Colorfront Engine

Advanced Perceptual Color Processing for Modern Content Creation and Delivery

Executive Summary

The Colorfront Engine™ (CFE) is a color processing system based on human visual perception, with applications ranging from handling camera original images to remapping finished masters.

- The CFE color pipeline allows for effortless creation of SDR or HDR deliverables from camera log files, offering a tunable, consistent creative look across all delivery formats.
- CFE is ideal for mapping finished content to specific display capabilities, preserving the intended look even when adapting to different peak luminance or color gamuts.
- The Colorfront Engine is available as an optimized, lightweight SDK, designed for seamless integration into any software or hardware platform, delivering a powerful and efficient solution for advanced color processing.

Introduction

In today's end-to-end content creation landscape, productions face unprecedented complexity in managing multiple deliverable formats across a growing number of display technologies.

Modern productions routinely employ multiple camera formats, each with unique color characteristics and technical specifications. Onset monitoring, Dailies, Editorial and VFX reviews are increasingly a mix of SDR and HDR. Deliverables are required in numerous formats, from traditional SDR broadcast to cutting-edge HDR streaming and cinema versions.

This exponential increase in format combinations demands a more sophisticated approach to color processing and management to ensure consistent creative intent across diverse viewing experiences.

The Colorfront Engine is a state-of-the-art parametric color processing pipeline mapping various input formats, including camera original (scene-referred) and graded (display-referred) images, to a wide range of SDR and HDR output formats at user definable brightness levels and gamuts while maintaining the creative intent. It is based on the extensive knowledge of how our eyes see light, and uses an internal processing color space where the perceived color and tonal relationships are preserved.

Colorfront Engine is engineered for implementation in all stages of the production pipeline, including broadcast and scripted content. It is not only integrated into all of Colorfront's products, but can be easily integrated into 3rd party technologies.

Key Features

Colorfront Engine is designed to maintain image integrity and preserve creative intent, using highly efficient workflows. Specific foundational features include:

- Automatic format detection and conversion (when possible)
- Perceptual color volume remapping based on human vision science
- Comprehensive support for all major camera formats and delivery standards
- Real-time processing capability for both file-based and live workflows
- Advanced tools for HDR workflow optimization

Core Technology

Perceptual Color Processing

The Colorfront Engine uses an advanced perceptual processing model that accounts for how humans perceive color and contrast in various viewing conditions. Its perceptual transform maintains the image's appearance across different brightness levels and color primaries, ensuring consistency despite varying surround brightness levels.

Leveraging insights from the human visual system, the CFE adapts images to match a display's brightness and environment while preserving the original creative intent with minimal manual adjustments. It is an ideal tool for mapping graded content to any display's capabilities, faithfully reproducing the intended look across different devices and viewing conditions.

Advanced HDR Processing

The latest version of Colorfront Engine includes sophisticated tools for HDR workflow management:

- **SDR to Dolby Vision Conversion:**
  Automated conversion with metadata generation that ensures the Dolby-derived SDR output matches the original SDR content
- **DCI to Dolby Vision:**
  Specialized processing for converting theatrical masters to home video HDR
- **HDR Cinema Versions:**
  Tools for managing emerging HDR cinema deliverables for direct LED screens and next-generation projection systems
- **HDR Rolloff:**
  Sophisticated highlight management with perceptual preservation of creative intent

Workflow Integration

On-Set to Delivery

Colorfront Engine provides a consistent color processing pipeline throughout the entire production workflow:

- **On-Set:**
  Real-time camera log processing for accurate monitoring
- **Dailies:**
  Efficient creation of viewing copies while preserving full creative potential
- **Editorial:**
  Color-accurate workflow for creative decision making
- **VFX:**
  Automated color conversion for VFX pulls
- **Finishing:**
  High-quality mastering for multiple delivery formats
- **Distribution:**
  Streamlined conversion for various exhibition platforms

Broadcast Applications

The Engine includes specialized tools for broadcast workflows:

- **Broadcast Converter:**
  Optimized controls for display-referred conversions between SDR, HDR PQ, and HDR HLG
- **Live Production Support:**
  Real-time processing for live broadcast applications
- **Quality Control Tools:**
  Automated analysis and correction of HDR content

Other possible Colorfront Engine applications could include implementation into consumer electronics devices and displays, exhibition hardware, and social media platforms.

Technical Implementation

Architecture

Colorfront Engine is designed for flexible deployment across various platforms:

- GPU-accelerated processing for real-time performance
- CPU fallback for systems without dedicated graphics
- Modular design for easy integration into existing workflows
- Support for all major operating systems

Integration Options

The Engine can be integrated in multiple ways:

- **SDK Integration:**
  Native C++ implementation for custom applications
- **OFX Plugin:**
  Integration with compatible post-production software
- **Hardware Implementation:**
  Embedded processing for broadcast equipment
- **Cloud Processing:**
  Scalable solutions for content management platforms

Notable Uses

The Colorfront Engine has already been implemented by technology partners, studios and post production facilities:

- **AJA Video Systems:** Powers FS-HDR, HDR Image Analyzer, and ColorBox
- **Major Studios:** Core technology for mastering theatrical and streaming content
- **Broadcast Networks:** Live production HDR conversion and quality control
- **Post-Production Facilities:** Integration into VFX pulls, picture finishing and deliverable creation platforms

Future Developments

Colorfront continues to advance the Engine's capabilities:

- Enhanced support for emerging HDR cinema standards
- Advanced neural network-based processing options
- Expanded real-time processing capabilities
- Cloud-optimized processing pipelines

Conclusion

As the industry continues to evolve with new formats and standards, Colorfront Engine remains at the forefront of color processing technology. Its perceptual approach to color management, combined with comprehensive format support and advanced toolsets, provides a robust solution for modern content creation and delivery workflows. The Engine's proven track record in high-end production, combined with its continued development and adaptation to new industry needs, makes it an essential tool for maintaining creative intent across the expanding universe of display technologies and viewing environments.

