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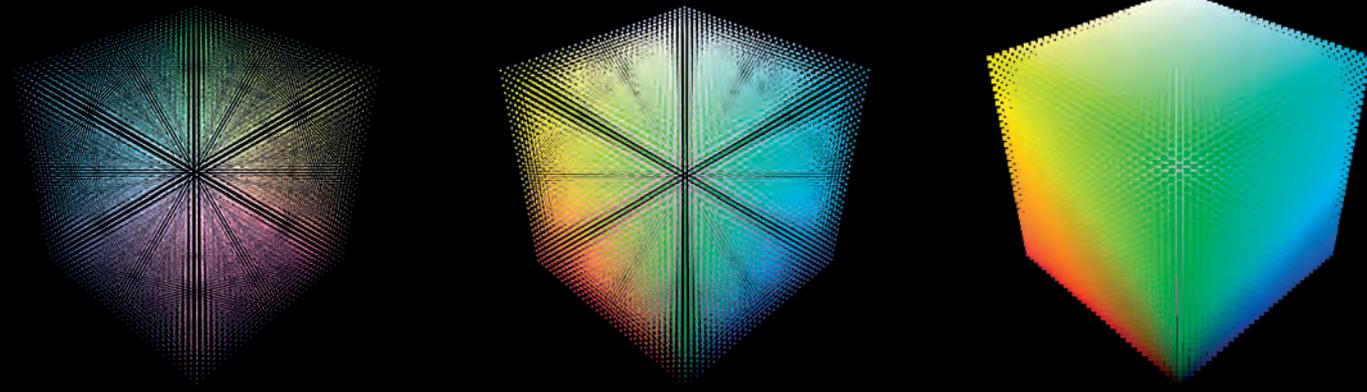
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ACES – Finally control over the primaries!

Discussions about color spaces and color pipelines are a tedious part of the work for many CG artists. However, the basic rule applies: Only those who know and can serve their digital color palette will make the technically correct decisions in the creative process. For an accurate work process, it is therefore necessary to know the pipeline in order to produce controlled results.

von Valentin Struklec

Some of the most advanced and recent developments in this area include the introduction of ACES. After more than 10 years of industry-driven development, the Academy Color Encoding System (ACES) was released in December 2014 in version 1.0. As a free and open standard, ACES offers a comprehensive color management infrastructure. A key application of ACES is the production of visual effects. Adding the ACEScg coding for compositing, lighting, rendering, and the rest of the CG workflow simplifies the sharing of elements and allows a color-accurate preview process across all preview media. Recent major projects that have relied on ACES color management include „Black Panther“, „Avengers: Infinity War“ and „Ant Man and The Wasp“ - just to name a few examples. ACES promises a lot,

and indeed photographic work processes for CG artists, easier exchange of working files between departments and studios, e.g. divided scenes, future-proof archiving and more independent, more flexible asset production, and generally fewer color workflow issues. Overall, the ACES standard consists of six color spaces, which in turn use two different sets of RGB primaries (color maxima that define the gamut). The two color spaces relevant to us are:

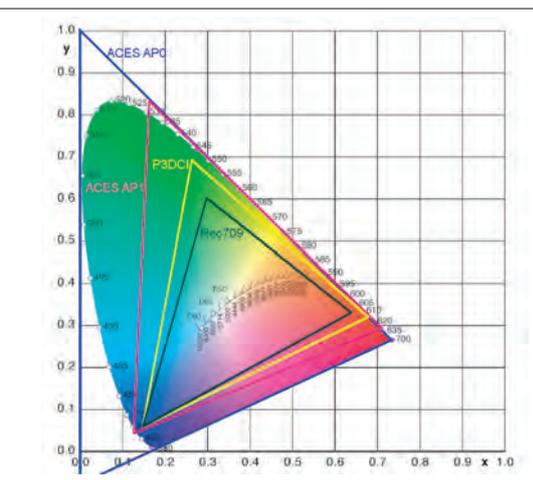
ACEScg

The ACEScg color space was created when it showed that the enormous size of the APO gamut causes problems for most render engines. The scope of AP1 is similar in scope to standard high-end digital cameras, but independent of these devices, and seems to be better suited for Physically Plausible Rendering.

