The DNG Dilemma: Establishing A Consistent User Interface for Objective Imaging Practices

William Scott Geffert; ImagingEtc; Glen Rock, NJ / USA

Abstract

It has been well documented via previous IS&T papers and oral presentations that the DNG file format holds great promise for cultural heritage imaging. The current challenge is that a technically sound raw file format specification does not necessarily translate into a successful end user experience. The current lack of UI standardization across DNG compatible cameras and editing software is putting DNG-based cultural heritage imaging programs at risk. If the goal is to capture images that we wish to open and exchange 10 to 20 years from now, it would be a good start to better define the tools we utilize today. While the Metamorfoze, FADGI and AIC guidelines have gained momentum for cultural heritage imaging process control, users of DNG workflow are often unable to take full advantage of these objective protocols due to a complete lack of user interface standardization. This paper is an effort to document the current dilemma, and to open up a dialog with the industry to improve the current user experience via user interface standardization.

DNG Potential

The DNG file format has been promoted as an ideal format for archiving raw capture data, and has been explored in great detail as a viable archival imaging format. see: **Raw as Archival Still Image Format: A Consideration** Michael J. Bennett, University of Connecticut Libraries and F. Barry Wheeler, Library of Congress (USA)[1]. The existence of a robust universal file format for archiving raw image data makes a lot of sense from an in that a universal raw format can store data from numerous brands of cameras and scanners as opposed to a managing a myriad incompatible proprietary raw formats.

A well-defined universal container for raw data, opens up tremendous opportunities for future automated data repurposing and migration. While many archival imaging workflows are based upon "finished" Tifff, Jpeg, or Jpeg2000 format "master image files", these files often serve as a jumping off point for further derivatives. The DNG file format offers the ability to store a Raw master file that can serve as the basis for any number of automated data-driven "on the fly" derivative renditions. Unfortunately, these data-driven transformations and other imaging pipeline productivity enhancements require a consistent set of data to operate upon. If there are no concrete rules underneath the core elements of a digital image, we not only lose the ability to apply productive data-driven image renditions, we risk leaving a legacy of data that is far more frail than traditional Tifff, Jpeg or Jpeg2000 images which can be well defined today.

The Current Reality

Many software tools allow DNG files to be opened but critical control elements are often completely disabled. In one glaring example the Capture One® application disables key features of DNG format cameras that the company deems "competitive" with it's own offerings. Specifically, the native DNG file from a Leica® M8 is fully functional in Capture One®, but the native DNG file from the Leica® S2 (competitive to the Phase One® Medium format cameras) has been disabled. This selective support is a type of DNG dilemma. If a format is marketed as "open" this means that it should be universally readable. Results of these baseline tests will help underscore the current challenges facing users and will hopefully shed some light on areas that can be improved.

While the omission of critical functionality is a current challenge, the larger issue looming over all raw image processing is an almost complete lack of standardization across tools for critical user interface elements. For example: some tools present a linear tone curve to the user while applying "film-like" curves to the data, and readouts for tonal values essential to modern process control are not implemented consistently-even across tools from the same company. Support for standardized ICC color profiling is inconsistent and adding to this user confusion, Adobe® has created and promoted it's own DNG profiling method and does not support traditional ICC profiles in it's DNG processing software tools.

The Test Method

Rather than getting lost in hypothetical or emotional discussions I decided to perform a simple exercise to provide an objective measure of the current end user experience using DNG files. The process was very straightforward: Take a camera that creates DNG data natively (The Leica® S2) and capture images of technical targets using the white (97L*) patch of an X Rite® Color Checker™ DCSG target as an exposure key. In addition to the DCSG color chart I created a prototype L* based grayscale with the help of XRite's Munsell division that is compatible of the L* based grayscale of the UTT specification. This grayscale target uses the exact same semi-gloss materials as the DCSG color chart and was used to graph the tonal response curve of Tifff exports.

To compare processing results across a number of applications, a single DNG file (directly from the camera SD card) was copied to individual folders created for each raw processor application to insure that various metadata and sidecar files did not interfere with the original source data. Using the default settings of fresh installs of each application files were exported and analyzed. In addition to the technical analysis, the various levels of feature support were documented. It is important to note that using default settings of each respective application is a key element of this evaluation as each tool has a myriad of configuration and

adjustment options. The only adjustment that was made during the testing is to use an eyedropper to neutralize on the white patch of the target (if supported) and to export the file to the eciRGBv2 color space (if supported).

