Photography in Heritage Research: In Search of Digital Standards for Image Capture, Image Processing, and Image Delivery
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PHOTOGRAPHY IN HERITAGE RESEARCH

In Search of Digital Standards for Image Capture, Image Processing, and Image Delivery

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Figure 1. “How Many Pixels Do We Need?” Photographic documentation of National Docks Tunnel, Jersey City, NJ, 2008. Digital illustration. (Joseph E. B. Elliott)
Although the efficacy of digital media as a replacement for traditional silver-based media is still being debated and the United States Department of the Interior (HABS) standards for high-level documentation still specify silver-based materials, the field is in a state of transition. The great majority of site documentation is currently captured digitally, and all retrievable images from the Library of Congress are currently delivered digitally. Digital cameras have evolved to the point where image quality can meet even the highest HABS standards at a cost that is comparable to traditional materials. For professional photographic practitioners, it is time to propose digital standards for HABS-level work that will ensure high image quality, accuracy, and integrity of digital information and retrievability of archival images over the long term. At the same time, it makes sense to propose less rigorous standards for field notes, National Register nominations, area surveys, and the like, to guide preservation professionals who use photography in their work. This paper examines the elements of lens, camera, recording material, image adjustment, image storage, and retrieval, comparing the specifications of traditional film practice with digital counterparts currently available. It then proposes new standards to allow for further advances in digital technology that are both mindful of international practice and cost effective.

Introduction

Trained as an artist/photographer, I have worked for over twenty years with the Historic American Buildings Survey (HABS) and its related groups, the Historic American Engineering Record (HAER) and the Historic American Landscapes Survey (HALS). In this paper, these groups collectively will be referred to as HABS. During this period, the field of photography has undergone a monumental transition from silver-based emulsion to digital technology. While this change is not yet complete in the area of architectural and site documentation, it seems only a matter of time before HABS-specified photography will be done completely digitally. Discussions about the transition have taken place within HABS, at the Library of Congress (LoC), and widely across the profession. The process of transition has been slow and deliberate, as it should be. As a professional working in both digital and analog formats, I have been considering this transition for some time, with a sense of the gravity and historical import with which this change is taking place.

This paper is the result of years of professional experience, a literature survey, tests of various combinations of cameras, lenses, and recording media, and several discussions with my colleagues at HABS and the Library of Congress. The analysis and proposal for new HABS standards for digital photography is offered from the perspective of a working photographer, with criteria that are straightforward and not jargon filled. The proposal is a point of departure for further discussion. It does not claim to speak for HABS or for the Library of Congress.
Why Document? Are (New) Standards Necessary?

One of the last bastions of traditional large-format photography is photodocumentation, as specified by HABS standards. HABS standards for architectural drawings, photographic documentation, and written historical narratives date from the inception of the HABS program in the 1930s. The HABS Collection, archived in the Library of Congress (LoC), contains over 500,000 entries documenting 38,000 sites, spanning the architectural and engineering heritage of the United States. Produced and supervised by HABS over the last seventy-five years, it is a vast and priceless resource. The HABS collection, now almost completely digitized, is among the most heavily used collections in the LoC. Additional documentation done to HABS standards is mandated by the National Historic Preservation Act of 1966 (Section 106). Conducted by other federal agencies, or by contracted professionals, this work is supervised by state historic preservation offices (SHPOs) and is housed in state and local repositories across the country. HABS is the oldest governmental entity in the world dedicated to the documentation of cultural heritage, and the only organization that has prescribed and maintained detailed rigorous standards for photographs, drawings, reports, and archival practice since its inception. A search of literature from English Heritage, ICOMOS, and RecorDIM revealed only very general guidelines for photographic documentation. The great tradition of sound recording practices maintained by HABSmust be continued and strengthened by the adoption of new photographic standards as the medium continues to evolve.

For photographic documentation of structures, sites, and landscapes of the highest significance, the Secretary of the Interior’s (HABS) standards prescribe the use of large-format cameras with perspective control (minimum 4- × 5-inch film), black and white safety film, archival processing of negatives, and archival contact prints on fiber-based paper. HABS continues to insist that all submissions to the HABS Collection at LoC meet these standards. These standards are admirable, and have produced thousands of information-rich records that have excellent long-term stability. Even as the collection is digitized for easier accessibility, the original negative remains the root source of information, carefully archived and preserved, ultimately retrievable for rescanning as technology changes. The LoC and HABS remain understandably reluctant to mandate born-digital standards for field photography, given their ephemeral nature as source material, and the complex and constantly changing methods of file translation and archiving of digital information. Born-digital records are those records that are created in a digital format. These records may never have a physical or analog expression. A typical question is “Will we be able to read a TIFF file one hundred years from now?”

