The Library of Congress
Technical Standards for Digital Conversion
Of Text and Graphic Materials

1   Introduction

"For the general public, the Congress has endorsed the creation of a National Digital Library through a private-public partnership that will create high-quality content in electronic form and thereby provide remote access to the most interesting and educationally valuable core of the Library's Americana collections. Schools, libraries, and homes will have access to new and important material in their own localities along with the same freedom readers have always had within public reading rooms to interpret, rearrange, and use the material for their own individual needs."
James Billington, Librarian of Congress, Fall 1995

By the time Dr. Billington announced the new National Digital Library, there already existed a significant history of digitization at the Library of Congress (hereafter referred to as the Library). The conversion of materials from the collections of the Library of Congress has roots in the pilot projects and programs of the 1980's. With the advent of the National Digital Library Program, the Library staff began to develop a series of standards and best practices that have guided the Library's digital conversion programs. These standards have been modified over time; this document presents the most current digitization standards available to-date at the Library, and also features the historical documents on which the standards are based.

Over time, a digitization process has emerged at the Library that follows a pattern of planning, content production, web assembly and site maintenance. This document focuses on the first two stages of this process. Topics within the scope of this document include planning, digital image capture (including device characterization, document handling, image quality standards, and imaging workflow), digital file management (including file formats, naming and storage), technical metadata (included technical, structural, preservation and descriptive metadata contained in the TIF header tags), and quality assurance.

1.1   Project Planning

The Library sets out a standard procedure for planning the digital conversion of materials from its collections. After specific material has been selected and the project goals defined, the process focuses on a formal requirements analysis that documents each element of the digitization process. In addition to general project descriptive information, the requirements analysis focuses on the materials proposed, the general digitization specifications, copyright, conservation, access, storage, and "digital object behavior" requirements.

The Library of Congress is careful to respect copyright and individual privacy rights. Copyright research and privacy clearances are done outside the actual imaging process. A preliminary assessment of copyright and privacy issues is part of the planning process and materials are not

scanned without an understanding that the project outcomes will be within the legal restrictions of copyright and privacy laws.

Please Note:
This presentation focuses on imaging of text and graphic materials – it does not include audio and video conversion standards. The following activities are also beyond the scope of this web site, including those that take place prior to imaging (materials selection, preservation and conservation), details of digital preservation, the development of descriptive metadata beyond the TIFF header data, the creation of derivative image files and the web design process.

2   Current Technical Standards

These technical standards are intended to summarize current standards and best practices used at the Library. These standards provide guidance for the production of the "master" image to be retained by the Library in its "warehouse" storage area. A variety of derivative files may be prepared from these master images for display on the Library's web site or for distribution. In the Library's best practices, TIFF master files are produced to different standards depending on the intended usage of the files -

- Grayscale TIFF files are produced where color content does not exist or is not deemed significant. Books, manuscripts and sheet music or books fall into this category.
- Fine quality grayscale or color TIFF image files are produced where color information exists in the content, or where the artifactual value is extremely important. Rare books, maps, and photographs are within this category.
- Rarely, bitonal TIFF files may be accepted when representation of the document content is the sole requirement. This consideration is generally the result of external relationships.

2.1   Document Management and Handling

Library Divisions manage all collection materials and handling requirements set by the Division must be adhered to. Additionally, the Library's Conservation Office must be involved from the beginning of all imaging projects.

2.1.1   Conservation

All materials must have a conservation assessment prior to scanning. Based on the assessment, materials may need conservation treatment or re-housing before they are taken to the scanning workstation. In all cases a complete document collation should be prepared before scanning.

2.1.2   Equipment

The Division curator and Library's Conservation Office staff must approve all equipment used in the scanning process. No equipment used for image capture shall damage original materials nor shall the manner of its use cause damage. This includes, but is not limited to –

Book cradles and other supports for bound materials.
- Weights and special supports for materials.
- The contractor may use other physical supports if approved by the Library such as flexible, wedge-like supports combined with materials to support the book spine as the weight of the text block shifts during scanning.
- The contractor shall not use any materials that may result in tearing or chipping of pages, damage to the spine or to the text block, or damage to the area where the text block is attached to the cover of the book.
- The contractor may use a sheet of glass applied gently by the operator to the single page that is being scanned. Any glass that spans a book gutter must have special approval.

Special supports for unbound materials.

- Certain unbound materials, such as folded sheets of music, may require other types of support. For example, fragile sheet music that has been folded for long periods of time has a tendency to tear at the fold.
- These types of folded sheets shall not be scanned with the crease pressed flat against the scanning bed. While these sheets can normally be inverted and scanned page-by-page on a book scanner and sometimes on a typical flatbed scanner, the area or page that is not being scanned must be supported to prevent damage or undue stress to the crease or to the pages themselves.
- The contractor shall provide a support mechanism that will accommodate these requirements. This support structure need not be elaborate, but must be functionally adequate to meet the requirements.

Lighting equipment of all kinds
- The Division curator and Library's Conservation Office staff must approve both general environmental illumination and scanner specific lighting.

2.1.3   Handling Pictorial Materials

The capture device(s) and production workflow to be utilized shall not cause harm to the materials being scanned. Harm may be caused by such factors as excessive handling, inversion of fragile items, flattening, surface abrasion, excessive illumination, and excessive heat.

Most of the black-and-white photographic negatives to be scanned are medium-format (4x5 and 5x7 inches) safety film. Other negatives range in size from 35mm to 11x14 inches. Any nitrate-based negative materials to be scanned will be identified in each project. Work with nitrate-based film shall be completed in accordance with the special handling rules and requirements as specified by the Library.