Colorfront Engine's perceptual color processing technology is available in software and hardware products, including AJA's FS-HDR, ColorBox, and HDR Image Analyzer, as well as in Colorfront's own dailies and mastering products.

Additional Information

Additional detailed information is included below for reference:

- **Appendix A: Challenges in Modern Content Creation**
- **Appendix B: Perceptual Color Processing**
- **Appendix C: Colorfront Engine™ Integrations**
- **Appendix D: Colorfront Engine™ Workflow Applications**
- **Appendix E: Colorfront Engine™ SDK Technical Overview**
- **About Colorfront**
- **Glossary of Terms**

Appendix A: Challenges in Modern Content Creation

Current Industry Practices

When considering current display technologies, we see a great variation in dynamic range, color gamut, and the recommended (or realistic) display environments in which content is viewed. It is a mistake to think about these displays as either HDR or SDR in a binary way. In reality, there is a continuum of different dynamic ranges between the two. There is no magic number defining where HDR begins and SDR ends.

For example, a 48-nit cinema version has lower peak brightness than a 100-nit broadcast deliverable. Does that mean 48-nit cinema is a sub-SDR if we call 100-nit SDR? Regardless of labeling them both SDR, they are simply displays with different capabilities, rendered in different viewing environments. Cinema venues continue to expand their offerings of enhanced and high dynamic range technologies, from laser projectors to emissive LED walls. By achieving very deep blacks levels in dark cinema environments, consumers are treated to premium experiences with higher contrast ratios.

That said, how do we master each of these different versions? Do we have a colorist producing every single one of these deliveries? To avoid the need to grade for each display, a managed color workflow is required that translates between different nit levels and color spaces while maintaining a perceptual match. In other words, when viewers look at the content, they need to see the same thing.

In an ideal situation, a reference master display should be a superset of all of the deliverables. For instance, if our maximum deliverable reaches 1000 nits, we should be able to visualize how all other possible deliverables will appear. However, this is often not possible. Instead, we may be limited to the existing viewing technology and unable to exceed its capabilities. To address this, we need systems that can translate from our particular arrangement to displays with different brightness levels.

Using a reference master with very high peak brightness presents its own challenges, as mapping to a lower dynamic range display with a possibly darker ambient surround is not straightforward. Without the right tools, it is easy to diverge from the original creative intent, resulting in an unfortunately altered look across various deliverables. Below, we discuss some typical use cases and current approaches that attempt to overcome these challenges.

HDR to SDR: Dynamic Range of Reference Master Larger Than Deliverable

A typical use case scenario arises when the reference master's dynamic range is high, graded on a brighter display, while a deliverable with a lower dynamic range is needed. For example, we may have a master graded on a bright 1000-nit HDR display that needs to be delivered to a cinema with a 48-nit display.

There are various ways to scale down the image and reduce brightness, but they all come with some loss of the full-range image. Clipping highlights produces poor image quality at the clipping points, while soft clipping also results in the loss of important tonal and color relationships. A more complex tone curve could be a better solution; however, color hue, saturation, and colorfulness may not match accurately with this approach either. Although these techniques could work reasonably well with black-and-white images, they are not ideal in most present-day cases where we work with color images.

Dolby Vision is one widely adopted technology for mapping HDR content to SDR, offering a comprehensive workflow to handle high-to-low dynamic range conversions. However, the Dolby Vision workflow requires both statistical pre-processing and scene change analysis, which adds to the overall complexity. This pre-analysis can make the process time-consuming, as it involves ensuring that the intended visual quality is preserved across all scenes. While this approach can deliver impressive results, it often requires a colorist to apply creative trims, which, combined with extensive pre-processing, may hinder the efficient use of creative time.

A technique often used is to grade down a higher-range image through color correction. A skilled colorist may then have to spend significant time scaling down the image to fit it into a lower dynamic range format for each scene, often using shapes and secondaries to achieve a visually pleasing result. This process consumes valuable creative time, preventing the colorist from focusing on enhancing the image and applying a unique creative look to the piece.

Consistency must also be maintained across scenes and deliverables, a process that takes a significant amount of time. However, with the proper transform, you can preserve perceived colors and tonal relationships, maintaining skin tones and grayscale, ultimately resulting in a match across various deliverables.

SDR to HDR: Dynamic Range of Deliverable Larger Than Reference Master

This opposite scenario involves mastering a deliverable at a lower nit level than the intended display. For example, starting with a 100-nit reference master and needing to adapt it to HDR. While manually increasing brightness is an option, this approach often results in an overly bright SDR image that lacks the intended aesthetic quality.

A common use case is remapping 48-nit cinema masters for display on newer emissive cinema walls. Given the time-intensive process of remastering movies with current industry practices, most films shown on these new screens are unfortunately unable to fully utilize the enhanced dynamic range capabilities of these displays.

Manually grading the image to achieve a balanced, visually pleasing brightness can be tedious and labor-intensive. Another option is to enhance only the highlights; however, this can disrupt color and grayscale relationships, leading to a loss of creative intent. Ideally, we want to maintain these color relationships and preserve the essence of the original image. By processing the content in a perceptual environment, these characteristics are naturally aligned, resulting in a cohesive and well-balanced image.