Over the past twenty years, photographic practice has moved with increasing rapidity to digital technology. Both the mass and commercial markets for photography are now almost completely digital. Professionals have given up their analog equipment, the availability of film and paper has shrunk drastically, and processing labs have nearly disappeared. At first it appeared that it would take many years for digital technology to match the tonal quality and resolving power of large-format cameras. This is no longer the case. Current sensor technology and lens quality is so high that medium-format digital cameras
now equal or surpass large-format film cameras in output quality. Current high-end 35-mm SLR (single-lens reflex) digital cameras are nearly there as well.

The difficulty of locating practitioners and continuous pressure to cut costs have led to many cases of documentation done at levels considerably lower than HABS standards. Since traditional black and white film processing and printing is a fairly simple process, it is likely that a few practitioners, capable of shooting and processing, will remain in business as long as there is a demand for their services. But as their services become more rarified, difficult to locate, and expensive, the pressure to modify specifications and ease the standards is increasing, especially at state and local levels. Section 106 documentation is often prescribed to mitigate cultural resource loss and change due to construction such as highway realignment, bridge replacement, or land development with the assistance of federal funds. In cases such as these, documentation cost is a minor part of the budget. But baseline documentation, and survey work undertaken by nonprofits or government agencies must often be done with limited budgets.

Born-digital or lower resolution photographic materials are already accepted by other federal agencies and state and local repositories as part of documentation packages. For example, the National Register of Historic Places and National Historic Landmarks Survey Photo Policy Expansion (March 2005) states that NR-NHL will accept photographic prints made from film or digital cameras that meet the “75 year permanence standard,” accompanied by a TIFF file of the image. The policy articulates at some length requirements for photographic paper and processing, digital printing paper, and digital printing ink. No resolution requirements are given for image creation by either film or digital cameras. The state of Vermont prefers documentation to HABS standards but has issued guidelines (August 2008) that modify the standards to be more cost effective. It requires a 35-mm digital or film camera with a “non-distorting lens,” “minimum pixel depth or dimension of 2000 × 3000,” “save as tiff files in RGB format,” “minimum 300 dpi.” And the state accepts digital prints as per the “75-year permanence standard” articulated in the National Register of Historic Places and National Historic Landmarks Survey Photo Policy Expansion (March 2005).

In Colorado the need for archivally stable documentation methods that could be produced quicker and at lower cost than full HABS documentation led to the establishment of three levels of historic site documentation. As of June 2011 the state’s Office of Archaeology and Historic Preservation (OAHP) does not accept any digital material, but for most state-level work requires medium-format film cameras. Level 3 documentation, equivalent to HABS large format criteria, is only rarely required for sites of national significance.

**What Elements Must Be Considered in Establishing New Standards for Digital Photography?**

The process of photographic image creation and management can be broken into three major areas: *image capture, image processing, and image archiving and dissemination.* Current Federal Agencies Digitization Initiative–Still Image Working Group (FADGI), LoC, and National Gallery digitization standards and procedures provide a well-defined basis on
which born-digital images can be specified in the areas of image processing and archiving. The main reference used throughout this paper is Guidelines for Digitizing Cultural Heritage Materials: Creation of Raster Image Master Files, produced by FADGI. This document provides a thorough analysis of the technical issues involved in digital image creation and management, and provides detailed procedures and specifications. These procedures form the basis of this proposal. They have been adjusted and augmented in order to address conditions particular to field photography.

The area that needs the most attention in order to establish specifications is image capture. Although digitization of archival materials is done with cameras and scanners using the same parameters as field photography, this work is done in highly controlled lighting environments by staff using highly structured procedures. The wide range of field conditions, especially wide variation of light intensity and color, equipment variations, expertise and goals of practitioners and clients make image capture the area in most need of new specifications. FADGI, LoC, museums, and other entities have already established parameters for digitizing negatives, prints, and flat art to reveal maximum detail and veracity of tone and color information. It makes sense to use these parameters as a starting point for requirements for born-digital images, but they will need to be augmented for field photography.

