



U.S. National Archives and Records Administration (NARA)

Technical Guidelines for Digitizing Archival Materials for Electronic Access: Creation of Production Master Files – Raster Images

For the Following Record Types- Textual, Graphic Illustrations/Artwork/Originals, Maps, Plans, Oversized, Photographs, Aerial Photographs, and Objects/Artifacts

June 2004

Written by Steven Puglia, Jeffrey Reed, and Erin Rhodes

Digital Imaging Lab, Special Media Preservation Laboratory, Preservation Programs
U.S. National Archives and Records Administration
8601 Adelphi Road, Room B572, College Park, MD, 20740, USA
Lab Phone: 301-837-3706
Email: preserve@nara.gov

Acknowledgements: Thank you to Dr. Don Williams for target analyses, technical guidance based on his extensive experience, and assistance on the assessment of digital capture devices. Thank you to the following for reading drafts of these guidelines and providing comments: Stephen Chapman, Bill Comstock, Maggie Hale, and David Remington of Harvard University; Phil Michel and Kit Peterson of the Library of Congress; and Doris Hamburg, Kitty Nicholson, and Mary Lynn Ritzenhaler of the U.S. National Archives and Records Administration.

SCOPE:

The *NARA Technical Guidelines for Digitizing Archival Materials for Electronic Access* define approaches for creating digital surrogates for facilitating access and reproduction; they are not considered appropriate for preservation reformatting to create surrogates that will replace original records. The *Technical Guidelines* presented here are based on the procedures used by the Digital Imaging Lab of NARA's Special Media Preservation Laboratory for digitizing archival records and the creation of production master image files, and are a revision of the 1998 "*NARA Guidelines for Digitizing Archival Materials for Electronic Access*", which describes the imaging approach used for NARA's pilot Electronic Access Project.

The *Technical Guidelines* are intended to be informative, and not intended to be prescriptive. We hope to provide a technical foundation for digitization activities, but further research will be necessary to make informed decisions regarding all aspects of digitizing projects. These guidelines provide a range of options for various technical aspects of digitization, primarily relating to image capture, but do not recommend a single approach.

The intended audience for these guidelines includes those who will be planning, managing, and approving digitization projects, such as archivists, librarians, curators, managers, and others. Another primary audience includes those actually doing scanning and digital capture, such as technicians and photographers.

The following topics are addressed:

- Digital Image Capture – production master files, image parameters, digitization environment, color management, etc.
- Minimum Metadata – types, assessment, local implementation, etc. – we have included a discussion of metadata to ensure a minimum complement is collected/created so production master files are useable
- File Formats, Naming, and Storage – recommended formats, naming, directory structures, etc.
- Quality Control – image inspection, metadata QC, acceptance/rejection, etc.

The following aspects of digitization projects are not discussed in these guidelines:

- Project Scope – define goals and requirements, evaluate user needs, identification and evaluation of options, cost-benefit analysis, etc.
- Selection – criteria, process, approval, etc.

- Preparation – archival/curatorial assessment and prep, records description, preservation/conservation assessment and prep, etc.
- Descriptive systems – data standards, metadata schema, encoding schema, controlled vocabularies, etc.
- Project management – plan of work, budget, staffing, training, records handling guidelines, work done in-house vs. contractors, work space, oversight and coordination of all aspects, etc.
- Access to digital resources – web delivery system, migrating images and metadata to web, etc.
- Legal issues – access restrictions, copyright, rights management, etc.
- IT infrastructure – determine system performance requirements, hardware, software, database design, networking, data/disaster recovery, etc.
- Project Assessment – project evaluation, monitoring and evaluation of use of digital assets created, etc.
- Digital preservation – long-term management and maintenance of images and metadata, etc.

In reviewing this document, please keep in mind the following:

- The *Technical Guidelines* have been developed for internal NARA use, and for use by NARA with digitizing projects involving NARA holdings and other partner organizations. The *Technical Guidelines* support internal policy directive NARA 816 – *Digitization Activities for Enhanced Access*, at http://www.nara-at-work.gov/nara_policies_and_guidance/directives/0800_series/nara816.html (NARA internal link only). For digitization projects involving NARA holdings, all requirements in NARA 816 must be met or followed.
- The *Technical Guidelines* do not constitute, in any way, guidance to Federal agencies on records creation and management, or on the transfer of permanent records to the National Archives of the United States. For information on these topics, please see the Records Management section of the NARA website, at http://www.archives.gov/records_management/index.html and http://www.archives.gov/records_management/initiatives/erm_overview.html.
- As stated above, Federal agencies dealing with the transfer of scanned images of textual documents, of scanned images of photographs, and of digital photography image files as permanent records to NARA shall follow specific transfer guidance (http://www.archives.gov/records_management/initiatives/scanned_textual.html and http://www.archives.gov/records_management/initiatives/digital_photo_records.html) and the regulations in 36 CFR 1228.270.
- The *Technical Guidelines* cover only the process of digitizing archival materials for on-line access and hardcopy reproduction. Other issues must be considered when conducting digital imaging projects, including the long-term management and preservation of digital images and associated metadata, which are not addressed here. For information on these topics, please see information about NARA's Electronic Records Archive project, at http://www.archives.gov/electronic_records_archives/index.html.
- The topics in these *Technical Guidelines* are inherently technical in nature. For those working on digital image capture and quality control for images, a basic foundation in photography and imaging is essential. Generally, without a good technical foundation and experience for production staff, there can be no claim about achieving the appropriate level of quality as defined in these guidelines.
- These guidelines reflect current NARA internal practices and we anticipate they will change over time. We plan on updating the *Technical Guidelines* on a regular basis. We welcome your comments and suggestions.

