

da vinci	Digital Film Restoration Re-Mastering Workflow
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White Paper

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Digital Film Restoration Re-mastering Workflow

Introduction

A number of requests have been received for a document that describes the workflow for a digital film restoration and re-mastering process that da Vinci supports or recommends. In fact there are as many variations to these processes as there are facilities and projects and so it's true to say, there is not one workflow that's best for all applications.

The intention here is to present an example of a known working workflow with some background to the process so the reader can have a basic understanding of restoration, re-mastering, and how the da Vinci 2K Plus, Splice, Revival and Resolve fit into the process.

What drives this need? Why film?

You would have noticed over the years an increasing number of delivery methods for video and film. Even the traditional television service of a channel or two runs to more than a dozen in most countries and more than 100 channels in the USA and The introduction of multiplex cinemas have greatly enhanced the film studios ability to have 'same day' release of new films to maximize profits and you may have noticed that unless the film is a major blockbuster it seems to run for only a short time before the next film is released.



Gone are the video tape rental shops, DVD's are in, with high definition disks just days away we can expect a number of consumers to 'buy again' their favourite films on HD-DVD.

Have you noticed the internet.... seems millions have... that's the latest delivery mechanism. Get your hit of week online, or search for that old classic and order a snail mail delivery of the DVD. And just around the corner is Digital Cinema, IPTV, mobile media and video kiosks.

All this means the consumer's desire for content is being satisfied by a greater selection of genre and delivery methods. It's not just broadcasting or narrow-casting but micro-casting. Everyone gets what they want, wherever they are whenever they want it. It's a dream that's coming to life.

To satisfy this increasing consumer demand with new material is cost prohibitive and so restoring those well loved and commercially winning films of yesterday is becoming a business case to invest in.

Why Film? Well just for starters, most movies new and old are shot and stored on film and this alone is reason enough. da Vinci has been involved in the restoration of many of the classics, and today's modern film post production facilities use da Vinci tools for new film. In fact it's estimated that 80% of the USA's films, TV programs and commercials have been touched by da Vinci.



There is another key reason for restoration of old films. They hold a special value to society, the countries culture, their history. Great moments in each society's past have been captured on film. Speeches which changed a nation's direction. Rallies that united groups to a cause. News reports of events far and wide have been captured on film for a hundred years and often are the sole visual record of history.

The national heritage is often archived by a small number of committed film technicians. They usually have little or no budget for restoration and they see first hand how time slowly eats away the countries legacy.

Fortunately for these holders of a society's time capsule the commercial demands of film restoration for consumer use have introduced very cost effective restoration solutions. We have unfortunately seen many thousands of films lost to time, heat, humidity, water and even fire so there is no time like the present to begin restoring.

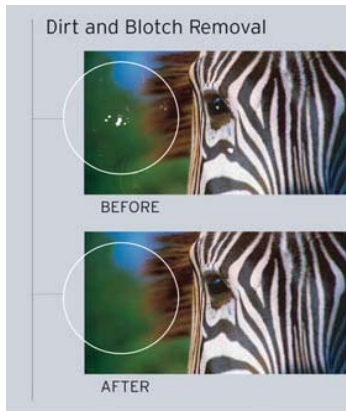
Ultimately this all means, if you have two, fifty, five hundred or ten thousand films in a library there is a market for you, and a solution to match.

Film Restoration & Re-mastering

While film is a proven storage medium there are as many reasons why films are in need of restoration and re-mastering and can not just be projected or transferred without attention. They generally fall into just a few categories, the original physical film construction, handling and mishandling, storage condition and time.

In some cases once the film is inspected, cleaned and splices replaced they can be transferred via telecine to a digital tape or disk and the audio synced to create a new master.

More often than not thought, there is more work to be done.



Here is a brief list of issues a film restoration and re-mastering facility needs to deal with.