A second phase of testing will continue between the submission of this paper and the oral presentation. This effort will focus on evaluating the ability of each tool to be configured to meet or exceed current Metamorfoze/FADGI tolerances for tone and color reproduction. Meeting the Metamorfoze/FADGI tolerances using DNG based cameras is not a simple task due to the inconsistent user interface elements and poor documentation. Initial tests indicate dramatic improvements in quality over default settings are possible.

One would assume that the same exact sensor data stored in a well-defined universal file format such as DNG would deliver perfectly consistent results, then again, I am sure anyone reading this already expects that this will not be the case.

The Software Applications

Being that Adobe® created the DNG format it is appropriate Adobe® Camera Raw® and Lightroom® were used as the first two applications in the testing. Lightroom® 3 and 4 were both evaluated. Adobe® recently launched a beta of Photoshop 6 and therefore ACR 7 was included. In addition to Adobe® products the following software programs were utilized for testing:

Capture One® - Phase One®
Raw Developer - Iridient Digital
Phocus® from Hasselblad®
iPhoto® - Apple®
Pixelmator - Pixelmator Team Ltd.
UFRaw - Udi Fuchs (open source)
Photivo - photivo.org (open source)
Raw Therapee - Gábor Horváth (open source)
Picasa - Google® (Free)
Raw Photo Processor 64 -Andrey Tverdokhleb (open source)
ACDSee® Pro - ACD Systems

While there are many more options for DNG processing, this sampling should give an indication of the current industry offerings. I encourage others to add to this list of software tools.

The Results

The word "scary" comes to mind as I try to summarize the results of this testing. Going in I knew that I would see some inconsistencies, but I never expected to see such a chaotic set of results. One could expect results like this from testing different cameras or scanners, but when you take a moment to consider that these test results are based upon output from a singular DNG file it is a real eye opener. As with any exploration, interacting with the various applications and the resulting data has revealed clues to potentially help improve a very bad situation.

What is Linear?

One of the greatest points of confusion across the photographic industry is the definition of linear encoding. In raw processing one would assume that linear file data would be easily accessible by the user. Unfortunately very few tools allow users to access this most basic functionality. Where things get confusing is that users are presented with curves and dialogs that present what appear to be linear settings yet under the hood, the readouts and data are not linear at all. Only six of the fifteen programs evaluated offered access to the true linear information.

Across the range of programs tested the results split into two general categories: One group of tools defaults to a "film like" curve even when the curve dialog indicates a "linear" response. The other group appears to render "linear" tone curves mapped to either the selected destination space or an often undefined internal working space. Analysis of the L* scales clearly illustrates this divide. (See illustration 1).

The interesting finding is that almost across the board, the lower cost or even free open source tools were closer to the target values by default. The more mainstream (and costly) tools appear to have been designed to offer general users "plug and play " simplicity at the expense of accuracy and control. Many of the open source tools offer a "none" setting or an equivalent setting to disable all color management and render a true linear rendition.

