Introducing the Digital Negative Specification: Information for Manufacturers

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The Digital Negative (DNG) specification describes a generalized raw format for digital cameras that can broadly support such files across a variety of workflows and products. Adobe® is introducing this new file specification as a solution to the increasing proliferation of camera-specific raw formats, which complicate shared workflows and create concerns about archiving over a long period of time.

DNG is designed with enough flexibility to have the capability to support just about any digital camera, and it can also evolve over time to keep pace with technology. It is designed to provide for native support within a digital camera, but photographers can also use it later in the workflow by means of conversion utilities. By offering a more universal approach for storing raw camera information, DNG simplifies the use of raw files for vendors and customers alike, and thus should be of interest to manufacturers of cameras, software, printers, and other hardware devices in the photographic workflow.

This document provides a brief overview of the motivation behind the creation of this specification as well as key details about the contents of a DNG file.

What is a raw file?

Manufacturers who have not yet incorporated raw support into their products may still have some questions about exactly what constitutes a raw digital camera file. The term "raw" is appropriate for these camera files, because they represent exposures that have been made, but have not yet been "developed." A raw file contains the actual pixel data captured by a camera sensor before it has undergone any processing inside the camera.

A full-color JPEG or TIFF file typically consists of three color channels—red, green, and blue. The color of each pixel in the image is determined by mixing values of red, green, and blue in varying amounts. However, most digital camera sensors are only capable of capturing one grayscale value at each pixel location. To compensate for this limitation, color filters are used at each pixel, so that each location can capture the amount of either red, green, or blue that is found in the scene. The resulting capture still has just one full channel of information, but some of those pixels represent red values, some represent green, and some represent blue. When the red, green, and blue pixels are separated, they create three incomplete color channels.

To create a JPEG or TIFF file, a digital camera starts with the incomplete color channels captured by the sensor, and does further calculations to fill in the holes in each channel. At this point some of the settings that the photographer specifies before taking the picture—such as white balance and sharpness—are actually applied.

You can think of this final processing of the file to create a JPEG or TIFF as "developing" the file. The raw file represents the information before it has been processed in this way. The raw file includes the actual, incomplete color channels captured by the camera sensor, along with additional metadata that describes the contents and how to make use of them. For example, the white balance and sharpness settings the photographer chose before taking the picture are typically stored as metadata in the raw file, so that they can be used later when the raw file is processed on the computer.

Thus, a raw camera file is the most direct representation of what was captured by the camera sensor, and provides photographers with the ability to more precisely control how the final JPEG or TIFF is generated. It also gives the photographer the ability to

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easily change his or her mind, such as by choosing a different white balance or sharpness setting during processing than was originally picked before taking the shot.

The problem with current raw file formats

Today, there is no accepted standard for storing raw camera files; not only do camera manufacturers create their own formats, but these formats often vary among cameras created by a single manufacturer.

If a photographer uses raw files only as a mechanism to delay the final processing of the files until he or she copies them onto the computer, then perhaps this lack of standardization doesn't appear to be a problem. After copying the raw files to the computer, the photographer can convert these files to JPEG or TIFF using the software provided with the camera. The result is a standards-based, widely-compatible file that's just as good—if not better—than the JPEG or TIFF file that would have been created directly in the camera. At that point, the photographer could even choose to discard the original raw file.

On the contrary, though, photographers do not want to discard their raw files. These raw files represent the original, unadulterated source material—the digital equivalent of the traditional film negative. Understandably, then, photographers want to archive these raw files permanently, so that they can choose to process them again—perhaps differently—in the future. Moreover, given the pace of technological change, it's quite possible that the raw conversion that they can create in the future will be better than the best they can achieve today, because new and better conversion routines may be developed. Therefore, failing to archive the original raw file today means sacrificing both flexibility and quality for the sake of compatibility.

But the current, camera-specific raw file formats are not suitable for archiving. The most important consideration for photographers when choosing an archive format is their confidence that the software will exist to open their files in the future. Camera-specific formats fail to provide photographers this confidence for a number of reasons:

- Eventual obsolescence: One of the best ways to ensure that compatible conversion software will exist in the future is to pick a format for which lots of files continue to be created. A large number of files create significant customer demand, which software manufacturers happily fill. Camera-specific formats, however, may fail to create this demand over time. Because only one specific camera model creates these formats, there is a limit to the total number of files in these formats. When the camera model is discontinued, so are the camera-specific formats.
- Lack of public documentation: For photographers, archiving their files in undocumented file formats is like storing their valuables in a safe for which they don't have the key. Public documentation is necessary to provide information about how to open the files in the future, even after the original products that created the files are no longer available.
- Poor track record: Already, several camera manufacturers have validated the worst fears of photographers by failing to continue support for files created by discontinued camera models. In some cases, photographers must keep older computers in their studio to run their original raw conversion software because the version of the software that was updated for the latest operating systems does not support the original format. This approach is workable—if inconvenient—in the short term, but ten years from now, the old computer may not run.

