



## IPP2: IMAGE PIPELINE STAGES

### OVERVIEW

IPP2 (Image Processing Pipeline 2) is new for RED cameras with HELIUM or newer sensors, although all RED customers can benefit in post-production with REDCINE-X PRO and the R3D SDK. An image processing pipeline encompasses all the steps that take us from raw sensor data through to a Standard Dynamic Range (“SDR”) or High Dynamic Range (“HDR”) output image.

All grading operations now occur in a single, well-defined, wide gamut log space—making them output independent. Other image quality improvements have been made to improve the sharpness/resolution of the demosaic and retention of highlight detail, among other enhancements.

IPP2 separates out the technical controls, which are standardized references that rarely change, from the creative controls, which are unique to the colorist/production and often change with every shoot or clip. Where possible, industry standard naming and specifications are also used throughout.

### STAGES

| STAGE | NAME                    | DESCRIPTION   | CONTROLS   |
|-------|-------------------------|---|--|
| 1     | Primary Raw Development | Conversion to REDWideGamutRGB   | Kelvin<br>Tint   |
|       |                         | Encode to Log3G10   | ISO<br>Exposure Adjust   |
| 2     | Grading                 | Grading via ASC CDL   | CDL Slope, Offset, Power and Saturation                              |
|       |                         | Creative 3D LUT allows user to place creative looks (that go beyond the scope of CDL).                  | Creative 3D LUT  |
|       |                         | Tools for fine-tuning existing CDL and 3D LUT results within REDCINE-X.                                 | Contrast, Curves   |
| 3     | Output Transform        | Development to output color space via gamut mapping algorithm to stop camera colors going out-of-gamut. | Tone Map Curve (high, medium and low contrast)<br>Output Color Space |
|       |                         | Output encoding to SDR or HDR with highlight roll-off and compression as appropriate.                   | Highlight Roll-Off<br>HDR User Nits Limit<br>Output Gamma            |

### 1. PRIMARY RAW DEVELOPMENT

The primary raw development stage includes look-independent technical controls such as the demosaic, exposure adjustments, and white balance. The first stage is the demosaic, which utilizes a new algorithm that improves detail and sharpness, and also seeks not to exacerbate axial chromatic aberrations.

After demosaic, the camera data is still in the camera color space and is converted to REDWideGamutRGB (RWG), a camera color space designed to encompass all colors a RED camera can generate without clipping. To preserve camera dynamic range, the RWG image is encoded using Log3G10 which provides for 10 stops highlight extent above mid grey, which is more than sufficient for HDR output peaking at 10,000 nits or raw developments of ISO 12,800.



It is best to think of Log3G10 as a large container for image data over a very wide range of brightness levels. The “size” of Log3G10 is large enough to avoid clipping under all reasonable circumstances, and thus it is normal for the image to not use the entire Log3G10 range. In-camera, a log histogram would be tricky to read as the image data would not spread across the entire width of the histogram. To avoid this issue, the in-camera histogram is scaled so that the far right edge always represents sensor clip given the current ISO and exposure gain settings in use.

## 2. GRADING

The second stage includes all the creative or stylistic adjustments to the image. CDL grading operations, which are industry standard and well supported, form the core of this part of the pipeline. For more creative looks than CDL can produce, a full creative 3D LUT is also supported. There are many ways this could be used because it is placed in the pipeline at a point where the data is still RWG/Log3G10. For example:

- ▶ User curves (either luma, or R,G,B)
- ▶ Creative color transforms (like 3 strip film emulation)
- ▶ Film looks (either to match stock, or more extreme like bleach bypass)
- ▶ Secondary color correction like per-color saturation control

Although code is not provided for these 3D LUTs, they are relatively easy to create and examples of these various looks can be provided. If additional grading needs to be performed after the CDL and 3D LUT, the familiar Contrast and Curves tools are available in REDCINE-X and applied at the end of the grading stage.

The grading section is designed to function with both input and output data still in the RWG/Log3G10 format. This means that with careful design (if you’re making your own creative 3D LUTs) the grade will function well for any of the Output Transform options across both SDR and HDR and the various output color spaces.

## 3. OUTPUT TRANSFORM

The final stage comprises output or display-specific settings, and should therefore not be treated as part of the creative process. The output transform converts the RWG/Log3G10 image into a standard color space that is ready to be output through an encoding curve to a display. The first part of the transform process is the use of a tone map curve to impart contrast to the image (this is automatically turned off for linear light and log exports, and can be turned off if you want to do your own as part of the creative 3D LUT), followed by the conversion of the color space with a gamut mapping process to stop out-of-gamut colors clipping when converting to a smaller gamut.

At the end of the Output Transform, the image has highlight roll-off applied (for SDR and HDR outputs if desired) and gamma, HDR or log encoding. For SDR, the roll-off is based on the full Log3G10 range and has settings that allow for modifying the roll-off to work better with high key or low key scenes. For HDR, roll-off is based upon the capabilities of the monitor. HDR highlights can be let through to the extent of the full SMPTE2084 range of 10,000 nits, or rolled off to map in any brightness above a desired nit level.

The Output Transform stage can also be encapsulated into a 3D LUT for use in post grading applications. When grading outside of the RED tools, the image is exported (or accessed from the R3D via the SDK, or ProRes / DNxHD) using only the Primary Raw Development. All grading can now occur on the RWG/Log3G10 data, and the Output Transform cube can be selected to produce the desired output image.