Color transparencies and color negatives range in size from mounted 2 x 2-inch slides to 8 x 10-inch sheet films. Color film materials are typically housed in Mylar jackets or sleeves within an additional paper sleeve. All film-based materials, such as black-and-white photonegatives and color transparencies not in Mylar sleeves shall be handled with clean cotton gloves and resleeved into their original housings. When rehousing, the emulsion side of film items shall face the non-sealed side (the side without an adhesive seam) of the sleeve or jacket. It may be required that glass negatives be scanned emulsion side up to prevent surface abrasion or image loss, and laterally reversed during image post processing.

Items identified as either fragile or being curved, cupped, or warped shall not (1) be flattened against or under glass or (2) turned face down for capture.

2.1.4   Other Materials

Specific handling instructions will be specified for each project.   In consideration of the safety of the collections, the Library may alter handling rules, workstation handling requirements, or withdraw materials from scanning. In some situations, the Library may require that a Library employee accompany and/or handle the material at the scanning station.

2.2   Scanner Characterization

The evaluation of technical image quality and adherence to standards generally is approached in two stages. First, scanners are "characterized" through the use of sample images and targets designed to measure tonal reproduction, dynamic range, resolution, noise, color accuracy and additional characteristics that are determined to be of particular importance for a given application. This data helps in the selection of an appropriate scanner for the project and helps operators install, configure, and set the equipment controls properly. Second, a target may be included with every image or on specific occasions such as the first and last image of a document. This data helps insure that the ongoing imaging work maintains the original quality specifications. Historically, the Library has used the USAF 1993 Visual Resolution Test Target (and similar derivatives) to establish that visual resolution is in compliance with requirements. Tonal representation has been evaluated through visual inspection of sample and actual images selected from scanner output.

Now ISO standards for the measurement of the appropriate image quality elements have been approved and the Library has begun to test and characterize scanners through the use of Standard ISO targets as well as with sample images. (Note that a more detailed discussion of image evaluation is provided in the section of Quality Assurance later in this document.) The Library is currently implementing test procedures following the standards listed below:

ISO No.	Date	Title	Description
14524	1999	Opto-Electronic Conversion Function (tonal reproduction)	Electronic still-picture cameras -- Methods for measuring optoelectronic conversion functions (OECFs)
16067-1	2003	Resolution -- Spatial resolution measurements	Electronic scanners for photographic images -- Part 1: Scanners for reflective media
16067-2	2004	Resolution -- Spatial resolution measurements	Electronic scanners for photographic images -- Part 2: Film scanners
15739	2003	Noise measurements	Electronic still picture imaging
21550	2004	Dynamic Range	Electronic scanners for photographic images
22028-1	2004	ICC Specification Revision	ICC.1:1998File format for color profiles, version 4.1

2.2.1   Standard Targets and Tests

2.2.1 - A   Resolution

In order to verify the calibration of the scanning equipment and to ensure the best possible images, the Library requires that certain standard targets be scanned and that procedures for use of the specified targets be followed. The Library may select targets that are appropriate to the project and these are to be scanned and submitted prior to work commencing. Additionally, the Library will require delivery of specified scanned technical targets during the installation and configuration of scanning equipment, and may require them during the ongoing production of images. Targets to be scanned and delivered will be specified by the Library at the time a project is initiated.

The Library will provide standard targets to be scanned by the service provider. Corporate owned targets may be used upon approval by the Library. The targets shall be delivered as image files for subsequent analysis by the Library. The contractor may include the company analysis and interpretation.

Target images may be required at the following times:

- Prior to the initiation of a project (before a scanner is installed at the Library);
- Upon initial installation of equipment at the Library;
- When new equipment is installed;
- Whenever a new operator is trained to operate the scanning or post-processing equipment;
- Whenever the Library's quality review indicates a significant increase in quality problems. The Library will notify the contractor of this requirement;
- On a regular basis for projects when many batches are delivered over a period of performance greater than one month.

In general the Library expects imaging equipment set to yield images at 1:1 using optical resolution without resampling. Thus a scanner with 6000 pixels in the long dimension (as reported in TIF 256 tag, ImageWidth) might be set at a working height to yield 300 pixels per inch (reported in the 282 tag, XResolution). A document as large as 20" on it's long dimension could be scanned. A straight vertical line 1/100 of an inch wide on a document would then show

on the image as a straight vertical line exactly 3 pixels wide. The line tonality on the image would be uniform and similar to the tonality on the document, the line edges would be straight and precise, and no stray pixels on either side on the line would be darkened. Unfortunately, many scanners that are presented as "300ppi" in manufacturer's literature cannot image the line precisely. Until recently, the standard test of scanner resolution has been a target prepared with pairs of lines of various widths presented for visual inspection. This test is not very rigorous – reviewers can distinguish fine lines that are not uniform in tonality and there may be many stray pixels inaccurately darkened; images from such equipment may look fuzzy and lack fine detail. ISO standard 16067 was designed to overcome this problem. Frequently the results of the ISO standard measurement are considerably lower than reported under the older visual inspection method. Currently the Library uses both visual and ISO 16067 targets to provide a more complete indication of scanner resolution.

2.2.1.A.1 Resolution Targets

The standard measure of resolution is based on Modulation Transfer Function (MTF) per ISO-16067-1 (for reflective materials) or ISO-16067-2 (for transmission materials) using slant-edge targets such as the QA-61 or QA-62 Targets. Visual measurements of resolution based on ISO 12223 Standard targets, on the USAF 1951 test target, or on the RIT Alphanumeric target may be used to supplement the MTF measurements.

2.2.1.A.2 Tests

- Software produced MTF/SFR curves of vertical and horizontal resolution in both center and at least one corner.
- Visual inspection of the center and at least one corner for both vertical and horizontal resolution may supplement the MTF analysis.

