



ALEXA SXT

ARRI Look Management

WHITE PAPER

Date: September 07, 2016

Table of Contents

| | |
|---|-----------|
| Table of Contents | 2 |
| Introduction | 3 |
| ARRI Look Management Main Features | 3 |
| About This White Paper | 3 |
| Definition of Terms | 4 |
| Color Space | 4 |
| Chromaticity Diagram | 5 |
| ALEXA Wide Gamut/Log C | 6 |
| ASC Color Decision List (CDL) | 6 |
| Look Up Tables (LUT) | 7 |
| 1D LUT | 7 |
| 3D LUT | 8 |
| Look File | 8 |
| Camera Access Protocol (CAP) | 8 |
| ALEXA SXT | 9 |
| ARRI Look Management Components | 10 |
| ARRI Look File 2 | 10 |
| ARRI Look File Compatibility | 11 |
| ARRI Look File Compatibility Guide | 11 |
| LutDesignData Metadata Field | 12 |
| ARRI Color Tool | 13 |
| ARRI Meta Extract | 14 |
| Third Party Support | 14 |
| Target Color Space vs. On-Set Monitoring Color Space | 14 |
| ALEXA SXT Image Processing and Menu Settings | 15 |
| Overview | 15 |
| Recording Image Path - Recording Format | 16 |
| Recording Image Path - ProRes REC Processing | 17 |
| Monitoring Image Path - MON OUT 1 Processing | 18 |
| ALEXA SXT Built-in Look Files | 20 |
| Monitoring Image Path - MON OUT Color Spaces | 21 |
| Use Cases | 23 |
| General Production Workflow | 23 |
| Use Case 1: TV Show, ProRes, no Look, no Offline | 24 |
| Note 1: Creating Proxies in your Editing Program | 24 |
| Note 2: Editing without the new ARRI Look Management | 24 |
| Use Case 2: TV Show, ProRes, no Look | 25 |
| Use Case 3: TV Show, ProRes, Look | 26 |
| But Wait, There's More! | 27 |
| Use Case 4: Feature Film, ARRIRAW, Look | 28 |
| A Note about Color Grading | 28 |
| Color on the Set | 29 |
| Typical Workflow "Pre-canned Looks" | 29 |
| Typical Workflow "Live Color" | 29 |
| Typical Workflow "Live Color" - Before ARRI Look Management | 30 |
| Typical Workflow "Live Color" - With ARRI Look Management | 30 |

Introduction

The switch from analog to digital production has brought many positive changes. Amongst them is a high quality preview of the images on set, as well as the ability to see those images with the intended look and to carry that look through to dailies and editing. Color management and look workflows have been the topic of much debate in the past years. Based on half a decade of customer feedback and what has been learned from D-20 to ALEXA XT, the new ARRI Look Management has been devised for AMIRA and ALEXA Mini and then expanded for ALEXA SXT. This highly refined, powerful and flexible system will be used by ALEXA SXT, ALEXA Mini, AMIRA and future cameras to provide a wide range of unique looks and to maintain and share the cinematographer's intended look on set, in dailies and in editing.

ARRI Look Management Main Features

- Powerful new ARRI Look File ALF-2
 - Contains ASC CDL, 3D LUT and name of target color space
 - Supports Rec 709, P3 DCI and Rec 2020 color spaces
 - Full look file always included in metadata of recorded image
 - Created and managed by ARRI Color Tool or ARRIRAW Converter
- Live grading on-set
 - ALEXA SXT replaces LUT box
 - Show and fine-tune cinematographer's intended look on set
 - Supported by Pomfort LiveGrade, Codex Live, Colorfront On Set Live!, Filmlight Prelight, Technicolor DP Lights and others
- Automated dailies
 - Looks from metadata are automatically applied by dailies software
 - Supported by Blackmagic Design DaVinci Resolve, Colorfront OSD, Pomfort Silverstack, Filmlight Daylight and others
- Editing with looks
 - Looks from metadata are automatically applied by editing software
 - Supported by Avid Media Composer, Apple Final Cut Pro X and Adobe Premiere Pro
- Flexible and future proof
 - Same look file and tools for ALEXA SXT, ALEXA Mini (SUP 4.0) and AMIRA (SUP 4.0)
 - Software library allows third parties to read/write ALF-2 files and use ARRI Color Tool functions
 - Camera Access Protocol allows third parties to up/download 3D LUTs and change CDL values in-camera
 - Special metadata in ARRIRAW and ProRes can transport vendor specific grading information
 - Rec 709 or Rec 2020 monitor outputs on ALEXA SXT
 - HDR ready

About This White Paper

This paper is designed for the end user (DIT, camera assistant, cinematographer, director) who wants to get an overview of the general workflow and advantages of the new ARRI Look Management. This paper is valid for ALEXA SXT Software Update Packet SUP 1.0. It provides

- a definition of relevant terms,
- an overview of the components of ARRI Look Management,
- an overview of ALEXA SXT image processing as it pertains to look management,
- a description of the most relevant use cases and
- a detailed discussion of the advantages of the ARRI Look Management on-set.

Definition of Terms

Color Space

A color space is a specific numerical method of describing colors, allowing for reliable reproduction. A color space consists of the definition of the three primary colors, a white point and a transfer curve.

Some color spaces are virtual, meaning there are no displays in existence that can show their primary colors. Examples are ALEXA Wide Gamut/Log C ("AWG/Log C" in this paper, often just called "Log C") or ACES. Such color spaces usually contain more colors than found in display-specific color spaces. Capturing more than what can be shown on today's displays provides greater flexibility in final grading and is another part of producing "future-proof" images. For previewing these images on-set, for creating dailies, editing, final grading and distribution, these images must be rendered into a display-specific color space.

Display-specific color spaces are defined by the physical characteristics of a display technology. For example, the "Rec 709" color space is based on the capabilities of Cathode Ray Tube (CRT) displays. Today, CRT monitors are not made anymore, but by adhering to the Rec 709 standard, manufacturers can make modern displays based on different technologies (TFT, OLED, etc.) that will render colors in the same way as CRT monitors did.

The three display-specific color spaces that are commonly used in digital motion picture production for monitoring images on-set and as target color spaces for final grading are Rec 709, DCI and Rec 2020.

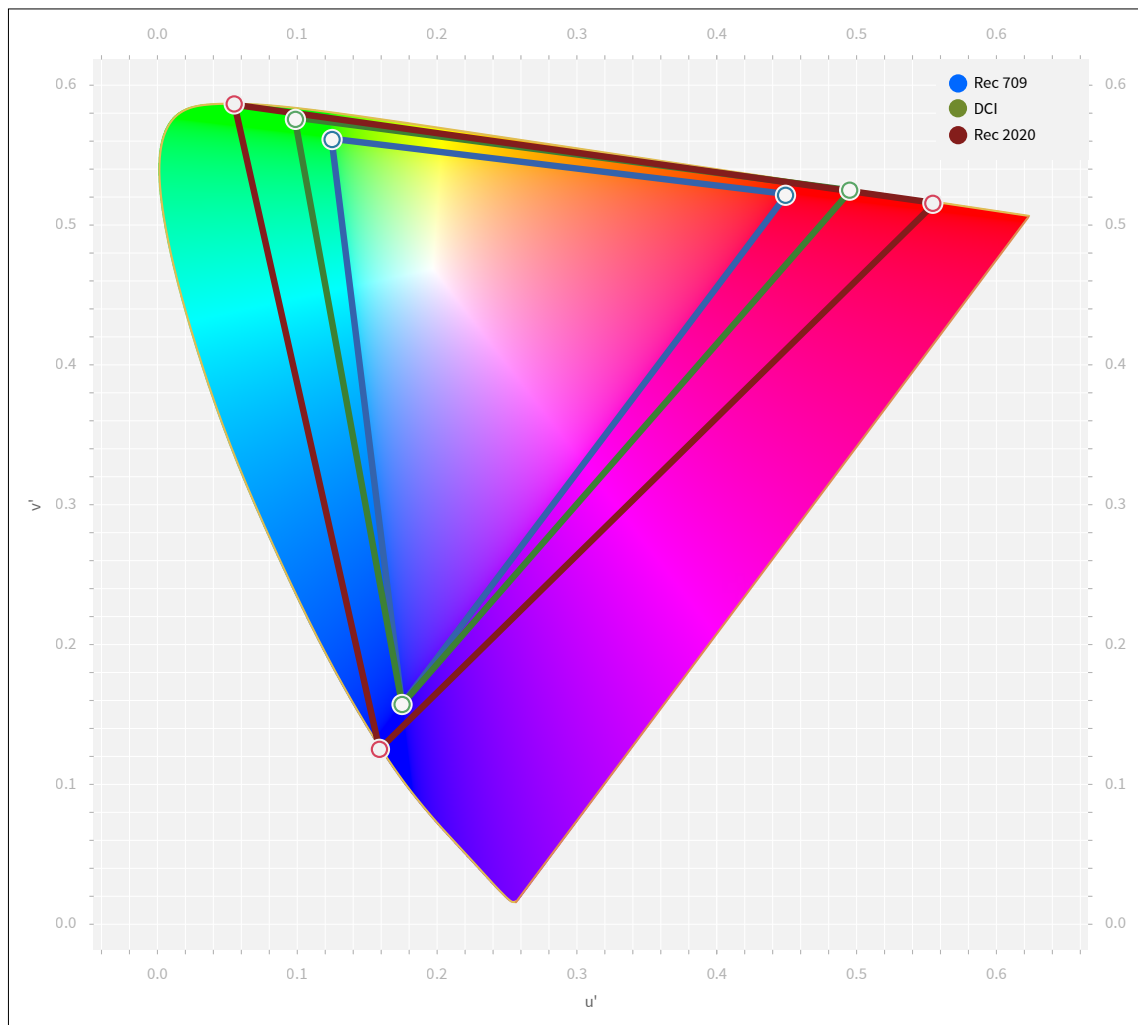
- **Rec 709** is the color space used for the majority of HDTV monitors. It is defined in ITU-R BT.709 and ITU-R BT.1886. While this is the smallest of the three color spaces, its gamut encompasses the colors of many natural or man-made things (like the colors on a MacBeth or CamAlign chart, for instance) seen under tungsten or daylight. Colors that cannot be displayed accurately in Rec 709 can be found in some particularly colorful clothing, paints, flowers and effect lights in stage shows.
- **DCI** is the color space used by digital projectors in movie theatres. It is defined in the Digital Cinema System specifications released by the Digital Cinema Initiative (DCI) and in SMPTE-RP 431-2. The DCI color space is larger than Rec 709 but smaller than Rec 2020.
- **Rec 2020** is the color space planned for 4K UHD TV monitors and is partially defined in ITU-R BT.2020. This is the newest and largest of the three color spaces. While some monitors support Rec 2020 partially, a lot of 4K UHD monitors still use the Rec 709 color space.