The second area that needs specification is digital processing, delivery, and verification. This area will be easier to specify since FADGI’s standards for image adjustment are comprehensive. With slight modification they will be well applicable to born-digital images.

Just as the current HABS standards apply only to image creation, the third area, archiving and dissemination, is beyond the scope of this paper.

Image Capture

The fundamentals of photographic image capture for site documentation remain constant even as the medium shifts from film to digital sensor. Lenses must be sharp and corrected for aberrations, the architecture of the camera must be properly adjusted, the sensor must receive the correct amount of light, the medium must be of high resolution and must be controlled to reveal maximum tonal information, and so forth. Existing HABS standards can easily be modified to control the same parameters in the digital environment. On the other hand, additional new standards must be implemented, particularly in the area of color representation. As will be seen below, the most difficult standard to design will be the standard for image size, since larger image sizes require vastly more expensive digital cameras, in comparison to film cameras. Field testing will be necessary to make a practical comparison and decision as to the most cost effective solution for HABS-quality images.

Lens Quality

Current HABS standards make no mention of lens quality. Best practice for traditional large-format photography includes the use of lenses that are highly corrected for color aberration and barrel distortion, and have a wide field image circle to allow for lens move-
ments. High-quality digital photography requires the use of similarly highly corrected lenses. Current technology also allows digital correction for lens aberration and distortion. This should be acceptable within new standards, provided that the correction software is designed by the manufacturer for the specific lens in use. Generic lens correction software, such as that available within Photoshop, should not be allowed given the high likelihood of further distortion.

Camera Leveling and Lens Movement for Perspective Control

Current HABS specifications require that images be “perspective corrected.” The aim of perspective control is to produce images in which the convergence of vertical lines (and sometimes horizontal lines) is eliminated. An elevation of a building façade in which both vertical and horizontal convergence are eliminated is also referred to as a rectified image. Proportions are accurate and the image is scalable. HABS specifies that a duplicate view of the principal façade of a building include a scale stick. This requirement should remain a part of new standards. All adjustments for perspective control should be done in-camera, as accomplished according to current HABS guidelines by the traditional view camera. The camera back must be horizontally and vertically leveled. The lens is then raised, lowered, shifted sideways, swung, or tilted to achieve proper framing, alignment of vertical and horizontal lines, and focus. These adjustments are possible by using a digital back on a traditional view camera, or by using tilt-shift lenses on SLR digital cameras. Although “perspective corrections” are possible within Photoshop and other software, unless there are measured reference points and specialized rectification software, the image is easily stretched and pulled to the point of inaccuracy. Therefore, perspective correction in Photoshop should not be allowed.

Rectification software has been developed that allows digital image adjustment, including photomontage for large wall elevations, with reference to a set of measured points on the structure. Digitally rectified photography is used widely in the field of historic preservation for assessing surface conditions because the resulting images are measurable. The drawbacks with rectification are that it is time consuming and capable of producing only elevations that are accurate in a single plane. If done properly, then converted to a TIFF file, digitally rectified images should easily fit the criteria for HABS photography. It is worth considering the inclusion of such images within the new digital criteria.

Resolution: Pixel Dimensions

The ability to resolve detail in traditional film is usually thought of as a function of film grain size and negative dimensions. The traditional requirement of 4- × 5-inch fine-grain film yields images of great clarity and detail, enlargeable to 20 × 24 inches or greater. Similarly, the ability to resolve detail in a digital camera image is a function of sensor size and the number of pixels per inch along each side of the sensor. This can also be expressed as total pixels. For example, a camera sensor of 3000 × 4000 pixels creates an image of 12 million pixels, or 12 megapixels. Maximum sensor size is currently limited to about 2
\( \times 3 \) inches and about 60 megapixels. Sensors of this size are available only on very high-end (and very expensive) camera backs, which can be mounted on medium-format DSLR (digital SLR) bodies such as a Hasselblad, or on traditional view cameras. The advantage of such large-size sensors used on traditional view cameras is that they allow full lens movements for perspective control, as described above. The largest sensor currently available in 35-mm format DSLR cameras (much more affordable) is capable of producing about 25 megapixels of information. DSLRs with this size sensor can be used with specialized tilt-shift lenses that allow perspective control. Most consumer DSLRs use an even smaller sensor, producing about 15 megapixels of information.