TABLE OF CONTENTS:

Scope - 1

Introduction - 5

Metadata - 5

- Common Metadata Types - 6
 - Descriptive - 7
 - Administrative - 8
 - Rights - 8
 - Technical - 9
 - Structural - 10
 - Behavior - 11
 - Preservation - 11
 - Image Quality Assessment - 12
 - Records Management / Recordkeeping - 15
 - Tracking - 15
 - Meta-Metadata - 16
- Assessment of Metadata Needs for Imaging Projects - 16
- Local Implementation - 18
 - Relationships - 20
 - Batch Level Metadata - 20
 - Permanent and Temporary Metadata - 21

Technical Overview - 21

- Raster Image Characteristics:
 - Spatial Resolution - 21
 - Signal Resolution - 21
 - Color Mode - 22
- Digitization Environment - 23
 - Viewing Conditions - 23
 - Monitor Settings, Light Boxes, and Viewing Booths - 23
 - The Room - 23
 - Practical Experience - 24
 - Monitor Calibration - 24
- Quantifying Scanner / Digital Camera Performance - 24
 - Test Frequency and Equipment Variability - 25
 - Tests:
 - Opto-Electronic Conversion Function (OECF) - 26
 - Dynamic Range - 26
 - Spatial Frequency Response (SFR) - 26
 - Noise - 27
 - Channel Registration - 27
 - Uniformity - 27
 - Dimensional Accuracy - 28
 - Other Artifacts or Imaging Problems - 28
- Reference Targets - 29
 - Scale and Dimensional References - 29
 - Targets for Tone and Color Reproduction - 30
 - Reflection Scanning - 30
 - Transmission Scanning – Positives - 30
 - Transmission Scanning – Negatives - 31

Imaging Workflow - 31

- Adjusting Image Files - 31
 - Overview - 32
- Scanning Aimpoints - 32
 - Aimpoints for Photographic Gray Scales - 35
 - Alternative Aimpoints for Kodak Color Control Patches (color bars) - 36
 - Aimpoint Variability - 36

- Minimum and Maximum Levels - 36
- Color Management Background - 36
 - ICC Color Management System - 37
 - Profiles - 37
 - Rendering Intents - 38
 - Color Management Modules - 38
- Image Processing - 38
 - Color Correction and Tonal Adjustments - 39
 - Sharpening - 39
- Sample Image Processing Workflow - 39
 - Scanning - 40
 - Post-Scan Adjustment/Correction - 40

Digitization Specifications for Record Types - 41

- Cleanliness of Work Area, Digitization Equipment, and Originals - 42
- Cropping - 42
- Backing Reflection Originals - 42
- Scanning Encapsulated or Sleeved Originals - 42
- Embossed Seals - 43
- Compensating for Minor Deficiencies - 43
- Scanning Text - 43
- Scanning Oversized - 44
- Scanning Photographs - 44
- Scanning Intermediates - 44
- Scanning Microfilm - 45
- Illustrations of Record Types - 46
- Requirements Tables:
 - Textual Documents, Graphic Illustrations/ Artwork/ Originals, Maps, Plans, and Oversized - 51
 - Photographs - Film/ Camera Originals - Black-and-White and Color - Transmission Scanning - 52
 - Photographs - Prints - Black-and-White, Monochrome, and Color - Reflection Scanning - 54
 - Aerial - Transmission Scanning - 56
 - Aerial - Reflection Scanning - 57
 - Objects and Artifacts - 58

Storage - 60

- File Formats - 60
- File Naming - 60
 - Directory Structure - 60
 - Versioning - 61
 - Naming Derivative Files - 61
- Storage Recommendations - 61
 - Digital Repositories and Long-Term Management of Files and Metadata - 61

Quality Control - 62

- Completeness - 62
- Inspection of Digital Image Files - 62
 - File Related - 62
 - Original/Document Related - 62
 - Metadata Related - 63
 - Image Quality Related - 63
- Quality Control of Metadata - 64
- Documentation - 65
- Testing Results and Acceptance/Rejection - 65

Appendices:

- A – Digitizing for Preservation vs. Production Masters - 66
- B – Derivative Files - 70
- C – Mapping of LDCRG Elements to Unqualified Dublin Core - 74
- D – File Format Comparison - 76
- E – Records Handling for Digitization - 79
- F – Resources - 82

I. INTRODUCTION

These *Guidelines* define approaches for creating digital surrogates for facilitating access and reproduction. They are not considered appropriate for preservation reformatting to create surrogates that will replace original records. For further discussion of the differences between these two approaches, see Appendix A, Digitization for Preservation vs. Production Masters.