2.2.1.A.3 Standards

- For content presentations that will not involve OCR, the current standard is a minimum visual resolution of 300 ppi in the image center (both measurements) with minimal loss of quality in the corners, and a minimum MTF10 resolution of 300 ppi in the image center (both vertical and horizontal measurements) with minimum loss of quality in the corners. A minimum resolution of 400 ppi is considered standard practice with 300 ppi generally only used for large format materials where lower resolution is mandated by device limitations and stitching is not practical or desirable.
- For images that contain text that will be OCR'ed, the standard will be 400 ppi for both visual and MTF measurements.
- For Rare Book and other special materials the standard is a minimum of 400 ppi and may be higher as planned project outcomes require.

2.2.1 - B   Tonality

Eight-bit grayscale is the minimum bit depth required for any digital conversion work at the Library. Previous and current standards require a visual comparison between the original and the image. The Library is beginning to formally characterize scanners using the ISO 14524 OECF targets listed below.

Targets for tonal analysis

- Sample scans of selected materials.
- ISO-16067-1 based scanner targets such as the Kodak Q-13 target or the QA-61 and QA-62 targets. (These targets commonly present a 20 step gray scale although specific targets may vary. When different targets are used, the software necessary to analyze the target may be requested by the Library)

2.2.1.B.1 Tests

- Software analysis of a 20 patch grayscale to determine the number of discernable steps, the relationship between steps, and the gamma of the tone curve.
- Visual inspection of the sample images to confirm that the tonal match is very close and that details in the dark and near white areas of the original have not been lost in the image.
- Visual inspection of the target to determine distinction of patches, particularly in the dark grays near black and light grays near white.

2.2.1.B.2 Standards

- No loss of detail in dark and light gray areas of the original.
- A minimum of 18 steps should be visible on a 20 step scale.
- Software analysis should show appropriate density steps and gamma.

2.2.1 - C Dynamic range

The dynamic range of an image is the ratio of the darkest area to the lightest area of the image. The range of reflective materials is limited – a scanner should be able to reproduce a similar range.

2.2.1.C.1 Targets for dynamic range analysis

- The grayscale targets used to analyze tonality will also be used to analyze dynamic ranges.

2.2.1.C.2 Tests

- The density difference between the darkest and lightest discernable patches shall be determined by visual inspection.
- Software will provide similar measurements

2.2.1.C.3 Standards

- For reflective 5.5 f-stops or greater (6 f-stops or 1.9 db is preferred),
- For transmission 8 f-stops, (10 f-stops or 3.0db is preferred),

2.2.1 - D   Noise

Noise introduced by the scanner must be limited and well controlled. Noise is most visible in broad areas of tonality such as the sky in a photograph or the page background of a manuscript document.

2.2.1.D.1 Targets for noise analysis

- The grayscale targets used to analyze tonality will also be used to analyze noise.

2.2.1.D.2 Tests

- The dark patches will be inspected for visible noise.
- Software curves and analytics will be generated.

2.2.1.D.3 Standards

- Software analysis should show well-controlled noise with minimal RGB and luminance channel variations.
- An average luminance channel noise of approximately $Y <= 5\%$ is expected.

2.2.1 - E   Color

The Library is creating color images for many projects. Two problems are apparent: capturing accurate color at the scanner and providing information to users that informs them how to display and prints images with reasonably accurate color. The first problem is being analyzed using the targets, tests, and standards listed below. The Library is now examining how color profiles are created, checked, and placed within a TIFF image tagged field so that the user is provided with the necessary data for accurate color information.

2.2.1.E.1 Targets for color accuracy analysis

- Gretag Macbeth ColorChecker - the large patch 8.5" x 11.5" target.
- The Gretag Macbeth Digital Color Checker when appropriate analytic software is available.

2.2.1.E.2 Tests

- Visual inspection under ISO standard viewing conditions.
- Software generated comparative analysis and delta-E.

2.2.1.E.3 Standards

- A delta-E of less than 8 is expected.

2.2.1 - F   OCR

2.2.1.F.1 Targets

The Library will supply representative sample page images of text for any project that includes OCR.

2.2.1.F.2 Tests

The Library will OCR and evaluate the supplied sample page images

2.2.1.F.3 Standards

OCR test results on library materials vary greatly.
The Library has found that 400 ppi images produce improved OCR.
The Library's general benchmark is 90% word accuracy on the text sample provided, but different standards may be specified for special materials, such as pre-1820 newspapers .

2.2.1 - G   Other Information

The Library is currently experimenting with controlled viewing conditions and monitor calibration to establish standard environment(s) for reviewing and analyzing target and sample images. New standards may be published on these topics soon.

2.3   Image Acquisition

2.3.1   Imaging procedures

Many procedures followed in the Library's digitization process are specific to the resources and policies of the Library. However certain standards are central to all imaging projects, including those performed by contractors either onsite or off.

2.3.1 - A   Target and test scans

Every imaging project requires certain target and test scans. Prior to beginning document scanning, equipment operators should image the set of targets necessary to characterize the scanner as described previously. This target set should be repeated as needed to insure that all scanning throughout the project meets the standards set at project startup.

If a significant number of images within a batch fail to meet the project specifications, the Library may require the entire batch be rescanned.

At project startup and on occasion throughout the project, sample scans of typical documents will be requested and evaluated as described below to insure that quality standards are met throughout the project.

