DT Digitization Guide

Digitization Workflows: Transmissive

CulturalHeritage

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Ansel Adams by Edward Weston
From the Center for Creative Photography
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Introduction

1.1 The Goals of this Document?

This document discusses the theory and practice of the preservation-grade digitization of transmissive materials. While the discussion of theory is informative regardless of the hardware and software used, the discussion of practice is in the context of solutions provided by the Digital Transitions Division of Cultural Heritage.

The end-product of preservation-grade digitization is a Preservation Digital Object (PDO) that can serve as a surrogate to the original object, replacing most needs for physical access to the physical original, aiding its preservation, broadening access to its content.

Many transmissive material collections are in a precarious physical state. That places great urgency on their digitization. But while the technology available to digitize transmissive materials has radically improved in the last decade, most film-scanning references were written well before the modern era of instant film capture (a.k.a. camera-based digitization). In this void we saw a need for a document that covered both the theory and practice of transmissive digitization written with modern-technology. Digital Transitions is a member of the ISO Technical Committee 42. There we will work with other stakeholders across the globe toward the goal of an international standard for the digitization of transmissive materials. However, such ISO efforts can take years and produce documents that must be brand/equipment agnostic, which limits their practical in-the-trenches utility. Therefore, we've undertaken to create this document, in hopes that it can immediately serve as a useful reference for the community.

While we are a commercial entity, our first and primary mission is to further the cause of Cultural Heritage Digitization. We hope you find that this document helps you fulfill that mission for your institution's transmissive material collections.

1.2 Tools Used in this Document

Capture Device:	DT RCam, Phase One iXG, or Phase One XF
Station:	DT Atom, DT Versa, DT Element, or DT XY Film Scanner
Transillumination:	DT Photon Cultural Heritage LED
Software:	Phase One Capture One CH
Targets:	ISA Standard Film Targets
Validation:	ISA Golden Thread
Even Fielding:	White matte Plexiglas, modestly larger than the largest film format to be digitized
Raw File Sample Set:	DT CH Transmissive Raw File Sample Set, with contributions from many CH institutions Available for download at dtdch.com

1.3 Feedback or Questions?

Please do not hesitate to contact us (212.529.6825, info@dtdch.com) with questions, feedback, or to arrange an in-person or remote training on the topics covered in this document. We hope the document fosters vibrant discussion; the more feedback we receive the better we can make this document in the future.

2

Needs

2.1 Compared to Reflective

To explore the questions raised by transmissive digitization we begin by discussing the relatively straight forward matter of reflective digitization. The digitization of film poses philosophical and aesthetic questions that are largely absent in the digitization of most reflective paper materials.

For the purpose of this document we use the goal of digitization defined by the Digitization Program Planning Guide by Digital Transitions Division of Cultural Heritage:

> *The goal of digitization is the creation of a Preservation Digital Object (PDO) which can act as a surrogate for most in-person use of the original object.*

Digitization which meets this standard serves the dual goals of improving both access and preservation. Access to the material is improved by providing remote viewing. Preservation is advanced, both in that less frequent physical access exerts a lower wear-and-tear toll on the original object, and in that the PDO is a failsafe in the case the physical original is lost to time or catastrophe. Finally, preservation is also advanced in that a PDO documents the state of the object at a given moment in time; in the case that the item shows deterioration over time or receives conservation treatments that PDO is the only record of the state of the object at that moment.

For reflective objects such as a handwritten note on paper the operative phrase "as a surrogate for most in-person use" has a reasonably obvious definition, namely that of viewing of the material in a reading room on a table, book support, or held in the hand. Therefore the goal for the reflective digitization of a handwritten note is that someone should be equally advantaged looking at the PDO on a screen as looking at the physical original.

There are some worthwhile exceptions to this simplified explanation, but they are minor in impact. There are technical nuances between emitted light (e.g. from a computer screen) and reflective light. There is reasonable debate about how bright reading room lights are and therefore how bright the surrogate digital screen should be. Moreover this simplified explanation pretends that paper and similar materials are two dimensional, which ignores the potential benefit of techniques that enhance or unveil the surface texture of the substrate. There are also uses that fall outside "most in-person use." For example, detailed chemical analysis or carbon dating cannot be done using a PDO, though multispectral imaging can produce a PDO that provides some insight into what pigments, dyes, or materials are present in the object.

Still, generally speaking, preservation-grade digitization of reflective materials simply needs to produce a PDO that looks like the object sitting in the reading room does. The particulars of how to precisely and consistently achieve that goal can (and do) take up entire volumes. But the goal itself is obvious and simple.

The same cannot be said of digitizing transmissive collections. If the goal of digitization is the "creation of a Preservation Digital Object (PDO) which can act as a surrogate for most in-person use of the original object" we must define "most in-person use" in the context of transmissive originals. In other words we need to understand the needs.

2.2 **Stakeholder Needs**

Depending on the nature of the material and the nature of the stakeholder there are three broad categories of needs that one might have from the Preservation Digital Object of a transmissive original.

Object Reproduction
Sometimes the stakeholder has needs that require viewing the original material as an object unto itself. For example, a researcher may want to examine the notch pattern on a 4x5 negative to determine what emulsion it is. This has nothing, directly, to do with the content of the image the negative contains, but does inform the researcher's interpretation of that content. As another example, a conservator may want to judge the condition of a strip of black and white 35mm strip film. To have an accurate understanding of the state of that film's physical condition requires a color image of the object even though the content of the image is monochromatic. The color image will allow the conservator to see if there are stains of residual processing chemicals on the film (which might warrant the film being washed) as these stains often show up as brown.

Content Reproduction
Sometimes the stakeholder has needs that require viewing the content of the image the film contains, devoid of and separate from the physical object (the film) that contains that content. For example, if a member of the general public conducts a search for "photos of the Yalta Conference" they are unlikely to benefit from seeing the sprocket holes that surround a relevant photographic image. In fact, seeing these sprocket holes may confuse the viewer, causing confusion or misunderstanding. As another example, a photographic negative contains a tonally-inverted ("negative") image. When viewed as a Object Reproduction the image remains tonally-inverted which makes it very difficult to understand the content of that image. A Content Reproduction of a photographic negative presents the image as a positive, greatly improving its legibility. Take, as a final example, a 35mm slide that contains a very dark/dense image, which obfuscates a proper understanding of the subject matter in the image. An Object Reproduction must faithfully reproduce the object as-is, dark image and all, whereas a Content Reproduction would adjust the image based on the content of the image.

Speculative Artist's Intention
The third category of stakeholder needs is the most challenging; it is the need to see the image as the artist would have intended. This is only relevant when the object in question was created by an artist with the intention of sharing an image with others. As discussed in "The Artist's Intention" section, the film itself is only one component of how the image was intended to be presented to viewers. A curator hoping to exhibit a collection of Ansel Adam's work may want to exhibit Content Reproductions of his work based on the film itself, but may want instead, or in addition, to present the final images as closely to how Ansel Adams would have presented them. If the relevant original photographic prints (made by Ansel Adams or commissioned by him contemporaneously) exist and are available for exhibition then they are the more direct way to accomplish that goal. However, if one or more of the images only exist on film then it may be beneficial to create a Speculative Artist's Intention asset.

This is an inherently subjective process and the precision of reproduction depends heavily on the amount of useful reference material available. Sometimes a great deal is known about the period, artist, general body of work, or specific work. For example, one of the artist's original prints may be available, or notes may accompany the transmissive object that indicate how the translation of that transmissive object into image was to be handled (e.g. an artist's darkroom processing notes written for a professional darkroom printer). Or more general information may be drawn on such as research that indicates the photographer almost always printed their work on a warm-tone paper, or almost always added contrast during the print process.

Summary Table of Stakeholder Needs

	Object Reproduction	**Content Reproduction**	**Speculative Artist's Intention**
Main Audience	Conservators Researchers Curators Art Authenticator Insurance	Researchers General public	Researchers General public Curators
Unique Information	Object physical condition Object type Artist's capture method	Easily readable Content discovery	Shows the image the way the artist intended it to be viewed.

2.3 Historical In-Person Uses

With complex and varying needs from different stakeholders, how did film collections historically facilitate those needs via in-person use? Put differently, when a user came to a film collection, what did they typically do with the film?

How do these uses inform the goals and methods of the modern digitization of transmissive collections? They reassure us that there has never been a single use-case for transmissive items. One reason modern film digitization is so involved is because there has always been a wide range of uses of film originals.

Lightbox viewing

One "in-person use" was the placement of the transmissive object on a light table or other transmissive light source to view the image with the naked eye or through a magnifying loupe. This was especially common with slide film or other positive transmissive media where the image is tone-normal (rather than tonally inverted, i.e. negatives).

However, it was also used when viewing negatives, especially when the viewer was seeking out technically-oriented information such as how bright or dark ("thin" or "dense") the in-camera exposure was. Notably, the brightness and color temperature of such light boxes varied throughout history and even in a given time period could vary significantly from one make/model to the next. Because the viewer was looking directly at the media itself their eye could adapt to the overall exposure of a given frame, making the experience of viewing an especially bright (thin) or dark (dense) frame less visually stressful and problematic than in other "in-person use."

Projector

Another "in-person use" was the use of a film projector to project the image held by the film onto a viewing surface such as a white wall or a dedicated projector screen. This was often done in the context of a presentation or other group viewing setting. The brightness and color temperature of the image from a projector generated image depended on the make/model of the projector, the distance between the projector and the surface, and the nature of surface on which it was projected.

Contact Print or Contact Sheet

A darkroom contact print or contact sheet were commonly requested from some transmissive archives, especially for large-format negatives and glass-plate negatives. When creating a contact print the negative was placed directly in contact with photographic paper and exposed to light, resulting in a reproduction of the same size as the negative. Dodging and burning was possible by means of waving a hand or tool between the light source and the negative, or by using chemistry to effect tonality.

Enlarger Print

A darkroom print made at an enlarger was a common requested use for some film archives. This was available as an option for negative materials since the early days of film photography. The advent of Cibachrome also allowed this option for positive slide film without requiring a cumbersome interneg to be generated. With an enlarger print the film was placed in a carrier in a photographic enlarger which used a lens and light source to project the image onto photographic paper. This allowed reproductions larger or smaller than the size of the film. Dodging and burning was possible by means of waving a had or tool between the light source and the negative. Notably, most of the processes used to print slide positives increased contrast and/or saturation of the image.

Film Duplication (a.k.a. "Slide Dupe")

Using a machine or manual process the image from a piece of film could be duplicated onto another piece of film. While there was some inherent loss in image quality through this process, high-quality film duplication was possible.

Microfilm transfer

When the stakeholder did not require a reproduction with accurate color, tone, or detail, a microfilm transfer allowed large quantities of film content to be economically carried or shipped. A microfilm duplication could not hold much detail compared to a larger format original (e.g. a 35mm slide contains more detail than will fit on microfilm) and the transfer process was often not well controlled, leading to additional loss of image quality. The resulting microfilm was then most commonly viewed by means of a Microfilm Reader, an optical device that optically magnified the content of the microfilm onto a screen or into an eyepiece.

Condition Check

Film is widely misunderstood to be inherently archival in nature. In fact all films can and do change over time, in both subtle and catastrophic ways. Conservators would occasionally survey a transmissive collection to evaluate their current condition and asses the collection's ongoing stability or deterioration. This included visual, mechanical, and olfactory inspection (the latter useful for detecting Vinegar Syndrome).

Catalog Check

Institutions periodically audit their collections to make sure that their collection is correctly described by their Collections Management System or other database or catalog. Transmissive collections would be audited for completeness and accuracy. Such audits are always time consuming and tedious, but transmissive collections were especially tedious to audit due to the difficulty of viewing transmissive material as quickly and easily as most reflective material.

3

Challenges

3.1 The Film Ecosystem

As an artistic medium a piece of physical film was rarely the end product; usually film was one component in a ecosystem of tools and techniques that were used to create and present a final image. The object of film cannot be fully understood without considering the rest of that ecosystem.

Ansel Adams, the Zone System, and the Utilitarian View of the Film Image

Ansel Adams' (American, b. 1902) images of the American West are iconic. But as significant as his photography was, his contribution to the theory and practice of film photography may have been even more influential.

Adams considered a photographic print to be the goal, with physical film only an intermediate step. Along with Fred Archer he crafted the Zone System, a technical framework to producing a photographic print with the exact range of tones, contrast, and subject rendering they desire. In the Zone System the final photographic print is the artistic object of merit and the content recorded on the photographic film is a carefully controlled means to that end. In fact, the Zone System often requires the photographer to purposefully skew the exposure on the film in a way would normally be considered a "thin" or "dense" incorrectly (or at least "abnormally") exposed negative.

When viewing a piece of film produced by a photographer who adhered to the Zone System it is wholly inadequate to consider the film itself as the complete and final indication of the artist's intention. Ansel himself said that "The negative is the equivalent of the composer's score, and the print the performance." That analogy is especially illuminative in terms of digitization theory. It highlights that the artwork itself is not fully preserved by a neutral digitization of the film (the "score"); something analogous to the print must also be produced. It simultaneously explains why we cannot dismiss the value of having a neutral and faithful reproduction of the composer's score. Both the score and the performance hold value; one speaks to the intention and the other speaks to the methods used to achieve it.

The Rest of the "Film System"

The "Film Ecosystem" included many technical and creative use of a variety of tools and techniques. A partial list includes:

In-Camera Choices	Film Choices	Enlargement Choices	Print Choices	Presentation
Film Emulsion	Push or pull processing	Paper Type	On-Print Retouching	Frame
Lens Filters	Processing Chemistry	Paper Size	Chemical Toning (e.g. sepia)	Mat
	On-film retouching	Crop	Chemical Dodge & Burn	Placement
		Optical Dodge & Burn	Printing Chemistry	Illumination
		Unsharp Mask		

We say these constitute an ecosystem in that these tools and techniques are deeply interrelated and were developed in symbiotic and concurrent ways. For example, the choice of Film Emulsion, Processing Chemistry, and Paper Type were often tied together by a brand; a photographer might have shot Kodak color-negative film stock, processed that film in Kodak chemistry, and then printed it onto Kodak paper processed in Kodak chemistry, which would result in a different image than if printed on a Fuji paper. Such an ecosystem of matched components (film+paper+chemistry) often imparted a non-neutral final rendering of the image; linear scans of that same film won't look the same, because part of that look is lost without the rest of the ecosystem.

Purposefully-Mismatched Processes

The challenge is even greater when the artist was purposefully using "mismatched" components. For example, some photographers would purposefully process color positive film ("slide film") through color negative chemistry such as C-41. This would result in imagery with a purposefully non-standard color rendering. How that resulting film would interact with various other parts of the film ecosystem was hard to predict even at the time, and even harder to reconstruct after the fact.




