establishing looks in early in the production process helps everyone, who is involved in the production. Being able to monitor images with their intended look during the shoot and during editing helps getting used to the visual language of the production. As a result, we hope to see less time spent in the color grading sessions, because everybody will have the same idea of what the images are supposed to look like.

To establish one or more looks, you can:

- Shoot some **reference images** representing the key visuals.
- **Establish the main looks** in a grading session with the colorist.
- **Use looks in camera** to monitor the image with look while on set.
- See images with look **during the edit**.
- Finalize color **grading based on looks**.

3.2. ASC CDL Transforms

The American Society of Cinematographers has specified a set of transforms that have become a standard in the post industry. The transforms are controlled by the parameters slope, offset, power and saturation (applied in that order), which are based on simple color manipulations of multiplying with a factor, adding an offset, or raising to an exponent. Noted as "Color Decision List" (ASC CDL), they serve as an exchange format for basic look transformations between color correction systems and editing tools by different manufacturers.

ARRI's image processing applies the ASC CDL transforms to the Log C encoded image. This enables manipulations like exposure correction or bringing down highlights before the picture is converted to the display color space with its steeper contrast curve.

The ASC CDL adjustments are available for AMIRA Advanced, Premium and ALEXA Mini.

Slope

The linear section of the Log C curve is equivalent to the gamma of a negative film stock. The Log C curve has a default gamma of approximately 0.51, which can be adjusted with the slope parameter.

A slope value of 1.2 will have a similar effect as using negative stock with a gamma of 0.6 (= 1.2 * 0.5). A parameter below 1.0 will lower the gamma accordingly.

Offset

Offset is the most intuitive of the CDL parameters. It has a similar effect as increasing the exposure index on the camera. If you are familiar with the motion picture print film process, it's the same as printer lights.
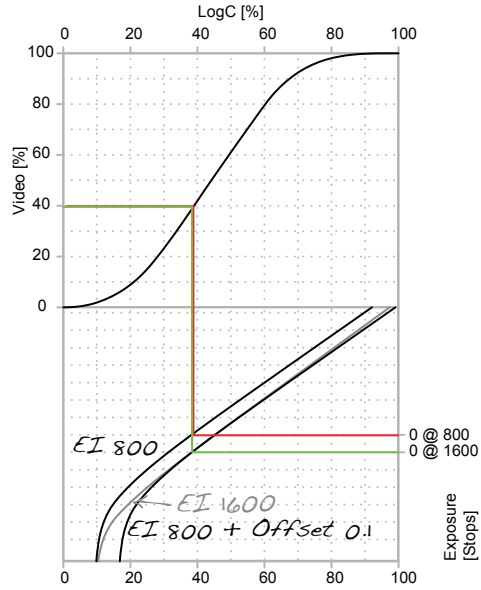
The images below show a scene that was exposed for 1600 ASA. In one case, the camera was set to EI 800, resulting in an underexposure of one stop. This was corrected with a CDL offset value of 0.07.
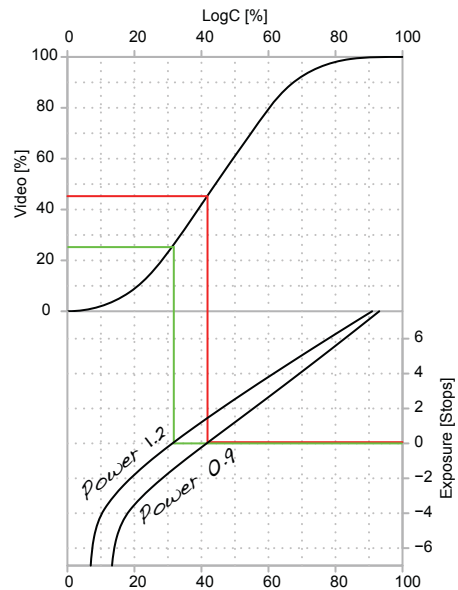
Power

Power can be used to adjust the mid tones, similar to the Gamma parameter in video color grading.