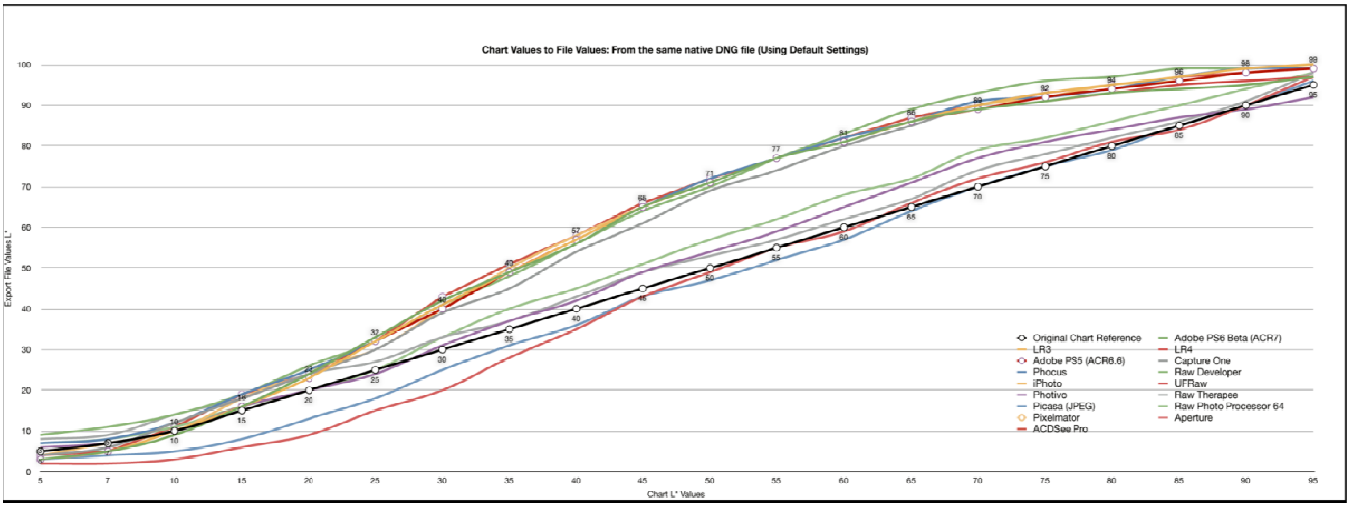

Illustration 1: In this graph the original L scale reference data (black) is compared to L* values of Tiff file exports from the exact same DNG source file processed through various Raw processing applications using default settings*

The lack of clarity over the rendition of tones in raw processing applications is the single most damaging issue for cultural heritage imaging applications. The seemingly random and undocumented tonal renditions have a direct impact on user exposure and lighting decisions at the time of capture and this compromises future repurposing. For example: during the course of this testing, Adobe® changed the approach to the default rendition settings between Lightroom® 3 and 4. This change reveals an almost one half half f-Stop shift in exposure. This means that a correctly exposed raw file created in Lightroom® 4 would be over-exposed when opened in Lightroom® 3 by up to one half f-stop assuming the default settings were used. (See Illustration 2) In short, the ambiguous nature of tonal curves in today's raw processors renders camera ISO speed ratings almost completely irrelevant. One encouraging finding was that the Leica S2's own histogram did seem to agree with the properly exposed linear raw data.

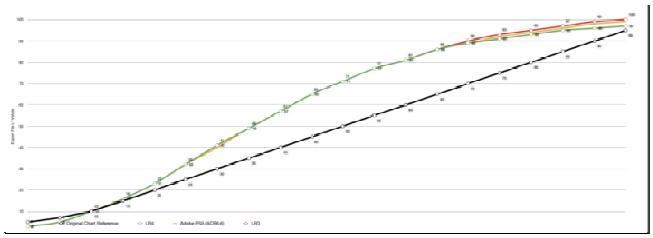

Illustration 2: Raw processing applications often default to render "film-like" curves even when UI settings indicate a linear tonal response. These proprietary "renditions" directly impact exposure thresholds and unfortunately change over time. This illustration of the gap between actual target values and captured values is typical of many raw processing applications.

Readouts

It seems quite obvious that accurate image information readouts are necessary for today's objective capture protocols. After exploring the various software tools, I found that the display of image information presented on readouts runs the gamut from no readouts at all to readouts that are ambiguous at best.

Beginning with RGB readouts there are three common approaches: One approach allows the user to read output values (destination RGB space). The problem here is that a good number of tools do not allow the user to define an output color space. Many tools do not provide a definition of the internal color space at all. This leaves the user unable to know for sure what values will be in the final exported files. The second common approach is the assumption of sRGB for the RGB readouts regardless of destination. A Long standing flaw in Adobe® Lightroom® for example is the use of so-called Melissa RGB encoding values presented as percentages in the image info dialog. Melissa RGB is essentially the ProPhotoRGB primaries with an sRGB tonal scale. This means that when you are reading values from a L* based scale in Lightroom® (3 or 4) and you capture a 50L* patch one would assume that the correct exposure would be a 50% readout, however the readouts do not correlate at all to the chart's L* scaling. In Lightroom® 4 Adobe® has offered some relief to users by offering a soft-proof feature where one could select a destination RGB space to read proper RGB values (or device destination space values) but this does little to help the user expecting a 50% value to represent the middle of the tone scale. Adobe® Camera Raw on the other hand, has always offered correct RGB destination readouts but unfortunately continues to limit users to four predefined working spaces with no option for eciRGBv2 L* based workflow. (See Illustration 3)