- Film cans sealed shut
- Bad splices
- Scratches
- Dirt/Dust
- Missing scenes due to censorship
- Broken or missing sprocket holes
- Missing reels
- No sound track
- Audio not in sync
- Staining
- Fogging
- Warping
- Flicker
- Water damage
- Base separation
- Instability of physical media
- Backing Residue
- Poor previous restoration
- Dye fade
- Misprints
- Brightness changes
- Flammability
- Delivery deadlines
- Storage of old film
- Temperature and humidity
- The client's timeframe for delivery
- etc.....

Before We Start

There are a few issues to consider before this process begins not the least is what format the finished product will need to be in. While a number of films have been restored and recorded back to film and this market is increasing, many restored to Standard Definition for television broadcast or DVD release.

There is also the emerging IPTV and mobile delivery market that requires sub SD resolution but also zero noise or grain artifacts as these do not compress well.

Some restoration is with a 4:3 aspect ratio in mind, most 16:9, some with stereo audio. However all are done on a tight budget.

There are a few facilities that use da Vinci systems to complete film restoration and re-mastering completely in 2K or 4K resolution. The 1956 movie "Carousel" is a recent example. Using da Vinci's Revival, more than 10 Terabytes of disk storage and more than a years work, the 4K restoration is an example of what can be done with sufficient time and money.

Besides the capital and operational costs, the design of a film restoration and re-mastering facility also needs to take into account the number of films per month that are required to be completed and the staff levels required for operations and technical management.

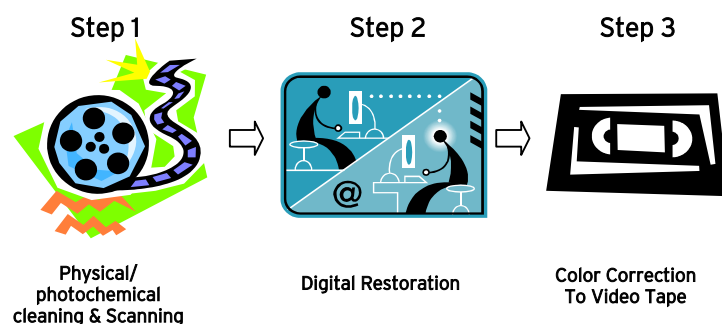
An increasing number are restored at HD resolution as a cost and time consideration in comparison to 2K, and HD works for down conversion for TV and other formats thus catering for multiple markets.

This down conversion process is often managed by third party systems, often an asset management system, that provides the appropriately formatted and resolution managed images for the various new media content delivery systems. These all come from the restored HD master.

For the benefit of descriptive simplicity this example will be for a HD resolution system with the option of SD, HD or 2K output from Resolve. The 2K files allow the final output to go back to film.

Three Steps

There are three major steps to film restoration that are to be considered. It is very likely that most steps will be required for every film reel and that each reel will also require a different processing time compared to every other reel.



As previously mentioned, In some cases once the film is inspected, cleaned and splices replaced they can be transferred via telecine and color corrected directly to a digital tape or disk, with the audio synced, to create a new master. Thus avoiding the digital restoration step or at least keeping this process limited to automatic dust busting and stabilization.

Experience suggests this does not occur as often as facilities would like.

Film Restoration - Preparation

As each film's condition, in fact each reel of each film, can be very different to another, every reel of film needs to be individually evaluated prior to deciding the restoration process that will be undertaken.

Revival from da Vinci is an electronic digital system for restoration and while it performs extremely well in dealing with a number of film problems, facilities should seriously consider the mechanical and photochemical processes prior to digital restoration.

Mechanical

All films should be inspected for physical condition and in a facility specifically designed for this task. Clean, cool and with humidity between 15% - 40% is ideal and if Nitrate films are to be checked special fire precautions should be considered.

We won't cover Nitrate films in detail but the simple rule is to handle it with extreme care. If your film is pre 1950, there is a good chance the film print was on a cellulose nitrate base. Nitrate reacts with air and as it browns it becomes sticky and produces nitric acid, which over time and especially if the film is stored in higher temperatures, eats the film, producing a dust. A volatile dust that is highly flammable and difficult to extinguish with water once alight. You may be able to identify a nitrate film without opening the film can as it can give an odour similar to chlorine.

Mechanical inspections can identify a number of physical issues, many of these can be dealt with physically prior to chemical cleaning.