After-Dinner Games. 1947




Still Life with Watermelon, 1947



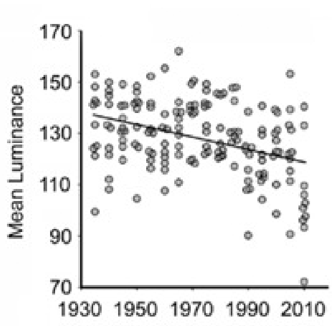

Salad Ingredients, New York, 1947

3.2 **Lost Aesthetic Context**

Time will erode the mechanical and technical knowledge of photography, but it will also slowly shift our visual understanding of it. There is an unpredictable shift in how viewers interpret visual art due to evolving aesthetic norms. For example, take the shift toward darker luminance among Hollywood films between 1935 and 2010 documented in a Cornell paper (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3485803/). Aesthetic shifts of this sort make it impossible for a modern viewer to experience the art in the context of a contemporary viewer.

This is true of viewing nearly any type of art and is instantly recognizable, for example, in cinema. The experience of watching Star Wars in a theater in 1977 is not something that can be recaptured by a modern viewer. Time Magazine's original review was impressed by "some of the most ingenious special effects ever contrived for film" but to a modern viewer these same effects are distractingly "dated" at times. The acting in the movie Paisan (1946) may have struck contemporary audiences as naturalistic, but to a modern viewer the same acting feels stilted and self-conscious.

However, photographic material can be mistaken for an accurate capture of reality, rather than an inherently creative and editorial creation of a new reality, so it might otherwise be overlooked that shifting aesthetic context alters our visual understanding of film images in the same way it alters our perception of other art.



For example, Irving Penn's 1947 color still-life series has a distinctly muted color palette bordering on pastel. It's impossible to say how much this color palette was influenced by the practical question of which film and print processes were available to him, and how much was influenced by Penn's aesthetic choices. It's not even possible to separate those two from each other. While an artist chooses their tools deliberately, they must select from the tools that are available. As an obvious example, a photographer living in 1830 had to execute their vision within a monochromatic palette, as color photography was yet to be invented.

A viewer in 2018 will likely perceive this work as muted in tone and color, because they, the 2018 viewer, are surrounded by images with significantly higher contrast and saturation. Unlike the 2018 viewer, a viewer in 1947 would have been most accustomed to color photography that was broadly similar in contrast and saturation to this series. This differing context may lead the 2018 viewer to imbue meaning to the selection of this color palette that the 1947 viewer would not.

To illustrate this see the images on the opposing page. The three images are all part of Irving Penn's still life series completed in New York. In the top row the color/tone is a faithful capture of Penn's original prints digitized by the Irving Penn Foundation. In the middle row the contrast and saturation have been increased to simulate an out-of-camera image from an iPhone. In the third row the Instagram filter "Clarendon" has been applied. As a thought experiment, imagine that you lived in a world where every color photograph you saw had the tones and color exhibited in the first row. Living in that world the other two rows might seem aggressively, surrealistically contrasty and colorful. Of course, for most readers the opposite will be true; immersed in a world full of high-contrast high-saturation images the first row seems somewhat drab and lackluster.

In the unknown future it may be that two-dimensional imagery is usurped by omni-present augmented-reality three-dimensional images. In a world where the prevailing use of imagery is three-dimensional the two-dimensional context of today's photographic work may itself become obscured to the viewer. Black and white family portraits strike many viewers of today (especially younger viewers) as immediately "historical" or "antiquated"; a similar effect may cause family portraits captured in "just" two dimensions to be immediately perceived as "old" and "distant".

3.3 Lost Technical Context

Niels Bohr, the Danish physicist, once wrote “Prediction is very difficult, especially about the future” and this adage is useful when discussing digitization of transmissive collections. It is very hard to know whether a future viewer will be familiar with a particular photographic process. This is obvious for niche knowledge such as what should be expected when cross processing E-6 color slide film in C-41 chemistry. But this is also true for more foundational/basic information such as what sprocket holes are, or how to tell the difference between a scan of one frame from a roll versus a scan of a stand-alone large format frame.

Consider that film sales peaked in 1999 which means there are college students in 2018 who were born into a world that already considered film photography to be “before my time.” Based on US Census projections (https://www.census.gov/newsroom/cspan/pop_proj/20121214_cspan_popproj.pdf) by the year 2060 only 18% of the country will have been born before film was on it's way out of popular use, and many of them will be retired. Cultural Heritage Preservation is meant for timescales of centuries, so the year 2060 is short-term planning.

Film photography, as a broadly-popular widely-practiced and commonly-experienced media, is a blip on the grand timescale of art and cultural history.

3.4 **Big Challenges Going Small**

Transmissive materials usually have very physically-small details. For example, the film emulsion on Provia slide film had a grain size of roughly 10 microns. As a point of comparison a single grain of table salt is approximately 300 microns across. The technical and physical challenges of imaging subject matter this small are significant.

Lens Design and Quality
Lens designs are typically optimized for a certain range of magnifications, so lenses that are well-suited for photographing larger material like A4 books or A2 maps may not be well-suited for digitizing smaller transmissive material. In general, when digitizing small material, a lens labeled "macro" is preferable to one that is not, but neither this label, nor a particular brand name, nor a particular price point will guarantee proper performance for the task of high-quality transmissive digitization. Only careful testing of a lens can determine its objective quality.

DT systems use four lenses: the Schneider 72mm digitar, Schneider 120mm ASPH, Schneider 120mm LS BR, and the Rodenstock 105HR. We selected these lenses after extensive testing of a variety of candidates and determined that they exceed the quality required to surpass FADGI 4-star image quality. Note that the Schneider 72mm Digitar performance is best for transmissive material 4x5 inches and larger.

Lens Performance
All lenses have imperfections that are masked by stopping the lens down to a smaller aperture. One attribute that defines a "high-quality lens" is that it does not need to be stopped down as far to achieve good results.

Using a smaller aperture opening (a higher aperture number) generally improves the performance of the lens, until diffraction becomes significant; this is discussed below.

Depth of Field
In all standard photographic systems there is a plane of perfect sharpness, in front of which and behind which there is a range called the "depth of field" that is not detectably or meaningfully different in sharpness, beyond which subject matter goes out of focus. It's important to note that subtle details may be lost well before the subject matter becomes obviously out of focus to an uncritical eye. When imaging general collections items like an A4 book the depth of field is often in the range of an inch or two. This means if the subject is not completely flat, or the plane of focus is off by a fraction of an inch, the entire subject matter can remain in crisp focus.

When imaging small transmissive material, the depth of field is often much less than 1 millimeter. That means the material must be very flat for it to all be equally in focus; any curvature, channeling, or other physical distortion risks falling outside the depth of field and losing subtle detail, or going entirely out of focus.

Using a smaller aperture opening (a higher aperture number) will increase depth of field.

Diffraction
It's widely understood among photographers that a given lens+camera combination will have a "sharpest aperture" and that if the aperture is stopped down too far (e.g. f/22) the image loses fine detail. But many photographers do not know that the aperture at which this effect occurs changes based on magnification (i.e. how close the camera is focused). When digitizing small objects that fill the frame, diffraction occurs earlier (at aperture values with lower numbers).

For example, for a Phase One iXG 100mp (which uses a full-frame 645 sensor with 4.6 micron pixels) loss of sharpness due to diffraction is acceptable up to around f/11 when digitizing large materials (e.g. an A3 poster) but when digitizing a frame of 645 film diffraction occurs earlier, such that apertures smaller in size (higher in number) than f/8 should not be used (i.e. an aperture of f/7 or f/8 is acceptable for digitizing 645 film but not f/9 or f/11).

For the technically minded, the formula underlying the above paragraph is "EffectiveAperture = MarkedAperture * (1 + Magnification)". Filling the frame of a 645-sized sensor with a piece of 645 film implies a magnification of 1.0x (since the size of the subject is the same as the sensor). Using the formula a marked aperture of f/8 at 1.0x magnification produces an effective aperture of ~f/11. Working backwards from the earlier statement that f/11 is acceptable for digitizing large materials (low magnification) with an iXG 100mp, that means f/8 will be acceptable for 1.0x magnification.

Using a smaller aperture opening (a higher aperture number) will increase diffraction which will decrease sharpness.

Planarity
In nearly all imaging of flat materials, the camera must be sufficiently parallel to the subject; that is, you must have sufficient planarity. In general collections imaging (e.g. capturing an A4 document) half a degree of misalignment may not prevent compliance with FADGI 4-star image quality. Therefore a variety of methods for of asserting camera alignment are often enough (e.g. "just eying it") and a camera mount that has a bit of rotational play (aka "wiggle") is not especially problematic.

When imaging small transmissive objects a small amount of non-planarity can cause significant loss or unevenness of sharpness. We recommend using a Parallel laser alignment tool to ensure the camera is completely perpendicular to the table. The DT AutoColumn provides four set-screws that allow the operator to perfectly level the camera to the laser alignment tool.

Using a smaller aperture opening (a higher aperture number) will decrease sensitivity to non-planarity.

Rigidity
Once planarity has been achieved, it must be rigidly held by the system and the focus must not drift. For workflow and productivity it is essential that the operator be able to trust that, once set, the focus and alignment of the system will remain correct. This requires that the camera focus mechanism, camera-arm, column, and working surface are all sufficiently rigid.

The focus mechanism should not drift or settle over time. With general-purpose cameras the focus mechanism is designed with speed of focus-changes as a high priority, often resulting in gearing that is especially "loose" such that the lens, when pointed straight down, can drift or settle. "Focus Drift" is the phenomenon of the lens continually changing (typically very slowly) after it is set, whereas "Focus Settling" refers to the focus settling into a focus position other than it was set to, but in a way that is not continuous. Tapping the lens focus mechanism with gaffers tape or painting tape, or using a large rubber band, can reduce or eliminate focus drift, but does not eliminate the possibility of Focus Settling since the focus mechanism may still settle into the elastic limit of the tape or rubber band. The DT RCam and Phase One iXG use focus mechanisms that do not drift or settle while pointing down.

The camera arm should be rigid and lockable. Some copy stands use lightweight arms that allow the camera to droop (often so much that it is easily visible) when extended or retracted, or which droop differently depending on whether their position is locked or not. This is highly detrimental to the digitization of transmissive materials. The DT AutoColumn and AutoColumn XL use a fully-sleeved design that does not droop when extended, retracted, or locked.

The column and working surface should also be rigid. Some budget copy stands have a column that is attached at one point and a base which is flat. Those design choices limit the rigidity of the system and introduce play that limits precision and repeatability. DT Stations always restrain the column at two points (one under the table surface) to increase rigidness. The base of a DT Station is a cube rather than a single surface, to maximize the rigidity and alignment of the working surface (the table top).

Using a smaller aperture opening (a higher aperture number) will decrease sensitivity to drifting alignment and focus caused by insufficient rigidity.

Vibration
If either the camera or the material vibrate excessively it can cause loss of sharpness. Even a very small amount of vibration can be problematic when digitizing transmissive material at high resolution. For example when capturing film at 5000ppi each pixel represents 1/5000th of an inch in the real world, so if a camera is vibrating such that it moves back and forth a mere 1/5000th of an inch the resulting image will be slightly blurry when viewed at 100% because details that should have been projected onto a single pixel will have oscillated between two pixels. Consider where to install the system. Ideal locations are those that have the fewest and furthest sources of external vibration such as air conditioning units, foot traffic, and vehicular traffic on nearby roads. It is equally important to take into account the material the floor is made of. When the floor supports are something other than concrete (e.g. a wood floor), using the corner of a room can be preferable to the center of a room where the floor has more give/bounce. Secondly, consider what type of table to use the system on; in general, the more sturdy the table and the stronger the support directly under the system, the better. Finally, consider using vibration-isolation material such as rubber or rubber+cork pads between the floor and table, and table and system. DT recommends PneumaticPlus-brand 4x4" pads.

The system also needs to create as little internal vibration as possible. The system should use rigid components that have minimal play. When the system has movements they should be smooth, but when the movement is meant to stop they should hold very firmly still by means of locks or detentes. DT uses detentes for the smooth lateral and fore-aft stitching movement of the DT XY Film Scanner. The DT Film Scanning Stage provides smooth but self-arresting movement of a strip or slide carrier.

If you're using a CMOS based camera with good live view, such as the iXG or DT RCam with IQ3 50mp or 100mp back, an easy check how well your system is handling vibration is to open live view and zoom to 100% on a sharply focused piece of film at the highest PPI you plan to use. With that live view running practice your normal digitization movements (e.g. move a loaded slide carrier across the stage, stopping at each slide detent). If the live view is visibly shaky then vibration is very likely to cause issues with sharpness.

Note that shutter speed is an important factor in vibration. The longer the exposure the longer it has for vibration to accumulate to a problematic level. As the aperture size decreases the exposure time lengthens, exposing the camera to vibration longer. Therefore using a smaller aperture opening (a higher aperture number) will indirectly increase sensitivity to vibration.

Aperture Selection Summary

The proper selection of aperture is critical to the digitization of cultural heritage materials. Complying with FADGI 4-star image-quality standards requires extremely good sharpness throughout the object, including in the edges and corners. Transmissive materials usually have a consistent grain throughout the image, so if the Preservation Digital Object is not homogeneously sharp, it will be clearly visible, as the grain will not be equally sharp throughout.

As you've read throughout this section many factors are effected by aperture, some of which improve with the size of the aperture opening and some of which do the opposite.

Factors that improve as aperture size decreases (i.e. as the aperture number increases):

- **Depth of field:** as the aperture size decreases the depth of field increases, which makes it easier to accommodate subjects that are not perfectly flat, larger errors in planarity, and more slop in rigidity.
- **Lens Performance:** as the aperture size decreases the performance of the lens improves.

Factors that degrade as aperture size decreases (i.e. as the aperture number increases):

- **Diffraction:** as the aperture size decreases diffraction will increasingly soften the image
- **Vibration:** as the aperture size decreases the exposure time lengthens, exposing the camera to more vibration

Accordingly, the ideal aperture is the one that best balances the above factors. It's hard to provide a single number that correctly achieves this balance for all DT systems and potential use cases and environments. Where possible, it's best to do your own testing wherein you capture representative materials and test charts at a series of candidate apertures (e.g. f/8, f/9, f/10) and evaluate them based on visual inspection on screen at 100% and numerical analysis of transmissive targets in Golden Thread.

However, to provide a starting point and a sanity check, our finding is that, for DT systems, f/8 is a good rule of thumb. Larger aperture numbers (e.g. f/12) may be warranted when you must prioritize depth of field, such as imaging channeled negatives, over a slight loss of sharpness. Smaller aperture numbers such as f/5.6 may be warranted when imaging at especially high magnification (e.g. using an RCam with a Rodenstock 105HR and two 60mm extension tubes to image 35mm slides at 8000ppi).