Table 1: Summary of LoC Image Quality Standards by Document Type and Expected Outcome

Document Type	Expected Outcome	Image Parameters Standards				Notes
		Resolution	Bit Depth	Grayscale Factors	Color Accuracy	
Printed text: books w/illustrations, pamphlets, typed pages, newspapers,	Image of text	300 ppi minimum	8-bit grayscale	minimum 18 steps minimum 5.5 f-stops Y channel noise <=5%		
	OCR'ed text	400 ppi	8-bit grayscale	minimum 18 steps minimum 5.5 f-stops Y channel noise <=5%		
Music: sheet music, annotated scores, music manuscripts	Access to content	300 ppi minimum	*8-bit grayscale	minimum 18 steps minimum 5.5 f-stops Y channel noise <=5%		*24-bit color should be used where color is an important attribute of the document.
	Recognition of artifactual features	400 ppi	8-bit grayscale	minimum 18 steps minimum 5.5 f-stops Y channel noise <=5%		
Manuscripts: handwritten, typewritten copies	Access to content	300 ppi minimum	*8-bit grayscale	minimum 18 steps minimum 5.5 f-stops Y channel noise <=5%	If 24-bit color Delta-E < 8	*24-bit color should be used where color is an important attribute of the document.
	Recognition of artifactual features	400 ppi	8-bit grayscale	minimum 18 steps minimum 5.5 f-stops Y channel noise <=5%	If 24-bit color Delta-E < 8	
Maps: printed tones printed color up to D-size 22" x 34" *oversized	Content Research	250 ppi minimum	24-bit color		Delta-E < 8	*ppi is dependant on map size – particularly when map sections must be stitched together and map filesize increases to 500 MBs and more
	Map reproduction	400 ppi	24-bit color		Delta-E < 6 ICC Profile	

Document Type	Expected Outcome	Image Parameters Standards				Notes
		Resolution	Bit Depth	Grayscale Factors	Color Accuracy	
Photographs: continuous tone, color	Access to content	300 ppi minimum	*8-bit grayscale	minimum 18 steps minimum 5.5 f-stops Y channel noise <=5%	If 24-bit color Delta-E < 8	*24-bit color should be used where color is an important attribute of the document.
	Reproduction	device maximum	24-bit color minimum		Delta-E < 6 ICC Profile	
Graphic Arts: Limited tone originals Continuous tone Color	Access to content	300 ppi minimum	8-bit grayscale	minimum 18 steps minimum 5.5 f-stops Y channel noise <=5%	If 24-bit color Delta-E < 8	*24-bit color should be used where color is an important attribute of the document.
	Reproduction	device maximum	24-bit color minimum		Delta-E < 6 ICC Profile	
Rare Books: Objects of High Artifactual Value	Recognition of artifactual features	400 ppi minimum	24-bit color		Delta-E < 8 ICC Profile	
	Research on artifactual features	600 ppi minimum	24-bit color minimum		Delta-E < 5 ICC Profile	

2.3.1 - B   Delivery

Generally, images will be delivered to OSI Central Receipt directly from the Library's network or on USB portable hard disk drives. At Central Receipt image batches will be reviewed using software that checks for conformity to the required image format (most often TIFF 6.0), following the required naming convention, and with the specific metadata properly placed in the appropriate TIFF tag fields. (*See* Section 2.5 – Technical Metadata)

2.3.1 - C   Scanning Instructions

A set of scanning instructions is delivered to the scanning workstation operator prior to the start of scanning for every digital conversion project at the Library. These instructions include all document handling procedures, all technical standards, all naming conventions, and all post processing requirements. A sample set of scanning instructions is provided in Appendix B.

2.3.2   Specialized information

2.3.2 - A   Reflective materials

Each object shall be scanned as specified in the task at a specifically stated spatial resolution appropriate for the material being scanned. The resolution requirement will be specified in pixels-per-inch (ppi). Spatial resolution shall be achieved utilizing the optical resolution capabilities of the equipment employed to capture the image. Interpolation of spatial resolution to achieve higher ppi values shall not be permitted.

2.3.2 - B   Transmission (see comments on "Reflective")

2.3.2 - C   Bound materials

Book Covers. Covers shall be scanned for certain books. When covers are required to be scanned, an instruction will be provided in a note included on the target. If both front and back covers are to be scanned, the front cover image shall be numbered to precede the images for the inside pages and the back cover shall be numbered to follow them.

The general rules for cover scanning are as follows:
  − Do scan covers (front and/or back) when the cover includes typography or illustrations that are original to the book, and when a legible image can be produced.
  − Do not scan the covers of books that will not render a legible image.
  − Do not scan covers that are devoid of any marking except the Library's call number.

Inside Pages. The images of the inside pages shall come after the images for the target and the front cover (if any). The first page of the book to be scanned shall be the first page containing significant information. Examples include a page containing a copyright stamp that precedes the title page, the title page itself, or end papers containing significant information, such as a map. Scanning of the remainder of the book shall continue in sequence, omitting blank pages. However, pages that contain no printed information but that contain handwritten inscriptions,

notes, marginalia or other written ephemera shall be scanned. End papers shall only be scanned if they contain significant information, such as a map. End papers that are merely decorative shall not be scanned. Blank pages or blank pages with stray pen or pencil marks shall not be scanned.

Foldout Pages. Foldout pages present special problems in capture and, if images are segmented, in numbering. These pages shall be removed from book bindings by the Library and scanned by the contractor as unbound pages. They shall be integrated in the delivery sequence of the rest of the bound volume.

2.3.2 - D   Maps

Map present special problems because of their size; contact the Digital Conversion Team of the Geography and Map Division for special instructions.

2.3.2 - E   Prints

Each object shall be scanned as specified in the task at a specifically stated spatial resolution appropriate for the material being scanned. The resolution requirement will be specified in pixels-per-inch (ppi). Spatial resolution shall be achieved utilizing the optical resolution capabilities of the equipment employed to capture the image. Interpolation of spatial resolution to achieve higher ppi values shall not be permitted. The spatial resolution requirements are anticipated to range from 200 ppi to 5000 ppi.

For mandatory images (8-bit grayscale), the digital values should be linear to the original density. The digital values for each area on the grayscale target shall not deviate by more than 10 from a linear least squares regression line fitted between the densities of the original target and the digital output values. A white area shall have values of r=243-250, g=243-250, and b=243-250, and a black area shall have values of r=5-12, g=5-12, and b=5-12. Care should be taken that no clipping (= loss of details) in either the highlights or the shadows occurs.