There are various transforms available to the industry, often fixed 3D Lookup tables. Many are based on the ITU-R BT.2390 specification which merely places the SDR content inside the HDR container at 203 nits, twice the brightness. This results in just a brighter SDR image. On the other hand, the Colorfront Engine's Perceptual Processor unbuilds the SDR image, places it into the internal perceptual processing space where it can be reconstructed into a beautiful dynamic HDR image as though it had been originally mastered in HDR, all the while preserving the creative intent of the original SDR image.

Output Display Transform

Once the master look is finalized and rendered to the desired nit level, the output is prepared for transmission systems, or "handshake spaces." For HDR, the primary transmission systems are HLG and HDR10. When correctly implemented, HLG and HDR10 should reproduce identical colors, ensuring a consistent appearance. For SDR, BT.709 is used for television and XYZDCI is used for cinema. Transmission systems and handshake spaces are designed not to alter the intended look when properly implemented.

Color Gamut Remapping

In cases where the master content has a larger color palette than the transmission system or intended display, colors from the larger color space must be constrained into the smaller one. Simply clipping these out of gamut colors can produce artifacts such as drastic hue shifts, blocking, and other distortions. The goal of proper out-of-gamut remapping is to find the most perceptually accurate substitute colors that fit into the delivery color space specification.

Soft Previewing

Soft proofing, or soft previewing, is essential for verifying color accuracy. We need to preview the content on a high dynamic range display, as well as on all deliverables with varying nit levels. It is important that monitor settings remain unchanged: the system should allow us to toggle between deliverables with a single button to ensure consistent grading quality. This capability allows us to soft proof across different dynamic ranges and color constraints, such as 100 nits for Rec.709 television, or 300 nits for a cinema wall, directly on the reference master display.

Creative Trimming

As discussed, relying on standard creative tools—such as lift, gain, and gamma to generate various SDR and HDR versions from a graded reference master is not ideal. These tools are not designed to preserve color perception accurately and therefore require advanced skills and significant time to achieve satisfactory results.

Even with the best color processing, there are instances when manual adjustments, or “trims,” are necessary to achieve the desired final image. When the target display’s dynamic range significantly differs from the reference master’s, the tonal relationships in the perceptually remapped image may not maintain their intended aesthetic qualities. For example, when expanding an SDR source to HDR, a bright background highlight might distract viewers from the primary subject, or an SDR image derived from HDR may appear overly contrasty in a dark viewing environment.

To address these issues on a scene-by-scene basis, specialized tools are essential. Standard color correction tools are intended for creative adjustments, not for aligning with different display nit levels and viewing conditions. The appropriate tools for these tasks include:

- **Dynamic range control**:
  to manage dynamic compression or expansion within the target nit range.
- **Ambient surround compensation:**
  to adjust for different viewing environments, from dark to bright and vice versa.
- **Colorfulness adjustment:**
  to regulate the perceived vibrancy of remapped colors.

Limitations of Industry Output Transforms

Current output transforms (ODTs) in the industry are not designed to ensure a perceptual match across different deliveries. Each transform introduces a unique look, often requiring a separate grade for each delivery to maintain visual quality. This makes preserving the original creative intent across all deliveries challenging and time consuming.

For example, an image may initially be rendered to 100nit Rec.709 with one of the standard ODTs, but later needs to be converted to cinema 48nit DCI P3. Simply changing the ODT for 48nit DCI P3 may produce a satisfactory result, but without perceptual matching, there will be noticeable differences in color and saturation, which the colorist would then need to correct. However, using a perceptual transform to create a darker version of the image ensures more accurate color and skin tone reproduction.

Appendix B: Perceptual Color Processing

Colorfront Engine™ Perceptual Color Processing

The Colorfront Engine's parametric color processing pipeline is tailored to support the full spectrum of production needs across both broadcast and scripted content, impacting every part of the imaging pipeline.

From on-set work and dailies through editorial, VFX, color grading, and mastering, it seamlessly maps diverse input formats, including camera-original (scene-referred) and graded (display-referred) images, to a wide range of SDR and HDR output formats. This includes user-defined brightness levels and color gamuts, all while preserving creative intent.

By mapping images into a perceptual space, content is tailored to the brightness and gamut of the target display, ensuring a consistent appearance across formats. In this non-linear space, color and brightness adapt in ways that reflect the non-linearities of human vision. For example, a bright image may show a hue shift on a scope due to the perceptual processing model, which is designed to mimic how the human eye perceives color and brightness.

The ambient surround used during mastering also influences image rendering, ensuring the final image on any display aligns with the reference master. This perceptual transform faithfully reproduces images across different displays, adapting to various viewing conditions while maintaining the image's appearance across different display brightness levels, color primaries, and surrounding brightness levels.