In summary, aperture selection is a complex task best achieved by carefully testing your specific set up, but if you're looking for the "short answer" we recommend DT customers use f/8 unless they have a clear reason not to.

3.5 Condition Issues

There are many causes and many symptoms of the physical deterioration of transmissive collections. This document is a practical guide to digitization, not a comprehensive manual for film conservation, so we will skip the very interesting chemistry and physics that explain these degradations. Instead, we will focus on the considerations important for those charged with the digitization of transmissive collections.

All types of transmissive materials are vulnerable to degradation. It's true that certain kinds of film are especially prone to certain kinds of degradation, but all major types of film are susceptible to at least one form of degradation, even when properly stored.

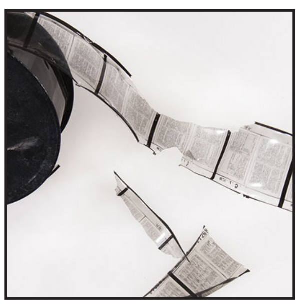
Degradation can be slowed by proper storage, but it cannot be completely stopped. The speed of degradation increases when film is stored at too high a temperature or outside the recommended relative humidity range. Freezing film radically slows degradation, but storing film frozen costs more money, reduces access, and makes digitization more difficult.

One of the most common symptoms of degradation is "vinegar syndrome" which, as its name implies, causes a distinct vinegar smell. But not all causes of deterioration carry such obvious symptoms, especially at early stages, and even obvious symptoms often occur only after the window for practical remediation has already expired. In other words symptoms like the smell of vinegar are often more of a hot-doorknob than a fire-alarm; they indicate a situation that is already very serious rather than constituting an early-warning-sign.

Below are some notable visual symptoms of various types of degradation.

Delamination or Channeling

The base of acetate films can shrink over time, causing the emulsion to bunch up in a way that creates visible channels.



Embrittlement

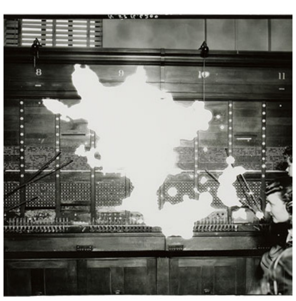
The base of acetate and nitrate films can lose elasticity over time, making the film susceptible to rips, tears, or breaks when handled.

Plasticizer Exudation

Plasticizers were chemicals added to film. As acetate film decays these plasticizers can create bubbles.

Distortion

When film shrinks it can do so, causing warping or curling. This is especially problematic when the film is too brittle to mount in a flat way for scanning.



Silver Fading

Black and white films can lose silver to corrosion, causing an overall fading that is often accompanied by discoloration.

Dye Fade

The natural breakdown of the dyes in color films. This can manifest as an overall loss of contrast or a shift or change in color content.

Mold Growth

Mold or fungus can attack the binder of a variety of film types.

All images on this page provided as a courtesy by the Image Permanence Institute at the Rochester Institute of Technology. Visit filmcare.org for more information.

3.6 Handling Issues

General Handling Thesis
The method of digitization should adhere to the same conservation handling procedures as those required for in-person viewing. The film should never be fed through an automatic feeding mechanism. The working surfaces of the digitization system which contact the film should be cleaned regularly to prevent the spread of any contamination (such as unwashed fixer or mold) from one batch of film to the next. The operator should wear conservator-approved gloves while handling the material, and should be careful of touching problematic surfaces with those gloves such as their face or food.

Carriers: Magnetic vs Glass
Most transmissive materials consist of a base layer and an emulsion layer (or layers). The emulsion bears or contains the actual image content. Moreover, the emulsion is typically less physically sturdy and easier to mar, scratch, or otherwise harm. For this reason, while the object of the entire safety must be looked after, the emulsion requires special attention.

Where possible it is best to use carriers that do not contact the emulsion at all, or only contact the emulsion outside of the primary image area. For example, the DT Magnetic Carriers hold the film at four edges and have an empty window for the image area, such that the carrier does not touch the emulsion within the image area. Such carriers must be specifically sized, so for unusual film sizes DT can produce custom-sized magnetic carriers as special-order items.

Glass carriers, such as the DT ANR Glass Carrier can be used when magnetic carriers are not well-suited. For example:

- **Physically-Distorted Materials:** e.g. film that is too curled, warbled, or channeled to fit in a magnetic carrier
- **One-Off Sized Materials:** e.g. hand-cut film
- **Thick Materials:** e.g. glass plates and lantern slides

Ideally only one layer of glass should be used, with the film laying on top. This is sometimes workable for glass plates and mounted film, but sheet film and roll film are rarely sufficiently flat for this method, and will require sandwiching between two sheets of glass. When transmissive material must be sandwiched several precautions should be taken:

- **Glass Weight:** The top layer of glass should be as light as possible. Any handles or attachments to the top glass should be of minimal weight. The DT ANR Glass Carrier is made in 5x7, 8x10, and 11x14 sizes; it's best to select the carrier that is the smallest size that accommodates the material to avoid excess weight.
- **Parallel Decent:** If the material has meaningful deformation that is keeping it from being flat, but is still stable enough to be imaged under glass, then it's best to lower the top glass down parallel to the bottom glass, rather than pivoting it downward from a joint. This ensures the glass comes into even contact with the material rather than producing a pinch point, and reduces shearing force. The DT ANR Glass Carrier provides a pseudo-hinge in the form of a rubberized rear rail; the operator can use the pseudo-hinge to hold the top glass with one hand or remove the top-glass, place the object, and then lower the glass parallel using two hands.
- **Buffer Space:** In some cases it may be prudent to place a set of "buffers" on the bottom glass so that the top glass doesn't come to a rest on the bottom glass, but comes to a rest shy of it, reducing the pressure it places on the subject. Note that this inherently increases the maximum non-flatness of the film and can introduce issues with depth of field which would require either reduced capture resolution or focus-stacking to overcome.

Cleaning and Dust
Dust is a significant challenge when digitizing film. In the era of film some scanners used a technology called ICE to identify the location of dust spots and apply a healing algorithm to fill in the missing data. These technologies meant that parts of the image were guessed at, which is against the ethos of cultural heritage digitization. It would be analogous to finding a book where letters were physically covered up by dirt, and making a scan where the dirt was removed and a best-guess was made as to what letter was covered.

Dust can either be embedded in the film, on top of the film, or on the equipment (e.g. on the glass of a glass carrier). A film conservator may be able to treat a piece of film to remove dust embedded in the emulsion, but this is rarely time or cost effective and carries risk. Dust on top of the film or on the equipment is much easier to deal with. Firstly, make every attempt reduce the amount of dust in the air by careful selection of the workspace in which film digitization is done and by the use of air filters. Secondly, remove as much dust from the film as possible by generous use of a hand-pumped air "rocket" or a house-air system with a filter and moisture trap that is approved by your conservation team. Digital removal of dust (automatic or manual) should not be performed on Object Reproduction masters or Content Reproduction derivatives, but may be performed on Speculative Artist Renderings.

Newton Rings
When two smooth surfaces come into contact they can form a colorful semi-concentric circular pattern called "Newton Rings." The visual symptom bears a passing resemblance to moire, but has a completely different cause. Newton Rings form as a result of the way light reflects and refracts between the two surfaces, and the air gaps between them. The rings are not part of the object or the content, and are highly undesirable both because they obfuscate the true content of the object and because they may be misunderstood by the viewer as part of the physical object.

The chance of Newton Rings can be eliminated or reduced by several methods:

- **Non-Contact:** Using magnetic carriers (see chapter 3.5) wholly eliminates the chance of Newton Rings.
- **Anti Newton-Ring (ANR) Glass:** As the name implies this is a type of glass where the surface has been etched to reduce its smoothness. Since Newton Rings form when two smooth surfaces touch, the rougher the surface of the ANR Glass the less likely they are to produce Newton Rings. However, the rougher the surface, the more the texture of the surface will interfere with imaging, causing the texture of the glass to appear in the image content, which is undesirable. The DT ANR Glass carrier has been tested at up to 10,000ppi with minimal loss of sharpness or introduction of texture.
- **Anti-Reflective (AR) Glass:** This glass is typically manufactured with the intention of reducing reflections. For example, they may be used in a framed art work to decrease the "mirror-like" reflection of lights or the person viewing the art. The anti reflective coating of the glass functions in a way that is similar to ANR glass, but with a typically finer (less rough) surface topography that is less prone to reducing sharpness. Some testing has shown that AR glass also reduces reflections between layers of glass when sandwiching transmissive material, increasing contrast and effective dynamic range of captures.
- **Wet Mounting:** By filling the space between the glass with a fluid the glass and film become "one" and Newton Rings are eliminated. This technique was used in the era of flat-bed scanners and drum-scanners. However, fluid contact of any kind is strongly discouraged in modern Cultural Heritage Digitization.

Temperature
Film is typically stored at room temperature or colder (up to and including a deep freeze). As film changes temperature the various layers may expand or contract at different speeds, resulting in deformation such as curling. Ideally, the digitization process should change the temperature as little as is practically possible. For example, it's typically not practical to digitize film within a deep-freeze storage unit without removing it from that storage unit. However, it is possible to limit the exposure to additional and unnecessary heat such as that of a physically hot light source.

Traditional light boxes used legacy light sources that generated a lot of heat. Placement on or near such a light will expose the material to problematic amounts of heat. While this is unlikely to damage film unless the film is already degraded (or the light is especially hot), the heat can cause temporary curling which will make it harder to hold the film flat enough for standard digitization methods.

The DT Photon series uses cool-running LEDs and a fan that remains on 100% of the time. Furthermore the DT Film Scanning Stage elevates the material being digitized several inches above the light surface, meaning film material will experience no meaningful change in temperature. Note that additional DT Photon units (with or without the DT Film Scanning Stage) can be used as stand-alone film-inspection stations so that such non-digitization functions also avoid introducing the material to unnecessary heat.

4

Recommended Strategy

As outlined so far, the digitization of transmissive materials presents many goals, some are in direct conflict with each other. For example, if a photographic negative is fading in density over time (due to physical deterioration) then presenting the image as-is will properly serve a conservator, but may mislead a researcher into falsely thinking the artist intended a dark moody image. Therefore the best strategy, presented in this chapter, is to create multiple derivatives alongside the Preservation Digital Object, and to leverage metadata and presentation cues.

4.1 Multiple Derivatives

The digitization of transmissive collections cannot be said to fully fulfill the goals of digitization (surrogacy of the original for most in-person uses) without the generation of multiple masters.

Here we use the words "multiple masters" to distinguish this set of files from traditional derivatives such as "web friendly" or "watermarked" derivatives which retain the same image content but with different technical specifications (e.g. different bit depth or resolution).

The authors propose three Master Files for each photographic original: an Object Reproduction Master File, a Content Reproduction Master File, and a Speculative Artist's Intention Master File. In most cases the Object Reproduction Master and Preservation Digital Object are synonymous.

<table>
<tr><th></th><th>Object Reproduction (Preservation Digital Object)</th><th>Content Reproduction</th><th>Speculative Artist's Intended Rendering</th></tr>
<tr><td>White Balance</td><td>Based on Light Source</td><td>Neutralize based on content</td><td rowspan="8">Follow the artist's intentions as best as they are understood.

This is best done by, or in consultation with, someone familiar with the artist and photographic processes.</td></tr>
<tr><td>Exposure</td><td>Based on Light Source</td><td>Adjusted if necessary</td></tr>
<tr><td>Crop</td><td>Four-Edge Inclusion</td><td>Crop to content</td></tr>
<tr><td>Tone Direction</td><td>If negative, leave negative
If positive, leave as positive</td><td>If negative, invert to positive
If positive, leave as positive</td></tr>
<tr><td>Tone Range</td><td>No adjustment</td><td>Adjusted if necessary</td></tr>
<tr><td>Color</td><td>No adjustment</td><td>No adjustment</td></tr>
<tr><td>Local Adjustments</td><td>None</td><td>None</td></tr>
<tr><td>B+W Images</td><td>Retain Color</td><td>Force Monochrome</td></tr>
<tr><td>Dust*</td><td>No adjustment</td><td>No adjustment</td><td rowspan="3">Remove where practical, unless intended by artist</td></tr>
<tr><td>Scratches*</td><td>No adjustment</td><td>No adjustment</td></tr>
<tr><td>Degradation*</td><td>No adjustment</td><td>No adjustment</td></tr>
</table>

*Steps can be taken to reduce the impact of these physical issues before the capture is made. "No adjustment" here refers to the fact that, once captured, no digital processing or retouching should be done to the captured file.

The Value of Doing Something over Nothing
Most guides written about film digitization do not include any recommendation similar to the Speculative Artist's intention. It's impossible to know exactly how an artist intended their image to be rendered. Parts of the Film Ecosystem are gone. Reference points such as prints and memory are faded. Our aesthetic context has shifted. Our tools are fundamentally different than the artist would have used.

Given the impossibility of perfectly recreating the artist's intended rendering some might decide that it's not worth trying. However, every factor just listed will worsen with time. Our ability to recreate the artist's intentions might be middling today, but is far better than it will be in the future. We are closer in time, technology, and aesthetic context to these artists and the film ecosystem they used then our progeny. There are individuals alive today who worked with the specific films, chemistry, paper, and processes used for much of the film in our institutions' collections. Therefore, there is great value in making our best guess now, as it is likely a better guess than future generations will be able to make.

That said, we must take caution to honestly present the results as the informed subjective inherently imperfect speculation that they are, and we must still capture and preserve a Preservation Digital Object.

4.2 Metadata

The topic of metadata is expansive and complex. Here we only discuss metadata in a narrow context: what information about a transmissive object can be recorded as metadata to mitigate some of the challenges outlined in this chapter. (E.g. loss of technical context and loss of aesthetic context).

As discussed in 3.2, a future viewer may not have even a basic understanding of photographic film. There are several obvious areas (and probably many subtle areas missed here) that can help decrease the chance of confusion.

Object Nature
It's important to record the basic type/category of object. For example, a capture of only the transmissive area of a 35mm mounted slide and a tightly-gated capture of a 35mm strip can look very similar to the end viewer. Only with a metadata notation can the viewer be assured an understanding of the true nature of the original object.

Object Condition
Film can have a variety of condition issues that can lead the viewer to misinterpret the content of the image. It's important that metadata record these conditions to help the viewer interpret the object and content correctly. For example, if 120 film rolls were not wound tight enough after capture then a light leak can lead to a bright artifact intruding into the content of several of the images of that roll. A film-savvy operator of the digitization system can easily identify such a leak because it is usually rhythmically repeated at the interval of the diameter of the rolled film. But a viewer who has lost the technical context of film may mistake those light leaks as being either an intentional artistic treatment or, worse, part of the scene itself (if the artifact fits reasonably with the content of the scene).