For desirable images the digital values should be linear to reflectance / or transmittance. A white area shall have values of r=4070-4086, g=4070-4086, and g=4070-4086, and a black area shall have values of r=5-15, g=5-15, and b=5-15. Care should be taken that no clipping (= loss of details) in either the highlights or the shadows occurs.

2.3.2 - F   Manuscripts

The majority of pages range from about 6x9 inches to about 82x11 inches. Because many are from periods before paper sizes were standardized, and because many pieces of personal correspondence are included, document sizes vary considerably, often from one page to the next. In addition, manuscript collections may include extensive quantities of slips of paper or cards on the order of 3x5 inches. These collections may also include folded posters, newspaper pages, or other sheets on the order of 11x17 inches. Collections also contain documents (like sheet music) that consist of folded sheets (creating Apages@) and sheets that exceed 11x17 inches in size. All

of these highly variable materials can appear in historical archival collections and all shall be scanned.

2.3.2 - G   Microfilm

The spatial resolution shall be 400 pixels-per-inch (ppi) relative to the original newspaper. If that is technically impossible, due to high reduction ratio of particular reels, the spatial resolution for those reels shall be 300 pixels-per-inch (ppi) relative to the original newspaper. 8-bit grayscale, TIFF 6.0 uncompressed. Two-up film should be split so that there is one page image per file. De-skew images with a skew of greater than 3 degrees.

2.4   Post Processing of Digital Files

The Library recognizes that some post processing in necessary to obtain images that closely match the original document in terms of sharpness, detail, tonal range, and color fidelity. The amount of post processing may be governed by the production expectations set by the nature of the project. Automatic processing of image batches may be appropriate done in batches for projects that produce hundreds of images daily. Manual adjustments for each factor may be done on each individual image for projects that involve rare and valuable materials. In either case the Library considers these standards for image post processing.

2.4.1   Cropping

Cropping of bound and manuscript materials. The Library requires presentation of the entire original sheet or page. In no event shall the actual document be cropped. Researchers using Library of Congress digital documents often wish to be reassured that the entire document has been captured. This is especially desirable for unbound manuscript documents. A "border zone" approximately 1/4-inch or less of the surface behind the scanned document shall be provided whenever possible.

For some combinations of document sizes and scanning equipment, capturing such a margin may not be possible for all four edges of the page. Therefore, the Library desires a 3-inch margin wherever possible, and requires at least that the entire original sheet or page is captured.

Cropping for Pictorial Materials. The Library wishes to provide researchers with a reproduction of the entire original item. Thus, images shall be framed and cropped to show the entire original item and beyond the item(s) edges. For negatives or other transmitted light items, each digital image shall reproduce that item(s) actual-image area, the border on the film that surrounds the image area, and a portion of the background (light box or scanner top) beyond the edge of the film. A similar approach shall be followed for reflected-light items; the whole print, whole mount, and a portion of the background (beyond the mount) shall be reproduced. In order to limit light flare or other technical anomalies caused by lighting, the contractor may propose to use filters or masks around the edges of negatives or other media that permit excessive light within the scanned scene.

2.4.2 Rotation, de-skewing

In addition to cropping, images may need to be rotated or deskewed. These processes are not generally applied unless the skew angle exceeds 3 degrees. Some OCR packages require more accurate alignment – if a project outcome requires OCR the scanning instructions will specify the acceptable skew and any corrections to be performed.

2.4.3 Sharpening

Image sharpening may be applied if necessary to increase the match between the image and the original. This process should not be used to overcome defects in the scanner quality or in the proper operations of the equipment. Sharpening should not be used to increase the apparent resolution beyond the resolution of the original. Currently, the Library prefers using the "unsharp mask" method using an image ratio of 1:1 to obtain a match between the original and the scan.

2.4.4 Tonal aimpoints

The Library generally expects that operators will use the device control software to adjust their equipment at least once each day using an ISO standard grayscale target such as the Kodak Q-13 or the Golden Thread. The scanner should be set to achieve a black aimpoint of approximately 1.95, a white aimpoint of approximately 0.10. At least 19 steps should be discerable. A midpoint aimpoint may also be set. At the same time, the image should be "neutralized" so that the RGB components of the white or middle gray patch are equal. This neutralization needs to be done on a quality target or on a special, carefully selected paper because documents from the collection may be on paper that has colorcasts or optical brighteners that mislead scanner sensors.

A sample document should also be scanned as a test image. This image should be checked carefully for a match between the blackest element of the document and the black aimpoint and for a match between the lightest element of the document and the white aimpoint. Then the image should be checked to match the detail in the dark and light gray areas to be sure the scanned image retains the detail of the original.

2.4.5 Color Management

Color management must begin with correct scanner operation and the time of capture so that the original scan is as accurate representation as possible. The aimpoint adjustments and white neutralization provide the starting point for good color management. However the Library expects that additional steps must be taken to capture color images that represent the original document well. When possible, the original document should be compared to the scanned image under controlled viewing conditions on a color-controlled monitor. Using graphics processing software such as *Photoshop,* the image may be adjusted so that the colors are a close match. During production, the required adjustment may be noted and run as a batch process. When imaging rare or valuable materials the adjustment may be done on each individual image.

Color images should be placed in standard RGB (sRGB) color space. The transformation of color into sRGB space may require that some imaged colors be adjusted to fit within the limits of the color space. This adjustment is done using a specific "rendering intent." The choice of rendering intent will depend on the type of original. This choice should be discussed with the digital conversion specialist and division curator and the decision included in the scanning specifications. Normally, a "relative colorimetric" intent should be chosen for text and graphic arts while a "perceptual" intent may be used for photographic materials.