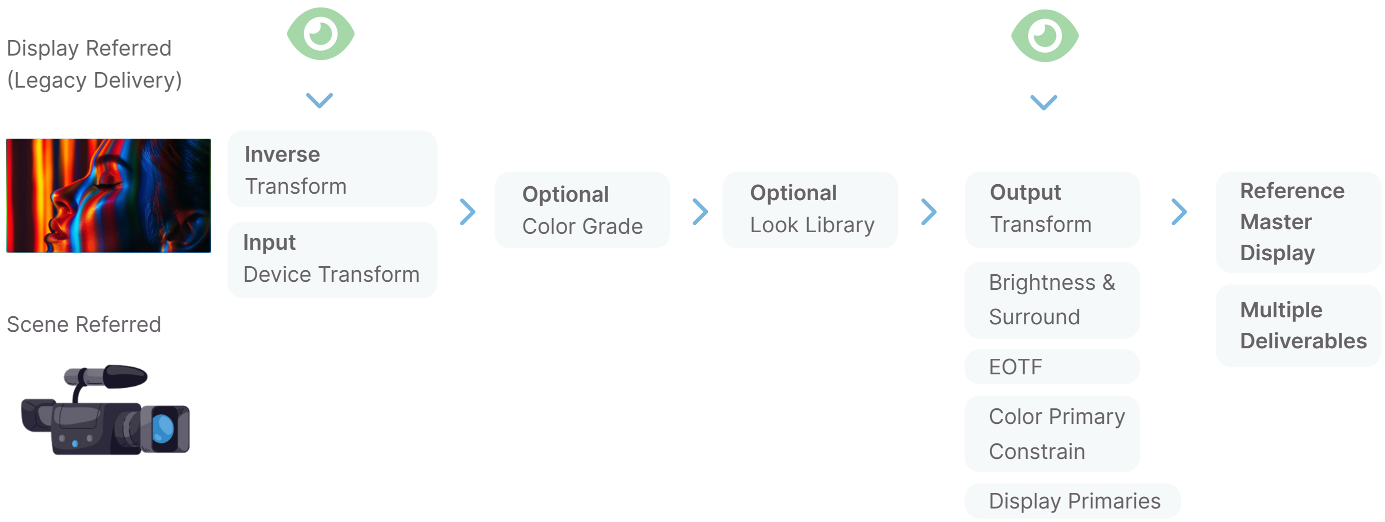
This custom processing color space is based on extensive knowledge of human color perception from scientific literature and years of experience in high-end feature film color management.

Human Visual Color Perception Considerations

Below are the some of the specific effects of human color perception considered in the Colorfront Engine's design:

- **Bezold-Brücke Hue Shift:**
  The hue of monochromatic light varies with luminance.
- **Abney Effect:**
  The hue of monochromatic light shifts with the addition of white light.
- **Stevens Effect:**
  Contrast increases with luminance.
- **Bartleson-Breneman Effect:**
  Display image contrast rises with the brightness of surrounding light.
- **Hunt Effect:**
  Colorfulness increases with luminance, requiring compensation when adapting an image to a different brightness level than the reference master. The Hunt effect describes how an increase in brightness can make a picture appear more colorful; proper compensation ensures color consistency.
- **Helmholtz-Kohlrausch Effect:**
  Brightness perception increases with saturation.
- **Chromatic Adaptation:**
  Human color perception adjusts to the white point of the lighting when viewing reflective objects.

Colorfront Engine Perceptual Model Visualization



In an end-to-end workflow, the image first passes through an IDT (Input Device Transform) into a common grading space, followed by an output transform that adjusts the reference look for various output levels.

Brightness and surround parameters can be tuned to compensate for different viewing environments, whether dark or bright.

Additionally, inverse transforms are available for legacy deliveries, enabling previously graded Rec.709 or other HDR materials to be reverted back into the grading space, as these transforms are fully invertible.

Appendix C:
Colorfront Engine Example Integrations

Live Broadcast and On-Set Look Management with AJA FS-HDR

The Colorfront Engine is integrated into the AJA FS-HDR, a 1RU rackmount universal converter and frame synchronizer. This device addresses the High Dynamic Range (HDR) and Wide Color Gamut (WCG) requirements of various environments, including broadcast, OTT, production, post-production, and live events AV environments. It offers real-time, low-latency processing with high color fidelity for 4K/Ultra HD and 2K/HD workflows. Developed in collaboration with AJA, the FS-HDR utilizes proprietary video processing algorithms from the Colorfront Engine to deliver its HDR/WCG capabilities.

On-Set and Post-Production Monitoring with AJA ColorBox

AJA's ColorBox utilizes the Colorfront Engine's video and color space processing algorithms to deliver HDR/WCG capabilities for on-set monitoring and a variety of post-production workflows, including editorial, VFX, and color grading.

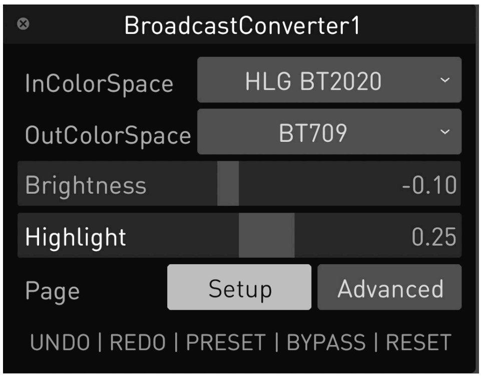
AJA HDR Image Analyzer

The HDR Image Analyzer is a hardware-based product equipped with a comprehensive suite of tools for analyzing up to four 4K/UltraHD signals, using both 12G-SDI and NDI connectivity. It supports a wide range of inputs, including camera Log formats, SDR (Rec.709), PQ (ST 2084), and HLG, and offers Wide Color Gamut (WCG) support for BT.2020, as well as traditional BT.709 and P3 color spaces. Additionally, it provides advanced analysis capabilities with Dolby Vision® dynamic metadata inspection, ideal for HDR mastering and quality control applications.