4.3 Presentation

The topic of how to provide access to a digital collection is, expansive. Our purpose here is only to bring to the fore the unique needs of transmissive collections.

When displaying a transmissive object to a viewer we should help them understand both the object and the content. This can be accomplished by providing immediate and intuitive access to viewing all three derivatives discussed in 4.1, providing the metadata referenced in 4.2 and providing links both to related objects and to relevant background information about the media, process, and artist in question.

Showing Object Reproduction, Content Reproduction, and Speculative Artist's Intended Rendering
The end user can benefit from seeing all three versions produced. These should be labeled and described in such a way that someone who is not familiar with film can access an explanation of the nature of the master they are viewing and linked to a more detailed explanation, such as this document.

Showing the Metadata
All the metadata described in 4.2 is largely wasted if it is not made easily accessible to the viewer.

Linking to Related Objects
Transmissive material often has built-in organization of associated images. For example an image on a roll of film is often intimately related to the images that precede and follow it on that roll, and may often be equally related to images on other rolls captured during the same shoot, day, or period. It is bad practice to present a single page from a book as a stand alone island, without an easy ability for the viewer to understand where that page fits in the context of the book it is from, and without an easy way for the viewer to navigate through the structure of that original object. In a similar vein, film images should be presented in their physical context and the viewer accorded the opportunity to easily navigate that structure.

Linking to Relevant Background Information
Keeping in mind that the future viewer may not have familiarity (discussed in 3.2 and 3.3), providing links to general information relevant to the object may help inform their understanding of the object. While this is true for nearly any museum, library, or archival collection it is especially true for transmissive materials. For example, when viewing a Cibachrome a user should be directed to information about the Cibachrome process; this process rendered an image made up of individual dots and this technical attribute of Cibachrome, if not described to the viewer, might lead a viewer to make a mistaken assumption that the original scene was made up of points. Or if the image is known to be cross

processed information should be presented to the user to help them understand what cross processing was and how it affected the content.

Note that IIIF (International Image Interoperability Framework) has taken on a myriad of image-presentation topics such as those above, along with the broader topics of providing controlled and intelligent access to your collection assets. We strongly suggest keeping up with this evolving specification.

5

Method: Object Reproduction

5.1 Select Lens & Extension Tubes

Different sizes of film will require different combinations of lens and extension tubes.
For the Phase One iXG and DT RCam: consult the charts below for the appropriate combination.
For the Phase One XF: use the Schneider 120LS Blue Ring lens with no extension tubes for all film formats.

To include all four edges of the physical film, a small margin or padding must be maintained. This chart assumes a very small amount of padding around the subject; a larger margin/padding may sometimes requires less extension.

This chart has been simplified and rounded for easier reading. For a more detailed and precise chart email info@dtdch.com and ask for the "DCH Distances and Measurements" document.

Phase One iXG 50 MP

Film Format	Lens	Tubes	Resolution
8 x 10"	72 mm	None	~800 ppi
	120 mm	None	~800 ppi
5 x 7"	72 mm	None	~1200 ppi
	120 mm	None	~1200 ppi
4 x 5"	72 mm	21 mm	~1600 ppi
	120 mm	None	~1600 ppi
6 x 7 cm	120 mm	42 mm	~2600 ppi
6 x 6 cm	120 mm	42 mm	~2600 ppi
645	120 mm	63 mm	~3500 ppi
35mm	120 mm	84 mm	~4700 ppi

Phase One iXG 100 MP

Film Format	Lens	Tubes Extension	Resolution
8 x 10"	72 mm	None	~1100 ppi
	120 mm	None	~1100 ppi
5 x 7"	72 mm	None	~1700 ppi
	120 mm	None	~1700 ppi
4 x 5"	72 mm	21 mm	~2200 ppi
	120 mm	None	~2200 ppi
6 x 7 cm	120 mm	42 mm	~3700 ppi
6 x 6 cm	120 mm	42 mm	~3700 ppi
645	120 mm	84 mm	~5400 ppi
35mm	120 mm	84 mm	~5400 ppi

Phase One iXG 150 MP

Film Format	Lens	Tubes Extension	Resolution
8 x 10"	72 mm	None	~1300 ppi
	120 mm	None	~1300 ppi
5 x 7"	72 mm	None	~2100 ppi
	120 mm	None	~2100 ppi
4 x 5"	72 mm	21 mm	~2600 ppi
	120 mm	None	~2600 ppi
6 x 7 cm	120 mm	42 mm	~4500 ppi
6 x 6 cm	120 mm	42 mm	~4500 ppi
645	120 mm	84 mm	~6000 ppi
35mm	120 mm	84 mm	~6000 ppi

Notes:
- The iXG 72mm can technically be used for film formats smaller than 4x5" but not with FADGI-4 Star performance.
- 63mm extension is achieved by stacking a 42mm and 21mm tube.
- 84mm extension is achieved by stacking a 21mm, 42mm, and 21mm tube, in that order. Capture One reports the wrong PPI with this much extension.

DT RCam 50 MP

Film Format	Lens	Extension	Resolution
8x10"	72 mm	None	~800 ppi
5 x 7"	72 mm	None	~1200 ppi
	105 mm	None	~1200 ppi
4 x 5"	72 mm	20 mm	~1600 ppi
	105 mm	None	~1600 ppi
6 x 7 cm	120 mm	20 mm	~2600 ppi
	105 mm	20 mm	~2600 ppi
6 x 6 cm	120 mm	20 mm	~2600 ppi
	105 mm	20 mm	~2600 ppi
645	120 mm	40 mm	~3500 ppi
	105 mm	40 mm	~3500 ppi
35mm	120 mm	80 mm	~5800 ppi
	105 mm	80 mm	~5800 ppi

DT RCam 100 MP

Film Format	Lens	Tubes Extension	Resolution
8 x 10"	72 mm	None	~1100 ppi
	105 mm	None	~1100 ppi
5 x 7"	72 mm	None	~1700 ppi
	105 mm	None	~1700 ppi
4 x 5"	72 mm	20 mm	~2200 ppi
	120 mm	None	~2200 ppi
	105 mm	None	~2200 ppi
6 x 7 cm	120 mm	20 mm	~3700 ppi
	105 mm	20 mm	~3700 ppi
6 x 6 cm	120 mm	20 mm	~3700 ppi
	105 mm	20 mm	~3700 ppi
645	120 mm	60 mm	~5400 ppi
	105 mm	60 mm	~5400 ppi
35mm	120 mm	120 mm	~8200 ppi
	105 mm	120 mm	~8200 ppi

DT RCam 150 MP

Film Format	Lens	Tubes Extension	Resolution
8 x 10"	72 mm	None	~1300 ppi
	105 mm	None	~1300 ppi
5 x 7"	72 mm	None	~2100 ppi
	105 mm	None	~2100 ppi
4 x 5"	72 mm	20 mm	~2600 ppi
	120 mm	None	~2600 ppi
	105 mm	None	~2600 ppi
6 x 7 cm	120 mm	20 mm	~4500 ppi
	105 mm	20 mm	~4500 ppi
6 x 6 cm	120 mm	20 mm	~4500 ppi
	105 mm	20 mm	~4500 ppi
645	120 mm	60 mm	~6000 ppi
	105 mm	60 mm	~6000 ppi
35mm	120 mm	120 mm	~9,900 ppi
	105 mm	120 mm	~9,900 ppi

Note: 20, 40, and 60mm RCam Extension Tubes can be stacked in any order to achieve the desired total.

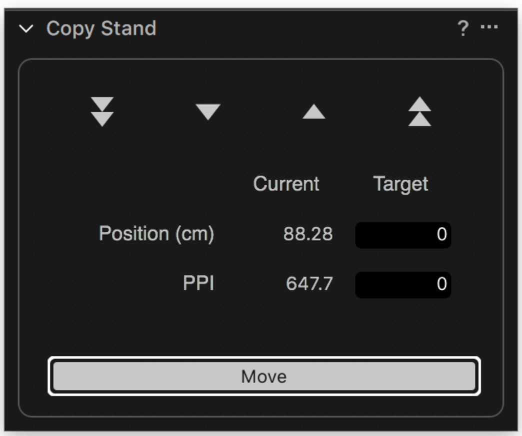
5.2 Set Camera Position & Focus

Load the film into the carrier and place the carrier in the DT Film Scanning Stage. The scan resolution (aka PPI) and scan area (aka Field Size) are determined by the camera position (aka camera-to-subject distance). In the previous step you selected the appropriate lens and extension tube. Now you must position the camera at the correct distance from the film, and focus the lens. The steps to do so depend on your equipment.

With a DT AutoColumn + Phase One iXG
Simply enter the desired Frame Size and push "Start". For more details see the document "DT AutoColumn with iXG Setup".

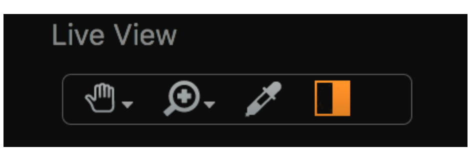
With a DT AutoColumn + Phase One XF or DT RCam
The first time you set up for a given type of film you will need to guess-and-check the appropriate camera-to-subject distance. Technically this distance can be mathematically calculated, but that's typically slower in practice. To Guess-and-Check:

1) Open Live View using the icon in the Camera tool, or by the dropdown menu [Window > Live View]



2) Using the Copy Stand Tool, move the camera up/down until the subject is in focus.

3) If the subject has too much margin: Move the camera closer. If it does not have enough margin or is partially cropped.



4) Zoom to 100% somewhere in the center. Click the Focus Meter cursor and then click in a area of the film. Ideally pick an area of the film with contrasty subject matter or film grain rather than a deep shadow or highlight. Details that are focused properly have more contrast than details that are mis-focused. The Focus Meter shows you the current level of contrast as well as the high-water-mark for contrast; at first these will be the same.

5) Slowly focus the camera to-and-then-beyond the perfect point of focus; as you move beyond the perfect point of focus the current-contrast-line will recede away from the high-water-mark. Finally, slowly return the focus until the current-contrast-line returns to the high-water-mark. This will be the point of perfect focus.

6) Repeat steps 3-5 until you've reached the exact right framing. As you get closer to the desired framing you will find that using the Column Control tool to move the camera up and down in single steps will become a more useful focusing method than using the focus of the camera.

7) Using the Column Control tool, take note of the resulting camera position (typically shown in centimeters) in order to easily return to this position in the future. Note that the PPI readout of this tool is only valid for a single combination of lens and extension; therefore, if you have the PPI calibrated for the 72mm the readout will not be accurate for the 120mm. For more details see the document “DT AutoColumn with DT Rcam or Phase One XF Setup”.

5.3 Set Mode, Profile, and Curve

Mode: Set your mode to Film Positive. This should be used even when imaging tonally-inverted materials (e.g. color negative film) because an Object Reproduction should show the object as it would appear on a lightbox.

Profile: For transmissive media digitization, choose the specialized ICC-Profile in Capture One CH for your light source. In most cases this will be the DT Photon.

Curve: Set the curve to Linear Scientific. This provides absolutely linear tonal values, without any contrast added or any compression of the tones present in the original negative. Do note that using Linear Scientific does not gracefully handle clipped highlight values. Therefore it's especially important to avoid any clipping during capture and adjustment. Since DT systems have a very large dynamic range it's possible to capture the entire tonal range of nearly any transmissive material, without clipping the highlights or shadows.

You can optionally use [... > Save As Default] to save the profile, mode, and curve as the defaults.

5.4 Set Sharpening & Noise Reduction

As a starting point, set the sharpening as follows:

Amount:	100
Radius:	1
Threshold:	0
Halo-suppression:	0

An amount of 100 provides modest visual sharpening without over sharpening the image. In the Quality Control Chapter we discuss sharpening in more detail.

A threshold of 0 means that the sharpening amount will be applied homogeneously across the entire image. Because we are effectively photographing the structure of the film grain itself, a threshold of 0 also prevents the artificial masking and sharpening of the image content recorded on the film.

Set your Luminance Noise Reduction as follows:

Luminance:	0 for CMOS backs, 50 for CCD backs
Details:	50
Color:	40 for CMOS backs, 50 for CCD backs
Single Pixel:	0

CMOS sensors (50mp, 100mp, and 150mp digital backs) inherently have a very low noise floor. Reducing the Luminance noise reduction to 0 prevents the software from artificially smoothing over the structure of the film grain.

You can optionally use [... > Save As Default] to save these settings as the defaults

5.5 Capture LCC Raw File

Even a high-quality light source like the DT Photon will have very slightly variations in brightness across the surface of the light. In addition, even high-quality lenses used in DT systems are slightly vignetted in the corners. While these variations are typically very small, they are worth correcting in the context of preservation-grade digitization.

Remove the film and the film carrier together from the positioning stage. Replace the carrier with a piece of matte, translucent Plexiglas seated in the same plane of focus as the film.

Make a capture of the Plexiglas, ensuring it is unobstructed and fills the entire field of view. Adjust the exposure and recapture as needed, so the resulting raw is around middle gray.

Rename the file so the name reflects the current capture setup (e.g. “35mm at 6000ppi”).

5.6 Analyze LCC

You can now generate an LCC profile from the image of the Plexiglas. There are two possible ways to begin:

Method One

Right-Click on the thumbnail of the gray cardboard and select Create LCC.

Tip: On a Mac without a right mouse button, use “CTRL + mouse click” for entering the context menu.

Method Two

Via the Lens tool tab select the image of the captured gray cardboard in the Browser and choose Create LCC in the LCC tool.

After pressing Create LCC (either started with the first or second method), a dialog box will open showing the following options for the LCC profile that will be calculated. DO NOT check any of the options. Press Create to start the calculating process.

After calculating you should see the selected reference image of the captured gray cardboard marked as a LCC reference file. The letters LCC will appear above the thumbnail image. In the LCC tool the boxes for Color Cast and Enable Uniform Light should be checked and available. You have now created a valid LCC Profile for this capture setup.

Note:

An LCC profile is only valid and usable for images taken with the same Digital Back or Camera under identical lighting conditions. You have to prepare a new LCC Profile to create luminance uniformity if you:

- Change the aperture
- Change the distance to the subject
- Change the angles of the light setup
- Change the lens or digital back

Tip:

You may wish to rename the capture of the gray board before you generate the LCC from it. For example, you could name it “72mm, f8, 600ppi distance”. This will be the name of the LCC that is subsequently applied to incoming captures and will be more intuitive.

5.7 Apply LCC

In the Camera tool tab there is a tool called Next Capture Adjustments. When shooting tethered with the camera attached to the computer, you can choose the settings and adjustments to be applied to the next capture. The factory default setting is useful in this example to automatically apply the LCC profile.