Negative scanners are capable of creating many more pixels of information because they can scan over a much larger area. FADGI has determined standards for scanning traditional large-format negatives to reveal a high level of information, deliverable to the public as downloadable TIFF files. It will be useful to use these standards as a point of reference for adequate information in a born-digital image, providing the low end of the range of a resolution standard.

- For scanning negatives up to \( 4 \times 5 \) inches, the FADGI standard is 4000 pixels across the long dimension, or about 3200 \( \times \) 4000 pixels. A 13-megapixel camera is capable of producing this level of information.
- For scanning negatives between \( 4 \times 5 \) and \( 8 \times 10 \), the FADGI standard is 6000 pixels across the long dimension, or about 4800 \( \times \) 6000 pixels. This would require a 29- to 30-megapixel camera.
- For another point of reference, LoC scanning of the HABS/HAER archive is done at 5000 pixels on the long side, or about 4000 \( \times \) 5000 pixels for all size negatives and transparencies. This level of information would require a 20-megapixel camera.

It can be seen that the LoC scanning standard of 20 megapixels falls about halfway between the FADGI standards. This is the threshold standard for pixel dimensions, a level of information achievable with a DSLR or digital back producing 21–25 megapixels. The upper end of a new standard should be the maximum number of pixels deliverable by current digital technology, approximately 50 megapixels.

To evaluate these parameters in practical settings, test exposures were made on various cameras on two different occasions. In both tests, camera locations were identical, or nearly so. Lens and media dimensions were matched to approximately equal fields of view. I include here the full uncropped images as well as enlargements of small areas.

**Test 1**

Elevations were made of a small commercial building in Philadelphia using three cameras: a 21-megapixel Canon digital SLR (Fig. 2, top), a 31-megapixel Hasselblad digital SLR (Fig. 2, middle), and a traditional view camera using \( 4 \times 5 \) film (Fig. 2, bottom). Camera and lens specifications are included in the appendix. I scanned the \( 4 \times 5 \) negative at 1200 dpi on a flat bed scanner. Since FADGI recommends sharpening of scanned images, I sharpened
each of the cropped images (amount 200%, radius 1 pixel, threshold 0 levels). These figures are shown in Figure 3. Finally, I made 16-× 20-inch digital prints of each image at 300 ppi on an Epson 9800 inkjet printer and a traditional darkroom print from the 4 × 5 negative.

Result of Test 1: In the printed images, both the Canon 5D and the Hasselblad H3D rendered detail equal to the 4 × 5 film camera, on the basis of 16 × 20 image size at 300 ppi. In the cropped enlargements (Fig. 3), the Canon appeared sharpest, the Hasselblad was in the middle, and the 4 × 5 camera image appeared least sharp. Sharpening the 4 × 5 image brought the apparent sharpness to the level of the unsharpened Canon image. Sharpening the Hasselblad image surpassed the unsharpened Canon file. But sharpening the smaller file of the Canon made it too harsh.

Test 2
A blast furnace plant in Steubenville, Ohio, was photographed in perspective, using only the Canon 5D (Fig. 4) and a view camera (Fig. 5). The negative was scanned at 1200 dpi, then scanned again at 2400 dpi. All three files were sharpened 125%, 1-pixel, 0-levels, and 33-inch-wide inkjet prints were made of the digital image as well as the negative scanned at 1200 dpi and 2400 dpi.

Result of Test 2: Examination of the prints showed only minimally lower resolution of detail in the image from the Canon 5D in comparison to the image from the scanned negative. The print from the 2400-dpi scan appeared identical to the print from the 1200-dpi scan.

In comparison to scanning standards, both the Canon and the Hasselblad cameras will yield pixel dimensions equal to or greater than LoC scanning of the HABS archive. In comparison to FADGI guidelines, the Canon falls in between the maximum and minimum and the Hasselblad exceeds them.