Chromaticity Diagram

RGB color spaces are often represented as triangles in a chromaticity diagram. The primary colors are those that define the corners of the triangle. A mixture of two primary colors lies on the line connecting the two colors. The area within the triangle represents mixtures of all three primary colors, including white. The triangle is also called the "gamut" of colors a display can reproduce.

The figure below shows the three color spaces used in digital postproduction and distribution. The chromaticity coordinates used for the figure are expressed in the CIE 1976 UCS. CIE is the International Commission on Illumination (usually abbreviated CIE for its French name, Commission internationale de l'Éclairage), which is the international authority on light, illumination, color, and color spaces. UCS stands for Uniform Chromaticity Scale. In this diagram, the distance between two points of colors in the diagram is proportional to the perceived color difference. This works only as a very rough estimate but it gives a better representation than the often used CIE 1931 (xy) chromaticity diagram.



ALEXA Wide Gamut/Log C

ALEXA Wide Gamut/Log C (AWG/Log C) is the native color space of ALEXA, ALEXA Mini and AMIRA. It is often referred to simply as "Log C".

Log C is ARRI's encoding scheme for image tonal values. AWG/Log C is designed to hold as much information and dynamic range as possible to allow for more grading possibilities in postproduction. In AWG/Log C, each stop of exposure increases the signal by the same amount. The "Log" in the name stems from the fact that stops are a logarithmic measure of scene brightness. The "C" derives from the fact that the tonal curve of the Log C encoding is similar to the tonal curve of film negative in the Cineon format. Cineon was the digital film scanning, processing and recording system developed by Kodak in the 1990s. Thus, the overall shape of AWG/Log C's characteristic curve is similar to the exposure curve of film negative.

The AWG/Log C color space maintains more tonal differentiation in the bright and dark parts of the image than any image prepared for display, and for this reason is an ideal intermediary recording format, one that provides a great deal of flexibility when color grading.

Since AWG/Log C is a virtual color space, there is no defined method for viewing it directly. Therefore on a Rec 709 or Rec 2020 display, AWG/Log C images look flat with desaturated colors (see left image below). To properly view AWG/Log C material, it has to be tone mapped and converted to the color space of the viewing device (e.g. to the Rec 709 color space to be shown on an HDTV monitor - see right image below). This image conversion can be performed using a 3D Look Up Table.



ASC Color Decision List (CDL)

The American Society of Cinematographers (ASC) has specified the Color Decision List (CDL), which is a format for the exchange of basic primary color grading information between equipment and software from different manufacturers. A CDL takes up much less space than a 3D LUT and thus is ideal for communicating on-set scene to scene color changes between laptop and camera, and for transporting basic look information. A CDL consists of a set of transforms: slope, offset, power and saturation (applied in that order).

Look Up Tables (LUT)

A Look Up Table (LUT) is a method for changing a value. While these value changes could be calculated, retrieving a value from a table in memory is often faster and takes less processing power for a computer than doing the actual calculation. A simple example of Look Up Tables are the multiplication tables many of us have memorized in school to speed up the recollection of the results of common multiplications.

For our purposes, a Look Up Table is a tool for quickly changing a value from one coordinate system into another coordinate system, i.e. a method to change a range of colors from one color space to another. When using a Look Up Table, the camera automatically locates the entry for a color in the original color space and then looks up the corresponding value for the new color space.

Look Up Tables in digital production and postproduction are used for three purposes: calibration, technical conversion and creative look. Sometimes there are individual LUTs for each purpose, sometimes two or three purposes are combined into one LUT.

- **Calibration LUTs** are used to ensure that a display shows colors accurately by compensating for any limitations and inaccuracies of the display. Calibrating a monitor is usually done with a probe that measures the monitor's output and then adjusts a LUT.
- **Technical LUTs** are used to convert from one color space to another, as is necessary, for instance, if one wants to view an image in the AWG/Log C color encoding on a Rec 709 monitor. A LUT will map the colors from AWG/Log C into the Rec 709 color space. This is sometimes also called a "viewing LUT".
- **Creative LUTs** are also called "looks", as they are used to endow an image with a specific artistic look. They are used on set to preview the cinematographer's visual intent and for the same purpose in the creation of deliverables (dailies and editing proxies) and in final grading.

1D LUT

A 1D LUT describes a change to the value of a single color channel and does not take into account values of the other two color channels. Each 1D LUT contains an input value and an output value. A simplified set of three 1D LUTs, one each for the red, green and blue channels, might look like this:

| RED | |
|-----|-----|
| in | out |
| 0 | 3 |
| 1 | 5 |
| 2 | 7 |
| 3 | 9 |

| GREEN | |
|-------|-----|
| in | out |
| 0 | 0 |
| 1 | 2 |
| 2 | 5 |
| 3 | 9 |

| BLUE | |
|------|-----|
| in | out |
| 0 | 0 |
| 1 | 1 |
| 2 | 3 |
| 3 | 9 |

- For an input value of 1 for the red channel, the red output value is 5
For an input value of 1 for the green channel, the green output value is 2
For an input value of 1 for the blue channel, the blue output value is 1
- If an individual pixel had an input value of 3/1/0 for RGB, the output pixel would be 9/2/0.

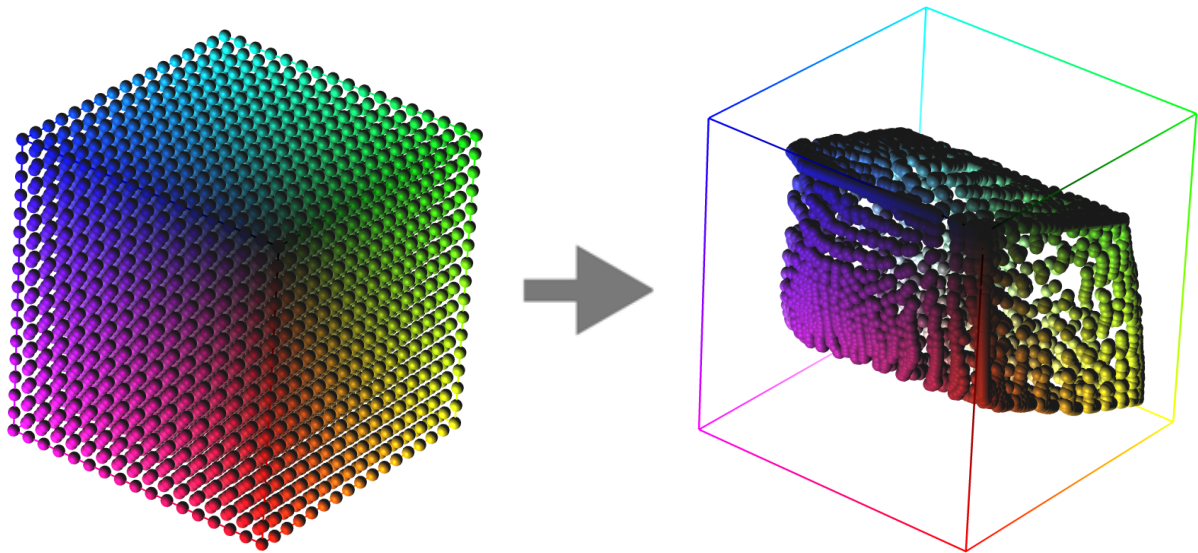
1D LUTs are useful for adjusting contrast and gamma per color channel. They are simple and therefore fast and, within their limitations, very accurate, as you get a clearly defined output number for each input number. However, since a 1D LUT treats each color individually, there are color transformations that cannot be expressed, especially those affecting color saturation and color space conversion. That is what 3D LUTs are for.

3D LUT

3D LUTs are more powerful than 1D LUTs as they can act on all three color channels at once. With a 3D LUT it is possible to independently control saturation, brightness and contrast. However, they are significantly larger than 1D LUTs and require some computation, since they only store key values and any in-between values are interpolated.

While a 1D LUT describes a change to each color channel individually, the 3D LUT deals in sets of three values, R, G and B. Imagine a 3D LUT as a cube, wherein the three axes represent red, green and blue. Any color can be defined as a location inside this cube expressed as three numbers: one for red, one for green and one for blue. The Look Up Table then defines for each color in the original image, represented by a triplet of numbers in the input cube, a new color: a new triplet of numbers in the output cube.

If a 3D LUT were to have values for each and every input to output combination, the LUT would be very, very large indeed. To reduce size, most 3D LUTs use cubes with a limited number of defined points for each axis. The values between these points are interpolated. Common numbers are 17 or 33 so-called "mesh points" along each axis. The example 17 x 17 x 17 ("17³" for short) 3D LUT shown below is a "Creative LUT" used to create a special look. The ALF-2 Look Files contain 3D LUTs with 33³ mesh points.



Look File

A Look File is a wrapper that contains information about color changes. A Look File is targeted for a particular type of display (for example, a Rec 709 display). It carries the name of that display's color space, and any 1D LUT, 3D LUT or ASC CDL values that are used to transform AWG/Log C values into that display's color space. It can be applied to an image to create a look and it helps to communicate the envisioned look from pre-production to production and into post. The AMIRA Look File or the ARRI Look File 2 (ALF-2) are good examples.

Camera Access Protocol (CAP)

The ARRI Camera Access Protocol (CAP) is an interface on ALEXA cameras that will also be available on ALEXA Mini and AMIRA cameras in future software upgrades. Through this interface, third parties can communicate with the camera and control some camera parameters. Currently, CAP is being used by third parties' on-set color grading software for live grading on-set, which includes up/downloading 3D LUTs, changing CDL values in real-time or downloading ARRIRAW still images.

ALEXA SXT

ALEXA SXT cameras are the next exciting step in the continuing evolution of the ALEXA family of cameras. Retaining the rock-solid foundation on which ALEXA is built, ALEXA SXT cameras additionally offer exciting new recording formats (including ProRes 4K), new ARRI Look Management, super flexible on-set monitoring, improved image quality, single speed mode and an exceptional new media bay with support for new high-speed, high capacity SXR Capture Drives. The term "ALEXA SXT" stands in this paper for the ALEXA SXT EV, ALEXA SXT Plus and ALEXA SXT Studio.