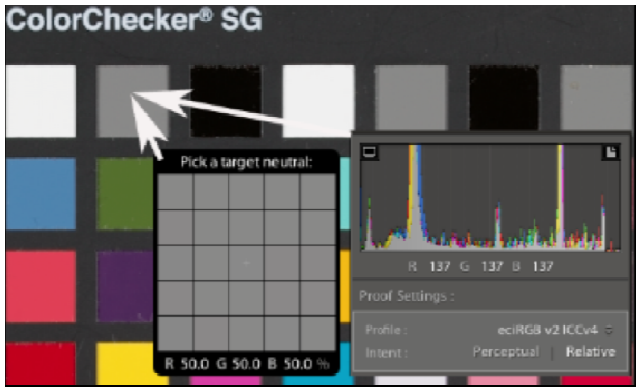

Illustration 3: Adobe Lightroom 4 eyedropper readouts are based upon an sRGB tone scale (Melissa RGB) as opposed to L. This leads to a situation where a user may assume that a 50% readout equals the middle of the RGB destination. The new soft proofing function in Lightroom 4 clearly illustrates that the 50% value over-exposes the middle gray 50L* patch of the DCSG chart (The proper value is 128 not 137). If Adobe used L* instead of sRGB encoding in it's "Melissa RGB space users would enjoy precise control of exposure and an increase in image quality. In addition, Adobe could help lead the industry to adopt more standardized utilization of the DNG file format.*

Several tools tested incorporated L*A*B* readouts along with RGB destination readouts. It is interesting to note that two of the tools that came the closest to the actual chart values use L* as opposed to a particular internal gamma encoding or sRGB assumption. L*A*B* readouts are user friendly because they correlate directly to the L* based grayscale target.(see Illustration 4)

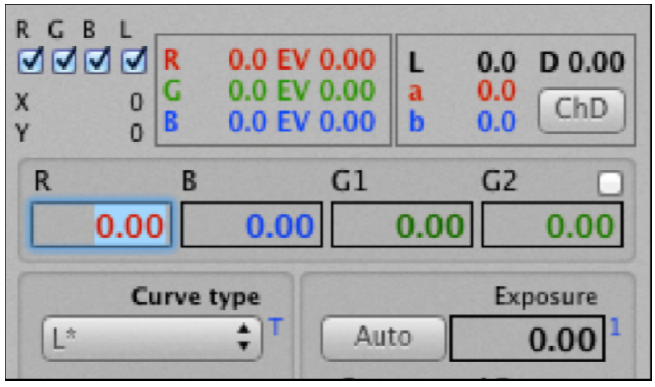

*Illustration 4: The application Raw Photo Processor 64 (an open source tool) offers RGB, L*A*B*, Density and EV readouts as well as L* Tone scaling. It is wonderful to have access to this concise information. Why can't all raw processors incorporate similar readouts?*

Why assuming sRGB may not be the best long-term strategy for raw processors

The use of sRGB as a default encoding for color and tone may have made sense in 1996, but the practice may be slowly moving towards obsolescence. The concept of sRGB was to define a space that represented a typical CRT display. The idea of hard-encoding images to a specific form of output can limit long term-viability as technology has a way of improving over time. Since the development of sRGB, display technology has fully migrated away from CRT technology to flat panel LCD and more recently LED technology that reaches or exceeds the sRGB Gamut, and of course most ink jet printers today exceed sRGB gamut as well. The new Apple iPad is a perfect example of rapid developments in display technology. Just imagine the color gamut of iPad displays five years from now.

Aside from color gamut, the use of 1.8gamma, 2.2gamma and sRGB gamma tonal encoding may also be irrelevant today for the same reasons. While technology moves forward faster than standards efforts there has been one constant; our visual response as described in the CIE LAB color model. People worldwide have enjoyed the benefits of L* encoding thanks to the eciRGBv2 specification. L* scaling in particular is used successfully worldwide via the Metmaorfoze Preservation Imaging Guidelines, and now appears to be finding it's way into the market as more tools offer support for L* encoding. The new L* based gray scale developed for this testing may ultimately replace the Kodak Q-14 grayscale worldwide. L* encoding is fully compatible with the device independent principles behind the ICC color workflow.

The advantages to perceptual encoding have been discussed within film, television, gaming and computer graphics imaging communities. As media continues to converge in the increasingly connected world, the use of legacy gamma encoding has become a barrier to productivity and interoperability.

