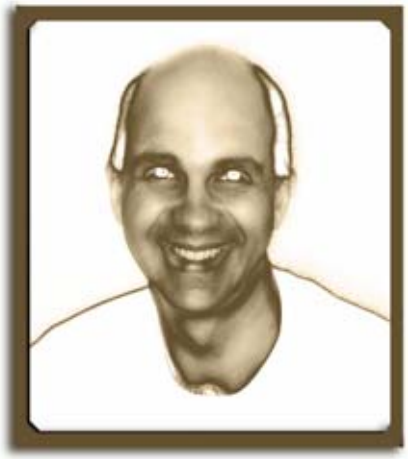
Digital Intermediates: Selecting A Video or Data Workflow



by Kevin Shaw

The term “digital intermediate” is thrown around a lot these days, and could justifiably be used for all digital video post-production. In that sense, the phrase has been with us since the introduction of the video disk recorder and D1 tape in the eighties. Today, however, “digital intermediate” most typically refers to digital post-production of theatrical release projects, including editing, compositing, special effects, and color enhancement.

Whether the entire movie or just a few scenes are finished digitally, a digital intermediate provides some obvious advantages over chemical solutions. A digital workflow offers more sophisticated tools, instant visualization, and the holy grail of the media world – the universal master. Still, the question remains: am I better off using a video or data workflow for my digital intermediate?

Image Quality

The first step in answering this question is to examine the image quality offered by each format. Kodak has measured 35mm negative film resolution to be approximately 4000 by 3000 pixels per frame, equivalent to 4k resolution. Others point out that this resolution is impaired by optical dupes and printing, so that a release print might have a much lower resolution. Common practice is to use 2k as an acceptable compromise, when recording to film from data.

HD video has a frame size of 1920 by 1080 pixels, which provides a resolution very close to 2K data while preserving the video methodology. Using HD video as a digital intermediate format is practical because existing skills and equipment are utilized, and economical because transfers are in real time and tape storage is readily available.

In fact some supporters use it not just for the intermediate process, but also the capture process. Box office successes such as *Star Wars: Attack of the Clones*, *Spy Kids 2* and *3*, and *Once Upon a Time in Mexico* are all shot with HD cameras.

While the high resolution and relative low cost of HD make video a winner in at least this chapter of the video vs. data war, pixel count is just one of the factors that determine quality. It is important also to consider where the final product will be viewed: in the living room, or on the big screen.

Image compression is far less tolerable on a big screen, so digital intermediate pioneers have historically favored uncompressed disk systems over compressed tape. These uncompressed video systems have the added benefit of supporting RGB color

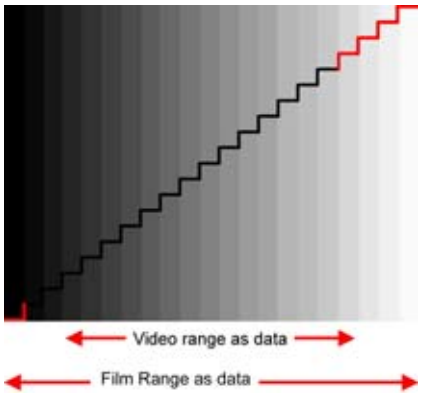
space. Complications with 3:2 pull-down can be resolved, or even avoided, by using progressive or segmented frame formats.

So it would seem that a real-time uncompressed 1080 24p disk-based video system makes an ideal digital intermediate. It's cheaper than data, provides acceptable resolution, and, as an uncompressed system, retains its quality from the source to the viewer. Why all the fuss about data then? Because film outperforms digital video in dynamic range as well as pixel resolution.

Dynamic range is the distance between the minimum recognizable density (D-Min or black) and the maximum recordable density (D-Max or white). The range of video is considerably less than that of film -- and data -- which causes two problems.

First, a limited range makes it difficult to accurately capture as many tones as there are in the original negative. That is one main reason why electronic color correction exists at all. Colorists have manipulated film to look good within the dynamic range of video since the 1950s.

The second problem is the viewing environment. Theatrical presentations are projected in a low-light environment that reproduces a dynamic range greater than video monitors. The limited dynamic range of a video source can appear flat, lacking tonal detail, when transferred to film.



Not to Scale: Film has approximately 16 times the dynamic range of video.

The number of digital steps that make up the dynamic range is called the bit depth and for practical reasons it is limited to 10 bits for both data and video. Greater bit depth would increase file size and transfer times.

10 bits is equivalent to 1024 steps in each of the red, green, and blue channels, combining to create an impressive 1 billion colors. The relationship between bit depth and dynamic range is similar to the relationship between pixels and resolution. With too few pixels an image appears aliased, while too little bit depth causes banding or, in extreme cases, posterization.

Increasing bit depth or reducing dynamic range would decrease banding, but neither of these solutions is practical for digital intermediates, since the larger file sizes and extended transfer times would go beyond what is feasible for the typical resources of a production facility.

Video and data are equal in this limitation, but there is a usable alternative. By varying the distance between the 1024 steps in a mathematical progression, there are more steps in shadows where we see and record the most detail and fewer steps in highlights where we see and use the least detail. This solution is referred to as 10-bit log, and is most commonly implemented in the Kodak Cineon format known as CPD.

The catch is that 10-bit log is considered a data format and there are no telecines that can produce 10-bit log video directly from film, so a video workflow cannot be strictly video-only when implementing 10-bit log. Some systems such as the da Vinci Server Interface can record 10-bit log data and output HD video so that only the scan stage involves non real-time data transfers, maximizing the use of video.