A power value below 1.0 will increase the brightness of the mid tones.
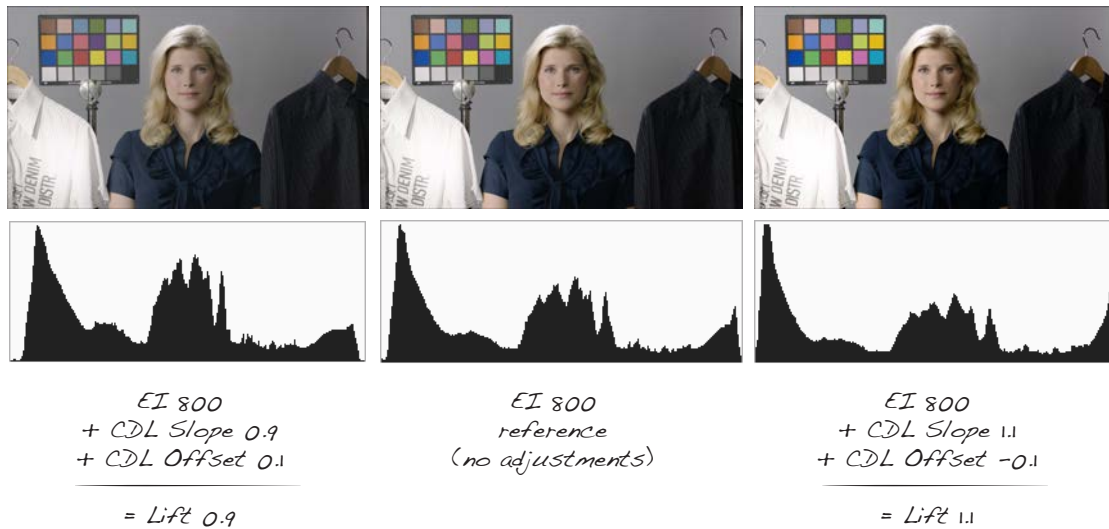A value greater than 1.0 will decrease their brightness.

(Log) Saturation

The saturation parameter affects all color components in the Log domain.

Slope + Offset = Lift

Very often, slope is combined with an offset to compensate the change in overall brightness. In other words, this operation tries to keep the white point at a fixed position and rotate the (Log C) curve around that point. In video color grading, this combination is called lift.

As an example, a slope of 1.15 with an offset of -0.15 will keep the highlights at a constant level.

EI 800	EI 800	EI 800
+ CDL Slope 0.9	reference	+ CDL Slope 1.1
+ CDL Offset 0.1	(no adjustments)	+ CDL Offset -0.1
= Lift 0.9		= Lift 1.1

3.3. 3D LUT and Video Look Parameters

The AMIRA uses a 3D LUT to generate a Rec 709 video image from Log C data. Next to the ASC CDL parameters, which apply to the Log C image, the camera also offers a set of Video Look Parameters (VLP), that influence the tone mapping and color transformation of the rendering 3D LUT.

The VLP control knee, black gamma and the gamma of the tone map curve, which affect the contrast characteristic of the output image. The VLP also include values for saturation and the saturation by hue for the six color vectors of green, yellow, red, magenta, blue, and cyan.

Regardless of the adjustments, the underlying 3D LUT always performs a Log C to Rec 709 color space conversion.

Video Look Parameters are available in all three AMIRA license bundles as well as in ALEXA Mini.
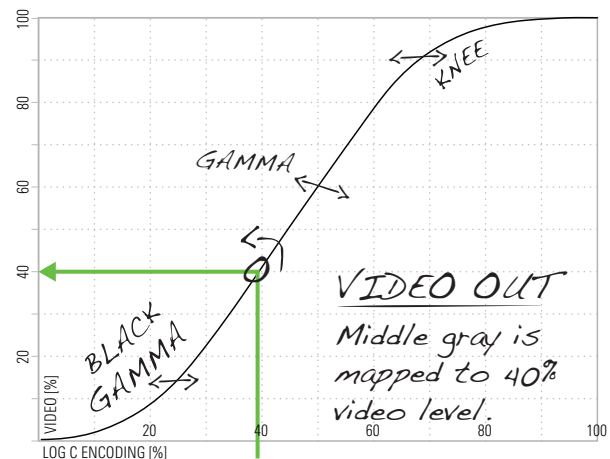