Appendix D: Colorfront Engine™ Workflow Applications

Broadcast-Oriented Processing

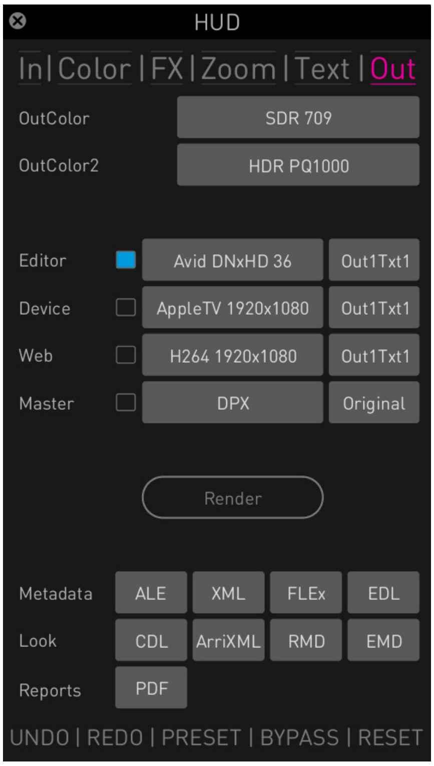
Broadcast Converter



The Colorfront Engine powers a broadcast conversion tool capable of handling display-referred conversions between SDR, HDR PQ, and HDR HLG formats, ensuring seamless color gamut mapping across different output display color spaces. In addition to the primary conversion controls as seen above, there is a full selection of advanced settings that may be applied for further refinement, including Exposure, Color Temperature, Tint, Lift, Gamma, Gain, and Knee controls.

HDR Harmony

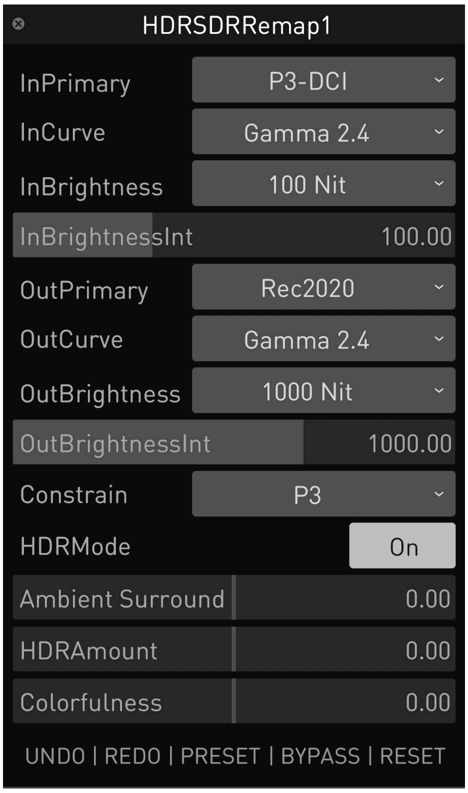
HDR Harmony is a specialized tool designed to correct overly bright and saturated HDR content. Leveraging the Colorfront Engine's perceptual image processing, this tool carefully protects against color artifacts and highlight clipping, resulting in a cleaner displayed image.



HDR Dailies in Express Dailies and On-Set Dailies

Onset and Express Dailies offers the option to utilize the Colorfront Engine (CFE) project type within dailies workflows. This enables dailies operators to apply ACES-compliant IDTs to map all input sources into the internal processing color space, with dedicated tools for adjusting exposure, color temperature, tint, and physically accurate saturation. The project can simultaneously render SDR 709, HLG, and HDR10 deliverables through the perceptual processing engine, enabling effortless production of tandem SDR and HDR dailies.

On-Set Dailies, with its customizable node-based pipeline, provides even greater flexibility in designing color workflows to deliver any type of output concurrently. Using the Pipeline Setup wizard on the Node Page, users can create a CFE pipeline for any camera format and combine it with their preferred color correction tools.



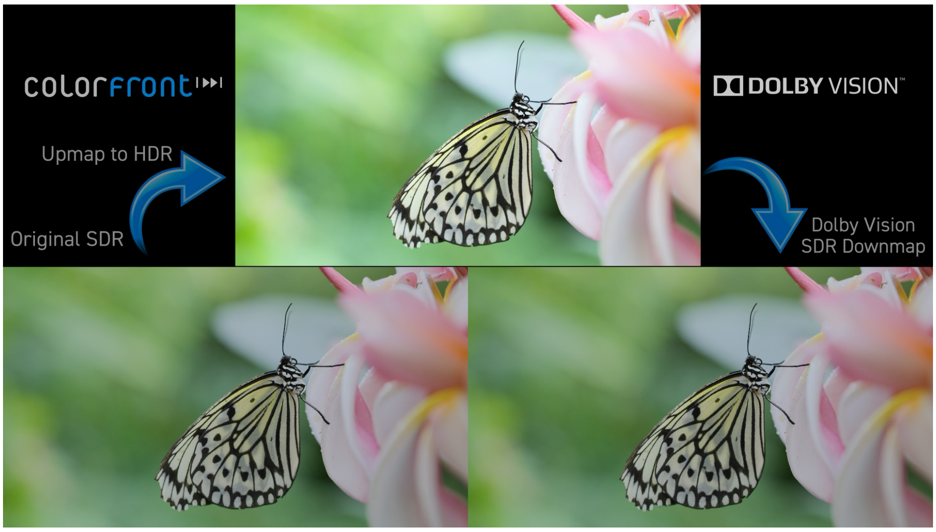
Mastering and Re-Mastering in Transkoder

Colorfront's Transkoder offers a comprehensive suite of analysis and processing tools to support single-master workflows. The HDR/SDR Remap tool, combined with a floating-point precision color space conversion tool, allows any display or scene-referred source to be re-mapped to any target display. Dedicated controls enable adjustments for output brightness, ambient surround compensation, HDR expansion, and colorfulness.