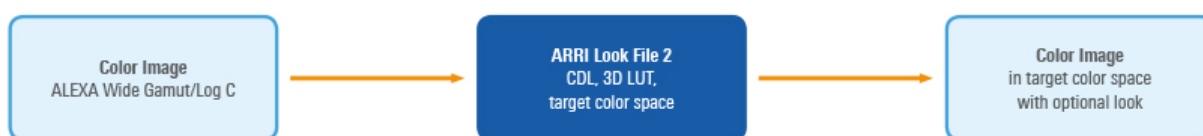


ARRI Look Management Components

ARRI Look File 2



The heart of the new ARRI Look Management is the ARRI Look File 2 (ALF-2). The ARRI Look File 2 controls the conversion of an image from AWG/Log C to a specified target color space and sets a look. An ALF-2 file contains an ASC CDL, a 3D LUT (with 33^3 mesh points) and the name of the intended target color space. ALF-2 files can be created with the ARRI Color Tool (ACT, formerly AMIRA Color Tool) or the ARRIRAW Converter (ARC). Once stored in the camera and made active, the values from the ALF-2 file can be manipulated live via on-set color correction software. ALF-2 files have the extension .aml.



- Target color spaces for the ALF-2 file can be set to Rec 709, DCI or Rec 2020. This is done when creating the ALF-2 file in the ARRI Color Tool or ARRIRAW Converter.
- ALF-2 files can be loaded into the ALEXA SXT, but, unlike in AMIRA and ALEXA Mini, neither the 3D LUT, CDL nor video look parameters can be changed directly in the ALEXA SXT menu.
- When the ALF-2 is turned on, both ASC CDL and 3D LUT are applied to the image. CDL values are much smaller than a 3D LUT in terms of data size and therefore preferred for on set scene-to-scene color correction. The 3D LUT is used to define the general look (which usually stays the same for a given project). The processing of the AWG/Log C image happens in the following steps:
 - ASC CDL slope, offset, power (in that order)
 - ASC CDL saturation
 - 3D LUT
 - Video signal level normalization
- The chosen ALF-2 file information is always included in the metadata of the recorded image. Since there is always one ALF-2 file chosen, there is always ALF-2 metadata in the recorded image of an ALEXA SXT.
 - When recording ARRIRAW, one ALF-2 file is stored per clip on the XR Capture Drive or SXR Capture Drive. During download, the ALF-2 file is stored in each ARRIRAW .ari frame.
 - When recording ProRes, the information from the ALF-2 file is stored in the QuickTime clip.
 - When recording ProRes, the camera (or the ARC, when creating QuickTime clips) will store multiple 3D LUTs in the QuickTime clip. This is so there is always a 3D LUT with a Rec 709 target color space in metadata for fast deliverables creation (deliverables are currently always produced in Rec 709). The original 3D LUT is copied from the ALF-2 file, and the other 3D LUTs are created on the fly by the camera or by the ARC.
 - If the target color space of the ALF-2 file is Rec 709, the camera or ARC places the following items into the QuickTime clip:
 1. the original 3D LUT with a Rec 709 target color space from the ALF-2 file and
 2. a 3D LUT with a Rec 709 color space, combining the color changes of the 3D LUT and the CDL values.

- If the target color space of the ALF-2 file is not Rec 709, the camera or ARC places the following items into the QuickTime clip:
 1. the original 3D LUT with its original target color space from the ALF-2 file and
 2. a 3D LUT with its original target color space, combining the color changes of the 3D LUT and the CDL values and
 3. the original 3D LUT with a Rec 709 target color space and
 4. a 3D LUT with a Rec 709 color space, combining the color changes of the 3D LUT and the CDL values.
- The HD-SDI output contains the CDL values and the name of the ARRI Look File 2 in metadata. The 3D LUT is too big to fit into HD-SDI metadata.
- The ALF-2 file information is recorded at the beginning of a take, in case recording is unexpectedly interrupted. At the end of the take, the ALF-2 file initially recorded is replaced with the current one. This is to capture the result of possible changes to the ALF-2 file while recording. If multiple ALF-2 file changes are made during the recording, only the last one replaces the initially recorded ALF-2 file.
- When a QuickTime clip with ProRes AWG/Log C images from an ALEXA SXT, ALEXA Mini or AMIRA is opened in an application supporting the ALF-2 metadata, it will display the images using the same look that was used in the camera, maintaining the creative intent of the cinematographer throughout the post process. The look is not baked into the image, however, and thus can be changed later.
- When the application used for editing or color grading does not support the ALF-2 metadata, the user can use the ARRI Color Tool to export the look information in a 3D LUT file and manually apply this LUT to the images. This LUT can either include the color changes from the ALF-2 3D LUT or from the ALF-2 3D LUT combined with the CDL values.

ARRI Look File Compatibility

There are currently three different types of Look Files in use with ARRI digital cameras.

- The **ARRI Look File (ALF)** is used by the ALEXA Classic, ALEXA XT and ALEXA 65 cameras. This Look File contains a 1D LUT and is created by a free Mac OS X utility called the ARRI Look Creator.
- The **AMIRA Look File** is used in ALEXA Mini (pre SUP 4.0) and AMIRA (pre SUP 4.0). This Look File contains a 3D LUT and an ASC CDL and was created by a free Mac OS X utility called the AMIRA Color Tool that is not available any more.
- The **ARRI Look File 2 (ALF-2)** is used in ALEXA SXT, ALEXA Mini (SUP 4.0 or later) and AMIRA (SUP 4.0 or later). This Look File contains an ASC CDL, a 3D LUT and the name of the target color space and is created by a free Mac OS X utility called the ARRI Color Tool (ACT) or the ARRIRAW Converter (ARC). For AMIRA and ALEXA Mini with pre-SUP 4.0 software, the ALF-2 Look Files created by the ARRI Color Tool are compatible, as long as Rec 709 is set as the target color space.

ARRI Look File Compatibility Guide

| Look File Tool | Look File Type | Ext. | Supported Target Color Spaces | Look File is Compatible With | | | | | | | | | |
|-------------------------------|------------------|------|--|------------------------------|---------------|-----------|-------|---------|-------|------------|---------|-------|---|
| | | | | ALEXA Classic | ALEXA XT & 65 | ALEXA SXT | AMIRA | | | ALEXA Mini | | | |
| | | | | ≥ SUP | all SUPs | ≥ SUP | ≤ SUP | SUP 3.0 | ≥ SUP | ≤ SUP | SUP 3.0 | ≥ SUP | |
| ALEXA Look Creator 1.0 | ALEXA Look File | .xml | Rec 709 | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| AMIRA Color Tool 1.0 | AMIRA Look File | .aml | Rec 709 | ✗ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| ARRI Color Tool 1.1 | AMIRA Look File | .aml | Rec 709 | ✗ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| ARRI Color Tool 1.2 | ARRI Look File 2 | .aml | Rec 709 (1) | ✗ | ✗ | ✓ | ✓ (2) | ✓ | ✓ | ✓ (2) | ✓ | ✓ | ✓ |
| ARRI Color Tool 1.3 | ARRI Look File 2 | .aml | Rec 709 (all), Rec 2020, DCI P3, DCI D60, DCI D65 (ALEXA SXT and ALEXA Mini) | ✗ | ✗ (3) | ✓ | ✓ (2) | ✓ | ✓ | ✓ (2) | ✓ | ✓ | ✓ |

Note: SUP = Software Update Package

(1) Do not select color spaces other than Rec 709 in ACT 1.2

(2) If Look is NOT Rec 709, the look will be not applied and there will be no WARNING

(3) To use a look from ALEXA Classic, ALEXA XT or 65 in ALEXA Mini: load ALEXA Look File (.xml) into ARRI Color Tool 1.3 or later and export an ARRI Look File ALF-2 (.aml) for use in ALEXA Mini

LutDesignData Metadata Field

ARRIRAW files and ProRes clips recorded with ALEXA SXT cameras have an extra metadata field called "LutDesignData". This field is designed to store vendor-specific grading information, which can be transferred to the camera from the color grading tool during live grading on-set. This could be extra information regarding the live grade, which can then be used by the dailies or final grading tool of the same vendor for a tight end-to-end color workflow. Please note that this metadata field is not available on the HD-SDI output.

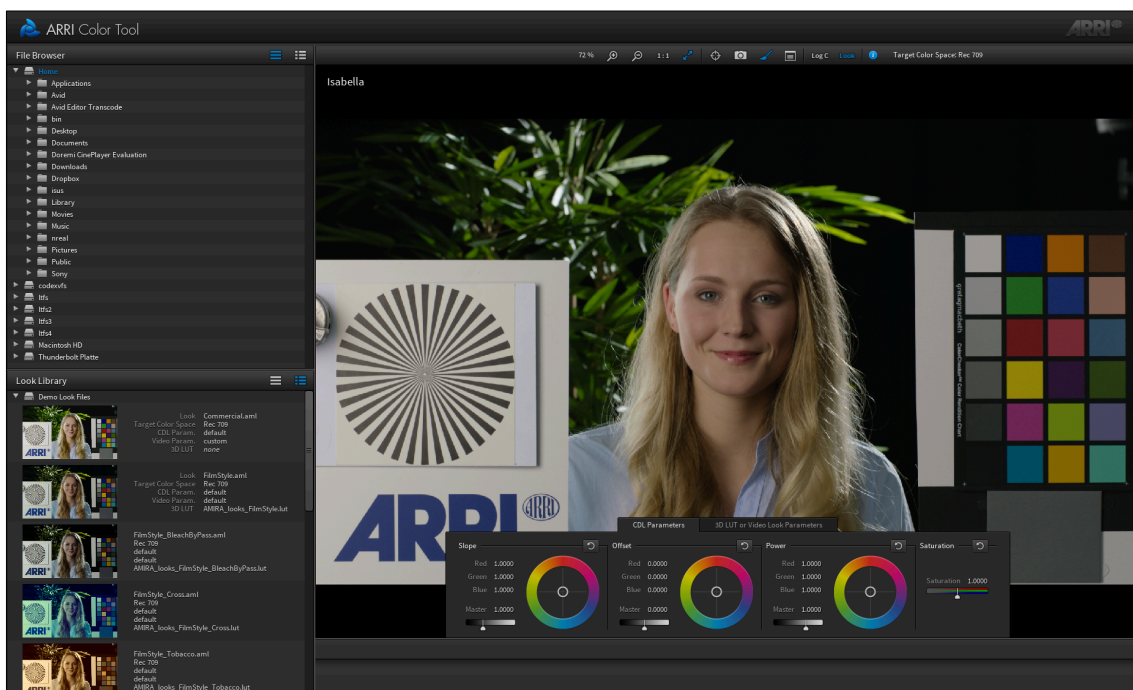
ARRI Color Tool



The ARRI Color Tool (ACT) is a free Mac OS X utility for managing ARRI Look Files 2. It can be downloaded from www.arri.com/camera/alexa/tools/arri_color_tool. Amongst other features, it can

- Import 3D LUTs (with 33³ mesh points) created with external applications like Resolve, Baselight, etc
- Create ARRI Look Files 2 (ALF-2) or AMIRA Look Files (ALF) either from an imported 3D LUT or by adjusting look parameters using ProRes/Log C or DPX/Log C images as reference.
- Adjust look parameters by changing the video parameters or CDL values.
- Extract an ALF-2 file from a QuickTime clip
- Convert an ALF-2 file into a 3D LUT. This is useful for software tools that cannot natively read the ALF-2 file, and the ACT provides a number of useful options:
 - The ACT can simply extract the 3D LUT that is part of the ALF-2 file.
 - The ACT can combine the color changes from the CDL values and 3D LUT contained in an ALF-2 file into a new 3D LUT.
 - The ACT can perform any transforms necessary to provide the new 3D LUT with a new target color space, disregarding what the original target color space in the ALF-2 file was.