Knee

The knee parameter controls the transition of mid-tones into highlights. Values below 0.5 (default) produce harder highlights, higher values soften them. Knee is applied to all channels equally (master control). It has no effect on the mid gray level.
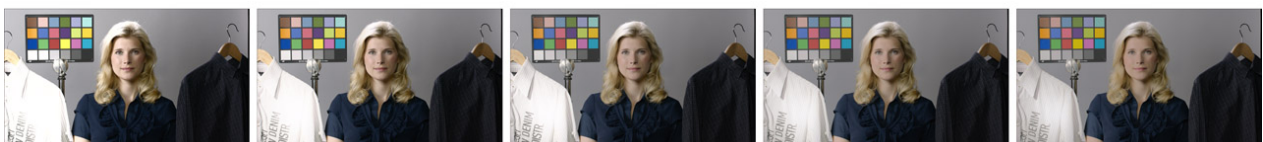
Black gamma

The black gamma controls the shadow detail in the image. Values below 0.5 (default) bring down the blacks, higher values brighten them. Black gamma is applied as master control. It only affects the mid gray level for very high values.
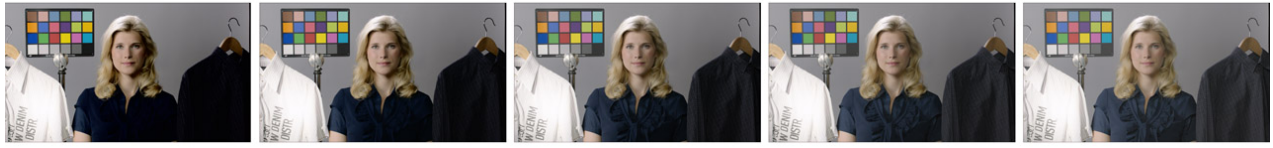
Gamma

The gamma setting can be used to brighten or darken the mid tones, while leaving the black and white level unchanged. Values below 1.0 (default) will darken the image, higher values will brighten the image.
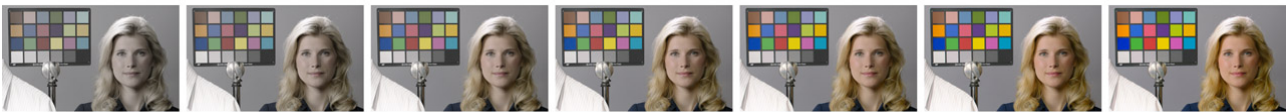

Gamma < 1   Gamma > 1

(Video) Saturation

The VLP set also includes a saturation control, which has a similar effect as the ASC saturation control. A value of 1.0 represents the default saturation.

Saturation by Hue

The AMIRA allows you to control the saturation for the six color vectors red, yellow, green, cyan, blue, and magenta. In the images below, the center shows the scene, photographed with default values. Starting at the top left, going clockwise, you can see the effect of turning the hue values for green, yellow, red, magenta, blue, and cyan to zero (left group) or maximum (right group).

3.4. Custom 3D LUT

The AMIRA Premium/ALEXA Mini can also use an ARRI Look File 2 that includes a custom 3D LUT, created and exported from a color grading tool. This LUT needs to be stored in the ALF2 file format (*.aml) with the free ARRI Color Tool.

Using a custom 3D LUT disables the video look parameter controls. The resulting look, however, can still be tuned with the ASC CDL parameters (also via live grading).

A grading system usually offers better and finer color adjustment options for all parameters described above. It also offers additional manipulations, that are not available with the set of CDL and VLP values, such as the ability to pick any key color, not just one of the six main color vectors, and change its chromaticity rather than just its saturation.
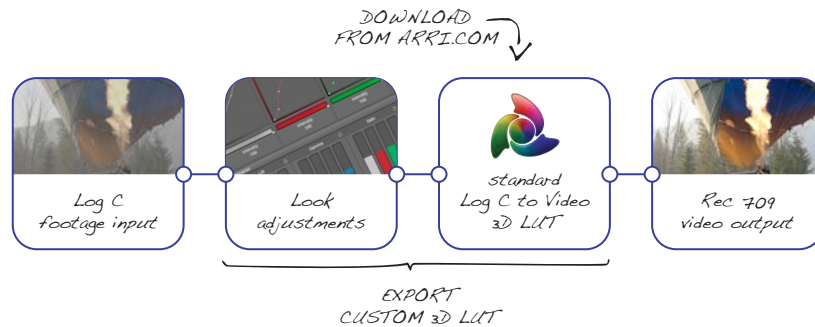
To generate a 3D LUT for use in the AMIRA/ALEXA Mini, you can follow these steps:

1) Load Log C footage
2) Apply creative color grading
3) Apply Log C to Rec 709 video rendering (or any other output color space)
4) Show resulting look on a reference monitor
5) Export the look for the camera as a combined 3D LUT, using the transforms from steps 2 and 3.