ICC Profiling Support

Of the fifteen software tools tested only eight supported the ability to create and use custom ICC profiles and only seven allowed the user to fully disable color management down to the linear data level. Two tools that normally support color management literally blocked access to the Leica S2 DNG file as it has been deemed "competitive". This is simply absurd for a file format heavily marketed as "open". In practice, DNG appears to be open with strings attached. Imagine if manufacturers treated Tifff, and Jpeg file formats in this manner? The first phase of this testing has been based upon default settings to serve as a baseline. I hope to document the results of efforts to meet the Metamorfoze and FADGI tolerances using ICC profiling and attention to exposure and tone using these same tools. Once more, it is fascinating that all of this effort needs to be expended to help the same exact DNG data input match it's own data output. Only one of the tools tested incorporates built-in profiling. While it only supports a 24 patch target, the process is completely documented in the application manual which is comforting.

Color Accuracy

While it was not an expectation that the default settings of these tools would generate files that would pass the Metmaorfoze or FADGI tolerances, I had anticipated that results would come close. The Metamorfoze tolerances for the DCSG chart allow for <4 Average DeltaE 1976 values and a maximum of 10. None of the tools met this threshold. Once more, I found it fascinating that the free open source tools tested better than the expensive applications one would expect to deliver better results. As a case in point, the best default result was from an open source tool called Raw Photo Processor 64 (5Avg/13.8Max) compared to Adobe® Camera RAW (18.6Avg/64.8Max). (See Illustration 4)

Why the huge disparity between two interpretations for the same exact file? The testing indicates that the "film-like" curve applied is a major contributor. The tone curve is so aggressive, it throws color and saturation into left field in terms of accuracy. If one simply took the time to adjust the tone curve to published chart values, the results would be greatly improved. It would be far easier if Adobe® and others offered a "reproduction mode" for people requiring accurate imaging. Between poor support for ICC profiling, the ambiguous nature of default tone curves, and confusing data readouts, cultural heritage users are working against many obstacles when it comes to working with the DNG file format.

There may be a value in the findings regarding the similarities of the "film based" curves as this may help manufacturers settle on two standardized curves: one for general use, and a 1:1 curve for reproduction. Users would benefit from clear definitions.

	User Selectable Internal Color Space	User Selectable Output Color Space	Supports eciRGBv2 Output Color Space L*	Support for Custom ICC Input Profiles	Ability to disable all color management	L*A*B* Readouts	RGB Destination Readouts	Built-in ICC profiling	L*A*B* Output	Vignetting/ Lens Corrections	Flat Fielding	Opens Native Leica S2 DNG files	Licensing Cost	Avg Delta E (CIE 1976) Default Settings	Max Delta E (CIE 1976) Default Settings
Lightroom 3		•	•							•		•	249.00	17.6	35.3
Lightroom 4		•	•				• (Via Softproofing)			•		•	145.00	17	33.7
ACR 6.6	• (Restricted)	• (Restricted)					•			•		•	649.95	18.6	64.8
ACR 7 (PS 6.0 Beta)	• (Restricted)	• (Restricted)					•			•		•	n/a	17	34
Capture One		•	•	• (Restricted)	• (Restricted)		•			• (Restricted)	• (Restricted)	• (Restricted)	399.00	16.4	29.8
ACDSee Pro	• (Restricted)	• (Restricted)								•		•	189.00	17.1	36.1
Phocus	• (Restricted)	•	•	• (Restricted)		•	•			• (Restricted)	• (Restricted)	• (Restricted)	Free	16.8	36.7
Raw Developer	•	•		•	•		•					•	125.00	17.9	42
iPhoto												•	14.99	16.8	38.5
Pixelmator		•		•	•		•					•	29.99	16.9	36.5
UFRaw	•	•	•	•	•		n/a					•	Free	8.2	23.7
Photivo	•	•		•	•	n/a	n/a			•		•	Free	7	17.4
Raw Therapee	• (Restricted)	• (Restricted)		•	•	•	•			•	•	•	Free	5	13.8
Picasa												•	Free	6.9	18.9
Raw Photo Processor 64	n/a	• (Restricted)	•	•	•	•	•	•(CC only)	•			•	Free	5	13.8

Illustration 4: This feature matrix indicates that many of the requested UI elements already exist in open source tools. It is interesting to note that 5 of the 6 open source tools tested were far more accurate than the commercial offerings that generally lock users out of essential control elements.