These guidelines provide technical benchmarks for the creation of “production master” raster image (pixel-based) files. Production masters are files used for the creation of additional derivative files for distribution and/or display via a monitor and for reproduction purposes via hardcopy output at a range of sizes using a variety of printing devices (see Appendix B, Derivative Files, for more information). Our aim is to use the production master files in an automated fashion to facilitate affordable reprocessing. Many of the technical approaches discussed in these guidelines are intended for this purpose.

Production master image files have the following attributes-

- The primary objective is to produce digital images that look like the original records (textual, photograph, map, plan, etc.) and are a “reasonable reproduction” without enhancement. The *Technical Guidelines* take into account the challenges involved in achieving this and will describe best practices or methods for doing so.
- Production master files document the image at the time of scanning, not what it may once have looked like if restored to its original condition. Additional versions of the images can be produced for other purposes with different reproduction renderings. For example, sometimes the reproduction rendering intent for exhibition (both physical and on-line exhibits) and for publication allows basic enhancement. Any techniques that can be done in a traditional darkroom (contrast and brightness adjustments, dodging, burning, spotting, etc.) may be allowed on the digital images.
- Digitization should be done in a “use-neutral” manner, not for a specific output. Image quality parameters have been selected to satisfy most types of output.

If digitization is done to meet the recommended image parameters and all other requirements as described in these *Technical Guidelines*, we believe the production master image files produced should be usable for a wide variety of applications and meet over 95% of reproduction requests. If digitization is done to meet the alternative minimum image parameters and all other requirements, the production master image files should be usable for many access applications, particularly for web usage and reproduction requests for 8”x10” or 8.5”x11” photographic quality prints.

If your intended usage for production master image files is different and you do not need all the potential capabilities of images produced to meet the recommended image parameters, then you should select appropriate image parameters for your project. In other words, your approach to digitization may differ and should be tailored to the specific requirements of the project.

Generally, given the high costs and effort for digitization projects, we do not recommend digitizing to anything less than our alternative minimum image parameters. This assumes availability of suitable high-quality digitization equipment that meets the assessment criteria described below (see Quantifying Scanner/Digital Camera Performance) and produces image files that meet the minimum quality described in the *Technical Guidelines*. If digitization equipment fails any of the assessment criteria or is unable to produce image files of minimum quality, then it may be desirable to invest in better equipment or to contract with a vendor for digitization services.

II. METADATA

NOTE: All digitization projects undertaken at NARA and covered by NARA 816 *Digitizing Activities for Enhanced Access*, including those involving partnerships with outside organizations, must ensure that descriptive information is prepared in accordance with NARA 1301 Life Cycle Data Standards and Lifecycle Authority Control, at http://www.nara-at-work.gov/nara_policies_and_guidance/directives/1300_series/nara1301.html (NARA internal link only), and its associated Lifecycle Data Requirements Guide, and added to NARA's Archival Research Catalog (ARC) at a time mutually agreed-upon with NARA.

Although there are many technical parameters discussed in these *Guidelines* that define a high-quality production master image file, we do not consider an image to be of high quality unless metadata is associated with the file. Metadata makes possible several key functions—the identification, management, access, use, and preservation of a digital resource—and is therefore directly associated with most of the steps in a digital imaging project workflow: file naming, capture, processing, quality control, production tracking, search and retrieval design, storage, and long-term management. Although it can be costly and time-consuming to produce, metadata adds value to production master image files: images without sufficient metadata are at greater risk of being lost.

No single metadata element set or standard will be suitable for all projects or all collections. Likewise, different original source formats (text, image, audio, video, etc.) and different digital file formats may require varying metadata sets and depths of description. Element sets should be adapted to fit requirements for particular materials, business processes and system capabilities.

Because no single element set will be optimal for all projects, implementations of metadata in digital projects are beginning to reflect the use of “application profiles,” defined as metadata sets that consist of data elements drawn from different metadata schemes, which are combined, customized and optimized for a particular local application or project. This “mixing and matching” of elements from different schemas allows for more useful metadata to be implemented at the local level while adherence to standard data values and structures is still maintained. Locally-created elements may be added as extensions to the profile, data elements from existing schemas might be modified for specific interpretations or purposes, or existing elements may be mapped to terminology used locally.