ACES 2065-1

This is the ACES standard color space. With its generously placed APO primaries, it not only covers the entire visible color range, but also areas that are invisible to the human eye, with the aim of being prepared for all future developments.

The flowchart of ACES provides the following procedure:



Viewing Process:

Source:	IT	Creative Process:	LMT	RRT	OT
Arri, Canon, Sony etc.	The input transform is usually provided by the camera manufacturer and transfers the recordings to the ACES color space.	Grading, VFX	The Look Modification Transform applies the „ACES LOOK“ to the material.	The Reference Rendering Transform applies the „ACES LOOK“ to the material.	The Output Transform transfers the data for the corresponding display (projection, monitor, etc.).

Input Transform

This process converts the image information from the present format into the ACES color space. According to the source, the appropriate IT should be chosen. In the current OCIO Nuke Config default settings are included for the following camera manufacturers: ARRI, Canon, GoPro, Panasonic, RED and Sony.

Reference Rendering Transform

The RRT includes a look defined by ACES, designed to mimic the traditional appearance of film. The ACES version 1 has reduced the excessive movie look of ACES VO.1, but still contains a look in the RRT.

Output Transform

The ODTs map the image data in the expected color space of the display (e.g., Rec. 709 or sRGB) to properly render the image.

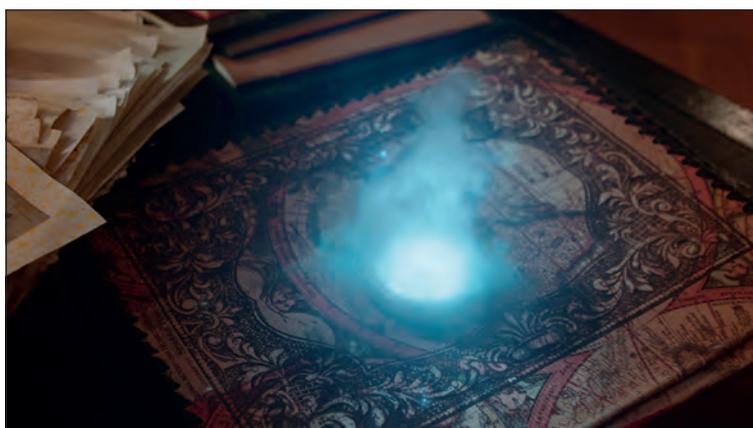
How does a current compositing pipeline work without ACES?

In order to be able to judge to what extent these developments are helpful, one has to take a closer look at the usual work processes. Three color spaces play an important role in VFX editing of feature movies. These are projection or presentation spaces. This means that the entire Color Pipeline is based on which output medium is used.

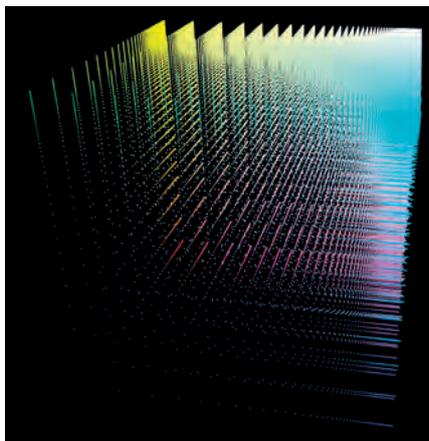
DCI-P3 is a standard target color space for movies. It uses the same primary blue color as Rec. 709, sRGB, and the Adobe RGB color space. However, the red and green primaries are much farther out in comparison to sRGB and Rec. 709 and thus



With Nukes sRGB viewer, we only see the high-lights up to a maximum value of 1.



The same picture with the corresponding movie Emulation LUT with details in the high-lights



A visualization of the used movie emulation LUT. The rolloff in the highlights is visible here through the finer gradations.