The first option – ICC Profile is set to Default in the factory default settings so it will choose the ICC Profile you set in the Base Characteristics tool (See also Chapter 3.2)

The All Other option is set to Copy from Last by default. This will ensure that every setting that is made with one of the Tools in Capture One is automatically applied to the next captured image. This includes the newly created LCC profile from the last image. All subsequent images will be precisely corrected, using this LCC, until you make changes to the lighting.

5.8 **Set White Balance**

When doing Object Reproduction you should white balance to the light source.

Remove the film and film holder from the positioning stage and photograph the light source directly. Adjust your exposure so that the light source renders roughly middle gray.

The White Balance picker is located in the Cursor Tools. It can also be found in the Color Tool Tab in the White Balance Tool or in the Capture Tool Tab in the Camera Tool. Using the White Balance picker, click your white balance in the center of the frame.

Do not place the film back onto the stage yet. Leave it off for step 5.8.

5.9 **Set Exposure**

For an Object Reproduction (the Preservation Digital Object) the exposure is set to accurately reflect how the object would appear in in-person use on a light table or other viewing device. In some cases this means the content itself will be impractical to view, for example a very dense glass plate negative may appear nearly black or a thin negative (one that was underexposed or under-processed at the time of creation) will appear both thin and low in contrast. However, the object reproduction should not attempt to correct for these situations because any such correction would obfuscate the true nature of the object. For example, a researcher may benefit from knowing that a series of negatives was thinner or denser as it may inform the researcher about the methods the photographer used, or the conditions in which the photographer was working. The creation of the Content Reproduction (in the next chapter) addresses adjusting exposure as needed to provide for practical viewing of the content itself.

Select the Add Color Readout cursor by clicking and holding on the white balance cursor. Using this cursor, place a color readout several places throughout the frame, including near the center. If the readout is in Red/Green/Blue then select [Lab Readout > Golden Thread > ICC] to switch to LAB readouts. Adjust shutter speed until the brightest luminance value of the LAB Color Readouts is as close to 98, without going over, as possible.

5.10 **About the Crop**

In step 5.2 we carefully established a specific frame size for the current material type. Typically no further cropping should be required for the Object Reproduction (Preservation Digital Object) since most cases transmissive materials are fairly homogeneous in size within a given type of material. For example, the variation among 4x5 sheet film negatives is typically quite small. The fact that we're using the entire frame (with only a small margin reserved to ensure all four edges are shown and to ensure it is practical to quickly place additional material within the same frame) maximizes resolution and eliminates the need to set a crop for the Object Reproduction. In chapters 6 and 7 further discussion of crop is provided in the context of Content Reproduction and Speculative Artist's Intended Rendering.

5.11 **Ready to Capture**

The system is now properly set up for scanning any transmissive material that fits within the field size established in step [5.2] and for which the current PPI is acceptable. Digitizing additional material with these settings is very fast, whereas changing to another field size or PPI requires repeating steps 5.1 to 5.11. Therefore it is desirable to collate your digitization such that like-sized materials are captured in batches. More information on this topic is in our Digitization Program Planning Guide in the chapter titled "Planning Collection Pulls."

6

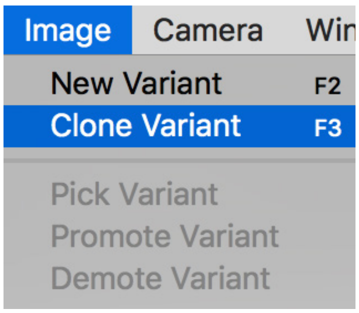
Method:
Content Reproduction

As discussed in Section 2.3.2, several derivatives be derived from transmissive media to fulfill digital surrogacy.
- **Object Reproduction:** A faithful reproduction of the entire physical object, as it would appear on a light table.
- **Content Reproduction:** A human-readable rendering of the image contained by the object.
- **Speculative Artist's Intention:** A best-guess at how the artist would have rendered their final work.

In chapter X we created a Object Reproduction Preservation-Digital Object (aka "master file"). In this chapter we look at how to create Content Reproduction derivatives using the tools in Capture One CH.

This does not require recapturing the physical original so steps 5.1 and 5.2 do not have an equivalent in this chapter. In addition, there is no change to sharpening, noise reduction (5.6) or LCC (5.7, 5.8, 5.9) so those sections are not repeated in this chapter.

6.1 Clone Variant



Select the Object Reproduction and select [Image > Clone Variant] or use the keyboard shortcut F3. This creates a virtual copy of the raw file, so does not increase disk space. Later this virtual copy (variant) can be processed (a.k.a. "Exported") to a TIFF or JPG separately from the first variant. This allows you to create an Image Reproduction derivative without having to capture the film material again.

6.2 Set Mode

For Object Reproduction (reminder)
For the Object Reproduction we used Film Positive no matter the kind of transmissive material we were digitizing.

For Content Reproduction of negative materials
Set your mode to Film Negative to invert the colors and tones of the image so that the user can view the negative as a positive. This retains the intuitive functionality of the image adjustment tools, in that moving the exposure slider to the positive direction brightens the image, while sliding it towards the negative direction darkens the image.

For Content Reproduction of positive transmissive materials
Set the mode to Film Positive. While at first glance, Film Positive will not seem all that different from Photography, this mode is aligning the color channels in a way that is more in tune with the non-linear tone/color distribution of photographic film.

6.3 Set Curve

For Object Reproduction (reminder)
For the Object Reproduction we used Linear Scientific to provide a 100% tonally faithful version of the physical material.

For Content Reproduction
Set the curve to Linear Response. This provides a very slight roll off in the highlights that maintains the color/hue of bright subject matter that clip in one channel. While this is technically (very slightly) less scientifically accurate it is more practical as it's less likely to lead to technical artifacts such as banding or abrupt tonal clipping.

6.4 White Balance

For Object Reproduction (reminder)
For the Object Reproduction we white balanced based on the light source. That ensured that any color bias in the subject itself was faithfully reproduced. For example, when digitizing black and white negative film the slight non-neutrality of the film itself is correctly captured by white balancing to the light source.

For Content Reproduction
Inside the image itself, locate a matte-finish object that is likely to have been roughly neutral in tone at the time of capture. Consider looking for asphalt, gray fabrics, paper, or other neutral materials with matte-like surfaces. Avoid shiny or reflective surfaces; for example, a gray car might, at first, seem like a good candidate for white balance, but since the paint is glossy, it is likely to be reflecting blue the sky, brown from a brick building, etc—all of which would result in an incorrect white balance for the scene.

The surface you select should be illuminated by the scene's primary light source (or "key light"). If a scene has two sources of light with different color temperatures the key light is the one that is strongest on the main subject of the image. For example, in an early morning sunrise image there are two sources of light: the sun itself that is harsh and warm and the blue dome of the sky that is diffuse and cool; if the main subject is being illuminated by the sun then the sun would typically be considered the key light.

By white balancing to neutral subject matter illuminated by the scene's key light we are (roughly) neutralizing the overall scene color. In some cases this may result in a dramatically different result than the Object Reproduction image, especially in cases such as:

- Film whose color has shifted over time due to physical deterioration
- Tungsten-balanced film shot in daylight scenes
- Daylight-balanced film shot in tungsten-scenes
- Scenes with unusual color balance like sunrise, sunset, stage lighting, or night scenes

6.5 **Set Exposure**

For Object Reproduction (reminder)
For the Object Reproduction we set the exposure based on the light source so the object appeared as it would on a light table.

For Content Reproduction
In some cases the content will require a change to exposure or contrast to serve as a practical Content Reproduction. For example, if the original physical material is a very thinly exposed negative then the inverted image may be too dark for the viewer to easily understand the content. However, unlike the Speculative Artist's Intended Rendering the Content Reproduction derivative is not intended to interpret or alter the underlying nature of the image content, only to ensure that it is visually accessible.

Using the exposure slider make the minimum change required for the viewer to visually understand the content.

6.6 **Set Crop**

For Object Reproduction (reminder)
For the Object Reproduction we did not crop the image, so that all four edges of the physical object were retained.

For Content Reproduction
For content reproduction it is appropriate to crop such that the final image does not include any borders or edges around the image content. By definition this means a very small amount of the content will be cropped.

7

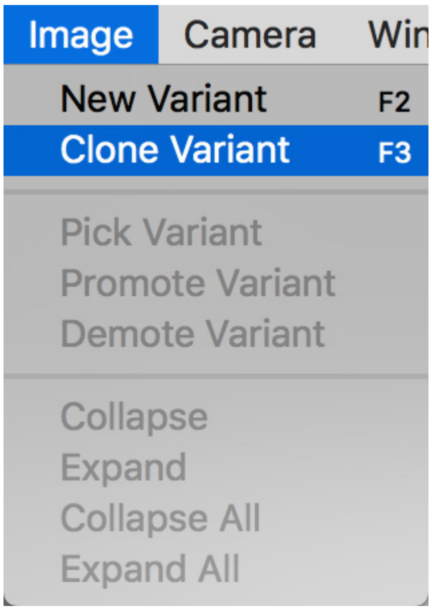
Method: Speculative Artist's Intended Rendering

As discussed in Section 2.3.2, several derivatives be derived from transmissive media to fulfill digital surrogacy.

- **Object Reproduction:** A faithful reproduction of the entire physical object, as it would appear on a light table.
- **Content Reproduction:** A human-readable rendering of the image contained by the object.
- **Speculative Artist's Intended Rendering:** A best-guess at how the artist would have rendered their final work.

In chapters X and Y we created a Object Reproduction Preservation Digital Object (aka "master file") and Content Reproduction derivative. In this chapter we look at making a Speculative Artist's Intended Rendering derivative using the tools in Capture One CH.

7.1 Clone Variant



Select the Content Reproduction variant and select [Image > Clone Variant] or use the keyboard shortcut F3. This creates a virtual copy of the raw file, so does not increase disk space. Later this virtual copy (variant) can be processed (a.k.a. "Exported") to a TIFF or JPG separately from the Content Reproduction variant. This allows you to create an Speculative Artist's Intended Rendering derivative without having to recapture the physical originals, and without having to repeat steps taken in chapter 6.

Because the Speculative Artist's Intended Rendering starts from the Content Reproduction Variant it does not require recapturing the physical original so steps 5.1 and 5.2 do not have an equivalent in this chapter. There is no change to sharpening, noise reduction (5.6) or LCC (5.7, 5.8, 5.9) so those sections are not repeated in this chapter. There is also no change to Mode (6.2) or Curve (6.3) or White Balance (6.4) so these sections are not repeated in this chapter.

7.2 Research the Artist's Intentions

The Speculative Artist's Intended Rendering is meant to produce an image similar to the one the artist themselves would have presented. Before we can pursue the creation of a Speculative Artist's Intended Rendering we need to research, to the extent practically possible, what methodological, technical, and aesthetic intents the artist would have likely employed. Potential sources for this information are listed below, starting with the sources most likely to provide useful and accurate information:

- Direct conversation with the artist themselves
- Prints or other outputs made by or approved by the artist
- Documentation of prints or exhibitions (e.g. photos of gallery shows)
- Notes or writing of the artist
- Historical interviews of the artist
- Consultation with experts such as curators or researchers
- The work of similar artists
- The work of other artists who used the same film
- The work of artists during the same time period

There are many practical limitations here. The artist may be deceased with no surviving prints, interviews, or notes. The work may not have a known artist. The film used may have been obscure or hand-made or the process created by the artist without documentation. Even in the best case, we are still limited to trying to recreate the rendering the artist would have intended using a tool-set that is fundamentally different than the tool set the artist would have employed. Nevertheless we cannot allow the perfect to be the enemy of the good. The motivation for creating a Speculative Artist's Intended Rendering is that *something* is better than *nothing*, especially given the strong likelihood that, in the future, even less will be understood about the Artist, Film Ecosystem, Aesthetic Context, and Technical Context of Film.

7.3 Color and Tone

For Content Reproduction (reminder)
For the Object Reproduction we used a white balance derived from the subject. This neutralized the scene so that subject matter that was neutral in the real world would also be neutral in the scan. We also used the minimum adjustment to exposure that was required to make the content visually understandable to the viewer.

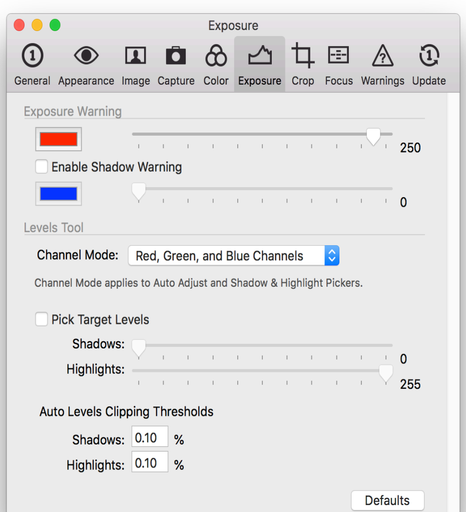
For Speculative Artist's Intended Rendering
We will leave the white balance set as it was in the Content Reproduction and use exposure, levels, curves, and Color Editor to adjust the color to be in line with artist's intended rendering.

There are several common sources of differences between the global color rendering of the Content Reproduction and the intention of the artist.

- **Physical Deterioration:** The color and tone range of the physical object may have drifted over time (see chapter 3.4)
- **Non-Neutral Intention:** The Content Reproduction image was white balanced based on the image content, producing normal content. But a non-neutral intention was very common. For example, an artist may have intended an image at sunset to be warm.
- **Film Ecosystem:** Many films were coupled with a specific printing process to produce a specific look. Without that printing process the color and tone will not match the intent without intervention.

Each of these categories calls, primarily, for it's own tool in Capture One.

Physical Deterioration & Film Ecosystem: Auto R,G,B Levels
The Levels tool is often helpful either when the color of film has shifted due to aging or improper storage or as a first stage in matching a particular film ecosystem. See Chapter 8.3 for more information.