The remap process can be separated into an input transformation (reverse tonemap) and an output transform, allowing custom grading tools to be inserted in between. This flexible pipeline is ideal for remastering workflows, enabling colorists to use creative grading tools to fine-tune shots where automatic mapping may not achieve the desired aesthetic.

Transkoder's integrated Second-Head Analyzer can be configured to operate in any color space, allowing the mastering operator to inspect brightness and gamut levels at both the input and output stages. With the continued advancement of immersive and high dynamic range cinema display technology, the ability to efficiently master for each specific display while preserving the artistic vision is essential.

Dolby Vision™ Re-Mastering in Transkoder

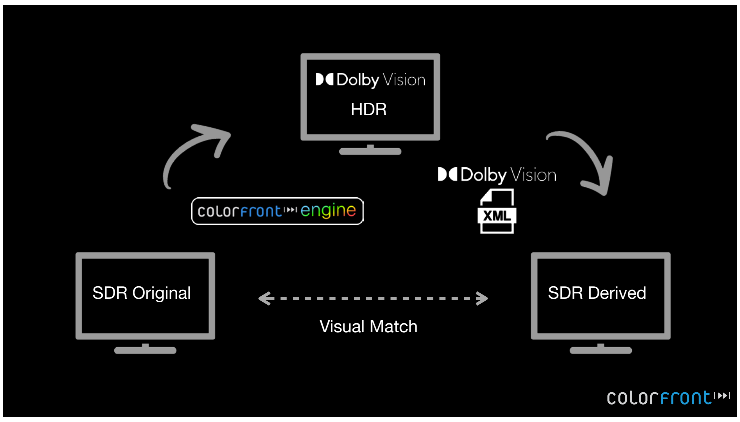


SDR to Dolby Vision™

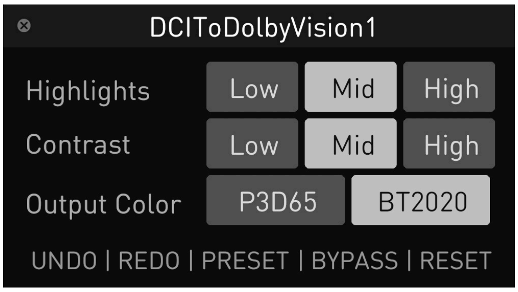
Dolby Vision offers a premium format that seamlessly bridges HDR and SDR consumer display technologies. While Colorfront fully supports traditional Dolby Vision mastering tools, we have also developed advanced tools for converting final graded SDR content to Dolby Vision.

The SDR-to-DolbyVision tool utilizes the Colorfront Engine to convert SDR content to Dolby Vision HDR, generating unique Dolby Vision metadata to ensure the Dolby-derived SDR output visually matches the original SDR content. This innovative round-tripping method enables a unified, streamlined, single-source workflow for mastering and distribution.

The SDR to Dolby Vision feature is also available in the AJA ColorBox. By previewing the SDR to Dolby Vision conversion within ColorBox, whether on set, in editorial, or in a color suite, you can be confident that your final Dolby Vision deliverables in Colorfront Transkoder will accurately reflect the look established during production and post.