These problems are presented primarily from the standpoint of individual photographers, but the problems become much more pronounced for large corporations and organizations that work with digital camera images. These organizations typically have a greater number of files to manage and a greater need to ensure that their archives are viable. For some companies, digital images represent a significant asset of the organization, so a loss of their archives equals a significant financial loss. Over many years, organizations acquire many files from many different cameras. Archiving a camera-specific raw file is simply not an option for them. If they followed this archiving method, in time they would find themselves with an archive containing hundreds of different file formats, many of which the organizations could no longer open.

Organizations that accept images from multiple photographers have other problems, however, even if the archival issues are ignored. Publishing organizations would like to incorporate raw files into their workflows to take advantage of the higher quality and flexibility of the files, but organizations are hesitant to do so given the diversity of photographers. If their photographers

submit raw files from different cameras, then the organizations would need to either maintain a library of all the various manufacturer-provided conversion software or use an application, such as Adobe® Photoshop®, that supports files from multiple photographers. In the former case, it can be a significant task to keep the organization's software library current.

How the Digital Negative specification offers a solution

Clearly, a universal raw format is needed to simplify workflows and provide greater archival confidence. However, given that raw files represent the actual data captured by a camera sensor, it's important that such a format be flexible enough to support the wide variety of camera designs that exist today and new designs that will be created in the future. The Digital Negative specification is specifically designed with this flexibility in mind.

The format for storing the image data in a DNG file is based on TIFF-EP, so it conforms to an existing, published standard. The key to the power of a Digital Negative, however, is in the metadata. The metadata in a Digital Negative contains all of the information that a software application needs to convert the file, even if that software application was not designed for the specific camera. This means that a camera that saves to the DNG format could work with any DNG-compatible software application or hardware device.

Of course, for the industry to accept a universal raw format, it needs to support innovation by manufacturers and differentiation of products. Although DNG specifies a required set of metadata that must be included in the file to permit high-quality conversions, it does not restrict the additional metadata that may be included. Manufacturers can extend the DNG file with private metadata that is not publicly documented, so that they can embed special features that may only be unlocked by their own solutions. Therefore, even as the DNG specification enables the image information in raw files to be universally understood, it also lets manufacturers differentiate their products with special features that may go beyond what exists in the specification.

For long term viability, however, the DNG specification must evolve to support new technological advances. The current specification is sufficiently flexible to handle a wide variety of new camera designs, but there is no way to predict exactly what technology breakthroughs could occur in the future. For this reason, a version number is one of the critical pieces of metadata in a DNG file. The version number in the DNG file references the version of the specification that was followed. If advancements in camera design require modifications to the DNG specification, the version number of the specification can be changed, and files created to this new specification can be saved with this new version number. Thus, updated raw converters will know which set of rules to follow when interpreting the files, and older converters will display an error message notifying users that they must update their converter to open this newer file.

Key features of the Digital Negative

For complete details about the contents of a Digital Negative, it is important to read the entire specification. A summary of some of the key characteristics follows:

- Image format: DNG is based on the TIFF-EP format, but DNG specifies the inclusion of a number of additional tags that let the converter properly interpret the raw file.
- Metadata: DNG enables inclusion of metadata in EXIF, IPTC, and XMP formats.
- Compression: Files can be stored as uncompressed (either bit-packed or padded to 16-bits per pixel) or with lossless JPEG compression.
- Color space: DNG files are stored in a linear, nonwhite-balanced color space (usually the native color space of the camera).
- Interpolation: DNG enables file storage either in mosaic (CFA) form or in demosaiced form. Generally, a mosaiced file is preferred because it represents the original data the sensor captured and enables maximum conversion flexibility. It is also smaller than a demosaiced file. In some instances, however, saving a demosaiced file can improve compatibility, particularly if the camera sensor contains an unusual mosaic pattern that all converters do not support.

Implementation options

There are multiple ways in which manufacturers can implement DNG in both hardware and software. Moreover, the existence of a common raw format, such as DNG, makes certain implementations feasible that would not be practical with camera-specific formats.

Camera manufacturers can support DNG in various ways. The most obvious approach is to adopt DNG as the native raw format of the camera. However, there are other options that do not require the same level of commitment. Manufacturers can offer DNG as an alternate raw format within the camera firmware. Just as photographers can choose between JPEG and TIFF, they could be offered the choice between a camera-specific format and DNG. Finally, camera manufacturers can choose to provide a software-only solution for DNG. They can maintain their camera-specific format within the camera firmware, but they can provide a software utility that converts their camera-specific format into Digital Negative. Although this choice is not quite as convenient as a firmware solution, it can ultimately be just as effective, and the resulting files can be of the same quality.