Those wishing to stick to a video-only workflow without crossing over into data are left with 10-bit linear dynamic range. The difference between 10-bit linear and 10 bit-log is huge. 10-bit linear transfers are usually optimized from scene to scene, but a calibrated 10-bit log setting can faithfully capture a negative without the need for grading decisions.

The 10-bit log characteristic of a data workflow is desirable for several reasons:

- The scan does not require a skilled colorist at the controls.
- The digital negative is ungraded and has the same nuances as the film negative.
- A calibrated one-light setting saves grading time.
- The one-light setting is calibrated so that a negative density is given a known digital value. The setting does not vary with content, and can be matched on different telecines.
- da Vinci Firstlight software generates the one-light setting by comparing the telecine output with a selected profile. The software compensates for changes in the telecine such as lamp age, so that black, white, and mid-tone values accurately match the digital profile.

Monitoring

The second factor in determining the appropriate digital intermediate format is monitoring. Video truly is a “what you see is what you get” environment. Professional video monitors are calibrated, but otherwise have the same characteristics as domestic televisions. Color enhancement especially depends on reliable monitoring that is representative of the final product.

Digital intermediates are recorded to inter-negative stock and then printed, often via more intermediates. In addition to changes introduced by the film stocks, there is chemical processing to consider. Finally, the final presentation is affected by the projector, which has a lower color temperature than a video monitor, and the dark theatrical environment.

Some colorists learn to allow for the transition from digital to cinema release, but it complicates client decisions and can cause costly corrections after the film is previewed. Many feature films go to digital intermediate just for color enhancement and are graded in environments that very closely mimic the final film experience. The three steps to successful monitoring are calibration, compensation, and projection.

There are two choices for digital intermediate monitoring, regardless of video or data workflows. Broadcast CRT monitors have the advantage of being stable and can be easily and cost-effectively calibrated to video standards. Projectors, however, reproduce the screen size and contrast of the cinema experience much better.

The influence of screen size on color enhancement is often underestimated. On a small screen, such as a television, the entire image fills only a part of the field of vision, so a colorist must control the center of attention using color, contrast and focus. In a cinema, the image is large enough that movement and content naturally attract attention without a heavy emphasis on color.

Video monitors have a standard calibration procedure, but data monitors and projectors must be analyzed and trimmed with a monitor probe or color meter to compensate for drift and offset. Without this calibration, look-up tables (LUTs) that emulate the film recorder, stocks, processing and projection cannot be considered reliable.

On the other hand, the whole monitor calibration process can be applied with stand-alone software or dedicated hardware. The 2K Plus color enhancement system uses a combination of both, by integrating Rising Sun Cinespace software and applying both calibration and print LUTs via hardware.

Seabiscuit**: Full digital intermediate color correction using digital projection and da Vinci 2K at Technique (LA). Image courtesy of Universal Studios **and DreamWorks

Whatever monitoring is used, a LUT is required to emulate the final grade, as it will be seen in its final cinematic form. Similarly, a colorist expects to be able to compare reference images and view waveform, vector scope, and parade displays. These are available as third-party products in the video domain, but are integrated into data devices. The caveat here is performance, since these displays are less useful if they do not keep pace with grading changes over time.

Tools

There is an increasing choice of products and toolsets for digital intermediates, either in the video or data format. The more basic ones improve on the lab process and enable better pre-visualization. At the other end of the scale are systems that offer all the features of video production. Since advanced toolsets are often the main reason for going digital, one would expect an extensive feature set. But because of the larger file sizes and the enormous amount of processing power required, many systems trade features for resolution in an attempt to keep response times acceptable. Only a few systems are designed with extensive toolsets for both video and data and are identical in either mode.

These high-end multi-format products are the ones most likely to succeed, but there are complications even here. Many are based on proprietary storage. With such large

file sizes, moving data from one system to another is time consuming. The proprietary systems try to offer a complete set of tools so that it is not necessary to move the data in and out, except at the beginning and the end of a project. This increases the need for expensive fast storage until the project is completed, and also limits choice.

Specialists prefer to choose the tool for the job, rather than be tied to a system. It is rare that a colorist, editor, and VFX artist all choose the same system; that usually only occurs when the three jobs are done by the same person. Some believe that in the future, the jack-of-all-trades will dominate the market, but history shows otherwise. Simultaneous operations and specialized skills always produce a better result, faster. Fortunately, many manufacturers recognize the need for compatibility, and are partnering with each other to solve the problem.

Conclusion

Dual-link HD video offers an economic and feature-rich digital intermediate solution. Data solutions offer higher resolutions and a variety of aspect ratios. They are better suited to multi-tasking workflows and to preserving the extended dynamic range we expect of film.

As facilities resolve their calibration and compatibility issues, and invest more and more in networks and storage, the data process will become more straightforward. Only data has any hope of producing a no-compromise universal master, and I believe it is safe to predict that data will become the preferred production format of the future. Film, HD, SD, DVD, and Web versions will be programmed as metadata and extracted from the data master.

Will data be the death of video? No. Video did not obsolete film, and data will not obsolete video. Each has its place, and the universal (data) master will ensure that they all coexist happily ever after.

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 First published in Cinema Report 2004

Authors Note: Since this article was written, Cintel DSX and Thomson Spirit 4K telecines have been developed with 10 bit log video outputs. The Spirit 4K is also capable of 16 bit linear data.

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