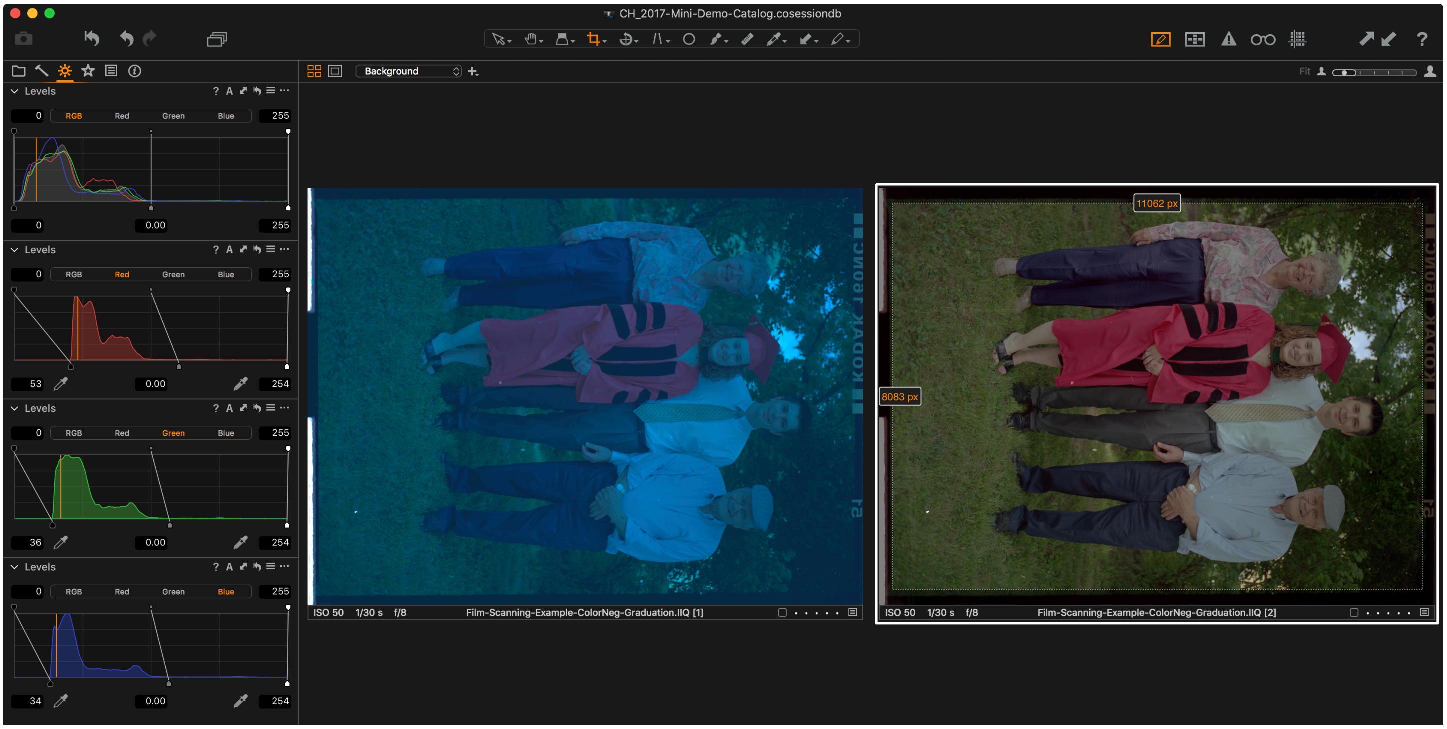
In [Capture One > Preferences > Exposure] select "Channel Mode > Red, Green, Blue Channels" and 0.01% for Auto Level Clipping Threshold for both Shadows and Highlights.

Crop the image such that only image content is visible. Neither the frame of the image, nor the light source under the film, should be visible in the crop.

If needed, use the Exposure Slider to move the histogram is centered and no content is clipped in the highlights or shadows.

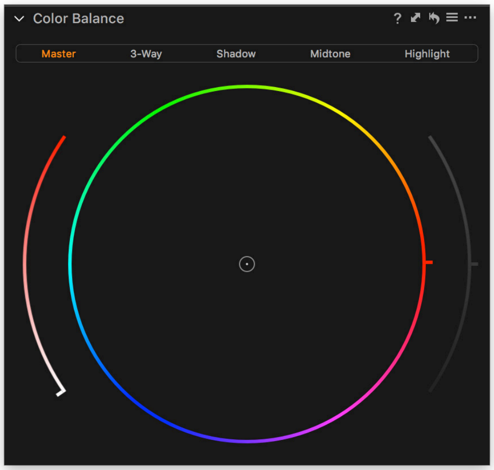
Use the White Balance cursor to roughly white balance the image using something reasonably neutral inside of the frame.

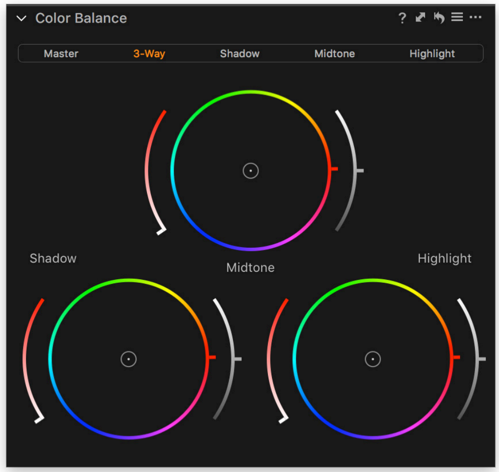
Click the Auto button in Levels. This will adjust each channel (red, green, and blue) such that the image now has a neutral black and neutral white. This automatic adjustment works best when the image content includes subject matter that should be black and subject matter that should be white. Images where the subject matter itself is intentionally low contrast or has a strong color cast; for example, a photo of a boat in fog should not have a true black or true white, but this automatic level adjustment will force both. In such cases manual adjustment of the levels may be required.



In the case that many similar frames are captured at the same time it may be more consistent and accurate to identify the frame that contains the most neutral shadow and highlight subject matter, auto adjust to that frame, and then copy-apply those adjustments to the other frames.

Non-Neutral Intention: Color Balance
It's very common that the artist's intention would be a warm or cool image, or even one that had an unusual color cast such as magenta or cyan. Rather than try to reproduce these intentions using Levels or White Balance we will do so using the Color Balance tool. This moves the adjustment later in the process and makes it easier to isolate it from other color-impacting adjustments.





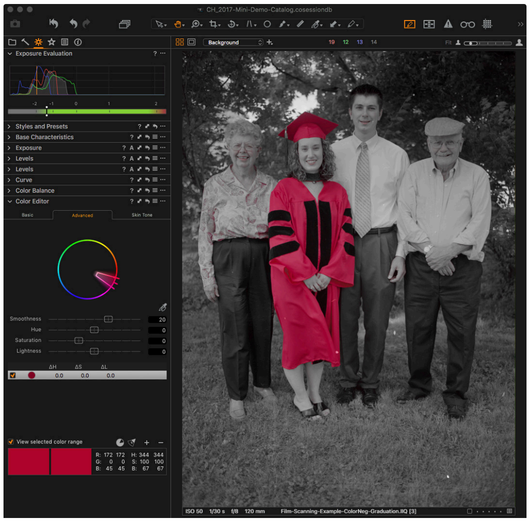
Use the Master Color Balance tool to imbue the desired color balance on the overall image. If needed, use the 3-Way Color Balance tool to tweak the color balance of just highlights, mid-tones, and shadows.

Film Ecosystem: RGB Levels, Curves and Color Editor
The nuanced color reproduction of specific films used with specific paper and printing processes are impossible to recreate with 100% accuracy. However, the broad strokes of such combinations can often be achieved through fairly straight-forward adjustments using the RGB Levels, Color Editor and Curves.

The levels tool was described earlier and is a common first step in this process.

The Curves tool in Capture One functions much the same way it does in other image editing software. By adding points to the curve you can brighten or darken specific tonal regions. Note that the steeper the line is in a given tonal region, the more contrast that tonal region will have. In most cases, because the dynamic range of DT systems is so high, the scan will be lower in contrast than is visually desired for an Speculative Artist's Intended Rendering, even after using an Auto Level command. It is therefore common to add contrast using the Curves tool.

Go to the Color Editor Advanced tab and use the Pick Color Correction Cursor to select a color that needs to be manipulated. Turn on View Selected Color Range to see what range of color is effected by the current selection.



Modify the four edges of the selection wedge and the smoothness slider until the desired color range is selected in the image. Generally the Smoothness slider should be left as high as possible to reduce the specificity with which the adjustment is made. This reduces the likelihood of artifacts and makes it more likely that the adjustment can be copy-pasted to other similar images. However, lower smoothness may be required to limit the selection to a specific color.

Turn off View Selected Color Range and modify the color's Hue, Saturation, and Lightness to better match the intention of the artist. Do not be surprised if some of the adjustments are fairly strong; many film era images departed from a "neutral" rendering quite profoundly.

In the case of modern color negative film with ongoing commercial availability there is also a profiling process that DT can provide. Please contact DT for more information.

8

Batch & Automatic Processing

In chapters 5, 6, and 7 we discussed how to capture a Object Reproduction (Preservation Digital Object), Content Reproduction, and Speculative Artist's Intended Rendering. Those chapters focused on working on a single image at a time. In practice, transmissive collections are often expansive in scale, so their digitization must leverage batch and automatic processing. In this chapter we discuss the many such tools and workflows in Capture One CH.

8.1 AutoCrop

Capture One CH can automatically crop many transmissive materials, saving the operator the time and tedium of manual cropping. However, transmissive materials present a complicated task for automatic cropping; such material often comprises cascading/concentric rectangles and are often missing edges or corners (e.g. an underexposed area in the corner of a frame may bleed into the unexposed base without presenting a visible corner).

Autocrop in Capture One CH is a tool that applies a crop to the selected raw file variants. Capture One CH is used for all three workflow steps: applying an automatic crop, QC'ing the resulting crops, and manually correcting any errant crops. This is far preferable to other automatic cropping tools that run on TIFFs and often require going backwards through the workflow in the case that an errant crop is uncovered.

Loose Material
This method is the most generic, and looks for the largest contiguously-enclosed shape within the current crop. This can be useful when using the ANR Glass Carrier to digitize sheet film or Glass Plate Negatives.

1. Select all relevant frames
2. Enter your desired padding. Note that this can be a negative or positive value.
3. Click AutoCrop
4. QC the resulting crops, manually adjusting the crop where needed

Roll Film
This method is specifically designed to address some of the complications presented by roll film. It requires the user to provide an example crop, which the algorithm them attempts to repeat on additional frames. One unique advantage of the Roll Film method is the confidence feedback it provides which helps the user more quickly QC the resulting crops and fine-tune their cropping workflow.

1. Select a frame that is representative of the overall group of images you wish to crop and which has four cleanly defined edges
2. Very carefully crop this frame to the relevant subject matter. For a Content Reproduction that means the crop edges should perfectly align to the edge of the exposed image frame. Padding will be added in a later step.
3. Click [Set Master Crop]
4. Enter your desired Padding. Note that this can be a negative or positive value.
5. Select all relevant images
6. Click AutoCrop

   Each image will then be tagged according to how confident Capture One CH was in the crop applied.
      Red: Low Confidence. The assigned crop is very likely to be wrong.
      Yellow: Medium Confidence. The assigned crop may be wrong.
      Green: High Confidence. The assigned crop is likely correct.
7. QC the images according to their tag. Using the filter tool filter the current view to red-tagged and yellow-tagged images and carefully check each crop with the assumption that each is wrong. Then filter the view to green-tagged images; while the crop of each of these images should be checked, they can be checked at a faster rate, and in some cases can be checked using the thumbnail-view only.

For roll film in good condition, and with clearly defined frame edges, the Roll Film algorithm should produce mostly green-tagged and correctly cropped images. If not, please contact DT's support team (support@digitaltransitions.com) so we can help you troubleshoot.

AutoCrop Tips: Pre-Crop ROI
AutoCrop (any mode) always begins with the currently assigned crop. Sometimes it is advantageous to apply a generic crop across a range of images, before engaging autocrop. For example, in the image

1. Crop the first image to the region you know the subject will lie within for all relevant images (e.g. crop out the top 100px and the left 200px)
2. Select-all relevant images
3. Copy-apply the crop using the local copy-and-apply in the crop tool

Run the autocrop tool.
Using the above workflow the AutoCrop will only search within the crop established in step 1; therefore anything outside that crop will be ignored when searching for the subject.

AutoCrop Tips: Contrast Enhancement
Slide film that is only transilluminated may have dark content at the edge or corner of the frame. However, this dark content is rarely as dark as the black non illuminated slide casing around it. Therefore you can temporarily increase the visual contrast between the slide and the slide casing by using the Levels or Curves tool. Likewise, when using the ANR Glass Carrier to digitize sheet film, the contrast between the edges of the film object and the unobstructed light source can be temporarily increased.

1. Select all relevant/similar raws
2. Toggle the viewer to Primary View
3. Adjust the curves or levels to increase the subject and background
4. Use the Local Copy-Apply button to sync this adjustment to all other selected raws
5. Run AutoCrop
6. Use the Local Reset button to remove the adjustment from step 4
7. QC the resulting crops and manually adjust any failed crops

The tool used to temporarily increase the contrast can be reset after the automatic cropping by using the reset button.

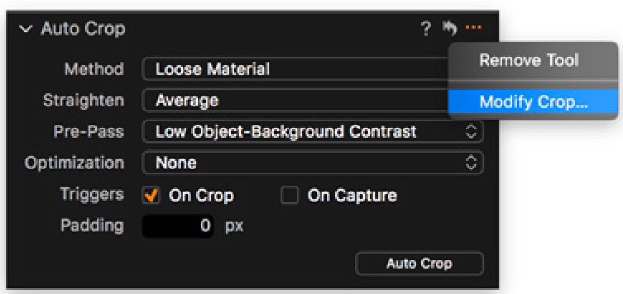
8.2 Modify Crop & DT Crop Control CH

Once AutoCrop or manual cropping has been used to establish an initial crop on a variety of images, the modify crop and DT Crop Control CH suite can be used to modify those crops. This is preferable to standard copy and apply methods because those would overwrite the unique current crop location and size of each image rather than starting with the crop as it already is.

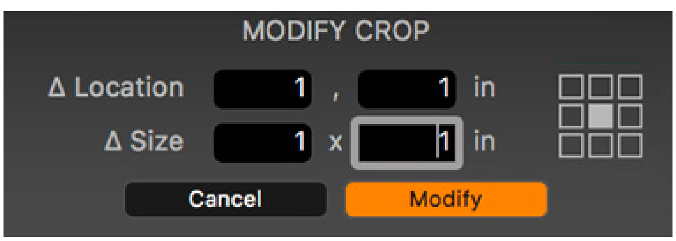
Modify Crop

Modify Crop is a native command of Capture One CH. It provides resizing and relocation, starting with each image's current crop. It provides less flexibility and power than the DT Crop Control CH Suite, and cannot be triggered by keyboard shortcut. However it may be more intuitive than the DT Crop Control CH Suite for first-time users.

Start by selecting all relevant images, and making sure that [Edit > Edit All Selected Variants] is enabled (orange). If this option is not enabled (grey), then only the Primary selected image will have the crop changed.



In the top right of the Crop or AutoCrop tools, click the [...] button.



- **Location:** To change the location of the crop, enter a value in the two Location fields, the first handles a horizontal move and the second a vertical move. Note that positive values will move the crop right and downwards, while negative values (adding a minus to the value) will move the crop left and upwards.
- **Size:** To change the size of the crop, enter a value in the two Size fields. The first changes the width and the second the height of the crop. Positive values make the crop larger, while negative values will make it smaller.
- **Anchor:** Choose where the current crop should be anchored when changing the size of the crop by clicking on one of the nine points in the Anchor box. By default, the changes will be done from the center out. By choosing the top-right corner, for example, it is possibly to make sure that all changes to the size happen in the opposite direction, e.g. to left side and bottom of the crop.