Please note that when you work in the ARRI Color Tool (ACT), make sure that the correct target color space is selected BEFORE you load a custom 3D LUT.



ARRI Meta Extract



ARRI Meta Extract

ARRI Meta Extract (AME) is a free Mac OS X and Windows utility for extracting metadata, including ALF-2 files, from QuickTime and ARRIRAW files. It can be downloaded from http://www.arri.com/camera/alexas/tools/arri_meta_extract.

Third Party Support



The ARRIRAW Partner Program offers a software library providing all the features of the ARRI Color Tool: embedding of 3D LUTs in ALF-2 files, extracting of 3D LUTs from ALF-2 files, creation of 3D LUTs using the ARRI look parameters and conversion of the target color space. This library can be used by third parties to embed these capabilities in their products, thereby gaining all the benefits of ARRI Look Management. In addition, a software protocol (Camera Access Protocol - CAP) allows access to the look files and look file parameters inside the camera via Ethernet.

A number of ARRI Partners have already availed themselves of this opportunity, including:

Live grading on-set by up or downloading 3D LUTs, manipulating CDL values live or downloading ARRIRAW screenshots is already supported by Pomfort LiveGrade, Codex Live, Colorfront On-Set Live!, Filmlight Prelight, Technicolor DP Lights, with others in progress.

Automated dailies, that include the same look as that seen on the MON OUT of the camera, can be created by Blackmagic Design DaVinci Resolve, Colorfront OSD, Codex Production Suite, Pomfort Silverstack, Filmlight Daylight, with others in progress.

Editing with looks, where the editor sees the same look as was seen by cinematographer and director in dailies and on set is supported by AVID Media Composer 8.1 and later, Apple Final Cut Pro X 10.1 and later and by Adobe Premiere Pro CC 2014 and later.

Target Color Space vs. On-Set Monitoring Color Space

In the following there is a lot of talk about color spaces, and it is worth noting that we are talking about two very different uses of color spaces here: one stored in the ALF-2 file for final grading and the other one chosen in the camera for on-set monitoring.

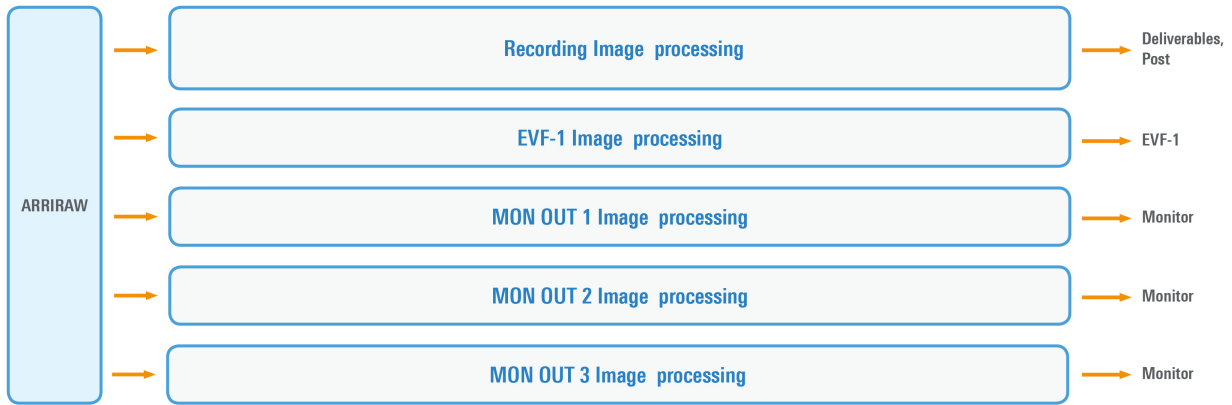
An ARRI Look File 2 contains the name of the target color space. This is the color space that will be used for **final grading**. This target color space is set in the ARRI Color Tool or ARRIRAW Converter when creating the ALF-2 file. This target color space is important in final grading, where colors are adjusted for a specific display technology used for the distribution of the images. This could be a digital projector (DCI color space), an HDTV set (Rec 709 color space) or a UHD TV set (Rec 709 or 2020 color space).

For **on-set monitoring**, one may encounter monitors for the Rec 709 or Rec 2020 color space. The ALEXA can perform the conversions necessary to make the images look as close to the target color space in the ALF-2 file as possible for either type of display. This is done in the MON COLOR SPACES menu on the camera.

ALEXA SXT Image Processing and Menu Settings

For a better understanding of ARRI Look Management, it helps to take a closer look at ALEXA SXT image processing and the menu settings affecting it.

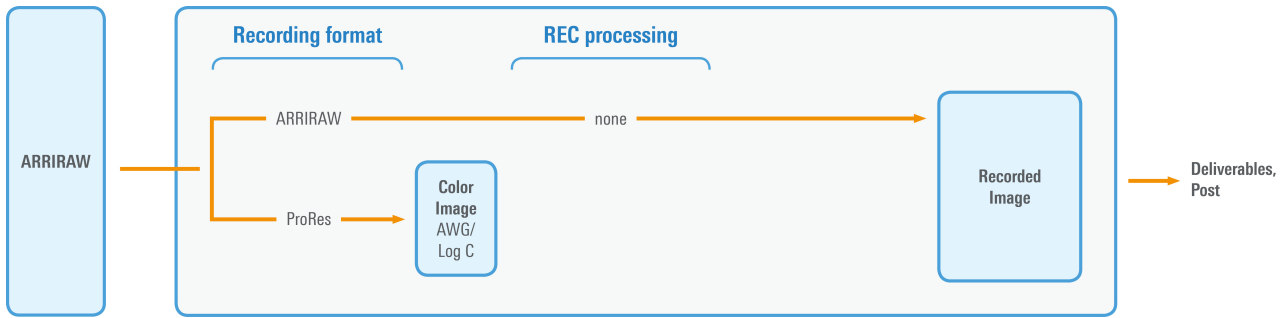
Overview



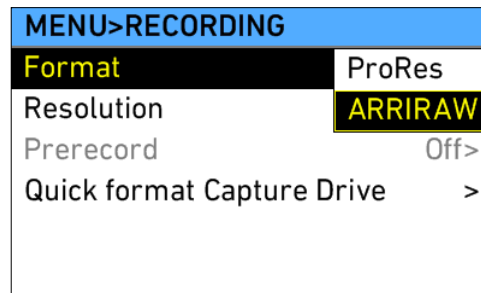
To maintain the highest overall image quality, all ALEXA in-camera image processing starts out with the uncompressed and unencrypted ARRIRAW data. This data goes through a recording image processing path and gets recorded, either as ARRIRAW or as ProRes. It is then used for creating offline deliverables like dailies and editing proxies and for further online postproduction like VFX and final grading.

At the same time the data goes through four monitoring image processing paths in-camera to render color images for the ALEXA Electronic Viewfinder EVF-1 and the three independent MON OUT outputs.

Recording Image Path - Recording Format

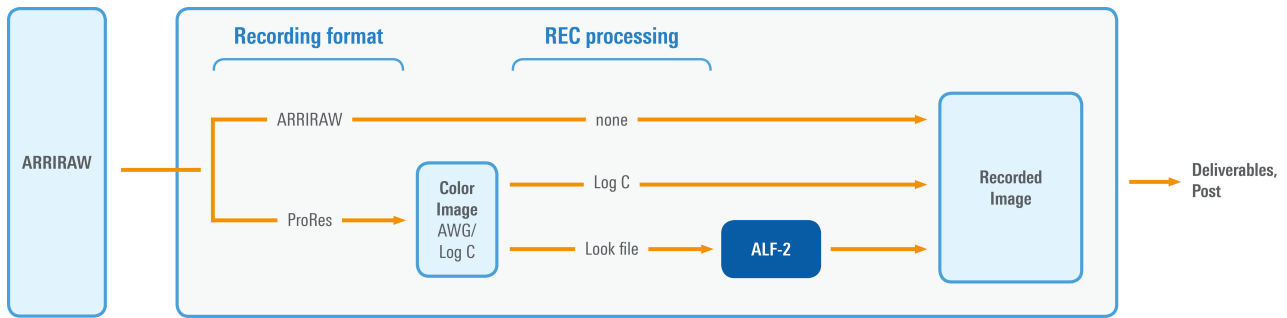


On any ALEXA SXT, in the RECORDING menu, you have the choice of recording ARRIRAW or ProRes.