After this transformation the image should be saved as a 24-bit TIFF file with an attached ICC color profile placed in the TIFF 34675 tag. The ICC color profile is essential for any user hoping to display reasonably accurate color. (It should be noted that the standard TIFF tags for BitPerSample (258), for PhotometricInterpretation (262) and for SamplesPerBit (277) only indicate that the TIFF image is an RGB rather than bitonal or grayscale image. The tags do not indicate the color space and color aware applications will note that the color space is unknown unless the proper data is in the 34675 tag.)

2.5 Technical Metadata

2.5.1 Descriptive Metadata

Although a detailed analysis of descriptive metadata is beyond the scope of this document, it is useful to note that Library of Congress American Memory digital collections are generally driven through MARC metadata. A MARC record is used to access books available online and specialized MARC records are used to access maps and photographs. A MARC record provides access to other collections and then a standardized non-MARC record provides access to individual items within the collection. The document handle and pathname are placed in the 869 field of the bibliographic record. Recent collections may also be accessible through the Open Archive Initiative – Protocol for Metadata Handling (OAI-PMH).

2.5.2 Structural Metadata

Structural metadata is particularly important in complex digital collections. Even paging through a book is much more complex than it appears to the average library user. The user expects to reach page 17 as printed on the page, by entering 17 into a "turn to" box – but image 17 is almost never page 17. Navigating manuscript collections, scrapbooks, sheet music, or map presentations may be much, much more complex. Document structural metadata has been handled in American Memory projects by filename conventions that are specified in the scanning instructions. The Library's Digital Scanning Center assigns the filename either at the time of scanning or during post processing. Other Library Web applications for digital collections, including Global Gateway, Veterans History Project, and The Library of Congress Presents: Music, Theater and Dance use METS records for structural metadata – METS metadata is developed outside our imaging process and is beyond the scope of this document.

2.5.3 Technical Metadata in TIFF headers

The TIFF format provides a large number of pre-defined, standardized tagged fields that are available for a range of metadata – primarily technical in nature. The TIFF standard also provides procedures for others to create and tag additional metadata designed to specific needs. Most scanner control and image post processing software can be configured to automatically provide much of this metadata. Commercial applications and vendor-developed routines are available to support the input of metadata that cannot be supplied automatically.

Introduction:

This report is intended to be a listing of proposed requirements for TIFF image header tags required by the Digital Conversion Services (DCS) and applicable to all digitization products for still image content regardless of the original format or method of digitization. The ability to store, access, and preserve content depends upon good metadata, and once finalized, the proposed requirements will serve as the core minimum required tags of metadata for these purposes. To insure DCS metadata requirements are met, images delivered by contractors and internal providers will be automatically checked by custom applications. Any files that do not

meet the core minimum requirements will be returned to the producer to be remedied and re-submitted.

This paper will discuss the header requirements for TIFF images included in the American Memory Web site, which are still in effect (and also used by Global Gateways, a program that came along later). It will also list the TIFF tags required National Digital Newspaper Program (NDNP) as detailed in the NDNP TIFF Profile.

The tags are in tables and are listed by tag number and name, along with comments.

<u>American Memory TIFF Profile</u>

In 1996, the Library of Congress issued RFP96-5, Request Proposals For Conversion of Microfilm to Digital Images for the National Digital Library Program American Memory Web Site. This document stated that TIFF images delivered by contractors were required to have "typical" or "expected" header data and defined these as "normally, the data supplied by software default settings." The RFP further explicitly listed TIFF tags then in use by the Library, thus appearing to make them the only explicitly required tags for TIFF images. Software developed specifically for the Library at the time allowed the automatic review and checking of these explicitly listed tags. Two RFP's that followed, Digital Images from Original Documents, Text Conversion and SGML-Encoding (RFP96-18) and Conversion of Pictorial Items to Digital Images (RFP97-9) followed the same TIFF requirements of RFP96-5. To date, these requirements are still in effect for digital images created for display on the American Memory and Global Gateways site.

2.5.4   TIFF Tags In American Memory

The following tags are explicitly checked by software for presence in the TIFF header and pre-determined values. The values of tags are not addressed in this report.

Baseline tags are those tags that are listed as part of the core of TIFF, the essentials that all mainstream TIFF developers should support in their products. Extension tags are those listed as part of TIFF features that may not be supported by all TIFF readers. Private tags are for organizations that wish to store information meaningful only to that organization in a TIFF file. Another set of private tags is Private EXIF tags. If one needs more than 10 private tags or so, the TIFF specification suggests that, rather then using a large amount of private tags, one should instead allocate a single private tag. In that private IFD, one can next use whatever tags one wants.

Table 2. LoC Standard Metadata for TIFF Tags

Tag	Name	Description	Tag Type
256	ImageWidth	The number of pixels per row	Baseline Tag
257	ImageLength	The number of rows of pixels in the image	Baseline Tag
258	BitsPerSample	Number of bits per component	Baseline Tag
259	Compression	Compression scheme used on image data	Baseline Tag
262	PhotometricInterpretation	The color space of the image data	Baseline Tag
273	StripOffsets	For each strip, the byte offset of that strip	Baseline Tag
277	SamplesPerPixel	The number of components per pixel	Baseline Tag
278	RowsPerStrip	The number of rows per strip	Baseline Tag
279	StripByteCount	For each strip, the number of bytes in the strip after compression	Baseline Tag
269	DocumentName	Document Name (path/filename)	Extension Tag
282	Xresolution	Horizontal pixel count per resolution unit (inches, centimeters)	Baseline Tag
283	Yresolution	Vertical pixel count per resolution unit (inches, centimeters)	Baseline Tag
296	ResolutionUnit	Unit of measurement for X and Y Resolution (inches, centimeters	Baseline Tag
306	DateTime	Date and Time image was scanned	Baseline Tag
315	Artist	Person who created image (default LoC)	Baseline Tag

2.5.5 NDNP TIFF Profile

The National Digital Newspaper Program (NDNP) requires the same tags as does American Memory and Global Gateways, as well as some additional tags within the TIFF 6.0 file format. The NDNP TIFF Profile also specifically excludes the 258 field (BitsPerSample), but this is because all images are expected to have 8-bits per pixel.