DCI to Dolby Vision™

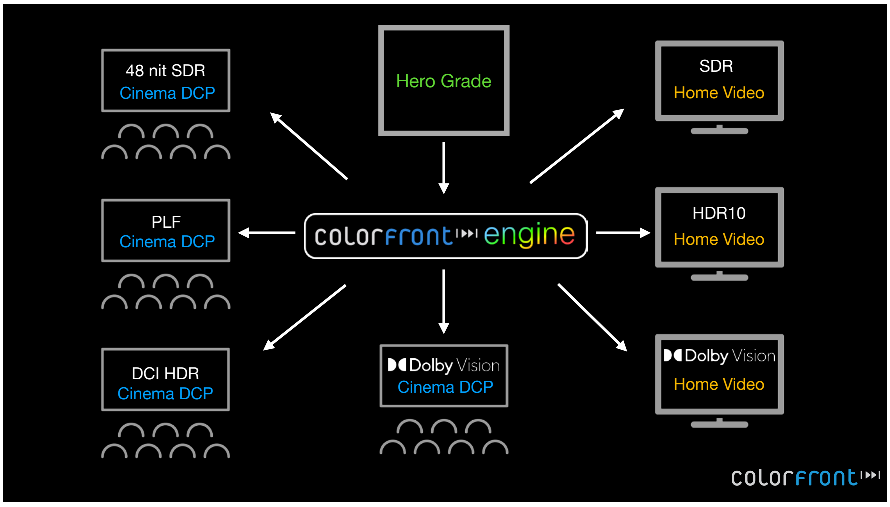


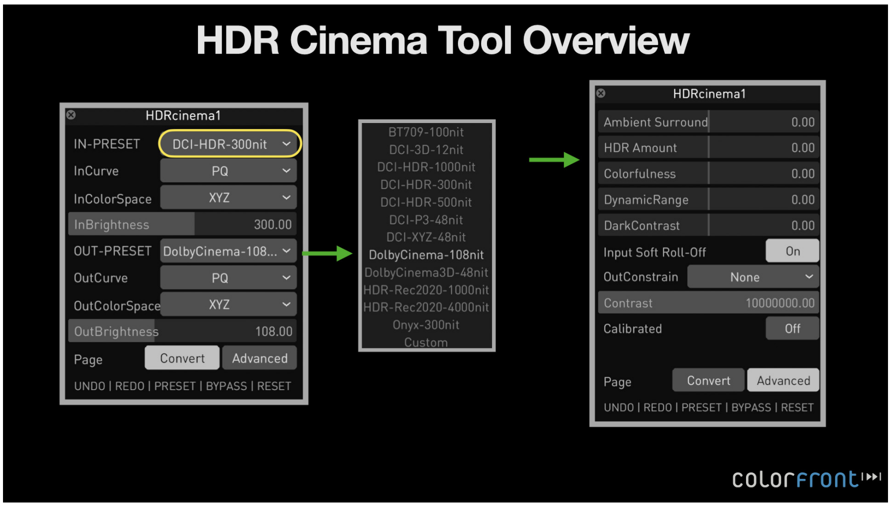
Building on the capabilities of the SDR-to-DolbyVision node, the DCI-to-DolbyVision tool in Transkoder enables the transformation of XYZ cinema masters, intended for 48-nit theatrical presentation into Dolby Vision HDR for home video. This tool preserves the original creative intent while generating a Dolby Vision master complete with corresponding metadata.

Cinema Mastering

HDR Cinema

With the growing diversity of HDR cinema technologies, including projectors and emissive displays, it is essential to have tools that can efficiently create additional deliverables without extending the color grading process significantly. Colorfront's new HDR Cinema tool is specifically designed to meet this need.





HDR Rolloff

Transkoder's HDR Rolloff tool allows you to easily manage highlight rolloff in HDR content, with controls for adjusting peak luminance and the softness of the rolloff curve. Performed within the perceptual color engine, this process carefully preserves the original creative intent. This feature is especially valuable for producing highlight-managed deliverables suited to emerging HDR exhibition technologies.

Appendix E:
Colorfront Engine SDK Technical Overview

The Colorfront Engine SDK provides a lightweight, high-performance C++ implementation designed for seamless integration of Colorfront's perceptual color processing technology across multiple platforms and applications.

Core Technical Specifications

Platform Support

- **Desktop:** Windows (x64), macOS (Intel/Apple Silicon), Linux (x64)
- **Mobile:** iOS (ARM64)
- **Processing Options:** CPU-based (SIMD-optimized) and GPU-accelerated (CUDA, Metal, OpenCL)

Input/Output Capabilities

- **Color Spaces:** BT709, P3-DCI, P3-D60, P3-D65, XYZ, XYZ DCI, XYZ D65, BT.2020, AP0, AP1, AP1-D65, ARRIWideGamut, ARRIWideGamut4, CanonCinemaGamut, CanonCinemaGamut-D65, CFColor, REDWideGamutRGB, S-Gamut3, S-Gamut3.Cine, V-Gamut, V-Gamut-D65, etc.

  Transfer Functions: PQ, HLG (BT.2100), Gamma 2.2, Gamma 2.4, Gamma 2.6, BT1886, ACEScct, AppleLog, CanonLog, CanonLog2, CanonLog3, CFLog, LogC, LogC4, RedLog3G10, S-log3, V-Log, Linear
- **Bit Depth Support:** 8-bit, 10-bit, 12-bit, 16-bit float, 32-bit float
- **Pixel Formats:** RGB444, YUV422, YUV420
- **HDR Standards:** HDR10, HLG, Dolby Vision related transforms
- **Data and Legal Range** support, over range headroom
- **Reverse Tone** Mapping Functions

Key Features

Color Processing Controls

- **Color Space Management**
  - Input/Output color space configuration
  - Transfer function selection
  - Brightness level adjustment (in nits)

- **Perceptual Processing**
  - Ambient surround compensation
  - HDR impact control
  - Perceptual colorfulness adjustment

- **Camera Controls**
  - Exposure
  - Color temperature
  - Tint
  - Saturation

- **Creative Grade Controls**
  - ASC CDL parameters
  - Slope/Offset/Power adjustments
  - Saturation
  - Printer Light adjustments

- **Look Modification Library**
  - Film and cinematic style looks
  - Broadcast style looks
  - Look blending functionality

Performance Optimization

Processing Efficiency

- Thread-safe design for parallel processing
- GPU acceleration with automatic CPU fallback
- Batch processing capabilities for automated workflows
- Efficient resource sharing between CPU and GPU

Memory Management

- Buffer preallocation for repeated operations
- GPU pinned memory support
- Optimal alignment for maximum performance

Quality Control Features

Analysis Tools (optional tools beyond the CFE)

Workflow Integration

- Direct SDK implementation
- GPU processing pipeline
- Integration with Dolby Vision processing and metadata generation
- Comprehensive error handling

Implementation Support

- Complete API documentation
- Integration examples and sample code
- Performance optimization guides
- Regular updates for new features and formats
- Technical support and consultation services

The Colorfront Engine SDK combines professional-grade color processing with efficient implementation options, making it suitable for a wide range of applications from broadcast equipment to post-production software.

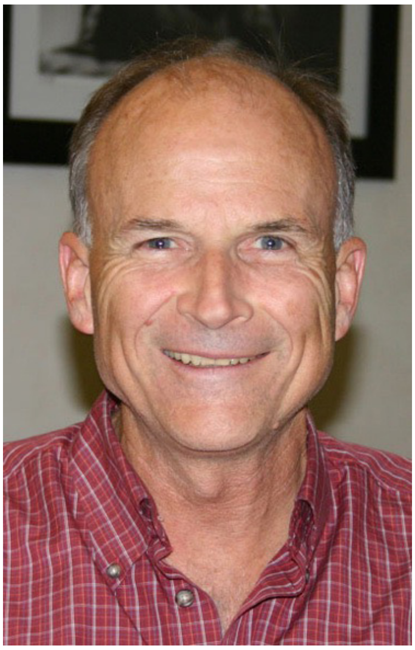
Please contact Colorfront to request the Colorfront Engine SDK Technical Implementation Guide.