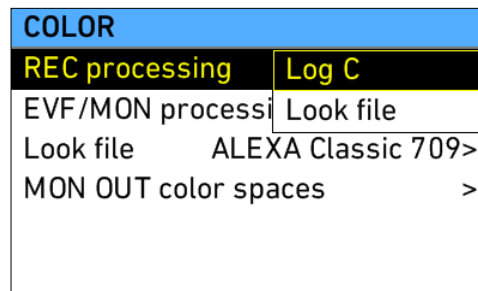
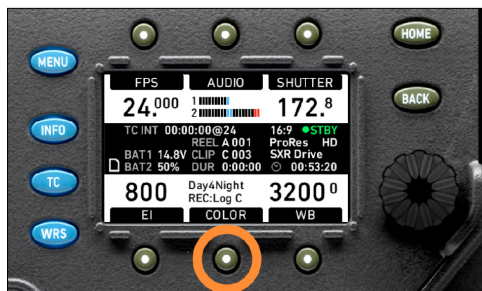


- If you set the recording format to **ARRIRAW**, the image data will bypass any image processing and move straight to the recording module. The "COLOR > REC processing" menu choice will be automatically set to "none", as the camera does not perform any processing on the image. In the recording module the ARRIRAW data is recorded onto an XR or SXR Capture Drive. When the drive is removed from the camera, the ARRIRAW data makes its way to deliverables-creation and post. ARRIRAW is the highest possible image quality ALEXA can record. ARRIRAW provides tons of flexibility in post and is the safest choice for archiving. This is the path chosen by most feature films and an increasing number of commercials. It does, however, mean that you have to use Capture Drives and you have to go through a debayering and a color correction step in post.
- If you set the camera to record **ProRes**, the ARRIRAW data goes through a debayering step and an ALEXA Wide Gamut/Log C (AWG/Log C) color image is created.

Recording Image Path - ProRes REC Processing



Once you have chosen ProRes, you have a further choice to make in the "COLOR > REC processing" menu, which is accessible through the COLOR button from the HOME screen.

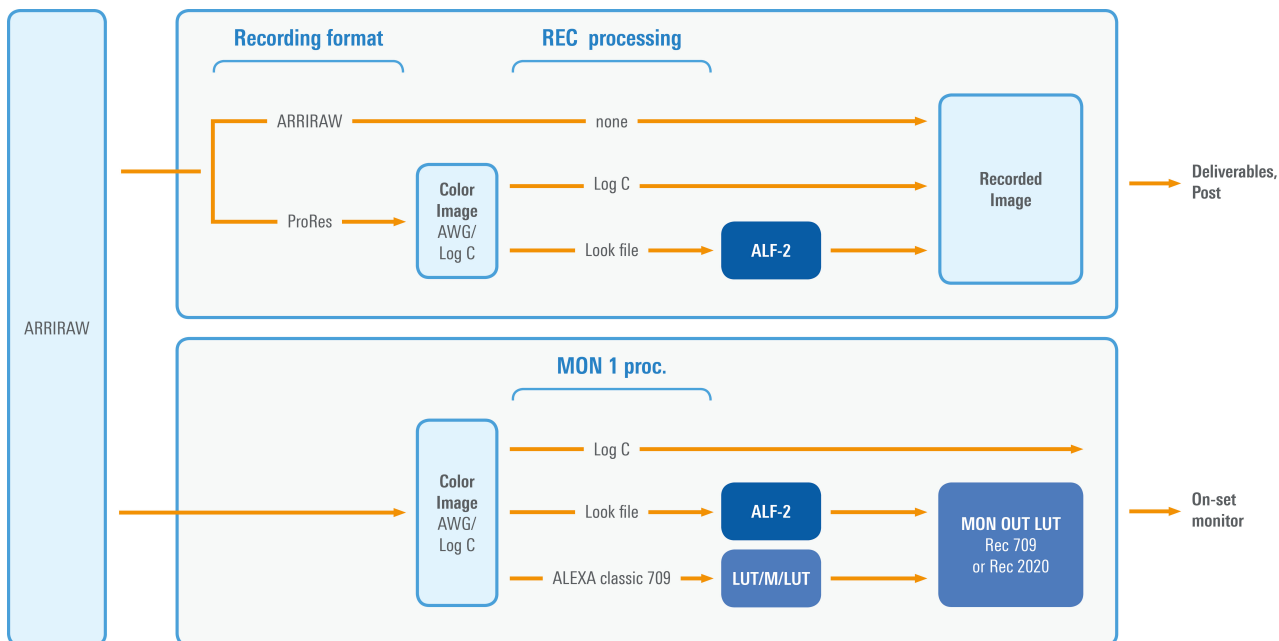


- Choosing **Log C** will send the AWG/Log C image straight to the recording module. There it gets recorded onto an XR or SXR Capture Drive, CFast 2.0, SxS PRO or SxS PRO+ card. When the drive or card is removed from the camera, the ProRes AWG/Log C data makes its way to deliverables-creation and post.

ProRes AWG/Log C, by the way, is how about 80% of all ALEXA television programs are being recorded, since AWG/Log C maintains a great deal of tonal differentiation in the bright and dark parts of the image - not as much as ARRIRAW, but more than any look created for Rec 709 or Rec 2020 displays. Recording AWG/Log C does, however, also mean that you have to go through a color grading step in post to convert the AWG/Log C images to one of the display color spaces.

- Alternatively, you can choose to record the image with an ALF-2 **Look File** irreversibly baked in. This is the least popular choice for recording, as it is irreversible and provides less flexibility in color grading in post. However, if you do not plan on post color correction, this is a good choice for a fast result: shoot, edit and distribute.

Monitoring Image Path - MON OUT 1 Processing



To gain a better understanding of the monitoring image path, we take a look at MON OUT 1, one of the four monitoring image paths. MON OUT 2 and MON OUT 3 function exactly the same. First, the ARRIRAW data goes through a debayering step and an AWG/Log C color image is created. What happens next depends on the choice made in the "MON 1 proc." menu of the "COLOR > EVF/MON PROCESSING" screen.

| COLOR | |
|---------------------------|-------------|
| REC processing | Log C |
| EVF/MON processing | > |
| Look file | ARRI 709> |
| MON OUT color spaces | > |

| COLOR>EVF/MON PROCESSING | |
|--------------------------|-------------------|
| EVF proc. | Look file |
| MON 1 proc. | Log C |
| MON 2 proc. | Look file |
| MON 3 proc. | ALEXA Classic 709 |

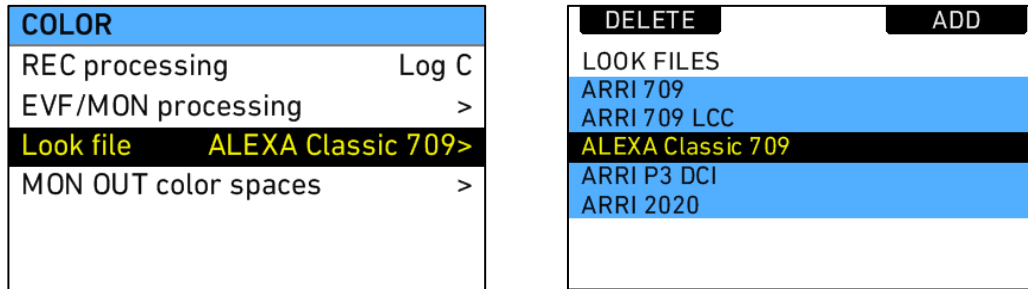
- If you choose **Log C**, the Log C image will be sent directly to the MON OUT 1 output. This is useful for feeding the image to the DIT station for further color processing or for taking a look at how much detail you have in the dark parts of the image.
- The **Look file** option will apply the chosen ARRI Look File 2 to the image. Five Look Files are available by default in ALEXA SXT cameras from the "COLOR > LOOK FILE" menu.
- **ALEXA Classic 709** is an extra monitoring option for a special situation: when one MON OUT is set to display an extreme look from an ARRI Look File 2, but the operator would like to see a regular video image for focusing. In that case, set the operator's MON OUT processing to "ALEXA Classic 709". Since the camera's main look processing is already busy with the ALF-2 look, this option uses a different processing path (LUT/Matrix/LUT) that is less processing intensive but sufficient to create the ALEXA Classic 709 look. This option is also available for the viewfinder.

| COLOR | |
|---------------------------|--------------|
| REC processing | Log C |
| EVF/MON processing | > |
| Look file | Extreme 709> |
| MON OUT color spaces | > |

| COLOR>EVF/MON PROCESSING | |
|--------------------------|--------------------------|
| EVF proc. | Look file |
| MON 1 proc. | Look file |
| MON 2 proc. | Log C |
| MON 3 proc. | Look file |
| | ALEXA Classic 709 |

ALEXA SXT Built-in Look Files

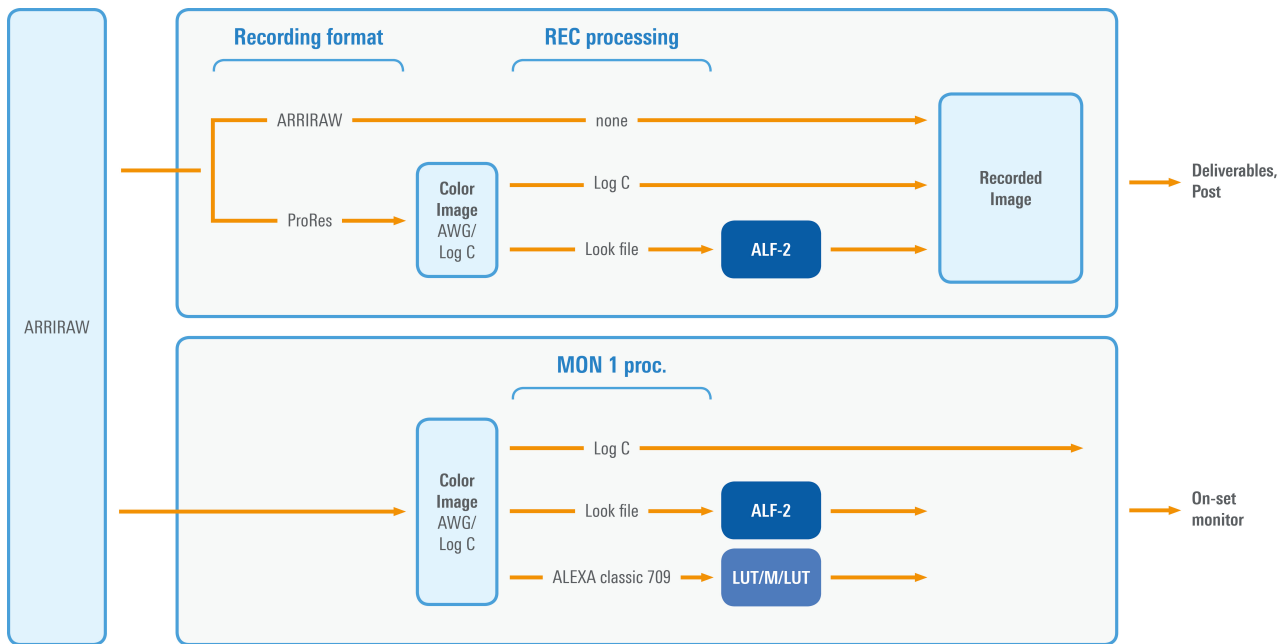
Five Look Files are always available in every ALEXA SXT, which can be chosen in the "COLOR > LOOK FILE" menu. ARRI 709 is chosen by default after a factory reset. Please note that the target color space in these Look Files indicates the final distribution color space and is independent of the type of monitors you have on-set.