A good line of action is to include a default ARRI Log C to Rec 709 video 3D LUTs as an output LUT (step 3) in the grade. This ensures that your color grade starts from a color-correct output image.

Remember, the default rendering 3D LUT performs a tone mapping and a color space conversion!
A default 3D LUT can be generated with our online ARRI LUT Generator at www.arri.com/alexa/tools.

4. Creating Looks

There are several ways to create a look. One option is to use a dedicated color grading tool using the steps described above, to create a look from a custom 3D LUT. This option, however, is only available for AMIRA cameras running the Premium license bundle or ALEXA Mini.

Another option would be the ARRI Color Tool (ACT), a free Mac and Windows software by ARRI, that can be used to create an ARRI Look File 2 with all CDL and VLP controls using a graphical interface.

Find ACT here: www.arri.com/alexa/tools

Last, but not least, the camera also offers a Look Parameter screen that will allow you to create or modify a look with nothing but the camera and a monitor, attached to the camera's HD-SDI output.

4.1. In-Camera Grading

The LOOK/Config menu in the AMIRA/ALEXA Mini can be used to import, export, duplicate, load, edit and save looks. The basic AMIRA (Eco) is limited to three look options and lacks the ability to load or export a look.

Creating a Look from Scratch

Start by duplicating the default "ARRI 709" look and saving it under the new look's name. You can also overwrite a look. Default looks can be restored from the menu.
Adjust the ASC CDL parameters and/or the Video Look Parameters and monitor the changes via the SDI output.
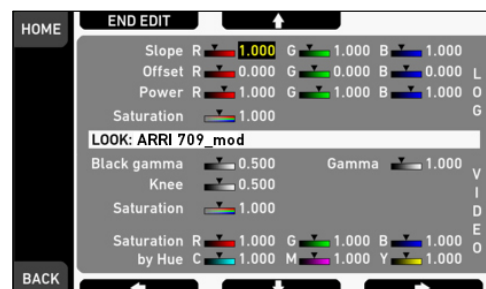
Tuning a Look

If adjustments like a change of the white balance cannot modify a look towards where you want it, you first should duplicate the original ARRI Look File 2 (ALF2) and save the copy under a new name. Next, use the ASC CDL controls to modify e.g. the color reproduction and/or the Video Look Parameters to adjust the tonal balance of the output. If the ALF2 was created from a custom User 3D LUT, you can only make adjustments with the ASC CDL parameters.

4.2. ARRI Color Tool

ARRI provides a free software that allows you to create, modify and store ARRI Look File 2 looks outside the camera. The software can read camera original ProRes files for playback and look creation. Look files can be created from scratch, im- and exported. As mentioned before, you can also import a custom 3D LUT that was created in a color grading tool and combine into an ARRI Look File 2 (*.aml).

Looks can also be exported as 3D LUT and separate CDL parameters (XML) or 3D LUT including CDL parameters for use in other applications.

Using the ARRI Color Tool lets you work faster and more convenient than the camera menu. The software offers easy to use mouse or keyboard color controls.
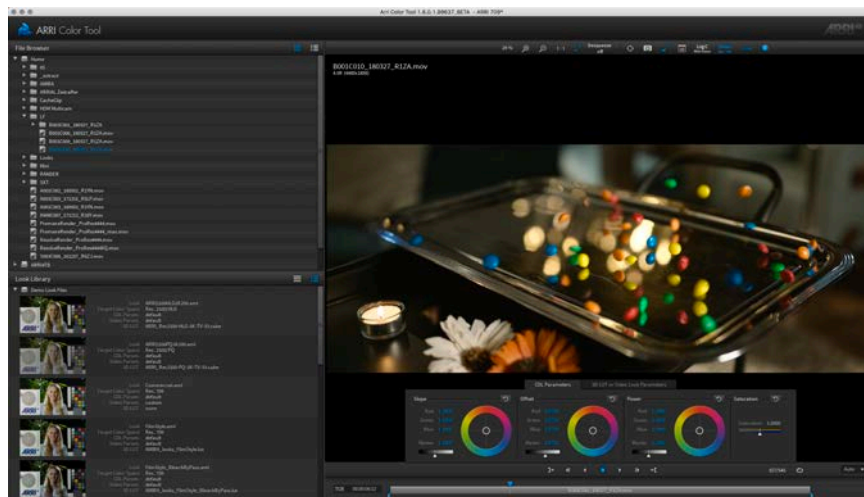
4.3. Look Examples