Because of the likelihood that heterogeneous metadata element sets, data values, encoding schemes, and content information (different source and file formats) will need to be managed within a digital project, it is good practice to put all of these pieces into a broader context at the outset of any project in the form of a data or information model. A model can help to define the types of objects involved and how and at what level they will be described (i.e., are descriptions hierarchical in nature, will digital objects be described at the file or item level as well as at a higher aggregate level, how are objects and files related, what kinds of metadata will be needed for the system, for retrieval and use, for management, etc.), as well as document the rationale behind the different types of metadata sets and encodings used. A data model informs the choice of metadata element sets, which determine the content values, which are then encoded in a specific way (in relational database tables or an XML document, for example).

Although there is benefit to recording metadata on the item level to facilitate more precise retrieval of images within and across collections, we realize that this level of description is not always practical. Different projects and collections may warrant more in-depth metadata capture than others; a deep level of description at the item level, however, is not usually accommodated by traditional archival descriptive practices. The functional purpose of metadata often determines the amount of metadata that is needed. Identification and retrieval of digital images may be accomplished on a very small amount of metadata; however, management of and preservation services performed on digital images will require more finely detailed metadata—particularly at the technical level, in order to render the file, and at the structural level, in order to describe the relationships among different files and versions of files.

Metadata creation requires careful analysis of the resource at hand. Although there are current initiatives aimed at automatically capturing a given set of values, we believe that metadata input is still largely a manual process and will require human intervention at many points in the object’s lifecycle to assess the quality and relevance of metadata associated with it.

This section of the *Guidelines* serves as a general discussion of metadata rather than a recommendation of specific metadata element sets; although several elements for production master image files are suggested as minimum-level information useful for basic file management. We are currently investigating how we will implement and formalize technical and structural metadata schemes into our workflow and anticipate that this section will be updated on a regular basis.

Common Metadata Types:

Several categories of metadata are associated with the creation and management of production master image files. The following metadata types are the ones most commonly implemented in imaging projects. Although these categories are defined separately below, there is not always an obvious distinction between them, since each type contains elements that are both descriptive and administrative in nature. These types are commonly broken down by what functions the metadata supports. In general, the types of metadata listed below, except for descriptive, are usually found “behind the scenes” in databases rather than in public access systems. As a result, these types of metadata tend to be less standardized and more aligned with local requirements.

Descriptive-

Descriptive metadata refers to information that supports discovery and identification of a resource (the who, what, when and where of a resource). It describes the content of the resource, associates various access points, and describes how the resource is related to other resources intellectually or within a hierarchy. In addition to bibliographic information, it may also describe physical attributes of the resource such as media type, dimension, and condition. Descriptive metadata is usually highly structured and often conforms to one or more standardized, published schemes, such as Dublin Core or MARC. Controlled vocabularies, thesauri, or authority files are commonly used to maintain consistency across the assignment of access points. Descriptive information is usually stored outside of the image file, often in separate catalogs or databases from technical information about the image file.

Although descriptive metadata may be stored elsewhere, it is recommended that some basic descriptive metadata (such as a caption or title) accompany the structural and technical metadata captured during production. The inclusion of this metadata can be useful for identification of files or groups of related files during quality review and other parts of the workflow, or for tracing the image back to the original.

Descriptive metadata is not specified in detail in this document; however, we recommend the use of the Dublin Core Metadata Element¹ set to capture minimal descriptive metadata information where metadata in another formal data standard does not exist. Metadata should be collected directly in Dublin Core; if it is not used for direct data collection, a mapping to Dublin Core elements is recommended. A mapping to Dublin Core from a richer, local metadata scheme already in use may also prove helpful for data exchange across other projects utilizing Dublin Core. Not all Dublin Core elements are required in order to create a valid Dublin Core record. However, we suggest that production master images be accompanied by the following elements at the very minimum:

Minimum descriptive elements

Identifier	Primary identifier should be unique to the digital resource (at both object and file levels) Secondary identifiers might include identifiers related to the original (such as Still Picture ID) or Record Group number (for accessioned records)
Title/Caption	A descriptive name given to the original or the digital resource, or information that describes the content of the original or digital resource
Creator	(If available) Describes the person or organization responsible for the creation of the intellectual content of the resource
Publisher	Agency or agency acronym; Description of responsible agency or agent

These selected elements serve the purpose of basic identification of a file. Additionally, the Dublin Core elements “Format” (describes data types) and “Type” (describes limited record types) may be useful in certain database applications where sorting or filtering search results across many record genres or data types may be desirable. Any local fields that are important within the context of a particular project should also be captured to supplement Dublin Core fields so that valuable information is not lost. We anticipate that selection of metadata elements will come from more than one preexisting element set—elements can always be tailored to specific formats or local needs. Projects should support a modular approach to designing metadata to fit the specific requirements of the project. Standardizing on Dublin Core supplies baseline metadata that provides access to files, but this should not exclude richer metadata that extends beyond the Dublin Core set, if available.