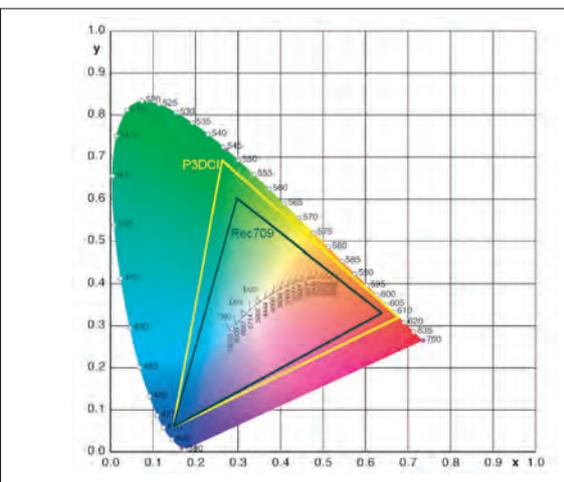
provide a larger gamut. According to the manufacturer, high-quality work monitors can usually represent a maximum of 99% of the DCI-P3 standard.

The other color space is Rec. 709 and sRGB. These two color spaces share the same primaries and therefore have the same color gamut. However, the gamma curve is different. While sRGB is designed for computer monitors, Rec. 709 is HDTV-standard.

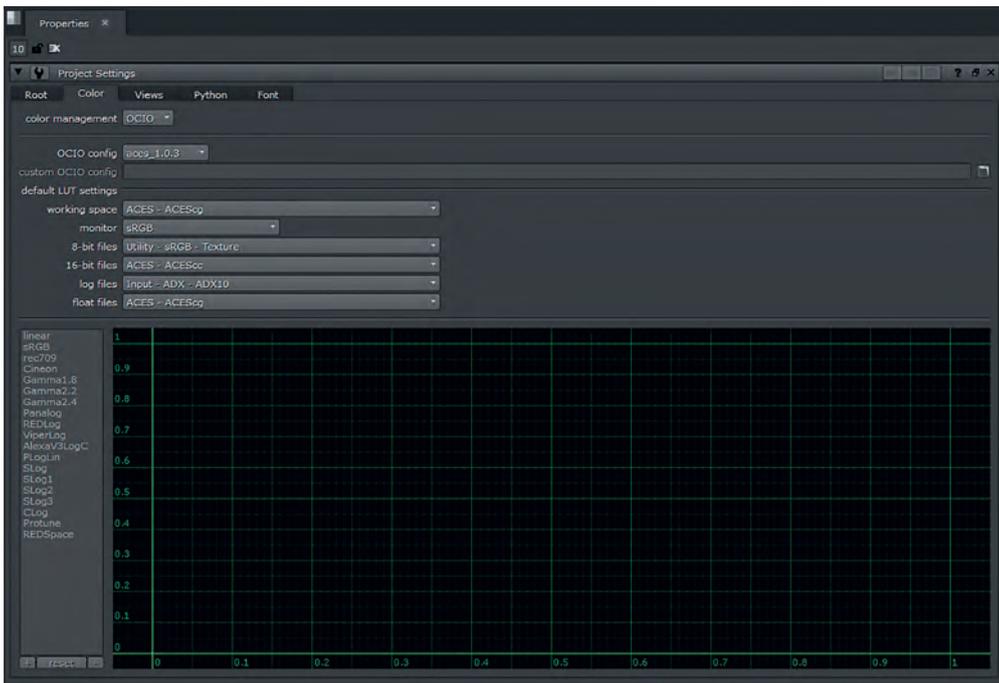
Already as a newcomer one learns that linear work processes have design advantages. Optical effects such as light and shadow are calculated more realistically, and while doing color adjustments in compositing, e.g. do not work against the implemented gamma curve.

In Nuke, this linear process can be covered in three steps ...