Noise is in part a function of bit depth and camera ISO setting (see below), but it is also related to pixel dimensions. After doing a large amount of digital printing recently I notice that images from the 21-megapixel camera begin to get noise (graininess) in the shadows faster than they lose sharpness at high magnification, even at the lowest ISO setting. This reinforces my opinion that we need a standard of high bit depth and low ISO setting, as below, but it also seems to call for higher pixel dimensions that are required for adequate resolution, since more pixels per inch will also provide smoother tonal transitions and better shadow detail.

For comparisons at higher pixel dimensions, Atkinson, Cramer, Reichman, and Sanderson conducted similar but more exhaustive lens/camera tests, comparing drum-scanned 4 × 5 film with cameras of resolution as high as 40 megabytes. They found only the slightest advantage of the 4 × 5 film over the 40-megabyte camera. It would seem that 40 megabytes might be the threshold of the higher end of the range for a resolution standard.

If we were to set the standard for image size (pixel dimensions) based on print resolution alone, and we determine that a 16 × 20 (or larger) print looks equally sharp from
any of the cameras tested, we would conclude that a 21-megapixel image size should be the new HABS standard. But if we also want to ensure minimal noise (better tonal information) in the shadows, then we would want a higher standard for image size, in the range of 40 megapixels.

**Exposure: Highlight and Shadow Detail, Noise, ISO**

Equal in importance to resolution in photographic documentation is the ability to render the complete tonal range, with full highlight and shadow detail. Field conditions often have a range of light intensities far in excess of that found in copy work. Negative film has a large tonal range and can be controlled during development, but still struggles to record all the detail in extreme conditions. Best practice is to work in diffused, even lighting conditions whenever possible. Even at low ISO speed and high bit depth (see below)
digital sensors will have more difficulty than film in recording both highlight and shadow detail in high-contrast light conditions.

The digital camera uses the most light to record the image when it is set at its lowest ISO (light sensitivity) setting. Raising the ISO means that the camera accepts less light to record the image, then amplifies it to produce full exposure range. Increased amplification results in noise (coarse, flat tones) in the shadows. Although advancing technology allows cameras to achieve impressive results at very high ISO settings, it still makes sense to work at the lowest practical ISO to minimize noise and achieve maximum shadow detail. Most recording photography can be done on a tripod at low shutter speeds, so it is not necessary to work at anything but the lowest ISO setting.

A new digital procedure for dealing with high-contrast situations (often referred to as high dynamic range or HDR) is to make multiple exposures to record highlight and
shadow detail, then combine them using automated software. While this procedure often works beautifully, it strays from the traditional single reference raw file. It requires that all exposures be in exact registration, and is easily overmanipulated to the point of unreality. From the perspective of archival rigor, it seems unwise to accept images produced from a composite of different originals. By readjusting the exposure of the original raw file and making several copies, an HDR procedure can be applied that similarly extends the tonal range captured from an image file.

Bit Depth: Tonal Subtlety

Bit depth determines how finely the tonal scale can be divided, therefore how subtly tones and colors can be rendered. Although LoC scans at 24-bit RGB, 8-bit gray scale, FADGI recommends 48-bit RGB, 16-bit gray scale. Higher bit depth can match shade and the
density range of film. Tonal adjustments will be finer, with less tonal loss if done at high bit depth. Although current monitors and printers work at 24-bit RGB, it makes sense to process and store final files at high bit depth. For image capture, 14–16 bits per channel should be required.

Working Space
Adobe RGB 1998 color working space is the industry standard and will make full use of the color gamut of most input and output devices. Final images should be adjusted and delivered with this profile. All digital cameras have distinct (embedded) profiles based on the manufacturer’s design of hardware and software, but most sophisticated cameras have the capability of in-camera conversion to Adobe RGB 1998. Best practice would be to set the camera profile to Adobe RGB 1998 and avoid conversion during the adjustment process.

White Balance: Color Neutrality, Accurate Color Rendition
This is probably the most difficult area to deal with in establishing new standards and procedures. In comparison to the highly controlled conditions in which digitization takes place, field photography is done in widely varying conditions of light intensity and color. Current HABS standards specify only black and white film, thus color conditions did not need to be considered at all. Traditional color film has fixed white balance, depending on film design. Each film type is designed to render proper white balance at only one color temperature, such as daylight (5000K) or tungsten light (3200K). Photographers must achieve proper white balance in other conditions by changing lights or adding filters over the lens.