Click on Modify to apply the changes.

DT Crop Control CH Suite

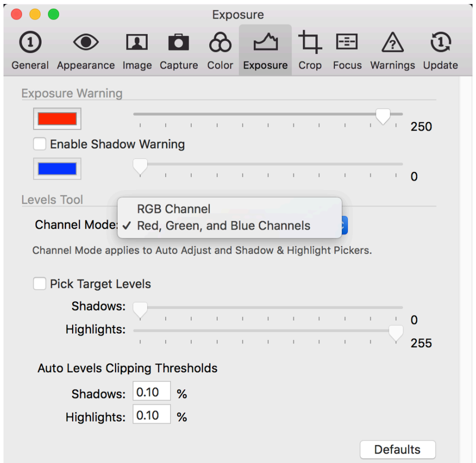
This suite of cropping tools can downloaded from dtdch.com/dt-crop-control-ch/. The below commands are available out-of-the-box and can be activated by keyboard shortcut.

- **Resize:** Expand or contract the height or width of the crop on the selected variants without moving the center. Useful for modifying the AutoCrop result to be asymmetrical (e.g. more padding on the left/right than on the top/bottom).
- **Trim:** Expand or contract one side (e.g. top, bottom, left, or right) of the crop on the selected variants without moving the other three sides. Useful for including Object Level Targets which are below the AutoCrop'd subject.
- **Set Size:** Set the width or height of all selected crops to a specific value without moving the center of the crop.
- **Standardize:** Adjust the width or height of all selected images to match the largest width or height of those images. For example if you select four variants which are currently cropped with widths of 400, 350, 550, and 500, all four images can be set to a width of 500, without changing the center of their crops.
- **Duplicate:** Duplicates the selected variants. When this command is used by itself it is no different than using Clone Variants in the standard Capture One interface. However, this command can be part of a chained sequence of commands to facilitate automatic page splitting and gutter sweeping.
- **(Page) Split:** When using the DT RGC180 to image two-up facing pages of bound material the AutoCrop tool's Book Scanning mode does a great job of cropping the frame to the page-spread. For those clients that would like a crop for each of the two pages this tool splits the crop to it's left and right halves. That creates a 0 pixel gutter in the dead center throughout the book; the user can then control the size, location, and sweep of the gutter with subsequent tools. Note that this tool assumes the selected range of images already have two variants each (i.e. that the Duplicate command has already been used).
- **Gutter Overlap:** Increases or decreases the amount of overlap between the left and right crops. This assumes the selected range has already been Duplicated and Page Split.
- **Gutter Shift:** Shifts the gutter left or right by a fixed amount without changing the size of the gutter. This assumes the selected range has already been Duplicated and Page Split.
- **Gutter Sweep:** Progressively sweep the gutter to the left or right. When scanning thick bound material it's common that the physical gutter slowly moves from the left-center to right-center rather than staying in the absolute center of the book.

This suite is open source and the user is encouraged to modify the code to fit their specific needs. More information, including a tutorial on modifying the code, can be found at dtdch.com/dt-crop-control-ch/.

8.3 Auto Levels

Note that the Auto Levels tool used in steps 7.3 can be used for batch automatic adjustment. When selecting more than one image. Each image will be assessed on its own and receive it's own levels adjustments as if it was selected individually. Since the histogram of each image must be individually analyzed running Auto Levels on large batches of images may take several seconds or even minutes.



In [Capture One > Preferences > Exposure] Auto Levels can be set to run in one of two modes:

- **Red, Green, Blue Channels:** Each color channel is treated independently. If the image has a color cast in the highlights or shadows, this mode will often successfully reduce or eliminate that cast. This is very useful for adjusting color negatives. Note that if the subject matter itself does not have neutral subject matter in the highlights and shadows using this mode can introduce a color cast. For example, in a photo of tightly-framed green grass (lacking neutral content like a cement path) this mode is likely to introduce a slight magenta cast to counteract what it sees as a green-cast.
- **RGB Channels:** This mode operates on the RGB composite channel. It therefore does not modify color, only contrast. This is especially useful for monochromatic subject matter (e.g. black and white negatives) or subject matter where Red, Green, Blue proves problematic (e.g. the green grass image described above).

In [Capture One > Preferences > Exposure] Auto Levels can be set to use a clipping threshold between 0.01 and 10% for the highlights and shadows. This much of the subject matter is allowed to be clipped. Generally a lower value is preferred so that very little of the image is clipped to black or white, since clipping causes a loss of detail. However, a higher value can be used to provide a greater chance that a very small image area will throw off the automatic removal of color cast.

8.4 Copy and Apply

The Copy and Apply tool is a basic tool for batch workflows. In other programs this functionality is called "synchronize adjustments" or "Lift and Stamp" or "Copy and Paste Adjustments". This allows you make adjustments such as changes to color or exposure, on one image and quickly apply those same adjustments to other images. There are two main ways to copy and apply adjustments in Capture One

Global Copy and Apply
When using the copy and apply icons in the top of the user interface all adjustments will be copied from the primary selected image and applied to the other selected images.

Local Copy and Apply
The copy-apply icons located in each individual tool allow you to quickly copy-apply just that tools settings to the other selected images.

For both Local and Global Copy and Apply image parameters that have not be adjusted from their default values will not be copied; for example, if the primary selected image has not been cropped then a global copy-apply or local copy-apply of the Crop Tool will not change the crop of the other selected images.

8.5 Naming and Folder Structures

Capture One provides a variety of tools that support advanced naming and organization workflows. These use "tokens" which are placeholders for metadata that will be completed at the time of capture or at the time of export/processing. These tokens are useful for setting Next Capture Naming and Process Recipe Output Folder. Images can be captured with tokens used to form the resulting file names, and exported with tokens used to modify the names or folder-structure of the exported files.

Useful Tokens

- **[Document Name]:** This is the name of the current session. This token is well suited for information representative of the overall set of objects.
- **[Destination Folder Name]:** This is the name of the current Capture Folder at the time of capture. This is most useful if the operator creates one or more sub-folders for captures and can be used to designate an intermediate hierarchy level.
- **[X Digit Counter]:** is a continuous counter with X digits forced. In the [...] menu of Next Capture Naming it can be set to increment by any positive or negative value, and can be set to any value. Note that keyboard shortcuts can be set for decrementing the counter, useful when deleting the most recent capture.
- **[Current Date]:** Date tokens such as YYMMDD can help collate projects spread across multiple stations and days. In contrast, Current Time is probably not desirable since, unlike [X Digit Counter], it will not properly handle the order of inserted or retaken images.
- **Fixed Text:** Fixed text is also allowed anywhere in the naming. For example, the Library of Congress could add a "LOC-" name prefix to all files. This is also how the user designates what character or characters to use to separate tokens (e.g. dashes, underscores, spaces etc).

Document Name - Destination Folder Name - 4 Digit Counter

Example Advanced Workflow: Box, Folder, Item naming
Some institutions follow a "Box ID - Folder ID - Item ID" naming scheme. In this scheme the filename "01458 - 05 - 08" would indicate the 8th item in the 5th folder of box #01458. Capture One can accommodate this naming with the following workflow:

1. Set Next Capture Naming to [Document Name] - [Destination Folder Name] - [X Digit Counter]
2. Create a New Session for each box, and give the session the name of the ID for that box.
3. Each time a new physical folder is reached, create a new Capture Folder named for the ID of that folder, and reset the counter.

Alternatively the box ID and folder IDs can be accommodated by naming each new Capture Folder with both the Box ID and Folder ID. This would be preferred when the number of items and folder per box is relatively small.

Note that AppleScripting can be used to automate the creation of new sessions and capture folders, either with manually names, or by drawing against a reference file or database.

8.6 AppleScript

Effective AppleScripting can make Capture One CH even more powerful, automating repetitive tasks, and removing drudgery. This Mac-only programming language integrates deeply with Capture One CH allowing to natively call many of its features and functions. To help our clients get started with AppleScripting we've developed a toolkit called DT Building Blocks: AppleScripts.

DT Building Blocks: AppleScripts is a powerful teaching aid designed to use as a reference when building their own scripts for Capture One. DT Building Blocks provide inspiration and reference code to improve the workflows of cultural heritage digitization. The kit includes 30 scripts. Some of the scripts especially useful for cultural heritage digitization include:

- Create Capture Folders from Clipboard
- Make Nested Capture Folders
- Toggle Capture Ready Alert
- DT CropControl CH
- Select every other variant
- Select every tenth variant
- Select next green tagged
- Select variants with blank copyright notice
- Select variants with vertical crops
- Selection List to Text Document
- Email Processed File
- Process Droplet – saved as application without start-up screen
- Process On Capture
- Pull Metadata from Numbers Spreadsheet

More info about the DT Building Blocks: Applescript can be found at https://digitaltransitions.com/building-blocks/.

9

Advanced Techniques

In the interest of keeping this guide as approachable as possible, chapters 5-7 omitted potentially useful advanced techniques, holding them back for discussion in this chapter. The fact that these techniques are in their own separate chapters should not be construed as an indication that they are unusual or esoteric. Indeed many of our clients use these techniques on a frequent basis.

9.1 Stitching

In some cases the amount of resolution available in a single capture is not enough for a desired purpose. For example, to scan an 8x10 piece of film at 3000ppi requires ~720 megapixels, which is far more than any camera can produce in a single capture. In such cases, stitching multiple captures together can be an effective means of increasing total resolution.

Future versions of this document may include a full step by step procedure for stitching. In this version we simply point out some of the factors that anyone undertaking film stitching should control as tightly as possible.

Factors to Control
The software used to stitch captures can adapt for a variety of unintended capture variation. However, the less such variation the better the stitch will be successful.

- **Illumination uniformity:** If the lens and camera move, but the light source does not, then each capture requires its own LCC. Less variation can be achieved by moving the film, while holding the light and camera/lens static. The DT XY Film Scanner takes this later approach.
- **Vibration:** Stitching algorithms work off of matching up detail. If vibration is degrading the sharpness of the captures then there will be less detail for the algorithm to match, and also the detail may be rendered differently in adjacent captured depending on the nature of the vibration at the time each is captured. The DT XY Film Scanner uses a heavy-duty column, heavy duty bench, carefully designed detents, and a wall-anchor to reduce the chance of vibration.
- **Non-Intended movement:** Stitching is achieved by X or XY movement. The system used to make this movement should reduce unintended movements such as rotation, displacement on the Y axis (toward/away from the camera) or roll/pitch (swinging, even slightly, off of parallel). The DT XY uses linear slides and rigid high-quality components to reduce non-intended movement to a minimum.
- **Light source variation:** The light used should be highly repeatable. Even high-end strobe systems vary in output from one frame to another, and repeated strobe pops can create ergonomic wear on the operator if high volumes of material are stitched. Therefore we suggest a continuous light source. The DT XY uses a DT Photon continuous LED light which produces an incredibly stable output.
- **Aperture variation:** Mechanical apertures vary from one frame to the next. We recommend using a camera that will stop the lens down once, and remain stopped down throughout the stitch, rather than returning the aperture to the maximum opening size each capture. The DT XY can use either the DT RCam or Phase One iXG, both of which keep the lens stopped down unless the user explicitly commands them to open.
- **Mechanical shutter variation:** Mechanical shutters will vary in their exact length of exposure. Use of an sensor-based electronic shutter can ameliorate shutter speed variation, but can introduce internal geometry distortion.
- **Internal geometry distortion:** The use of a sweeping sensor-based electronic shutter, or a focal plane shutter, can cause the image to slightly compress in parts of the image compared to the rest of the image. This occurs when vibration in the system moves the subject in a different direction during part of the exposure compared to the rest. While the impact on single-frame captures is minimal, this can cause micro detail to misalign between frames in a stitch. The DT XY allows the use of a sweeping sensor-based electronic shutter and a heavy-duty column, heavy duty bench, carefully designed detents, and a wall-anchor to reduce the chance of vibration. In the case ambient vibration makes the sensor shutter inoperable the system also provides an electronically-controlled shutter.
- **Lens distortion:** The lens should have as little distortion as possible, as this will cause image content not to line up between captures, unless the stitching software specifically addresses lens distortion. Even in the case that the stitching software addresses lens distortion the correction of distortion will decrease image detail in the areas affected. The DT XY uses three lenses, all of which are natively extremely low in distortion.

Tools
There are several tools that stitch tiled captures into a composite image. During the development of the DT XY we evaluated AutoPano Giga, PTGui, and a few others. Our testing showed that AutoPano Giga offered the best workflow but, regardless of settings, often produced slight “echo” artifacts along the stitching seams. In contrast to this, Adobe Photoshop’s PhotoMerge tool produced the best quality but had no provisions for batch workflows. For this reason we developed DT BatchStitch, an open source script that uses Photoshop’s PhotoMerge math with a custom interface that supports stitching in large batches. More information at dtdch.com/dt-batchscript-bulk-stitching-photoshop/

9.2 **Reflective Content**

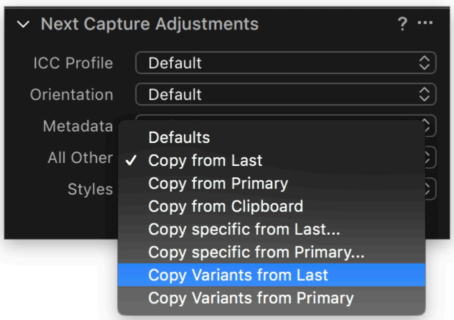
Some transmissive collections contain both reflective and transmissive content. For example, mounted slides contain transmissive image content in the film area and also contain reflective content such as a stamped date, slide number, or handwritten annotation. Both reflective and transmissive content can be captured. Below we outline the suggested steps for doing so with a DT Atom, but the process is similar with our other benches.

1. Leave one DT Photon in the standard location for transillumination of the transmissive content.
2. Mount and turn on a second DT Photon on one of the arms of the DT Atom
3. Follow the steps outlined in Chapter 5 to set up for a Object Reproduction
4. Depending on the reflective content it may make sense to add a sheet of ND Filter to the DT Photon to reduce the ratio of the reflective light to the transmissive light. To do so, remove the four thumbscrews that hold the frame of the DT Photon, remove the frame, cut the sheet to fit the inside dimension of the frame, and place the ND filter between the clear Plexiglas and lensed Plexiglas, and replace the frame and frame thumbscrews.

The DT Photon on the arm of the DT Atom provides a low-angle of illumination across the film. That decreases the chance of glare in the transmissive content area. However, the introduction of any light above the plane of the film can cause a loss of contrast, and loss of shadow detail. Check the image quality with and without the reflective illumination and if there is a meaningful difference you may need to capture two versions: reflective+transmissive and transmissive-only.