For large-scale digitization projects, only minimal metadata may be affordable to record during capture, and is likely to consist of linking image identifiers to page numbers and indicating major structural divisions or anomalies of the resource (if applicable) for text documents. For photographs, capturing caption information (and Still Photo identifier) is ideal. For other non-textual materials, such as posters and maps, descriptive information taken directly from the item being scanned as well as a local identifier should be captured. If keying of captions into a database is prohibitive, if possible scan captions as part of the image itself. Although this information will not be searchable, it will serve to provide some basis of identification for the subject matter of the photograph. Recording of identifiers is important for uniquely identifying resources and is necessary for locating and managing them. It is likely that digital images will be associated with more than one identifier—for the image itself, for metadata or database records that describe the image, and for reference back to the original.

For images to be entered into NARA’s Archival Research Catalog (ARC), a more detailed complement of metadata is required. For a more detailed discussion of descriptive metadata requirements for digitization projects at NARA,

¹ Dublin Core Metadata Initiative, (<http://dublincore.org/usage/terms/dc/current-elements/>). The Dublin Core element set is characterized by simplicity in creation of records, flexibility, and extensibility. It facilitates description of all types of resources and is intended to be used in conjunction with other standards that may offer fuller descriptions in their respective domains.

we refer readers to NARA's Lifecycle Data Requirements Guide (LCDRG), at: http://www.archives.gov/research_room/arc/arc_info/lifecycle_data_requirements.doc (June 2004), and NARA internal link- http://www.nara-at-work.gov/archives_and_records_mgmt/archives_and_activities/accessioning_processing_description/lifecycle/index.html (January 2002), which contains data elements developed for the archival description portion of the records lifecycle, and associates these elements with many different hierarchical levels of archival materials from record groups to items. The LCDRG also specifies rules for data entry. The LCDRG also requires a minimum set of other metadata to be recorded for raster image files at the file level, including technical metadata that enables images to display properly in the ARC interface.

Additionally, enough compatibility exists between Dublin Core and the data requirements that NARA has developed for archival description to provide a useful mapping between data elements, if a digital project requires that metadata also be managed locally (outside of ARC), perhaps in a local database or digital asset management system that supports data in Dublin Core. Please see Appendix C for a listing of mandatory elements identified in the Lifecycle Data Requirements Guide at the record group, series, file unit and item level, with Dublin Core equivalents.

Because ARC will be used as the primary source for descriptive information about the holdings of permanent records at NARA, we refer readers to the LCDRG framework rather than discuss Encoded Archival Description (EAD) of finding aids. NARA has developed its own hierarchical descriptive structure that relates to Federal records in particular, and therefore has not implemented EAD locally. However, because of the prevalence of the use of EAD in the wider archival and digitization communities, we have included a reference here. For more information on EAD, see the official EAD site at the Library of Congress at <http://lcweb.loc.gov/ead/>; as well as the Research Library Group's Best Practices Guidelines for EAD at <http://www.rlg.org/rlgead/eadguides.html>.

Administrative-

The Dublin Core set does not provide for administrative, technical, or highly structured metadata about different document types. Administrative metadata comprises both technical and preservation metadata, and is generally used for internal management of digital resources. Administrative metadata may include information about rights and reproduction or other access requirements, selection criteria or archiving policy for digital content, audit trails or logs created by a digital asset management system, persistent identifiers, methodology or documentation of the imaging process, or information about the source materials being scanned. In general, administrative metadata is informed by the local needs of the project or institution and is defined by project-specific workflows. Administrative metadata may also encompass repository-like information, such as billing information or contractual agreements for deposit of digitized resources into a repository.

For additional information, see Harvard University Library's Digital Repository Services (DRS) User Manual for Data Loading, Version 2.04 at http://hul.harvard.edu/ois/systems/drs/drs_load_manual.pdf, particularly Section 5.0, "DTD Element Descriptions" for application of administrative metadata in a repository setting; Making of America 2 (MOA2) Digital Object Standard: Metadata, Content, and Encoding at <http://www.cdlib.org/about/publications/CDLObjectStd-2001.pdf>; the Dublin Core also has an initiative for administrative metadata at <http://metadata.net/admin/draft-iannella-admin-01.txt> in draft form as it relates to descriptive metadata. The Library of Congress has defined a data dictionary for various formats in the context of METS, Data Dictionary for Administrative Metadata for Audio, Image, Text, and Video Content to Support the Revision of Extension Schemas for METS, available at <http://lcweb.loc.gov/rr/mopic/avprot/extension2.html>.

Rights-

Although metadata regarding rights management information is briefly mentioned above, it encompasses an important piece of administrative metadata that deserves further discussion. Rights information plays a key role in the context of digital imaging projects and will become more and more prominent in the context of preservation repositories, as strategies to act upon digital resources in order to preserve them may involve changing their structure, format, and properties. Rights metadata will be used both by humans to identify rights holders and legal status of a resource, and also by systems that implement rights management functions in terms of access and usage restrictions.