In the shift from film to digital sensor as recording material these color parameters
became much more malleable. Since all sensors operate in color it would be absurd to throw out color information to maintain a black and white standard. White balance can be applied to raw data by adjusting color temperature before or after the exposure is made. Only on conversion to a JPEG or TIFF file are color temperature determinations permanently embedded in the file. To allow for full control of color and exposure it is essential that born-digital images be shot in raw camera format, then adjusted during the editing process.

Proper procedure for accurate color representation of originals (FADGI) specifies the insertion of a color reference scale or target, and/or grayscale within the image area, just outside the object. Reference targets provide known measurements of color information and can provide a baseline for numerical adjustment, and for visual comparison and adjustment of images based on monitor viewing or other outputs.

For field photography it makes sense to begin with a custom white balance (color temperature) setting for the light conditions of each series of views. Second, include a duplicate image that uses a reference target (X-Rite Color Checker or equivalent) for each series of views made in the same light conditions. During processing, the images can all be adjusted to proper white balance using the same settings. The reference image should remain with the submitted documentation for future calibration.

File Format

Raw format yields unprocessed color and light data, which can be adjusted for tone, exposure, contrast, and lens aberrations using the camera manufacturer’s software, as well as by using industry standard software such as Photoshop. The adjustment of raw data yields the finest possible control of image characteristics. Conversion of raw files to universally accepted formats such as JPEG or TIFF converts this data to images that are readable with a wide range of software. Further color and tonal decisions such as intensity, hue, and saturation, as well as image size, proportion, and the like are also possible.

It makes sense to capture the raw data, then deliver the adjusted TIFF file as well as the original raw file. For a time it was felt that raw data were useless to anyone but the original creator, due to the nonstandardization of raw formats among manufacturers. With better accessibility through Photoshop plug-ins this argument is diminished. It is essential that the raw file be provided as a reference for checking adjusted files for geometric, color, and tonal accuracy. After discussion with colleagues at HABS and LoC it seems that, at best, the inclusion of the raw file with the adjusted TIFF archival image would only be useful as a check for accuracy. At this point it, seems unlikely that it would be archived permanently.

Metadata

A great advantage of digital photography over traditional photography is the inclusion of vast amounts of information in the metadata within each image file, including all camera and lens settings. Even as images are converted from raw to TIFF files, metadata is auto-
matically migrated between formats. Metadata will be vital for future reference, and for verification of accuracy and proper procedure in born-digital photographs.

Accurate camera location and date of exposure have always been essential to HABS practice. New HABS standards should include GPS (global positioning system) information in the metadata for each image. This can be accomplished by manual entry, preferably by plug-in GPS devices available for professional-level cameras.

**Image Processing, Delivery, Verification**

Once a proper image has been made in the camera, image adjustment and processing can follow guidelines very similar to those recently established by FADGI. Although adjustments and conversions to readable files can be done strictly numerically, the skills of an experienced visual technician (usually the photographer) will be necessary to adjust the image for high-quality tone and color control.

If images have been exposed properly, only the minimal amount of image adjustment for tonal range and color accuracy will be necessary during the processing phase. These adjustments are analogous to the exposure and tonal adjustments made in traditional darkroom processing. If the image was made properly with good exposure and good color control it should be nearly correct as shot. Drastic corrections for bad exposure will cause multiple tonal aberrations in color balance and saturation shifts.

Image adjustment should take place in an environment controlled for color neutrality and light level, using a properly calibrated monitor. For a more thorough discussion of a proper working environment see FADGI guidelines. The working space of the computer and software should be set to Adobe RGB 1998. Workflow should begin by making initial tonal and color adjustments to the raw file software from the camera manufacturer or within Photoshop. The image should then be transferred to Photoshop where final color and tonal adjustments can be made. It is recommended that these adjustments be done using adjustment layers.

**Tonal Adjustment: Levels, Contrast, Open Shadows**

Tonal adjustments include setting of black and white points, exposure adjustment, highlight recovery, and contrast adjustments. These adjustments can be done first through the raw dialogue box, and then in Photoshop using levels, curves, and shadow/highlight adjustments. It is best not to use coarse adjustments such as auto levels, and brightness/contrast. Traditional HABS practice requires relatively low-contrast images with good detail in both highlights and shadows.