The AMIRA and ALEXA Mini ship with some ready-to-use technical or creative looks. Except for the ALEXA Classic 709 look and HDR Looks, all are created with Video Look Parameters and thus can modified to your liking.

LCC (Low Contrast Curve)

Black Gamma = 0.8, Knee = 0.85, Saturation = 0.7
If you cannot use Log C encoding, but need better highlight handling, you can use the LCC look. With this flattened Gamma curve, highlight definition and some black detail that would be lost by the typical Rec 709 tone mapping can still be accessed. For the final image, you can adjust the contrast to all critical image detail remains visible, but the overall softness is taken out again. Since the look already includes a Log C to Rec 709 color space conversion, no additional rendering step is required.

Commercial

Black Gamma = 0.3, Knee = 0.4, Gamma = 1.4
A creative, brighter look for nicer skin tones.

Landscape

Black Gamma = 0.3, Knee = 0.2, Gamma = 1.4, Saturation = 1.15
A creative look with a steeper contrast curve and lifted saturation.

Vibrant

Black Gamma = 0.4, Knee = 0.4, Saturation = 1.05, Saturation by Hue G/B/C/M = 1.15
This creative look boosts the color saturation except for red and yellow.

ALEXA Classic 709

**3D LUT (AMIRA Premium and ALEXA Mini only)**
This technical look produces a Rec 709 video output, closely matching that of an ALEXA Classic camera. This look is based on a 3D LUT and requires a premium license. To tweak this look, you can only use the CDL parameters.