- Bad splices
- Brittleness
- Shrinkage
- Stickiness
- Tearing
- Lacquering
- Scratches
- Cinch marks
- Dirt
- Dust
- Digs
- Curling
- Newton's rings
- Patches
- Emulsion separation
- Edge damage

Chemical

Once physical examination and repair is complete the film should be cleaned and if required have a chemical treatment to remove residues and lacquers. Some films should be copied by contact printing in solution to assist in the removal of surface scratches and cinch marks.

The cleaning is a minimum prior to placing the film on to the telecine or film scanner. You can assume that no matter how much you clean the telecine film path, any dirt and dust from reel A will end up on reel B and C and every film thereafter. Another option is a wet gate telecine transfer but this is generally an additional step not an alternative to good film cleaning.

Digital Restoration

The third step is digital restoration and really the subject of this document. There are a number of world class facilities using da Vinci's Revival for the actual digital restoration but this is only a part of the process.

The film needs to be transferred to a digital medium for storage repair and manipulation. This is done by using a film scanning device and a da Vinci controller and color corrector.

Scanning

The first phase is scanning the original image. Whether the film is negative, IN, IP or print a high quality telecine or film scanner is required to produce an image for digital capture.

If you have the Original Camera Negative (OCN) then the multiple reels will have different exposures to deal with and with all film the operator needs to adjust the telecine light levels, Dmin and Dmax settings to extract the full extent (contrast) of the image.

The field proven and most common process is to use a da Vinci 2K Plus color corrector to control the telecine and adjust for the films unique condition.



Many operators choose to make an HD resolution recording of this film transfer on HD tape so the film needs only this one "Best Light transfer. This minimizes potential damage to the film which can then be safely returned to the storage archive. Should more material be required from the original scan the HD tape can be used. This tape can also be used for the audio restoration work. At the same time as this HD recording is made on tape, the images are ingested into the restoration system storage with Splice.

For facilities using 2K or 4K DATA, generally the colorist will grade the material in HD and then switch the systems to DATA for image transfer. The DATA transfer process is considerably slower so in some cases the transfer is at 4 frames per second.

This means the 120min movie will take 12 hours to transfer AFTER it has been graded. For this reason, some facilities do HD grading and transfer and up-res to 2K later if a film-out is required. This can easily be done in the da Vinci Resolve including consideration for film color space.

Digital Restoration

Automatic Mode

Revival has two primary modes of operation, Automatic and Interactive. The images from the telecine transfer are generally treated with a range of automatic operations to clean up the majority of issues.

The automatic process can generally deal with 75-90 percent of issues and the balance is by the interactive mode.

The Revival technician will review the images and set a range of adjustments, based on experience, for a number of automatic processes. These can be set-up in a 'Batch Process' queue so the system can work on frames independently of constant operator supervision.

These processes include;

- Dirt/Dust Removal
- Grain Reduction
- Aperture Correction
- Noise reduction
- Speckle Removal
- Scene Splice Repair
- Vertical Scratch repair
- Image Stabilization
- DeFlicker of Image
- Re-registration

The automatic mode uses artificial intelligence to compare pixels and the power of multiple CPU's in a pool. These "PowerHouse" systems are scaled at installation time according to the frame or data size being used and the time requirements for repair.

It is common for SD material to use six to eight CPU's, for HD material, ten to sixteen CPU's and for DATA (2K or 4K) we have systems with more than sixteen CPU's dedicated to one Revival system.



Interactive Mode

After the automatic processes are complete, the technician will use the interactive mode to work on individual frames that require further work. Often this includes further dirt and speckle removal, or for some scratches, manual touch ups.

For these operations a "Region of Interest" (ROI) is generally selected to reduce processing time and the brush tools, Reveal, Luminance, Clone and Paint, come into their own. Splice damage, scene cut errors and Cadence issues can also be reviewed and repaired interactively.

There is a color module for RGB lift, gain, and gamma adjustments as well as da Vinci's Power Windows for secondary color corrections.