Conclusions

There is a common misconception that the beauty of storing raw data is that it is protected for the future and as technology improves it can be revisited and even "improved" over time. While opening a DNG file will most probably be possible down the road, this initial review underscores the need for better definition of common UI elements. Until the industry matures to a point where the data being created today is clearly defined, storing DNG files as the only representations of cultural heritage materials is a risky proposition.

While it's convenient to market formats as "Digital Negatives" the difference between analog film and digital, is that with film it was impossible to perfectly define the interaction of emulsion batch, camera variables and processing variables. With digital technology every aspect can be perfectly defined. The fact that the same exact DNG file spawned a chaotic mix of results is an indication that the DNG format and the industry as a whole are still extremely immature.

To be clear, the issues are not related to the file format itself, the DNG file format is a solid long-term option for the industry to build upon. The issues raised in this paper are about how the DNG format is currently being supported at the application level. The most positive outcome of this exercise for me is that there ARE existing tools that incorporate the recipe for success. There are user interface elements and core functionalities that can be incorporated into ALL raw processors. Wider adoption of these common elements can serve to uplift the user experience across the board while still allowing companies to differentiate their products in the marketplace:

1) RIMM internal color space (default)
This wide gamut linear working space prevents clipping data and is perfectly suited for raw processing.

2) User selectable output color space (with no restrictions)
There is absolutely no reason to limit the user's choice of destination encoding. There is nothing wrong with a default and advanced mode option to keep things simple for the less advanced user.

3) RGB and L*A*B* Readouts
The Lightroom® model of showing editing values as percentages is quite logical from and end user perspective, but the mapping to sRGB as opposed to L* is a serious flaw that needs to be corrected. Moving to L* readouts gives the user unambiguous access to tonal values that translate properly to destination space upon output.

Tools that show RGB destination AND L*A*B* readouts are the easiest for end users to use as long as it is clear what these numbers represent. L*A*B* readouts are also helpful for users wishing to verify spectral colors using L*A*B* spectrophotometer samples of actual materials.

4) Ability to disable color management (Scene Referred)
The ability to disable color processing to gain access to linear data is helpful for creating custom ICC color profiles.

5) Support for traditional ICC profiles.
While DNG profiles are a new twist on traditional ICC profiles they have limitations. Support for traditional ICC profiling is an absolute necessity. All DNG processors should support ICC profiles.

6) Lens Corrections and Flat Fielding
The ability to incorporate custom lens corrections and flat fielding across various raw processors is an important effort to allow for truly reversible corrections. Settings created in one processor need to be portable to others to insure future viability.

Running these tests has been an eye-opening experience, and the next phase of testing will prove to be extremely challenging. Barbara Bridgers of the Metropolitan Museum of Art once told me of a quote her father Dr. John Bridgers used to describe exploring problems:

1) the problem you are trying to solve
2) the problem you uncover
and the problem you inadvertently create

I set out to solve a simple problem, and have hopefully uncovered some issues through this testing, but I am afraid that I have inadvertently created a larger set of challenges.

In 2011 I helped organize a face-to-face technical meeting between a number of Image Muse Members and Adobe® engineering and marketing representatives to illustrate the challenges we face. The meeting led to some minor changes in Lightroom 4, but even though Adobe® has seen these issues firsthand and even agreed with the findings, I was disappointed to find that the latest versions of Lightroom® 4 and ACR 7 remained for the most part unchanged. I can only take this as a message that Adobe is not taking the DNG format for cultural heritage imaging very seriously. If I appear to be singling out Adobe®, I feel that as they put forth the DNG format it is their responsibility to insure that is it applied in a consistent open manner.

References

[1] **Raw as Archival Still Image Format: A Consideration** Michael J. Bennett, University of Connecticut Libraries and F. Barry Wheeler, Library of Congress (USA)
(IS&T, Den Haag, the Netherlands, NL, 2010) pg. 185.

Author Biography

Scott Geffert is President of ImagingEtc Inc. www.imagingetc.com. A New Jersey based consulting firm specializing in digital imaging workflow and standards compliance. ImagingEtc Inc consults museums and corporations worldwide. Scott has been involved in photography since 1975 and has been active in digital imaging since 1984.