**Color Adjustment**

If white balance adjustment was done properly at the time of exposure, the image should have little or no color cast and need little adjustment. Within a series of views made in the same light conditions, matching of the color temperature of the raw files will put all the colors in the same place. Once the files are opened in Photoshop the image containing
the color reference target can be adjusted for gray neutrality either numerically or by visual comparison to the target. For a more thorough discussion see FADGI guidelines.

**Sharpening**

Sharpening is a digital process that raises contrast at tonal edges, thus raising perceived sharpness. In other words, it articulates tonal differences and textural detail more clearly. Appropriate sharpening can enhance most images, but sharpening is achieved at a loss of resolution, since pixels are given up to increase contrast. Oversharpening degrades sharpness and introduces artifacts into the image. Since sharpening can be done both with in-camera software and at the image processing stage, it makes sense to create the original raw file with no sharpening, yielding the highest resolution possible. Appropriate sharpening can easily be done after the point of image delivery by the end user, thus it does not make sense to sharpen the master archival image.

**Resizing**

The main requirement here is that cropping and resampling (changing the total number of pixels) should not be allowed. Images are easily resized to increase pixel dimensions, but no new information is created. The existing information is simply distributed to a larger number of pixels. Submitted TIFF files should be checked by comparison to the original raw file: the total pixel dimensions of each should match. Repositories may choose to require images be delivered in standardized dimensions and pixels per inch, but these adjustments would best be done by repository personnel.

**Conversion to TIFF Master Image**

After image adjustment is complete, images should be flattened and saved in uncompressed 48-bit TIFF format.

**Proper Metadata**

Metadata should be added to the TIFF file according to protocol established by the repository. This could include maker, caption, location, HABS number, and so on.

**Print**

HABS has traditionally required that an archival contact print be submitted along with the negative. LoC uses the contact prints, mounted on photomount cards in binders as indexing devices, and as a backup image in case the negative is lost. In recent years, LoC has accepted archival digital prints from scans of the negatives in place of contact prints. As a backup against loss of the master TIFF file it would be wise to require an archival 8 × 10 at 300 ppi digital print.

**Delivery and Evaluation**

Evaluation of image quality is a vital part of the documentation process. For traditional large-format photography the submission of the negative and a contact print showing the
edge of the cut film provide proof of camera position and geometry, proper focus, and exposure, assuring accuracy of representation. In addition, negative and prints can be tested to be sure they are free of residual processing chemicals, assuring their archival longevity.

Born-digital imagery will similarly need to be inspected for adequate resolution, focus, and exposure. Camera geometry will need to be more carefully verified, given the absence of a negative, and since cropping and perspective adjustment can be so easily done with processing software. The easiest way to check accuracy will be to require the submission of the original raw file (with appropriate software plug-in) along with the adjusted TIFF master file. Original metadata will identify pixel dimensions, exposure, and color information as recorded by the camera, and visual comparison will verify camera geometry. The raw file could be discarded after checking, but it makes more sense to archive it for reference.

Finally, it would be wise to have the maker submit credentials and equipment and software specifications.

Cost Considerations
How much information is enough? Should we set standards based on the maximum that technology can deliver, maintaining the great tradition of HABS photography as the benchmark of photographic documentation practice? Or should standards be based on Web-deliverable information that can be accessed by the public? What is the end use of this visual information? What about cost considerations?

It is easy to advocate for state-of-the-art digital equipment, able to capture information equal to or exceeding current HABS film standards. Documentation may be the only thing that survives (as in Section 106 work), so it should be the most thorough possible, even though very expensive. View cameras equipped with high-resolution digital backs (40 + megapixels) and appropriate lenses can easily run as high as $50,000.

The purpose of work undertaken by HABS, or by others governed by HABS guidelines, is to provide a record of the built environment of the United States, in written and graphic form. The materials are to be accurate, clear, and reproducible, and decipherable by the general public. They are interpretive, not intended as engineering, construction, or as-built drawings, nor are they intended as condition surveys. Since access to this information will be almost entirely Web based, detail in excess of that provided by current LoC or FADGI scanning standards may be unnecessary, and unnecessarily expensive. Will standards that are too high result in lower quality documentation being performed, or more attempts to circumvent the standards? A high-resolution 35-mm DSLR with appropriate lenses, able to produce images that meet FADGI scanning standards and print beautifully at 16 × 20 inches, can be had for under $10,000. Given the cost constraints associated with many recordation projects, this level of resolution may be the most sensible way to go. On the other hand, should we look to the future, when improved technology makes huge file sizes easily archivable and deliverable over the Web, and argue for the high cost solution?
Conclusion: Proposal to HABS/ LoC for New Digital Standards