- ARRI 709** is the new standard look for images from an ARRI digital camera destined for a Rec 709 display. This look file can be chosen when the final distribution is in HDTV.

On the ALEXA Mini and AMIRA this look used to be called "AMIRA Rec 709", but got re-named in SUP 3.0 to "ARRI 709" so that we have the same names in all ARRI digital cameras. ARRI 709 is based on and close in look to ALEXA Classic 709. However, since ALEXA SXT, ALEXA Mini and AMIRA are capable of 3D LUTs, and since we had requests to change the ALEXA Classic 709 look, we made slight adjustments to the look. The ARRI 709 look has darker and more muted red tones in comparison to ALEXA Classic 709.
- ARRI 709 LCC** is a "Low Contrast Curve" based on ARRI 709, designed to maintain the largest range of tonal differentiation in the bright and dark parts of the image without using Log C. While Log C preserves more dynamic range, it also requires color grading in post. ARRI 709 LCC images, on the other hand, need only minor color adjustments to create an image with proper contrast. ARRI 709 LCC is designed for those who do not have the time for Log C, but still want a bit more highlight and dark details than ARRI 709 would give them. This option is most often used for recording and rarely for monitoring.
- ALEXA Classic 709** is the same look that is available on ALEXA Classic and ALEXA XT cameras under the name of "Rec 709" and on ALEXA Mini and AMIRA cameras with software before SUP 3.0 under the name of "X-2-ALEXA". Choose this if you want your MON OUT look to exactly match an ALEXA Classic or ALEXA XT set to "Rec 709".
- ARRI P3 DCI** is the new standard look for images from an ARRI digital camera destined for a DCI projector. It is very similar to the look obtained by converting Log C images with a 3D LUT (as can be downloaded from the online ARRI LUT Generator) to the P3 DCI color space.
- ARRI 2020** is the new standard look for images from an ARRI digital camera destined for a Rec 2020 display. It is very similar to the look obtained by converting Log C images with a 3D LUT (as can be downloaded from the online ARRI LUT Generator) to the Rec 2020 color space.

Monitoring Image Path - MON OUT Color Spaces



If you choose Log C in "MON 1 proc.", the Log C image is not processed any further, and is fed directly to the MON OUT 1 output. Since AWG/Log C is a virtual color space, there is no meaningful definition for how it should be displayed, and therefore we do not offer the option of transforming the image for Rec 709 or Rec 2020. AWG/Log C images will look more saturated on a Rec 2020 monitor than on a Rec 709 monitor.

For the Look File and ALEXA Classic 709 processing paths there is another choice to be made in the "COLOR > MON OUT COLOR SPACES" menu: will this image be shown on a Rec 709 or Rec 2020 monitor?

| COLOR>MON COLOR SPACES | |
|------------------------|----------|
| MON OUT 1 | REC 709 |
| MON OUT 2 | REC 2020 |
| MON OUT 3 | REC 709 |

- If you choose a Look File for MON OUT 1 processing, there are three possible scenarios:
 - **Scenario 1** (normal color processing): The target color space in the ALF-2 file is the same as the color space of your display. All is well. If the ALF-2 file has, for instance, a Rec 709 target color space, the camera's MON OUT is set for Rec 709 and the connected monitor is indeed a Rec 709 monitor, the monitor should display the correct colors.
 - **Scenario 2** (destination device preview): The target color space in the ALF-2 is smaller than the color space of your display. In this case, you will see the colors of the ALF-2 color space and not more. For instance, if the target color space in the ALF-2 file has been set to DCI, but the camera's MON OUT is set to Rec 2020 (a larger color space) and the connected monitor is a Rec 2020 monitor, the camera will perform any necessary color transformations, so the monitor will show you all the DCI colors, but not more.
 - **Scenario 3** (gamut mapping): The target color space in the ALF-2 is larger than the color space of your display. This is slightly trickier. The camera will perform any necessary color transformations so the image can be displayed in the smaller color space of the monitor. But, since there are some colors that the monitor simply is not capable of reproducing, the camera has to change some colors to still produce an image that is as close to the intended image as is

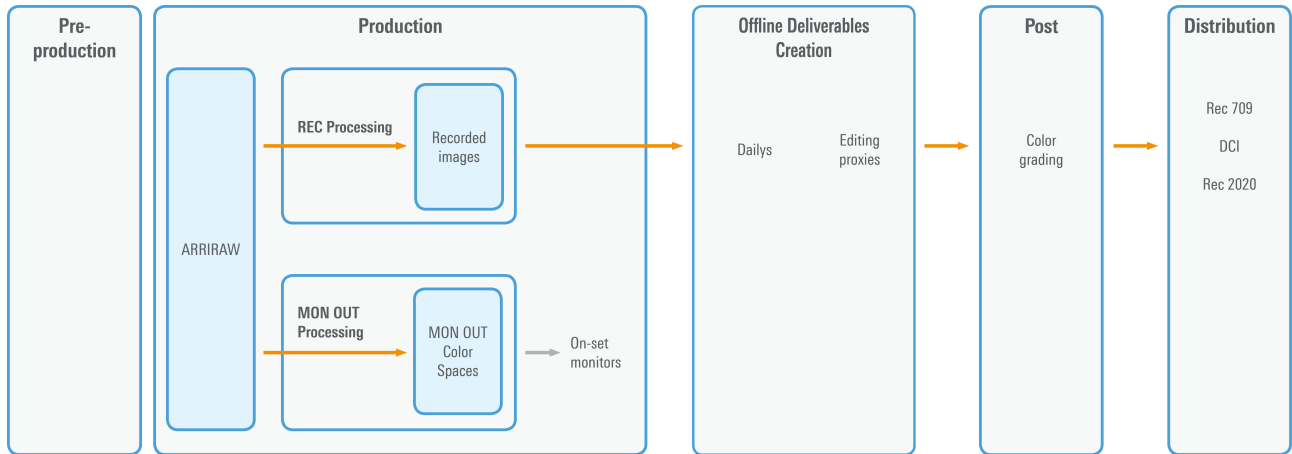
possible in the smaller color space of the monitor. So, for instance, if the target color space in the ALF-2 file is set to DCI, but the camera is set to Rec 709 on MON OUT and is connected to a Rec 709 monitor, the result will look different from what it would look like on a DCI projector. How noticeable this difference is depends on image content.

- If you choose "ALEXA Classic 709" for MON OUT 1 processing, this look has Rec 709 stored as its target color space. Since Rec 709 is the smallest of the three possible target color spaces, you will find yourself either in scenario 1 or 2 and all is well.
- Note that the ALEXA Electronic Viewfinder EVF-1 has its own color space, and the camera will automatically transform the chosen Look File to that color space, so no user intervention is needed.

Use Cases

In order to understand how the new ARRI Look Management helps production and how flexible it is in its application, it helps to look at some use cases. There are, of course, a myriad of workflows out there. These represent the four most common ones.

General Production Workflow



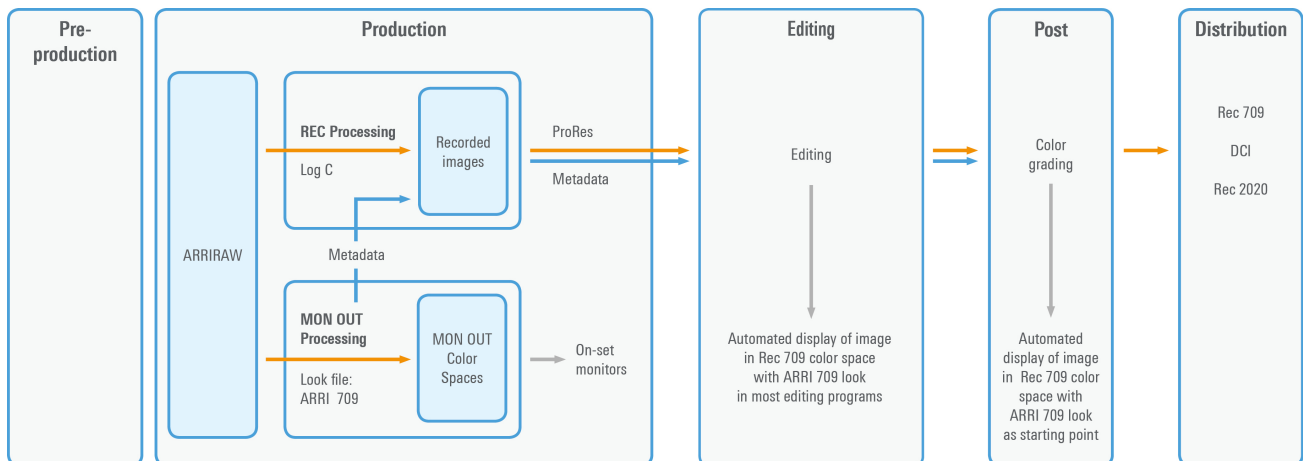
During **pre-production**, a recording format is chosen, the workflow is worked out, (hopefully) fully tested and choices for a specific look are made.

During **production**, the ALEXA internally always starts out with ARRIRAW images. Those images get processed in-camera to feed the recording image path to record images, and to feed the monitoring image paths to provide images for on-set monitors.

The recorded master images then go to the next step, where **offline deliverables** are being created. Those are usually dailies and editing proxies.

Then the master images go into online **post**, where they experience the joy of VFX and color grading. To simplify these use cases, we are excluding VFX here. During color grading, the colorist needs to decide if **distribution** is for a Rec 709, DCI or Rec 2020 type display. If distribution to multiple different display types is required, a different color grading (or separate trim passes) has to be created for each one.

Use Case 1: TV Show, ProRes, no Look, no Offline



This is a TV show recording in ProRes. The production does not want to deal with any color on-set. To simplify (and save money), they have also decided to not create any offline deliverables (dailies and editing proxies), but to look at and edit the master images. Note: this is a popular workflow also for smaller projects, like commercials or promos.