□

Because rights management and copyright are complex legal topics, the General Counsel's office (or a lawyer) should be consulted for specific guidance and assistance. The following discussion is provided for informational purposes only and should not be considered specific legal advice.

Generally, records created by employees of the Federal government as part of their routine duties, works for hire created under contract to the Federal government, and publications produced by the Federal government are all in

the public domain. However, it is not enough to assume that if NARA has physical custody of a record that it also owns the intellectual property in that record. NARA also has custody of other records, where copyright may not be so straightforward – such as personal letters written by private individuals, personal papers from private individuals, commercially published materials of all types, etc.—which are subject to certain intellectual property and privacy rights and may require additional permissions from rights holders. After transfer or donation of records to NARA from other federal agencies or other entities, NARA may either: own both the physical record and the intellectual property in the record; own the physical record but not the intellectual property; or the record is in the public domain. It is important to establish who owns or controls both the physical record and the copyright at the beginning of an imaging project, as this affects reproduction, distribution, and access to digital images created from these records. □

Metadata element sets for intellectual property and rights information are still in development, but they will be much more detailed than statements that define reproduction and distribution policies. At a minimum, rights-related metadata should include: the legal status of the record; a statement on who owns the physical and intellectual aspects of the record; contact information for these rights holders; as well as any restrictions associated with the copying, use, and distribution of the record. To facilitate bringing digital copies into future repositories, it is desirable to collect appropriate rights management metadata at the time of creation of the digital copies. At the very least, digital versions should be identified with a designation of copyright status, such as: “public domain;” “copyrighted” (and whether clearance/permissions from rights holder has been secured); “unknown;” “donor agreement/contract;” etc.

Preservation metadata dealing with rights management in the context of digital repositories will likely include detailed information on the types of actions that can be performed on data objects for preservation purposes and information on the agents or rights holders that authorize such actions or events.

For an example of rights metadata in the context of libraries and archives, a rights extension schema has recently been added to the Metadata Encoding and Transmission Standard (METS), which documents metadata about the intellectual rights associated with a digital object. □ This extension schema contains three components: a rights declaration statement; detailed information about rights holders; and context information, which is defined as “who has what permissions and constraints within a specific set of circumstances.” The schema is available at: <http://www.loc.gov/standards/rights/METSRights.xsd>

For additional information on rights management, see: Peter B. Hirtle, “Archives or Assets?” at <http://techreports.library.cornell.edu:8081/Dienst/UI/1.0/Display/cul.lib/2003-2>; June M. Besek, Copyright Issues Relevant to the Creation of a Digital Archive: A Preliminary Assessment, January 2003 at <http://www.clir.org/pubs/reports/pub112/contents.html>; Adrienne Muir, “Copyright and Licensing for Digital Preservation,” at <http://www.cilip.org.uk/update/issues/jun03/article2june.html>; Karen Coyle, Rights Expression Languages, A Report to the Library of Congress, February 2004, available at http://www.loc.gov/standards/Coylereport_final1single.pdf; MPEG-21 Overview v.5 contains a discussion on intellectual property and rights at <http://www.chiariglione.org/mpeg/standards/mpeg-21/mpeg-21.htm>; for tables that reference when works pass into the public domain, see Peter Hirtle, “When Works Pass Into the Public Domain in the United States: Copyright Term for Archivists and Librarians,” at http://www.copyright.cornell.edu/training/Hirtle_Public_Domain.htm and Mary Minow, “Library Digitization Projects: Copyrighted Works that have Expired into the Public Domain” at <http://www.librarylaw.com/DigitizationTable.htm>; and for a comprehensive discussion on libraries and copyright, see: Mary Minow, *Library Digitization Projects and Copyright* at <http://www.llrx.com/features/digitization.htm>.

Technical-

Technical metadata refers to information that describes attributes of the digital image (not the analog source of the image) and helps to ensure that images will be rendered accurately. It supports content preservation by providing information needed by applications to use the file and to successfully control the transformation or migration of images across or between file formats. Technical metadata also describes the image capture process and technical environment, such as hardware and software used to scan images, as well as file format-specific information, image quality, and information about the source object being scanned, which may influence scanning decisions. Technical metadata helps to ensure consistency across a large number of files by enforcing standards for their creation. At a minimum, technical metadata should capture the information necessary to render, display, and use the resource.

Technical metadata is characterized by information that is both objective and subjective—attributes of image quality that can be measured using objective tests as well as information that may be used in a subjective assessment of an image’s value. Although tools for automatic creation and capture of many objective components

are badly needed, it is important to determine what metadata should be highly structured and useful to machines, as opposed to what metadata would be better served in an unstructured, free-text note format. The more subjective data is intended to assist researchers in the analysis of digital resource or imaging specialists and preservation administrators in determining long-term value of a resource.