9.3 Capture Multiple Variants

Capture One CH has the ability to create multiple variants immediately after creation. This has a variety of applications.



General workflow

1. Make a capture
2. Make one or more additional variants of that capture, and adjust them as desired
3. Select Copy Variants from Last
4. Capture a new image. The new image will come in with the same variants as the last image.

Positive/Negative Use-Case

When digitizing negative materials it can be useful to see both the Object Reproduction and Content Reproduction versions at the time of capture. To do so, simply use the workflow above, making sure these two variants are created in step 2.

Multiple Crop Regions Use-Case

DT systems feature up to 150mp resolution. This provides three main advantages: capturing a given material size at higher PPI, capturing larger subjects at a given PPI, and the ability to capture (with good resolution) more than one object at a time. For example, six hundred envelopes can be captured in fifty batches of 12 slides arranged on the DT ANR Glass Carrier in a grid of 4 columns of 3 rows. In bulk, every slide can be saved as a separate, perfectly cropped and deskewed file, using Copy Variants from Last and AutoCrop in the following workflow:

1. **Setup Physical Grid:** Create a grid on your working surface to help place each item within a consistent area of the frame. We will call these regions of interest or ROIs. For example, you could place a mat board over the entire working surface and use a ruler and conservation-friendly drawing implement to draw lines. Each ROI should be large enough that an item can be quickly placed entirely inside the lines with padding.
2. **Setup Digital Grid:** Capture an image of the table-with-physical-grid. Crop it to the first ROI. Use F3 to Clone this variant and in the clone, shift the crop to the second ROI. Repeat this for each ROI. Set Next Capture Adjustments to Copy Variants from Last.
3. **Capture All Material:** Replace the material with the next set, and capture. The new capture will come in with as many variants as there are ROIs. Ensure that all material fits entirely within its respective ROI. Repeat until all material has been captured.
4. **Run AutoCrop:** Select all variants of all captures, and run AutoCrop. Since AutoCrop always begins with the current crop, each variant will start looking for the subject in the ROI it represents. Accordingly each item digitized will now have its own properly cropped and deskewed variant.
5. **Handling Naming:** Capture One does not allow you to name a variant separately from the name of the raw file it is a variant of. However, you can use a Counter or Variant Position token in Output Naming to produce cohesive, ordered naming upon output.

APPENDIX A

What PPI is Best?

A.1 **Methods to Pick a PPI**

In a camera-based digitization systems the camera-to-subject distance and lens determine the size of the scan area (aka"field size") and the scan resolution (ppi). There are two approaches to making this selection:

- **Specific PPI:** Such a PPI can be selected based on a guideline like FADGI, or based on an established institutional practice a specific PPI is selected based on the material type. Regardless of how the specific number is selected, this method means the PPI is set without regard to how much or how little of the object fills the frame.
- **Fill the Frame:** Alternatively, the operator can fill the frame (with a small margin/padding outside the edges) with a given material type ensures the highest PPI the system is capable of for that film in a single capture.

Intuitively it might make sense that filling the frame is always preferable, as it maximizes resolution for the camera system being used. However, this path is equates the question of "What PPI is Best?" with "what ***can*** we do?" rather than "what ***should*** we do?" which is not well-aligned with the goal of preservation-grade digitization. If the goal is the creation of a PDO that can serve as a surrogate to the original object, replacing most needs for physical access to that original object then the selection of PPI must be based on the content of the original transmissive material.

A.2 **What do the Standards Say?**

The FADGI, Metamorfoze and ISO imaging guidelines outline those elements of image quality that are required to achieve such surrogacy. Currently FADGI is the only one of those three that provides detailed resolution requirements for digitization of transmissive materials. FADGI first formally addressed transmissive digitization in the 2010 version of their document Technical Guidelines for Digitizing Cultural Heritage Materials.

FADGI 2016 vs FADGI 2010

The more recent 2016 revision of this document significantly increased the suggested resolution at which to digitize transmissive materials. Some institutions, especially lower-end service bureaus still refer to the legacy 2010 version because its lower resolution requirements make it easier to claim FADGI conformity. We strongly advice institutions to specifically use "FADGI-2016" rather than simply "FADGI" when specifying a number of stars for any in-house, in-sourced, or outsourced digitization.

Summary of Standards

Below is a quick-reference chart not meant to substitute for a thorough reading of the Technical Guidelines for Digitizing Cultural Heritage Materials document. Also note that resolution and sampling efficiency are not the only metrics by which FADGI measure image quality.

	FADGI 2016 4-Star	**FADGI 2010 4-Star**
35mm Film	4,000 ppi at 90% Sampling Efficiency	2,800 ppi at 95% Sampling Efficiency
645 Film		1,800 ppi at 95% Sampling Efficiency
4x5 Film		1,200 ppi at 95% Sampling Efficiency
8x10 Film	2,000 ppi at 90% Sampling Efficiency	600 ppi at 95% Sampling Efficiency

Variation in Materials

The purpose of FADGI is to provide guidelines, not hard-and-fast rules. The resolution cited by FADGI is based on a survey of common transmissive materials with the goal of picking a resolution that was sufficient for nearly all. However, some materials will contain denser content than would be covered by the FADGI guidelines. For example, the super-fine-grain film Kodak TechPan may benefit from higher PPI. As a more extreme example the world of transmissive materials includes physical specimen slides that may benefit from digitization at 10,000 ppi or higher.

When possible, we suggest surveying your collection for representative materials and digitizing them at FADGI-2016 recommended resolution as well as higher resolutions, to see if your specific materials benefit from higher resolution.

A.3 Practical Considerations

File Size

File storage strategy is out of scope for this document. But for completeness we mention the obvious trade-off of scanning at a resolution higher than is needed for preservation goals: file size. Below are

	PPI for FADGI-2016 4-Star	Pixel Dimensions	16 Bit TIFF File Size	Space required for 100,000 scans
35mm Film	4000	5,700 x 3,800	123 MB	~12 TB
645 Film	4000	9,400 x 7,100	380 MB	~37 TB
4x5 Film	4000	20,000 x 16,000	1,800 MB	~174 TB
8x10 Film	2000	20,000 x 16,000	1,800 MB	~174 TB
11x14 Film	2000	28,000 x 22,000	3,500 MB	~336 TB
Numbers rounded to the nearest 100 pixels, 100 MB, and 1 TB. They do not include any margin/padding, and do not account for use of optional compression.				

File Format Size/Pixel Limitations

Note that the TIFF specification is limited to 4 GB which becomes problematic

The BigTIFF format and PSB (Photoshop Large Document Format) support file sizes and pixel dimensions far larger than any foreseeable use in Cultural Heritage imaging would require. The Library of Congress lists BigTIFF as having favorable sustainability factors, but BigTIFF is not broadly supported by commercial software (e.g. neither Adobe Photoshop nor Capture One CH support this format). PSB is supported by Adobe Photoshop but is not listed by the Library of Congress as having favorable sustainability factors.

If a cultural heritage digitization project runs up against the limitations of TIFF, it is likely to do so in the context of stitching. In such cases we'd recommend saving the individual tiles alongside the composite format chosen.

Collation: PPI Changes vs Additional Captures At Current PPI

Earlier in this chapter we discussed using a Specific PPI rather than Fill the Frame method of selecting a capture PPI; one benefit of this is the reduced number of times the PPI will need to be changed. With any camera-based capture system it is faster to capture the next item at the same PPI than to change PPI. Therefore, selecting a fixed PPI is a faster workflow than changing the PPI for each new object. For example with an IQ 150mp at 4000ppi the capture window is 3.5" by 2.6" which means 35mm, 645, 6x6, 6x7, and 6x8 film can all be captured without changing PPI or stitching.

Where possible, materials should be collated prior to arriving at the digitization stage, so that like-sized materials can be digitized in batches. More information on a collated workflow can be found in our Digitization Program Planning Guide.

Not Enough Resolution?

When a required PPI cannot be captured with a given capture system there are four options.

- **Compromise:** Use the highest single-shot PPI possible
- **Stitch:** Capture the object in multiple tiles, and stitch these tiles to a composite output. For more information see chapter 9.1.
- **Upgrade Capture Systems:** Invest in a capture system with a higher resolution. For example, if your capture system is 50mp, upgrade to 100mp or 150mp.
- **Wait:** Delay digitization of the material until capture systems with higher resolution are available.

The Wait option is typically a matter of intra-project prioritization rather than absolute delay. That is, digitization of a large collection is often a multi-year project, and scheduling the largest material for the end of the project may pay dividends in efficiency as higher-resolution capture systems become available to the project. Of course, this is just one of many considerations when determining the priority and scheduling of digitization. For more information about Prioritization of materials see our Digitization Program Planning Guide.

APPENDIX B

Additional Resources

B.1 Written Resources

FilmCare.Org, Image Permanence Institute
FilmCare.org is a web-based film resource created by the Image Permanence Institute, a non-profit preservation research lab devoted to the development and deployment of sustainable practices for the preservation of images and cultural property since 1985. The Image Permanence Institute is a department of the College of Imaging Arts and Sciences at Rochester Institute of Technology (RIT) in Rochester, NY, USA.

FADGI Guidelines
Federal Agencies Digitization Guidelines Initiative (FADGI), Technical Guidelines for the Still Image Digitization of Cultural Heritage Materials
www.digitizationguidelines.gov

International Standards Organization
ISO 19262: Photography - Archiving Systems - Vocabulary
ISO 19263: Photography - Archiving Systems - Best Practices for Digital Image Capture of (reflective) CH Materials
ISO 19264: Photography - Archiving Systems - Image Quality Analysis

Other Documents by Digital Transitions
Digitization Program Planning, a Comprehensive & Practical Overview of Cultural Heritage Digitization
www.dtdch.com/digitization-program-planning/

Color Guide for Reflective Digitization by Digital Transitions
www.dtdch.com

B.2 Expert Individuals

Tom Rieger
Library of Congress
Digital Collections Management and Services Division
trie@loc.gov

Don Williams
Owner and Lead Image Scientist
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APPENDIX C

Workflow Summaries

C.1 iXG, AutoColumn, & DT Photon

Object Reproduction			
Section	**Page**	**Step**	**Summary**
5.1	29	Select Lens & Extension	Consult table for lens and extension tube options.
5.2	30	Set Camera Position & Focus	Enter desired Frame Size in Camera Focus and push "Start"
5.3	32	Set Mode	[Base Characteristics > Mode > Film Positive]
5.3	32	Set Profile	[Base Characteristics > ICC Profiles > Cultural Heritage > DT Photon]
5.3	32	Set Curve	[Base Characteristics > Curve > Linear Scientific]
5.4	32	Set Sharpening & Noise Reduction	Sharpening: Amount=100, Radius=1, Threshold=0, Halo=0 Noise Reduction : Luminance = 0, Color = 40, Single Pixel =0
5.5	32	Capture LCC Raw File	Remove film. Insert Plexiglas. Expose for mid-gray.
5.6	34	Analyze LCC	Right Click thumbnail and select Create LCC.
5.7	34	Apply LCC	[Next Capture Adjustments > All Other > Copy From Last]
5.8	35	Set White Balance	With film removed, white balance to the light source
5.9	35	Set Exposure	With film removed, change shutter speed until exposure warning of 250 barely shows
5.10	35	About the Crop	Step 5.2 already set the crop. No need for further crop.
5.11	35	Ready to Capture	Capture all material of this type

Content Reproduction			
Section	**Page**	**Step**	**Summary**
6.1	37	Clone Variant	Select Object Reproduction and use keyboard shortcut F3
6.2	37	Set Mode	[Base Characteristics > Mode > Film Positive]
6.3	38	Set Curve	[Base Characteristics > Curve > Linear Scientific]
6.4	38	Set White Balance	With film removed, white balance to the light source
6.5	39	Set Exposure	With film removed, change shutter speed until exposure warning of 250 barely shows
6.6	39	Set Crop	

Speculative Artist's Intended Rendering			
Section	**Page**	**Step**	**Summary**
7.1	41	Clone Variant	Select Content Reproduction and use keyboard shortcut F3
7.2	41	Research Artist's Intentions	Consult primary sources (artist, print, writing), secondary sources (curators, researchers), or similar artists to the extent possible and practical
7.3	42	Adjust Color and Tone	Physical Deterioration: Auto R,G,B Levels Non-Neutral Intention: Color Balance Film Ecosystem: R,G,B Levels, Curves and Color Editor

C.2 DT RCam, CMOS, DT AutoColumn, & DT Photons

Object Reproduction			
Section	**Page**	**Step**	**Summary**
5.1	29	Select Lens & Extension	Use 120mm lens (if available) with no extension tubes for 8x10, 5x7, or 4x5. For smaller formats consult table for number of extension tubes.
5.2	30	Set Camera Position & Focus	Move camera up/down using Copy Stand tool, roughly refocusing each time, until framing is close. Then use Copy Stand tool with Focus Meter to fine tune focus.
5.3	32	Set Mode	[Base Characteristics > Mode > Film Positive]
5.3	32	Set Profile	[Base Characteristics > ICC Profiles > Cultural Heritage > DT Photon]
5.3	32	Set Curve	[Base Characteristics > Curve > Linear Scientific]
5.4	32	Set Sharpening & Noise Reduction	Sharpening: Amount=100, Radius=1, Threshold=0, Halo=0 Noise Reduction : Luminance = 0, Color = 40, Single Pixel =0
5.5	32	Capture LCC Raw File	Remove film. Insert Plexiglas. Expose for mid-gray.
5.6	34	Analyze LCC	Right Click thumbnail and select Create LCC.
5.7	34	Apply LCC	[Next Capture Adjustments > All Other > Copy From Last]
5.8	35	Set White Balance	With film removed, white balance to the light source
5.9	35	Set Exposure	With film removed, change shutter speed until exposure warning of 250 barely shows
5.10	35	About the Crop	Step 5.2 already set the crop. No need for further crop.
5.11	35	Ready to Capture	Capture all material of this type

Content Reproduction			
Section	**Page**	**Step**	**Summary**
6.1	37	Clone Variant	Select Object Reproduction and use keyboard shortcut F3
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6.5	39	Set Exposure	With film removed, change shutter speed until exposure warning of 250 barely shows
6.6	39	Set Crop	

Speculative Artist's Intended Rendering			
Section	**Page**	**Step**	**Summary**
7.1	41	Clone Variant	Select Content Reproduction and use keyboard shortcut F3
7.2	41	Research Artist's Intentions	Consult primary sources (artist, print, writing), secondary sources (curators, researchers), or similar artists to the extent possible and practical
7.3	42	Adjust Color and Tone	Physical Deterioration: Auto R,G,B Levels Non-Neutral Intention: Color Balance Film Ecosystem: R,G,B Levels, Curves and Color Editor

CulturalHeritage

$20.00

www.dtculturalheritage.com