During **production**, REC Processing is set to Log C, and MON OUT Processing is left in its default setting: Look File. The "Look File" menu is also left in its default setting: ARRI 709. This ensures getting the most out of the recorded images in post (since they are recorded in Log C) and seeing a good looking image with proper contrast on the Rec 709 monitors on-set. During recording, the ARRI 709 Look File information is automatically stored as metadata in the image.

Editing is now easy: modern non-linear editing programs (Avid Media Composer, Apple Final Cut Pro X and Adobe Premiere Pro) already understand the ALF-2 files, so during editing, an image in the Rec 709 color space with the ARRI 709 look will be automatically shown on the monitor with correct colors, all without any user intervention required.

On to **post**: if the software for color grading understands ALF-2 files, it can automatically extract the look information from metadata and present an image in the Rec 709 color space with the ARRI 709 look as a starting point. If the software for color grading does not understand ALF-2 files, the ARRI Color Tool or ARRI Meta Extract can extract a 3D LUT from the QuickTime clip or from the ALF-2 file as a starting point for color grading.

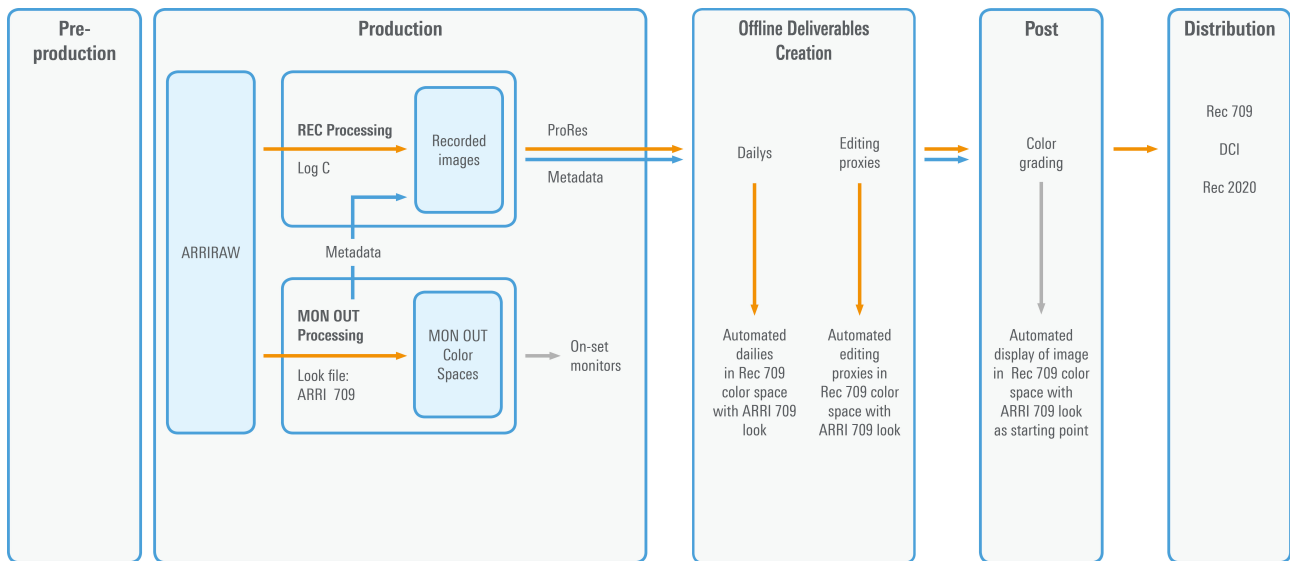
Note 1: Creating Proxies in your Editing Program

Since modern non-linear editing programs understand the ALF-2 files, they can also be used to create editing proxies to reduce storage demands. While in the feature film world this is done by a dedicated piece of software, the color management capabilities of modern editing programs can greatly streamline the workflow for TV productions.

Note 2: Editing without the new ARRI Look Management

While the new ARRI Look Management makes look handling in the prominent editing programs easy and transparent, there is a fallback built into Apple FCP X, AVID Media Composer and Adobe Premiere Pro: When those programs encounter an ALEXA Log C file without the ALF-2 metadata, they will automatically apply a Log C to Rec 709 conversion 3D LUT provided by ARRI. This is the standard "K1S1 LogC2Rec709" 3D LUT that can also be downloaded from the online ARRI LUT Generator.

Use Case 2: TV Show, ProRes, no Look



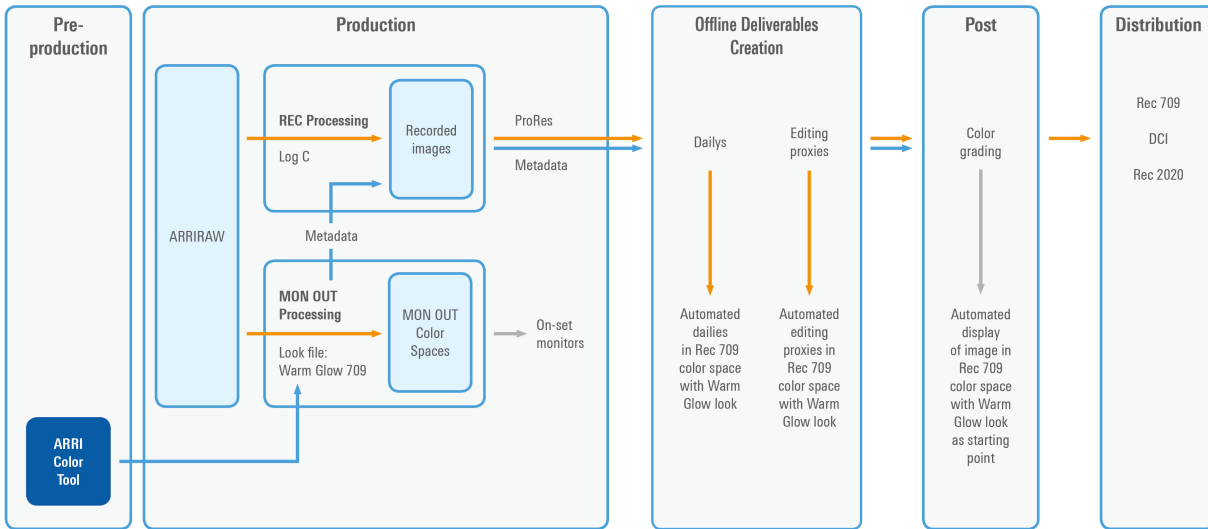
This is a typical TV show recording in ProRes. The production does not want to deal with any color on-set.

During **production**, REC Processing is set to Log C, and MON OUT Processing is left in its default setting: Look File. The "Look File" menu is also left in its default setting: ARRI 709. This ensures getting the most out of the recorded images in post (since they are recorded in Log C) and seeing a good looking image with proper contrast on the Rec 709 monitors on-set. During recording, the ARRI 709 Look File information is automatically stored as metadata in the image.

If the software that creates the offline **deliverables** (dailies and editing proxies) understands ALF-2 files, it can automatically extract the look information from metadata and create deliverables in the Rec 709 color space with the ARRI 709 look. This saves the operator one step and ensures that the offline deliverables look just like what the director saw on-set. If the software that creates offline deliverables does not understand ALF-2 files, the ARRI Color Tool or ARRI Meta Extract can extract a 3D LUT from the QuickTime clip or from the ALF-2 file, and generate a 3D LUT for offline deliverables creation.

On to **post**: if the software for color grading understands ALF-2 files, it can automatically extract the look information from metadata and present an image in the Rec 709 color space with the ARRI 709 look as a starting point. If the software for color grading does not understand ALF-2 files, the ARRI Color Tool or ARRI Meta Extract can extract a 3D LUT from the QuickTime clip or from the ALF-2 file as a starting point for color grading.

Use Case 3: TV Show, ProRes, Look



This TV production company wants to actively use looks to get a better sense on the set of what the final image will look like. This is certainly something the director and cinematographer will appreciate.

In **pre-production**, the ARRI Color Tool would be used to create one or more looks. In the example here, a look called "Warm Glow" was created. Since this is an HDTV production, the target color space is set to Rec 709 in the ARRI Color Tool. To indicate this, we have added the numbers "709" to the name: Warm Glow 709.

During **production**, this look gets copied onto the camera's SD card and loaded into the camera. "REC processing" is set to Log C and "MON OUT processing" is set to Look File. From the "COLOR - Look File" menu the "Warm Glow 709" look is chosen. As in the previous examples, the ALF-2 Look File information is stored automatically in metadata and travels with the master images to the offline deliverables creation step.

If the software that creates offline **deliverables** (dailies and editing proxies) understands ALF-2 files, it can automatically extract the look information from metadata and create deliverables in the Rec 709 color space with the Warm Glow look. This saves the operator one step and ensures that the offline deliverables look just like what the director saw on-set. If the software that creates offline deliverables does not understand ALF-2 files, the ARRI Color Tool or ARRI Meta Extract can extract a 3D LUT from the QuickTime clip or from the ALF-2 file, and generate a 3D LUT for offline deliverables creation.

On to **post**: if the software for color grading understands ALF-2 files, it can automatically extract the look information from metadata and present an image in the Rec 709 color space with the Warm Glow look as a starting point. If the software for color grading does not understand ALF-2 files, the ARRI Color Tool or ARRI Meta Extract can extract a 3D LUT from the QuickTime clip or from the ALF-2 file as a starting point for color grading.