After extensive discussion with colleagues at LoC and HABS it seems best to require camera standards that are currently at the highest level available in digital capture, thus continuing HABS specifications as the “gold standard” of photographic documentation. Given the high cost of camera equipment necessary for this level of quality, I suggest that HABS consider a second level of resolution, achievable at more reasonable cost, for sites and structures that are not of the highest national significance. At this second level, pixel dimensions would be reduced, but all other specifications would remain the same, ensuring integrity of dimension, perspective, color reproduction, and the like. I offer the following elements to be considered in establishing new HABS photographic standards. As per the original HABS film-based standards, I have tried to keep them clear, simple, and practical.

Image Capture
- Minimum pixel dimensions:
  - Highest level: camera/digital back must be able to create at least 8000 pixels on the long side or at least 50 megapixels of information
  - Second level: camera/digital back must be able to create at least 5000 pixels on the long side or at least 21 megapixels of information
- Camera must be leveled and perspective adjustments made with movable lens
- Working space: Adobe RGB 1998
- Lowest practical ISO must be used
- Bit depth 14–16 bits per channel, 42–48 bit RGB
- Image file format: Camera RAW
- GPS information included in metadata for each view
- Elevation of principal façade must include duplicate view with scale stick and color calibration target
- Additional view with color calibration target must be included with each set of images produced under different light conditions

Image Processing
- Working space: Adobe RGB 1998
- Bit depth of image during processing: 48-bit RGB
- Raw file to be adjusted for exposure, contrast, and white balance
- Acceptable adjustments: exposure, tone, contrast range, and color neutrality
- Unacceptable adjustments: Cropping, perspective adjustments, resampling to increase pixel dimensions, and sharpening

Delivered Images, for Each View
- Original RAW file, needed to verify accuracy of final TIFF file
- Flattened final file delivered as TIFF format 48-bit RGB
- 8 × 10 at 300 ppi archival digital print
Basic capture metadata: camera, file format, image dimensions, color space, GPS data, creator, and date

Due to the relatively limited amount of data available for the tests I made, it is clear that more extensive testing needs to be performed before standards can be implemented with confidence. It would be best to do several large-scale recording projects in varying environments using 4 × 5 film, a 20- to 25-megapixel camera, and a 40- to 50-megapixel camera in parallel, then compare results. I am confident, however, that the standards ultimately implemented will not be far from what I am proposing here.

Even as new digital standards are introduced, HABS should leave in force existing standards, as long as traditional film, paper, and processing are available. At present, traditional materials continue to be the most cost-effective means of high-quality documentation.

In thinking through these requirements it has become clear that HABS should also create a new set of guidelines, or best practices, for digital image production. In addition to technical guidelines, best practices should also include the proper approach to thorough documentation, requisite views for typical projects, including the duplication of historical views, and other critical information necessary for creating a photographic archive.

Appendix

Camera test data

Figure 2, top
Canon EOS 5D Mark 2
5616 × 3744 pixels
22.65-megapixel raw file size
ISO 200
f/16
Lens: TS-E 24 mm f/3.4L

Figure 2, middle
Hasselblad H3D 11–31 HCD 28
6534 × 4908 pixels
39–44 megapixel raw file size
ISO 100
f/16
Lens: 28 mm

Figure 2, bottom
Horseman 4 × 5 monorail view camera
Kodak TMax 400 film
ISO 320
f/16
Lens: Fujinon 75 mm f5.6
Negative Scanned at 1200 dpi
5588 × 4425 pixels

Figure 4, top
Canon EOS 5D Mark 2
5616 × 3744 pixels
22.65-megapixel raw file size
ISO 200
f16
Lens: TS-E 24 mm f3.4L

Figure 4, bottom
Sinar 4 × 5 monorail view camera
Kodak TMax 400 film
ISO 320
f16
Lens: Schneider Super Angulon XL 90 mm f5.6
Negative scanned at 1200 dpi

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References