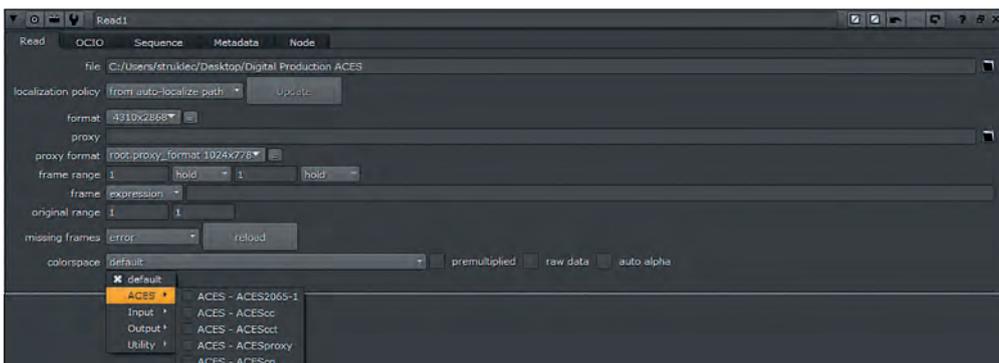
The color workflow in Nuke already starts with the Read Node. In this case, an inverse 1D look-up table (LUT for short) can be used, which converts the material from its original gamma to a linear representation. As an example: Artwork from the ARRI Alexa is usually coded with an AlexaV3LogC



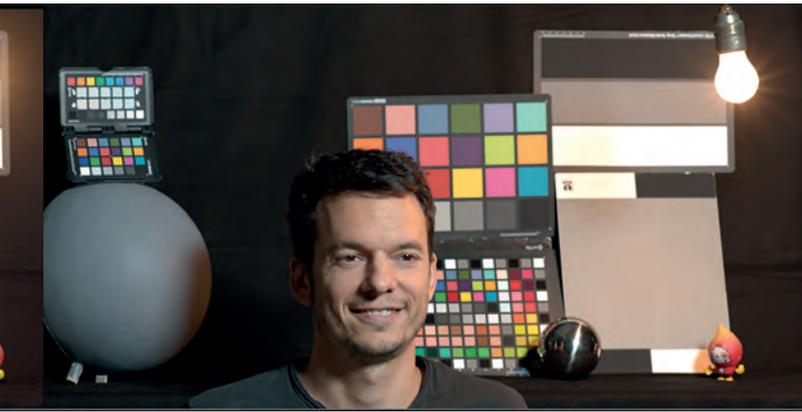
A color space is defined, among other things, by the maximum values of the three colors red, green and blue - the so-called primaries. The combination of these three values forms a triangle - the gamut, which represents all the colors that can be represented in the color space.



If the color management is set to OCIO and the OCIO Config is set to aces_1.0.3, the color space settings of the read and write nodes are also automatically adjusted.



The choices are explained quickly. For material already transferred to ACES, the corresponding ACES Color Space should be selected. For example, an export of the Plates encoded on ACES 2065-1 (Conforming or Grading rendered VFX Pull) should be transferred to the Working Space (ACEScg) with the corresponding Color Space Setting of the Read Node. In the meantime, input transfers are available for most cameras, and the usual formats can also be easily imported through the provided input transfers.