4.4. 3D LUT/Look Warnings

If certain conditions are being fulfilled (see below), the ARRI Color Tool issues a "3D-LUT/look warning". An active warning is being indicated by a blue tinted i-Icon on the very right of the toolbar.
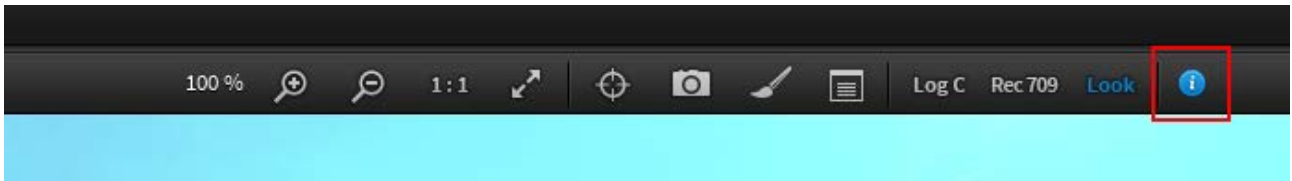
A click on the icon reveals the details of the warning: in this example the red channel indicates elevated blacks – code value 6648 instead of zero (16bit space). Comparing the warning to the image shows the *intended* result: rusty, reddish blacks. So this warning should be read as a technical not as a creative one.
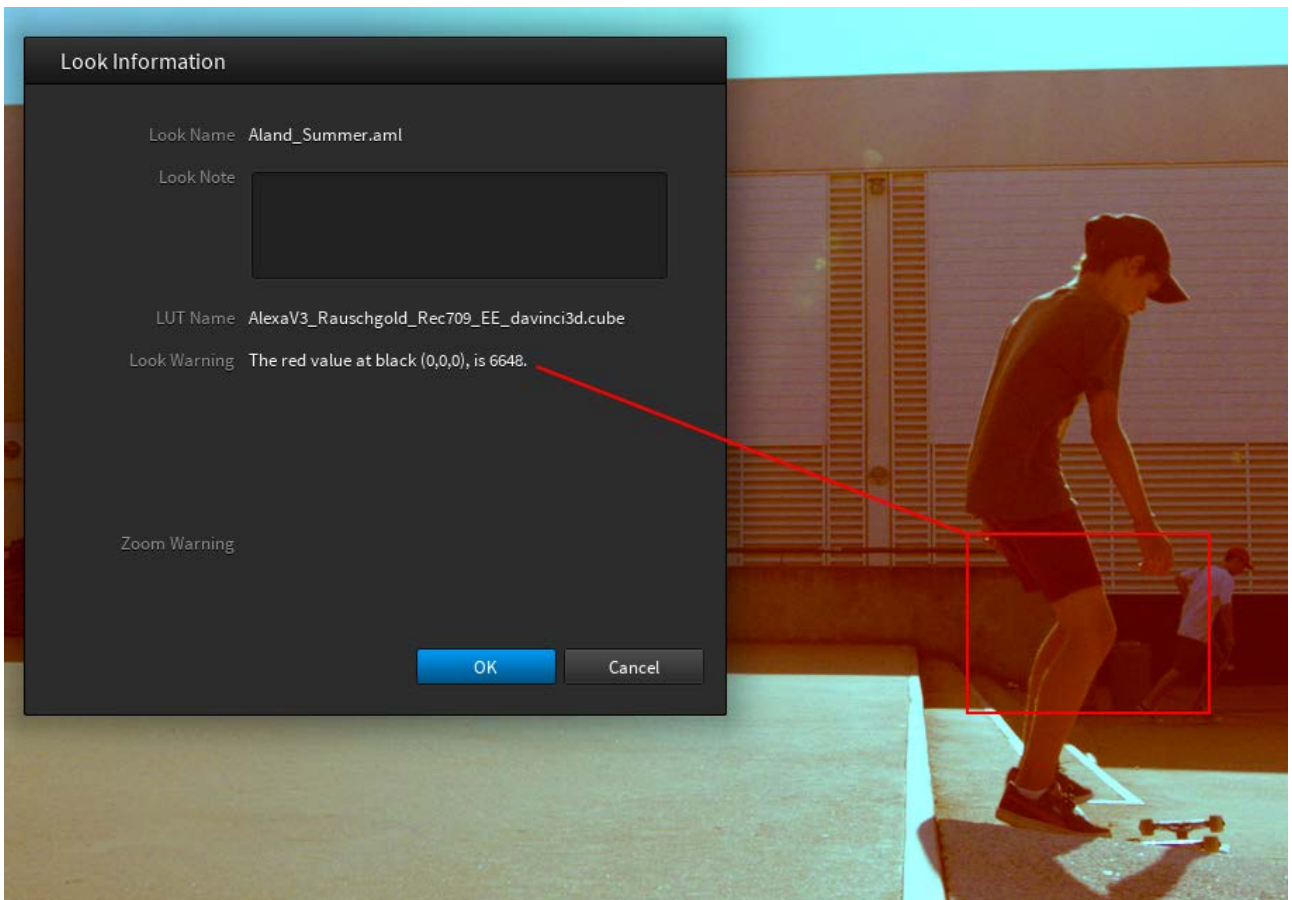
Types of Warnings

1. Values not monotone

"The red/green/blue channel is not monotone along the gray axis."

Occurrence: if values in one or more channels do not increase in a monotonous nature.

2. Black value

"The red/green/blue value at black (0,0,0), is ..."

Occurrence: if the black value in one or more channels is not zero and exceeds a threshold of 65 code values.

3. Maximal white value

The red/green/blue value at max. white (65535, 65535, 65535) is ..."

Occurrence: if the max. white value in one or more channels is not 65535 and exceeds a threshold of 65 code values.

5. Looks in editorial

Full ARRI Look File 2 support

At NAB 2014 Apple, Adobe, Avid, Colorfront and Pomfort were the first to embrace this look concept. They presented versions of their software that can read the look information from the QuickTime metadata in each AMIRA Log C clip and automatically perform the video rendering based on that look file.