In Asia, a common issue with old films is emulsion staining. If stored incorrectly, the high humidity of many Asian markets allows mould to grow on films, which over time stain the image. da Vinci has a de-stain module which provides a powerful tool to repair images affected by the stains.

Editing

It may seem odd to discuss editing in a restoration workflow however here is where the re-mastering aspect comes into play. It is common for material to need reediting and certainly to re-sync the audio. (Audio is not discussed here however it is an important aspect and audio tools from CEDAR Cambridge and Protools or the like should be considered).

Editing is often required to fix previous censorship re-cuts, to make different versions for TV or DVD and also for adding subtitles. Often the HD videotape that was made during the best light and ingest process is used in an off-line suite to generate a new EDL for this re-conforming operation.

The actual reconform of the hires images is performed by the Resolve prior to the final color correction.

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Final Color Grading

After the images are restored and edited, and sound, subtitles and formatting complete the final stage is to complete a full color balance of the film.



Resolve is a resolution independent nonlinear color enhancement and re-mastering system that can read image files directly from disk, including the image SAN, and can color

correct and format for output as completed DATA files or to a SD or HD VTR for broadcast transmission.
A full length feature of 120 minutes can require between two to ten days to color correct depending on the extent of the correction required and the finished result desired.

It is vital to the visual quality of the finished product that the restoration work to old films is not compromised by rushing, or worse, missing this vital re-mastering process. The colorist who works in this suite will be part artist, part technician, part politician and will bring all the life into the old classics that they deserve.

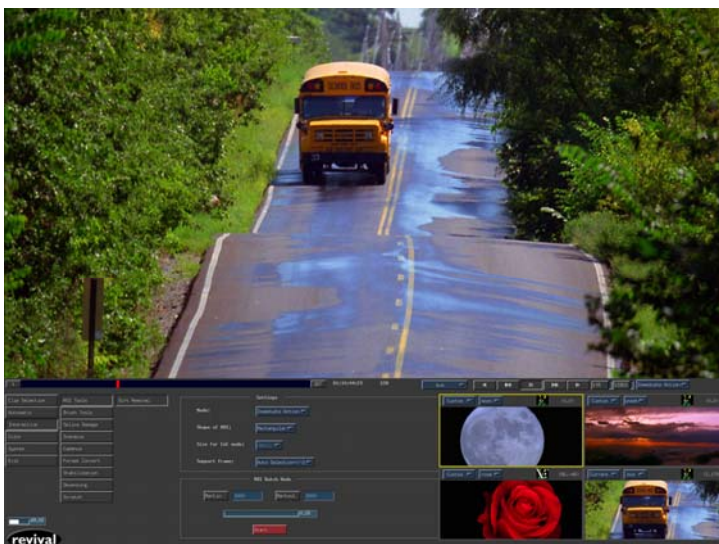
Conclusion

Film restoration facilities have started to multiple to supply the endless demand for new media, Digital Cinema, DVD and TV broadcast releases.

For government owned film archive facilities, there is now a practical and cost effective process for checking, cleaning, scanning, digitally restoring and color correcting the thousands of films that have captured the countries culture and history. Restoration of these films not only preserves them for generations to come, but also as a by product makes them accessible via the wide variety of asset management and content delivery systems which can supply these historical films by new media delivery systems to business, government and the public at large.

Finally, given the large cost of motion picture production there is an obvious business case for restoring the old classic movies, many of which were box office hits, and re-mastering these gems for yet another audience.

For film re-release, restoration is vital if the distributor is to get audience acceptance.



About da Vinci Systems®, LLC

da Vinci Systems, a JDSU company, is the leading provider of color enhancement and image restoration products used in post-production facilities worldwide. Incorporating the company's Emmy® Award-winning technology, da Vinci's products support SDTV, HDTV, data, and digital film. Since the introduction of the company's first color corrector in 1984, da Vinci has been a front-runner in the field of image enhancement, shaping color enhancement into the vital role it holds in post production today. The company is headquartered in Coral Springs, Fla., with offices in Los Angeles, New York, London, France, Germany, and Singapore.

Visit da Vinci at www.davsys.com.

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