In addition to the digital image, technical metadata will also need to be supplied for the metadata record itself if the metadata is formatted as a text file or XML document or METS document, for example. In this sense, technical metadata is highly recursive, but necessary for keeping both images and metadata understandable over time.

Requirements for technical metadata will differ for various media formats. For digital still images, we refer to the NISO Data Dictionary - Technical Metadata for Digital Still Images at http://www.niso.org/standards/resources/Z39_87_trial_use.pdf. It is a comprehensive technical metadata set based on the Tagged Image File Format specification, and makes use of the data that is already captured in file headers. It also contains metadata elements important to the management of image files that are not present in header information, but that could potentially be automated from scanner/camera software applications. An XML schema for the NISO technical metadata has been developed at the Library of Congress called MIX (Metadata in XML), which is available at <http://www.loc.gov/standards/mix/>.

See also the TIFF 6.0 Specification at <http://partners.adobe.com/asn/developer/pdfs/tn/TIFF6.pdf> as well as the Digital Imaging Group's DIG 35 metadata element set at http://www.i3a.org/i_dig35.html; and Harvard University Library's Administrative Metadata for Digital Still Images data dictionary at http://hul.harvard.edu/ldi/resources/ImageMetadata_v2.pdf.

A new initiative led by the Research Libraries Group called "*Automatic Exposure: Capturing Technical Metadata for Digital Still Images*" is investigating ways to automate the capture of technical metadata specified in the NISO Z39.87 draft standard. The initiative seeks to build automated capture functionality into scanner and digital camera hardware and software in order to make this metadata readily available for transfer into repositories and digital asset management systems, as well as to make metadata capture more economically viable by reducing the amount of manual entry that is required. This implies a level of trust that the metadata that is automatically captured and internal to the file is inherently correct.

See <http://www.rlg.org/longterm/autotechmetadata.html> for further discussion of this initiative, as well as the discussion on Image Quality Assessment, below.

Initiatives such as the Global Digital Format Registry (<http://hul.harvard.edu/gdfr/>) could potentially help in reducing the number of metadata elements that need to be recorded about a file or group of files regarding file format information necessary for preservation functions. Information maintained in the Registry could be pointed to instead of recorded for each file or batch of files.

Structural-

Structural metadata describes the relationships between different components of a digital resource. It ties the various parts of a digital resource together in order to make a useable, understandable whole. One of the primary functions of structural metadata is to enable display and navigation, usually via a page-turning application, by indicating the sequence of page images or the presence of multiple views of a multi-part item. In this sense, structural metadata is closely related to the intended behaviors of an object. Structural metadata is very much informed by how the images will be delivered to the user as well as how they will be stored in a repository system in terms of how relationships among objects are expressed.

Structural metadata often describes the significant intellectual divisions of an item (such as chapter, issue, illustration, etc.) and correlates these divisions to specific image files. These explicitly labeled access points help to represent the organization of the original object in digital form. This does not imply, however, that the digital must always imitate the organization of the original—especially for non-linear items, such as folded pamphlets. Structural metadata also associates different representations of the same resource together, such as production master files with their derivatives, or different sizes, views, or formats of the resource.

Example structural metadata might include whether the resource is simple or complex (multi-page, multi-volume, has discrete parts, contains multiple views); what the major intellectual divisions of a resource are (table of contents, chapter, musical movement); identification of different views (double-page spread, cover, detail); the extent (in files, pages, or views) of a resource and the proper sequence of files, pages and views; as well as different technical (file formats, size), visual (pre- or post-conservation treatment), intellectual (part of a larger collection or work), and use (all instances of a resource in different formats--TIFF files for display, PDF files for printing, OCR file for full text searching) versions.

File names and organization of files in system directories comprise structural metadata in its barest form. Since meaningful structural metadata can be embedded in file and directory names, consideration of where and how structural metadata is recorded should be done upfront. See Section V. Storage for further discussion on this topic.

No widely adopted standards for structural metadata exist since most implementations of structural metadata are at the local level and are very dependent on the object being scanned and the desired functionality in using the object. Most structural metadata is implemented in file naming schemes and/or in databases that record the order and hierarchy of the parts of an object so that they can be identified and reassembled back into their original form.

The Metadata Encoding and Transmission Standard (METS) is often discussed in the context of structural metadata, although it is inclusive of other types of metadata as well. METS provides a way to associate metadata with the digital files they describe and to encode the metadata and the files in a standardized manner, using XML. METS requires structural information about the location and organization of related digital files to be included in the METS document. Relationships between different representations of an object as well as relationships between different hierarchical parts of an object can be expressed. METS brings together a variety of metadata about an object all into one place by allowing the encoding of descriptive, administrative, and structural metadata. Metadata and content information can either be wrapped together within the METS document, or pointed to from the METS document if they exist in externally disparate systems. METS also supports extension schemas for descriptive and administrative metadata to accommodate a wide range of metadata implementations. Beyond associating metadata with digital files, METS can be used as a data transfer syntax so objects can easily be shared; as a Submission Information Package, an Archival Information Package, and a Dissemination Information Package in an OAIS-compliant repository (see below); and also as a driver for applications, such as a page turner, by associating certain behaviors with digital files so that they can be viewed, navigated, and used. Because METS is primarily concerned with structure, it works best with “library-like” objects in establishing relationships among multi-page or multi-part objects, but it does not apply as well to hierarchical relationships that exist in collections within an archival context.