As a result, the editor, DIT or data wrangler sees the same image including the look that is active in the camera, as the footage was shot. This step is fully automatic, adjustable and reversible. It represents a big improvement to Log C workflows as it combines the superior elasticity of Log C footage with the simplicity of video workflows.
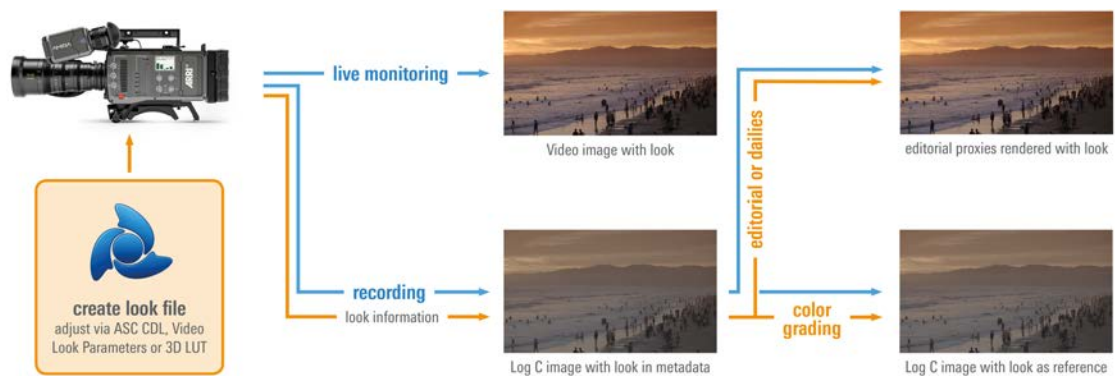

Basic Log C Support

Many major editing tools already offer at least basic support for Log C material. In some cases (Adobe Premiere, Final Cut Pro X, Media Composer 7 and later), the application will automatically detect Log C encoded material and apply a default Log C to Rec 709 video conversion.

Without Log C or Look Support

If the editing tool in use does not offer Log C support of any kind, you can use the ARRI Color Tool or ARRI Meta Extract to extract the look from the footage, export the look as a 3D LUT and render Rec 709 video dailies with a tool such as the free Blackmagic DaVinci Resolve.

To learn how this can be done, please have a look at the ALEXA Dailies Creation in Blackmagic Resolve 12.5, available from www.arri.com/alexa/downloads.
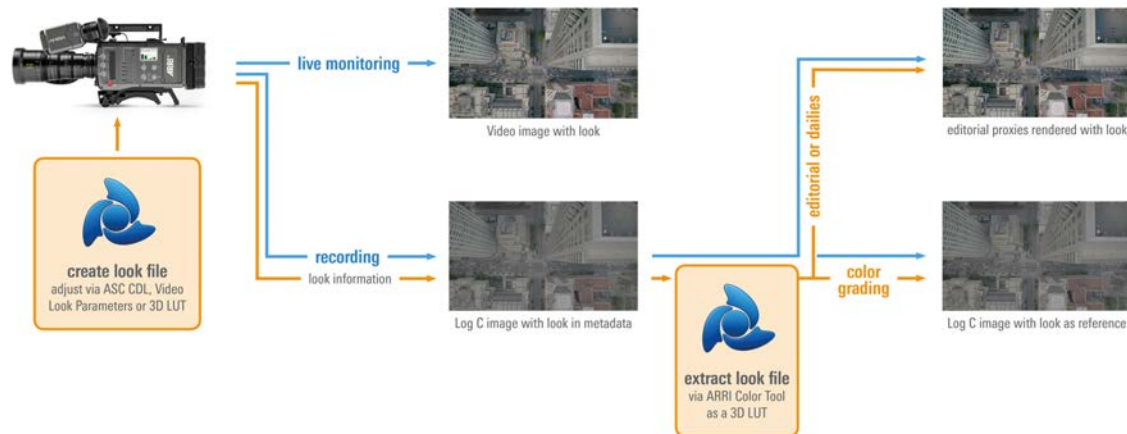
Keeping looks available

One advantage of the color/look concept in the AMIRA and ALEXA Mini is, that it is based on 3D LUTs, which are supported by a great number of post production tools. When a look is used (with Log C recording), the AMIRA/ALEXA Mini stores different flavors of this look as metadata in the QuickTime clips.

- Complete 3D LUT including all CDL and VLP settings, or CDL and custom 3D LUT.
- 3D LUT including only VLP settings, without CDL values.
- CDL values without VLF settings.

Even if it takes years until you get back, for example to re-master the original footage, you will be able to extract the original intended look and use it as a reference for your work.

6. Contact

If you have questions or recommendations about this paper, please contact the ARRI Digital Workflow Solutions group at digitalworkflow@arri.de.