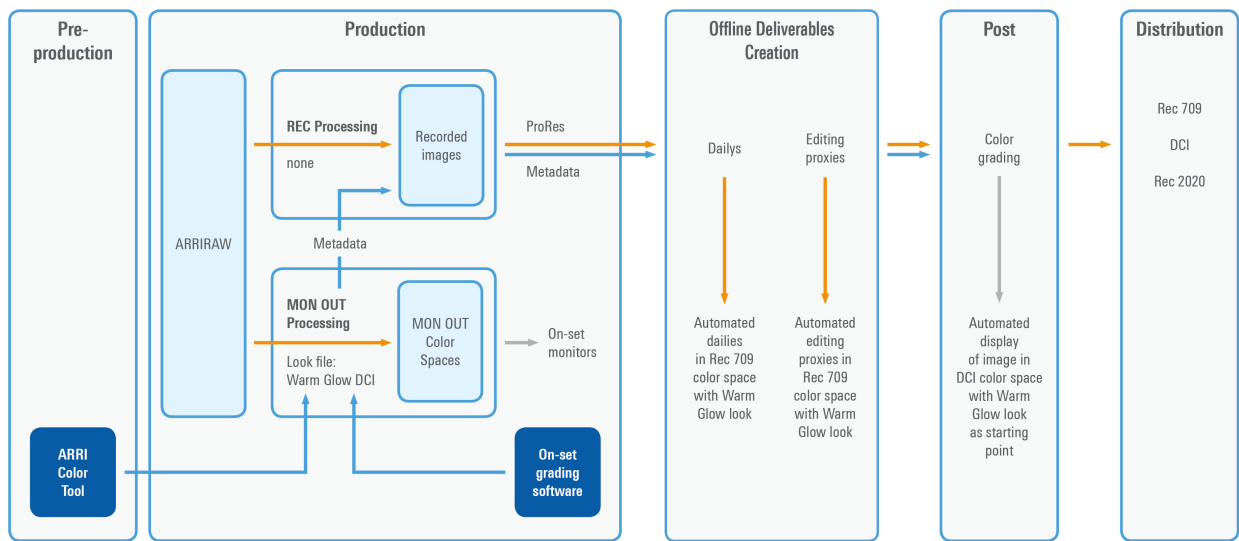
But Wait, There's More!

Here is an extra service provided by ARRI Look Management. Rec 709 currently is the standard color space for offline deliverables. When recording QuickTime/ProRes clips, the camera will create extra 3D LUTs and record them into the QuickTime metadata to facilitate fast deliverables creation.

- If the target color space of the ALF-2 file is Rec 709, the camera places into the QuickTime clip:
 1. the original 3D LUT with a Rec 709 target color space from the ALF-2 file and
 2. a 3D LUT with a Rec 709 color space, combining the color changes of the 3D LUT and the CDL values.
- If the target color space of the ALF-2 file is not Rec 709, the camera places into the QuickTime clip:
 1. the original 3D LUT with its original target color space from the ALF-2 file and
 2. a 3D LUT with its original target color space, combining the color changes of the 3D LUT and the CDL values and
 3. the original 3D LUT with a Rec 709 target color space and
 4. a 3D LUT with a Rec 709 color space, combining the color changes of the 3D LUT and the CDL values.

Thus, even if the target color space set in the ALF-2 is Rec 2020, for example, no extra effort is needed to quickly and automatically create Rec 709 offline deliverables, since the ALEXA SXT QuickTime/ProRes clips will always have a Rec 709 3D LUT in metadata. Note: the ARRIRAW Converter can do the same when creating QuickTime/ProRes clips.

Use Case 4: Feature Film, ARRIRAW, Look



This use case describes a typical feature film.

In **pre-production**, the DIT starts at the end by looking at the color grading: digital projectors work in the DCI color space, so in final grading the DCI color space will be used. Therefore, the target color space is set to DCI in the ARRI Color Tool. In the example here, a look called "Warm Glow" was created and named Warm Glow DCI.

During **production**, this look gets copied onto the camera's SD card and loaded into the camera. We record ARRIRAW, and "MON OUT processing" is set to Look File. From the "COLOR - Look File" menu the "Warm Glow DCI" look is chosen. The basic look of "Warm Glow DCI" is determined by the 3D LUT portion of the ALF-2, and the DIT can make scene to scene adjustments by changing the CDL values of the ALF-2 file with on-set grading software. The ALF-2 "Warm Glow DCI" file contains the values from the end of the take, so the result of any live changes are recorded in metadata.

If the software that creates offline **deliverables** (dailies and editing proxies) understands ALF-2 files, it can automatically extract the "Warm Glow DCI" look information from metadata and create offline deliverables in the Rec 709 color space with the Warm Glow look. This saves the operator one step and ensures that the offline deliverables look just like what the director saw on-set. If the software that creates offline deliverables does not understand ALF-2 files, the ARRIRAW Converter (ARC) or the ARRI Meta Extract (AME) can extract the "Warm Glow DCI" ALF-2 file from the ARRIRAW data. The ARRI Color Tool can then extract a 3D LUT from the ALF-2 file and generate a 3D LUT for offline deliverables creation.

On to **post**: if the software for color grading understands ALF-2 files, it can automatically extract the "Warm Glow DCI" look information from metadata and present an image in the DCI color space with the Warm Glow look as a starting point. If the software for color grading does not understand ALF-2 files, the ARRIRAW Converter (ARC) or the ARRI Meta Extract (AME) can extract the "Warm Glow DCI" ALF-2 file from the ARRIRAW data. The ARRI Color Tool can then extract a 3D LUT from the ALF-2 file and generate a 3D LUT for color grading.

A Note about Color Grading

One should always master and color grade a project in the largest color space in which the project will be distributed. In a separate step or trim pass, one should convert to any smaller color spaces. The other way around, mastering in a smaller color space and then displaying in a larger color space, will provide exactly the colors from the smaller color space, but not any more. By mastering in the larger color space it is ensured that any displays capable of the larger color space can take advantage of the expanded color palette.

Color on the Set

There are two reasons for having Look Files on-set: first, to allow the cinematographer and director to monitor a preview of the intended look. Second, to create deliverables (dailies and editing proxies) with the intended look. This is usually done in one of two ways: either by just using pre-canned looks or by starting with pre-canned looks and additionally adjusting the look live on-set. The new ARRI Look Management has significant advantages for both those methods.



Typical Workflow "Pre-canned Looks"

This is the simpler of the two workflows, as it does not require a DIT to make live adjustments on-set. However, it does not afford as much control over the look scene-by-scene while shooting. In pre-production, the DIT or the post house uses the ARRI Color Tool to create multiple looks. The resulting ALF-2 files are loaded into the camera via the SD card. On-set, the DIT or camera assistant calls up looks as required. These looks are then used to create offline deliverables (dailies and editing proxies), and in color grading the colorist can use them as a starting point. Using the new ARRI Look Management for this type of workflow has a number of advantages:

- The ARRI Look Management uses 3D LUTs (instead of 1D LUTs used by older ALEXA cameras and some competitors), which are the standard for accurate color transformation.
- The ARRI Color Tool is a very flexible and powerful software program that can create ARRI Look Files 2 (ALF-2) either from an imported 3D LUT or by adjusting look parameters using ProRes/Log C or DPX/Log C images as reference.
- Monitoring the image with the look applied from ALEXA SXT does not require an external 3D LUT box.
- The ARRI Look File 2 travels as metadata with the master images, so it is always available and cannot get lost. As more and more third party software supports the ALF-2 file, turning looks on and off is available at the click of the mouse.
- Faster and less complex dailies creation, editing and final grading.

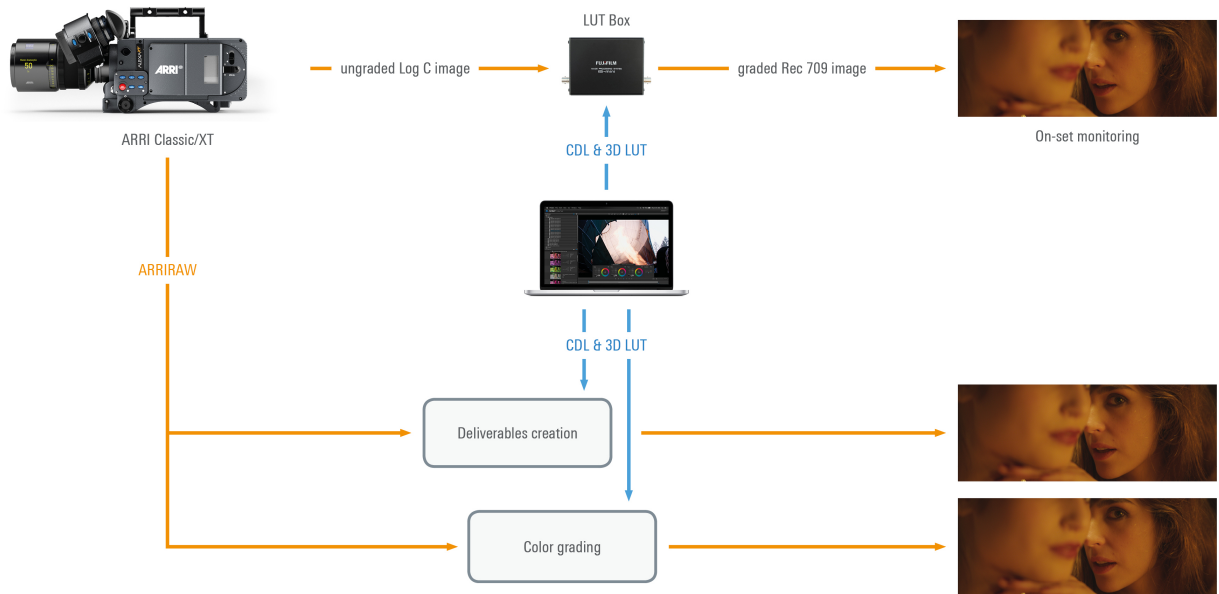
Typical Workflow "Live Color"

This workflow is similar, but with one difference. The DIT can make live adjustments to the color on-set, by connecting a laptop to the camera via an Ethernet cable or Wi-Fi. A large number of tools are already supporting this function. In pre-production, the DIT or the post house uses the ARRI Color Tool to create multiple looks. The resulting ALF-2 files are loaded into the camera via the SD card. On-set, the DIT changes color live in close collaboration with the cinematographer. The resulting looks are then used to create offline deliverables (dailies and editing proxies), and in color grading the colorist can use them as a starting point. Using the new ARRI Look Management for this type of workflow has a number of advantages:

- The ARRI Look Management uses 3D LUTs (instead of 1D LUTs used by older ALEXA cameras and some competitors), which are the standard for accurate color transformation.

- The ARRI Color Tool is a very flexible and powerful software program that can create ARRI Look Files 2 (ALF-2) either from an imported 3D LUT or by adjusting look parameters using ProRes/Log C or DPX/Log C images as reference.
- Monitoring the image with the look applied from ALEXA SXT does not require an external 3D LUT box.
- Live update of ASC Color Decision List (CDL) values.
- The ARRI Look File 2 travels as metadata with the master images, so it is always available and cannot get lost. As more and more third party software supports the ALF-2 file, turning looks on and off is available at the click of the mouse.
- Faster and less complex dailies creation, editing and final grading.

Typical Workflow "Live Color" - Before ARRI Look Management



Typical Workflow "Live Color" - With ARRI Look Management