2.5.6 Additional TIFF Tags in the NDNP TIFF Profile

Table 3. Additional TIFF Tags in the NDNP TIFF Profile

Tag	Name	Description	Tag Type
42016	UniqueImageID	Indicates an identifier assigned uniquely to each image	Private IFD - Exif Tag
274	Orientation	The orientation of the image with respect to the rows and columns	Baseline Tag
41728	FileSource	Indicates the image source, e.g. microfilm, book, etc.	Private IFD- Exif Tag
271	Make	The scanner manufacturer	Baseline Tag
272	Model	The scanner model name or number	Baseline Tag
305	Software	Name and version number of the software package(s) used to create the image.	Baseline Tag

2.5.7 Proposed Minimum Core

The proposed minimum core is all of the tags from the American Memory Profile and tags 271,272, and 305 from the NDNP TIFF profile. The following table contains the proposed core minimum.

The tag numbers, names, descriptions and sample values are taken from:
- The draft NISO Z39.87 / AIIM 20-2002 Standard, http://www.niso.org/standards/resources/Z39_87_trial_use.pdf
- TIFF tag reference at http://www.awaresystems.be/imaging/tiff/tifftags.html.

The Notes field provides Library specific information.

Table 4: Proposed LoC Baseline Tags for TIFF Images:

Tag	Name	Description	Sample Values	Notes
256	ImageWidth	The number of pixels per row		
257	ImageLength	The number of rows of pixels in the image		
258	BitsPerSample	Number of bits per component		
259	Compression	Compression scheme used on image data	1 = Uncompressed 4 = CCITT Group 4	
262	Photometric-Interpretation	The color space of the image data	1 = Black is zero 2 = RGB	RGB is assumed to be sRGB If RGB, an ICC Profile should be present in the 34675 tag
271	Make	The scanner manufacturer		
272	Model	The scanner model name or number		
273	StripOffsets	For each strip, the byte offset of that strip		
277	SamplesPerPixel	The number of components per pixel	8 8 8	
278	RowsPerStrip	The number of rows per strip		
279	StripByteCount	For each strip, the number of bytes in the strip after compression		
269	DocumentName	Document Name	path/filename	
282	Xresolution	Horizontal pixel count per resolution unit (inches, centimeters)		
283	Yresolution	Vertical pixel count per resolution unit (inches, centimeters)		
296	ResolutionUnit	Unit of measurement for X and Y Resolution (inches, centimeters		
305	Software	Name and version number of the software package(s) used to create the image		It is acceptable for this field to include only the capture software. It is preferred that both capture and post-capture processing software (if applicable) are included and separated by ";"
306	DateTime	Date and Time image was scanned		
315	Artist	Used for ImageProducer		Institution name followed (if applicable) by ";" and name of scanning contractor.

2.5.7 - A   Library Supported Metadata Standards

A number of new metadata standards have been prepared recently. In addition to the Data Dictionary - Technical Metadata for Digital Still Images (Draft standard for trial use) published

jointly as NISO Z39.87-2002 and AIIM 20-2002 referenced above, the Library has details of MIX (Library Web Site, Nov. 2004.) and PREMIS (Library Web Site, Oct. 2005) on its web site. In the near future the Library expects to review and revise our technical, preservation, and administrative metadata requirements in light of these standards.

2.5.7 - B   References

http://www.awaresystems.be/imaging/tiff.html
http://memory.loc.gov/ammem/techdocs/conversion.html
http://www.loc.gov/ndnp/pdf/TIFFSpecs.pdf
http://partners.adobe.com/public/developer/tiff/index.html#spec

2.6   File Management

2.6.1   File Formats

Approved file formats for digital master images include:
> TIFF Version 6
> Bitonal with Group IV compression
> Grayscale and Color with no compression

2.6.2   File Naming

All item IDs and filenames are lowercase and consist of not more than 8 characters.
Filename Pattern Legend:

c	Control page number
p	Print page number
f	Feature identifier
x	Horizontal grid coordinate,
alpha (for segmented images)	
y	Vertical grid coordinate,
numeric (for segmented images)	

For TIFF files: The following letters are used as feature codes only for TIFF files.

X	A raw TIFF file, not post-processed
Z	A TIFF file of multiple images that has been joined and post processed

Other feature codes are:

e	East
i	Introduction
m	Map
n	North
p	profile
r	recto (front)

s	South
t	Text
v	verso (back)
w	West
x	Index

For each set of images (uncompressed archival image, compressed reference image(s), and thumbnail image) that reproduces the same source item, the filenames shall end as follows:

a.tif - for exceptionally high quality files, may be compressed if bitonal (up to 10,000 pixels in the long dimension for most pictorial works, 400 ppi for architectural drawings)

u.tif - for uncompressed archival files (usually between 3,000 and 5,000 pixels in the long dimension)

v.jpg = Very high resolution compressed display image (1024 or 1280 pixels in the long dimension)

r.jpg - for JPEG compressed reference image files (640 pixels in the long dimension)

t.tif - for thumbnail image files, (150 pixels in the long dimension)

t.gif - GIF format thumbnail files derived from the "t.tif" file

v.jpg = Very high resolution compressed display image (types 5DI, 4DI, and 3DI; see C.4.3.4)

DIGITAL ID

The field begins with a word or phrase that explains the source used to create the digital image: for example, the "original" work or a "b&w copy film neg." The Library's digital images are often created by scanning one or more of the copy negatives, slides, or transparencies listed in the Reproduction Number field. The Library uses a brief file identifier for its locally programmed image displays. The URL (http) and URN handle identifiers are provided to aid display of images in other environments.