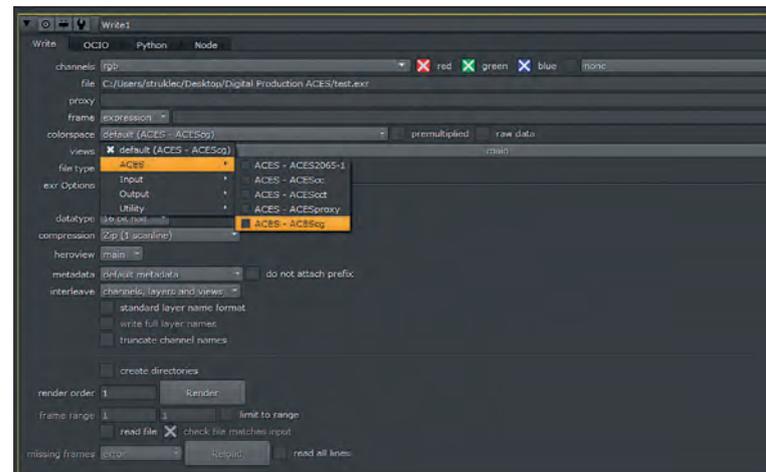
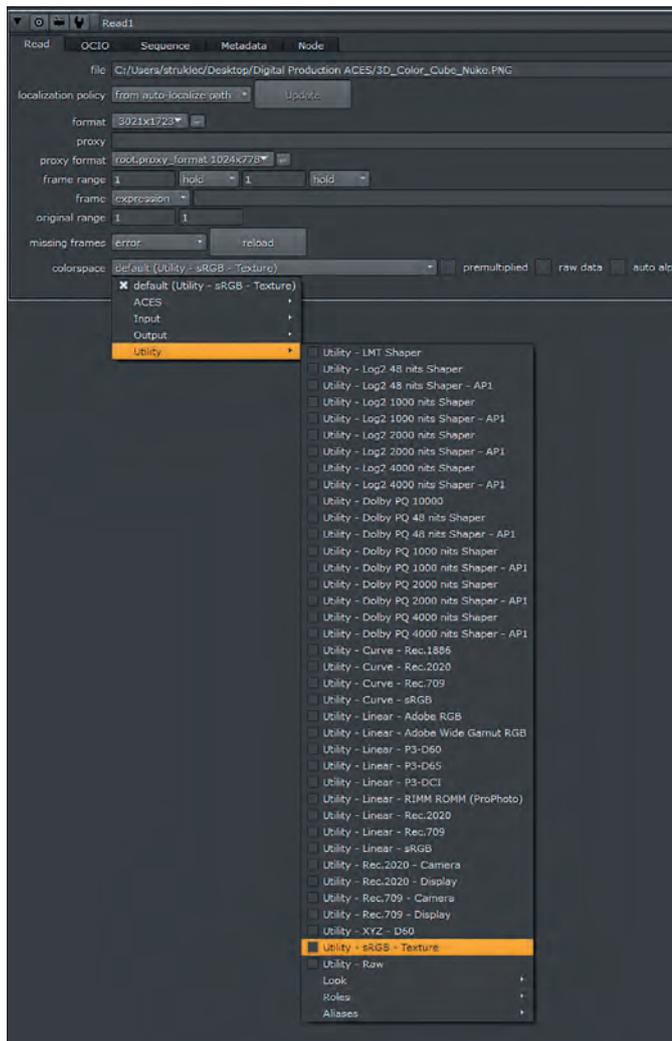


In direct comparison (Canon C500, Sony F65 and the ARRI Alexa side-by-side), the details of ACES show. The upper row of pictures shows the Nukes standard workflow with the well-known linearization method and the sRGB Viewer LUT. The bottom row uses the ACES workflow. IT makes the material uniform. The Viewer LUT uses the sRGB representation in ACES in the lower row. The RRT used makes the material more rich in contrast.

color space, which should be converted when importing into Nuke to get a linear image. 1D LUTs are unable to affect the gamut, so the gamut remains untouched. The image material is linearized from this step and can be edited as desired. During the writing process, the original gamma value is usually reapplied to bring the delivered plate and the finished compositing into the same format.

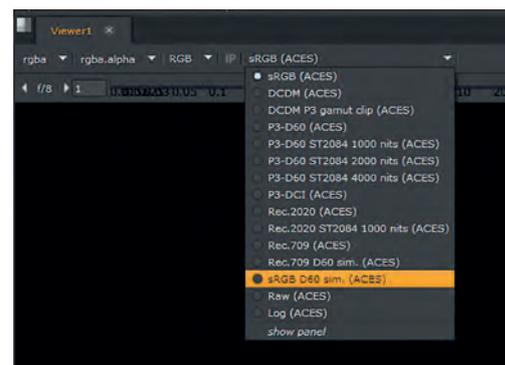
The linear images are displayed with a viewing LUT. Nuke has presets for sRGB and Rec.-709 screens. These presets are able to represent values from 0 to 1. Higher values are available, but are not displayed (clipped).

When working in the film industry, however, it is common for highlights and pings, such as those that arise when looking into a direct light source, to be far above this maximum value of 1 that can be represen-



For example, an sRGB image can be interpreted correctly using the Utility> Utility - sRGB - Texture setting.

The write node contains the same settings.



The Viewer LUTs also change according to the OCIO Config.

ted. Usually one helps oneself here with a adapted Viewing LUT. The ARRI offered LUT for Rec.-709 monitors accesses e.g. only very subtle in the saturation and color distribution, but has a pleasant roll-off in the bright areas. Visualized as a point cloud, the finer gradations become visible in the bright area:

If set up correctly, the optical effects work as expected. The most relevant is a controlled setup with light effects like pings and glows. These react better and more lifelike in a linear image with accurate brightness information.