For software manufacturers who already provide a raw conversion solution, the choice to support DNG should be an easy decision. It's likely that these manufacturers are already supporting a variety of different camera-specific formats, so DNG can become another format to support. The incremental work is small, given the benefits. As cameras begin to natively support DNG, future software development costs will decrease.

In addition, software manufacturers who do not currently support raw conversion may find that the introduction of DNG provides a good reason to add such a feature. By supporting one publicly documented format instead of dozens of undocumented ones, the cost of entry is lower.

Hardware manufacturers also may find that supporting DNG expands their options, making it feasible to add raw file support where it was once impractical. For example, a printer manufacturer might choose to add direct support for DNG files from an inserted media card. It's likely that the user of such a device would not receive extensive conversion options, but the default settings encoded in the file could be used to print the raw image just as easily as a JPEG. In general, the presence of a universal raw format promotes broader adoption of raw files across a wide variety of workflows and devices.

Benefits of DNG support to manufacturers

Regardless of the implementation approach that manufacturers use, there are a wide variety of benefits they could potentially experience by adopting DNG. In different ways, hardware and software manufacturers should experience these benefits:

- Increased customer satisfaction: Users are increasingly demanding a universal format mostly because of their archival concerns. User discontent will only increase over time as their collections of raw files increase in size. By supporting DNG, manufacturers can demonstrate their commitment to their users' needs.
- Decreased development and testing costs: DNG can reduce development costs for camera and software vendors. Camera vendors can potentially save money not only by not having to develop their own formats, but also by testing compatibility with off-the-shelf software solutions before their camera has been publicly released. Software vendors can potentially save by not having to develop and test custom support for each camera on the market.
- Broader adoption: When raw files are broadly incorporated in both professional and consumer workflows, everyone involved can benefit. Over the last few years, many of the most exciting developments in digital imaging workflows have centered around raw workflows. A universal format makes it easier for more people to adopt raw files, thereby providing more ways for manufacturers to evolve their products to reach more customers.

Of course, if anyone is to receive these benefits, a company needs to take the first step by encouraging photographers to adopt DNG. That's where Adobe is making a significant investment.

Adobe Photoshop CS and the Adobe Digital Negative Converter

DNG is now supported by Adobe Photoshop, the professional standard in desktop digital imaging. In addition, DNG is also supported by Adobe Photoshop Elements, the market-leading digital imaging software for hobbyists. Support by these applications provides photographers with assurance that they can open DNG files in the future with software they may already be using today.

However, the success of DNG also depends on there being accessible ways to create DNG files. For this reason, Adobe has developed the Adobe Digital Negative Converter, which is available at no charge from the Adobe website. This converter accepts all camera-specific raw formats supported by Photoshop (more than 65 formats) and easily converts them to DNG. The DNG Converter is updated on the same schedule as the Adobe Camera Raw plug-in for Photoshop, which means that it remains current with the latest camera formats that the plug-in supports and provides a simple, free way to generate Digital Negatives.

DNG files that camera manufacturers directly create will always be preferable, but the Adobe DNG Converter achieves two important goals:

- Archival confidence: Photographers who are concerned about the lack of documentation for camera-specific formats can easily convert their files to DNG prior to archiving.
- Compatibility: If a photographer is using a raw converter that does not support their specific camera model—but that does support DNG—they can use Adobe's free converter to convert the file to DNG, and then use their preferred software to generate a final JPEG or TIFF.

It should be noted that the Adobe DNG Converter will not necessarily maintain all of the private metadata in certain camera-specific raw formats because this information is not publicly documented and therefore not available to Adobe. However, the Adobe DNG Converter will maintain all of the original image data as well as all of the metadata needed for a high-quality final conversion. Arguably, the private metadata is not really archival, regardless of the format used, simply because it is undocumented. Nevertheless, Adobe recommends that, when photographers use the Adobe DNG Converter for archival purposes, they should maintain both the resulting DNG file and the original camera-specific file. The DNG file offers greater assurance of longevity, but the camera-specific file may contain more metadata. This distinction does not exist, however, for DNG files created by camera manufacturers because they can include all of the private metadata within the Digital Negative.

What's next?

With the introduction of the Digital Negative specification and the Adobe DNG Converter, Adobe is putting the necessary pieces in place to facilitate a move by the imaging industry toward a universal raw format. Adobe's efforts solve many customer problems related to archiving raw files. But the true promise of a universal raw format will only be achieved when DNG gains support across a wider array of hardware and software solutions. Ultimately, DNG is not intended as an Adobe-only solution. It needs to evolve to suit the requirements of all digital photography vendors and customers, and Adobe welcomes feedback about how the format should be enhanced in future revisions. Ultimately, it may make sense to turn over DNG to an appropriate standards body for further enhancement, so that its evolution can truly be a collaborative effort.

The use of digital camera raw files has been one of the most significant developments in digital photography over the past few years. With the broad adoption of the Digital Negative specification, the power and flexibility of raw files can reach more people across more workflows and have an even greater impact on the advancement of photographic technology.

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