> *Example from Adams's Manzanar photographs:*
> (original print)
> ppprs 00376
> urn:hdl:loc.pnp/ppprs.00376
> http://hdl.loc.gov/loc.pnp/ppprs.00376

2.7   Quality Assurance

The Library's quality assurance plan follows a-two stage model. The Office of Strategic Initiatives, Digital Conversion Group maintains a Central Receipt operation. Image files are delivered on CD, DVD, USB hard disk, or over the Library network. At the first stage an automated software system counts and checks all files for format validity, metadata requirements, and file naming conventions. At the second stage, thumbnails of all images are reviewed and selected images are viewed at 1:1 to insure that files meet project quality specifications. The accuracy rate requirements for image batches breaks down into two categories: 99.5% accurate and 100% accurate.

2.7.1   Image receipt and validation

Upon receipt, an automated software review of all files is run. Items required to be 100% accurate include:

> File format
> Content of file headers and tags
> Compression algorithm
> Resolution Pixel Depth

The items required to be 99.5% accurate include:

> File naming convention
> Missing images
> Duplicate images,
> Images our of order

If the errors exceed the standard, the batch is held and a software-generated list of problems is provided to the scan operator.

2.7.2   Visual inspection

2.7.2 - A   Initial inspection

Following the automated review, thumbnails are generated for all images – When possible 100% of the images are reviewed as thumbnails.

The items required to be 99.5% accurate include:

Blurred or indistinct image
loss to distinct features or lines
incomplete capture of page content
skewing
failure to apply treatment to printed halftones
failure to capture illustration captions

2.7.2 - B   Detailed visual inspection

From the thumbnail view, specific images are selected for detailed visual inspection. The number of Images selected at random is governed by the project specifications; additional images may be reviewed if possible defects are apparent on the image thumbnail.

2.7.2 - C   Image Tonal Range

The tonal range of the delivered digital images shall be representative of the original artifact or, in the case of images whose source is a photographic negative, of the expected representation of the original scene when the negative is reproduced as a positive print.

Utilization of general imaging industry standards for library materials and those as agreed to and established during each project startup and testing phase shall be followed. Consultation with Library staff may be required and is encouraged in order to ensure that appropriate operator judgments are made throughout the run of a particular project or batch.

For black-and-white or color prints or positive film (slides or transparencies), the objective is to reproduce the tonal range of the items as they are viewed under typical lighting conditions.

For black-and-white or color negatives, the objective is to create a positive image in a manner that may be compared to creating a print in a darkroom. Providing images with acceptable tonal qualities shall require that the scanning operator exercise judgment when producing the images. The Library will offer guidelines regarding expectations for the viewing and use of the images that will inform and improve operator judgment. For example, when scanning film negative photographs that are intended to provide visual documentation about a particular subject in the image, such as building details, the operator would be encouraged to ensure accurate tonal rendition of that area of interest.

The Library also requires that the broadest range of tonal information available from the object be captured in the tonal values of the delivered image files. Areas of extreme highlight and shadow information shall not be clipped from the resultant image file. As a guideline, the Library desires that all of the content information from the source object be represented within a range of pixel values that does not approach absolute black or absolute white. Therefore, in a typical 8 bits-per-pixel grayscale image, for example, most of the darkest black values in the content areas should begin around pixel value 5 and the lightest white values should not exceed pixel value 251.

2.7.2 - D   Noise

The Library inspects all broad tonal areas – particularly in the darker tone and in the sky – for visible noise. While it is recognize that some visible noise will be present the Library does not accept images where the noise level
- obscures detail,
- exhibits artifacts and color fringing, or
- shows significant patterns within smooth tonal areas.

2.7.2 - E   Resolution

The image may be compared to the original to determine if the sharpness of the image matches the sharpness of the original. A check will be made to determine that details visible in the dark and light areas of the original visible in the image.

If OCR is to be used, the OCR results will be considered as an indication of image resolution. The Library has determined that an optical resolution of 400 ppi provides improved OCR accuracy and poor OCR results may be an indication of inadequate resolution.

2.7.2 - F   Color

Color specifications and requirements vary greatly with the expected outcome of the project. In many cases, color is merely an aid to content presentation or an indicator of artifactual values. In other cases, the color accuracy of an image is considered essential to the presentation. In the first case, the overall color of the image may merely be reviewed from visual memory; in the second case the color of the original object will be compared with the colors of the image on a color managed workstation under controlled viewed conditions. Consultation with Library staff may be required and is encouraged in order to ensure that appropriate operator judgments are made throughout the run of a particular project or batch.

2.7.3   Documentation

All visual image evaluations will be recorded using a standardize list of defects and a report generated for the scan operator. *However, if the number of defective images exceeds the established standard the entire batch may be returned to the scan operator. It is not the job of the Library to list every defect in every image when an entire batch fails visual inspection – the scan operators are expected to perform their own QC prior to delivery and the Library will not accept responsibility if the operator fails to inspect their images properly.*

3   Complete Document (pdf)

4 Change History

Date	Rev.	Section	Type	Change
03/07/2007	.01	2.5.7 Table 4	Substantive, *Clarification*	*Deleted text in 305 notes field:* Capture software followed (if applicable) by ";" and post-capture processing software *Added text in 305 notes field:* It is acceptable for this field to include only the capture software. It is preferred that both capture and post-capture processing software (if applicable) are included and separated by ";".
03/07/2007	0.2	2.5.7	Editorial *Modification*	*Edited Title of Section 2.5.7 from*: "Proposed LoC Baseline Tags for TIFF Images "to "LoC Baseline Tags for TIFF Images."
03/07/2007	0.3	2.5.7	Editorial *Modification*	*Edited Title of Table 4 from*: "Proposed LoC Baseline Tags for TIFF Images "to "LoC Baseline Tags for TIFF Images."