Film Emulation LUTs allow you to visualize these bright image areas in the available viewer spectrum. This does not change the picture information, just the presentation of it. Often, such a 3D viewer LUT, including creative color correction adjustments, is supplied by the DI vendor to the VFX studio to capture the final grading in the VFX previews. Often these look stylizations cause problems, and the artists have to work against the color shifts of the LUT.

For example: Sometimes it is necessary to make color corrections in a completely different area of the color spectrum (magenta) to get the desired result (blue). In other cases, there are steppings or artifacts that interfere with the presentation of the images. These problems even accompany the large VFX studios, where dedicated color specialists usually take care of creating these preview LUTs and color workflows.

What is an example workflow for ACES in practice?

With the recent implementation of OCIO in Nuke, a transition to an ACES workflow can be accomplished in just a few steps. The Nuke project settings show us the options: After the color management of Nuke-Standard has been set to OCIO, the current ACES configuration (here `aces_1.0.3`) should be selected as OCIO Config. As working space, it is advisable to stay in ACEScg.

What does this change mean and what do you have to think about in an ACES Color Pipeline?

The advantages in the compositing department are obvious: So far, it has been customary to bring the various materials into the target color space by means of grading and color corrections. A manual process, which can only lead to an inconceivable approach, but never to a truly accurate solution due to the infinite variety of possibilities of transformation in the color spectrum. ACES offers us a way to bring these color transformations under control.

In the 3D department, ACEScg provides a well-functioning render color space that provides stability even in extreme situations. Another advantage is the controllable preview possibilities: In a uniform OCIO setup, no difference between the 3D preview and the compositing preview should be visible. Properly implemented, ACES continues to provide a way to introduce more photographic work processes. The lighting and look development process will be more like a cameraman's work.

The typical problem of a color workflow is usually that Photoshop is used in the matte painting department. A common workflow is to export the images in a log encoding before editing in Photoshop. Without this editing step, values above 1 will be clipped by Photoshop. About ICC profiles, the flat-looking image is bent back to give the artist a preview opportunity. Photoshop always seems to work most reliably when working with normalized display-related data that can be managed by the ICC system.

This leads to a possible workflow that is being tested by some studios: The source images are usually converted to Nuke via an output transform. Animal Logic e.g. has created a color space based on the AP1 primaries and at the same time assigns the images a synthetic ICC profile that describes this space. The work in Photoshop is thus possible as usual, and the dynamic range of the material is only regulated on reasonable 16 stops. When exporting an EXR is calculated, which is provided with an adjustment LUT.

For smaller studios that need a more flexible workflow in Matte Painting, there

is also the option to use OCIO for Photoshop. However, this requires that each artist knows the color workflow and works on his own responsibility. Download here: bit.ly/OCIO_photoshop.

Creative side effects

The first ACES show will be an unusual experience for every artist. The main reasons for this are: The RRT contains an S-curve or a movie look that is always applied and deviates from the usual sRGB / Rec.-709 / P3 display. In direct comparison to a traditional performance, the result is darker, has stronger contrasts and shows more details.

The ACES white point is not as usual with D65 (6,500 Kelvin), but with D60 (6,000 Kelvin). Monitors and projectors must be recalibrated accordingly. In 2015, there was already a collective agreement to switch to the D65 standard. The implementation has not yet been done.

Applying the IT and converting it to the ACES color space removes the look of the camera. In a direct comparison, differences are still visible - especially in the skin tones. On the part of the colorists one hears that the similarity of the material facilitates the approximation, but creative design possibilities get lost. The similarities in image aesthetics will redefine camera selection in the future. > ei



Valentin Struklec has been active as a compositor, VFX supervisor and VFX producer since 2006 in advertising and film. He has worked as a Digital Compositor on such films as Total Recall, Prometheus, Xmen: First Class, Maleficent, and The Secret Life of Walter Mitty at companies such as ILM, MPC, Prime Focus, etc. Since 2013 he is managing director of the Viennese company VAST and teaches in the department Digital Art - Compositing at the Vienna Film Academy.