About Colorfront

Headquartered in Budapest, Hungary, with an office in Los Angeles and a network of sales partners worldwide, Colorfront is known for its popular, award-winning on-set dailies and transcoding systems. These systems are widely used by companies of all sizes to process and deliver media for Hollywood blockbusters, high-end episodic TV, and OTT streaming.

Founded in 2000 by Mark and Aron Jaszberenyi, pioneers of non-linear DI color grading, Colorfront combines deep expertise in color science with advanced software development. The company's R&D team received an Academy Award in 2010 for Lustre, Autodesk's DI grading system, and a Primetime Engineering Emmy in 2012 for Colorfront On-Set Dailies.

Today, Colorfront is celebrated for the innovation, excellence, and performance of its camera-to-post products, including On-Set Dailies, Express Dailies, and Transkoder. Leveraging its technology, the company has expanded into Colorfront Cloud Services and operates a state-of-the-art DI and post-production facility in Budapest.



Bill Feightner, Colorfront's CTO, is the visionary behind the Colorfront Engine and continues to drive groundbreaking features tailored to the industry's evolving workflows.

Throughout his career, Feightner has held key technical leadership roles at Compact Video, Laser Edit, Composite Image Systems, and EFILM, where he served as CTO and Executive VP of Technology. At EFILM, he spearheaded innovations in digital laboratory calibration, image processing and management software, and multi-site, collaborative workflow solutions.

Feightner's contributions have earned him multiple prestigious awards. In 2007, he received an Academy Award for Technical Achievement for developing a Digital Color Separation process for film archiving. His accolades also include an Emmy for special effects on Moonlighting and a Monitor Award for The Magical World of Disney. In 2013, SMPTE honored him with the Technicolor/Herbert T. Kalmus Medal for his outstanding

Glossary of Terms

ACES (Academy Color Encoding System)
A color management framework developed by the Academy of Motion Picture Arts and Sciences to maintain consistent color across various devices and workflows in filmmaking and television production.

Ambient Surround Compensation
A method to adjust image processing to account for the brightness or darkness of the viewing environment, ensuring visual consistency across different display conditions.

Bartleson-Breneman Effect
A perceptual phenomenon where the contrast of a display image appears higher when viewed in a brighter ambient surround.

Bezold-Brücke Hue Shift
A shift in perceived hue (color) as luminance levels change, particularly noticeable in monochromatic light.

Chromatic Adaptation
The process by which the human visual system adjusts to the color of the ambient light source, affecting color perception of objects under different lighting conditions.

Color Gamut
The range of colors that can be represented by a particular device or color space. Common color gamuts include Rec.709, P3, and Rec.2020.

Color Primaries
The set of primary colors (usually red, green, and blue) used by a display device to create its full range of colors.

Creative Intent
The intended look, mood, and feel that creators aim to convey in their images or films, which color processing seeks to preserve across formats and displays.

Display-Referred
An image format or color space that is tied to the specific characteristics of a display, including brightness dynamic range and color gamut.

Dynamic Range
The range between the darkest and brightest parts of an image that a display or camera can capture or show, typically measured in ‘nits’ for displays.

HDR (High Dynamic Range)
A technology that allows displays and content to show a greater range of brightness levels and colors compared to Standard Dynamic Range (SDR).

Helmholtz-Kohlrausch Effect
A phenomenon where colors appear brighter as their saturation increases, affecting the perceived brightness of an image based on its colorfulness.

HLG (Hybrid Log-Gamma)
An HDR transfer function jointly developed by the BBC and NHK for high dynamic range (HDR) displays.

Hue
The aspect of color that differentiates colors like red, blue, or green.

IDT (Input Device Transform)
A conversion process used to map camera input data into a standard color space for consistent processing, commonly used in ACES workflows.

LUT (Look-Up Table)
A color look-up table is a mechanism used to transform a range of input colors into another range of output colors

Mastering Display
A reference display used during post-production to define the hero creative intent.

Nit
A unit of measure for luminance, describing the brightness of displays. For example, standard broadcast SDR is typically 100 nits, while HDR can reach 1,000 nits or more.

ODT (Output Device Transform)
A final conversion step used in color management to process images so that they appear correctly on a specific output device.

Perceptual Color Processing
A color processing technique that aligns with human visual perception, adjusting colors and brightness to look natural and consistent across varying display types and environments.

PQ (Perceptual Quantizer)
An HDR transfer function that maps brightness levels in a way that closely matches human perception, commonly used in HDR10.

Reference Master
The "hero" image, typically created on a reference display, that represents the intended look of the content across all deliverables.

Scene-Referred
Image data that directly relates to the original scene's photometric values before it has been altered for displaying.

SDR (Standard Dynamic Range)
A traditional display standard that has a limited range of brightness and color compared to HDR.

Soft Proofing
A process to simulate the appearance of a final image on different output devices without requiring physical displays for each.

Stevens Effect
A perceptual effect where the apparent contrast of an image increases with luminance, affecting how details are perceived at different brightness levels.

Tonal Relationships
The relative brightness, contrast, and color levels between elements in an image, shaping its overall look and feel.

Transmission Color Spaces
Color spaces used for encoding and transmitting video content, such as HLG or HDR10 for HDR content.