See <http://www.loc.gov/standards/mets/> for more information on METS.

Behavior-

Behavior metadata is often referred to in the context of a METS object. It associates executable behaviors with content information that define how a resource should be utilized or presented. Specific behaviors might be associated with different genres of materials (books, photographs, Powerpoint presentations) as well as with different file formats. Behavior metadata contains a component that abstractly defines a set of behaviors associated with a resource as well as a “mechanism” component that points to executable code (software applications) that then performs a service according to the defined behavior. The ability to associate behaviors or services with digital resources is one of the attributes of a METS object and is also part of the “digital object architecture” of the Fedora digital repository system. See <http://www.fedora.info/documents/master-spec-12.20.02.pdf> for a discussion of Fedora and digital object behaviors.

Preservation-

Preservation metadata encompasses all information necessary to manage and preserve digital assets over time. Preservation metadata is usually defined in the context of the OAIS reference model (Open Archival Information System, <http://ssdoo.gsfc.nasa.gov/nost/isoas/overview.html>), and is often linked to the functions and activities of a repository. It differs from technical metadata in that it documents processes performed over time (events or actions taken to preserve data and the outcomes of these events) as opposed to explicitly describing provenance (how a digital resource was created) or file format characteristics, but it does encompass all types of the metadata mentioned above, including rights information. Although preservation metadata draws on information recorded earlier (technical and structural metadata would be necessary to render and reassemble the resource into an understandable whole), it is most often associated with analysis of and actions performed on a resource after submission to a repository. Preservation metadata might include a record of changes to the resource, such as transformations or conversions from format to format, or indicate the nature of relationships among different resources.

Preservation metadata is information that will assist in preservation decision-making regarding the long-term value of a digital resource and the cost of maintaining access to it, and will help to both facilitate archiving strategies for digital images as well as support and document these strategies over time. Preservation metadata is commonly linked with digital preservation strategies such as migration and emulation, as well as more “routine” system-level actions such as copying, backup, or other automated processes carried out on large numbers of objects. These strategies will rely on all types of pre-existing metadata and will also generate and record new

metadata about the object. It is likely that this metadata will be both machine-processable and “human-readable” at different levels to support repository functions as well as preservation policy decisions related to these objects.

In its close link to repository functionality, preservation metadata may reflect or even embody the policy decisions of a repository; but these are not necessarily the same policies that apply to preservation and reformatting in a traditional context. The extent of metadata recorded about a resource will likely have an impact on future preservation options to maintain it. Current implementations of preservation metadata are repository- or institution-specific. We anticipate that a digital asset management system may provide some basic starter functionality for low-level preservation metadata implementation, but not to the level of a repository modeled on the OAIS.

See also A Metadata Framework to Support the Preservation of Digital Objects at http://www.oclc.org/research/projects/pmwg/pm_framework.pdf and Preservation Metadata for Digital Objects: A Review of the State of the Art at http://www.oclc.org/research/projects/pmwg/presmeta_wp.pdf, both by the OCLC/RLG Working Group on Preservation Metadata, for excellent discussions of preservation metadata in the context of the OAIS model. A new working group, “Preservation Metadata: Implementation Strategies,” is working on developing best practices for implementing preservation metadata and on the development of a recommended core set of preservation metadata. Their work can be followed at <http://www.oclc.org/research/projects/pmwg/>.

For some examples of implementations of preservation metadata element sets at specific institutions, see: OCLC Digital Archive Metadata, at http://www.oclc.org/support/documentation/pdf/da_metadata_elements.pdf; Florida Center for Library Automation Preservation Metadata, at http://www.fcla.edu/digitalArchive/pdfs/Archive_data_dictionary20030703.pdf; Technical Metadata for the Long-Term Management of Digital Materials, at http://dvl.dtic.mil/metadata_guidelines/TechMetadata_26Mar02_1400.pdf; and The National Library of New Zealand, Metadata Standard Framework, Preservation Metadata, at http://www.natlib.govt.nz/files/4initiatives metaschema_revised.pdf.

Image quality assessment (NARA-NWTS Digital Imaging Lab proposed metadata requirement)-

The technical metadata specified in the *NISO Data Dictionary - Technical Metadata for Digital Still Images* contains many metadata fields necessary for the long-term viability of the image file. However, we are not convinced that it goes far enough in providing information necessary to make informed preservation decisions regarding the value and quality of a digital still raster image. Judgments about the quality of an image require a visual inspection of the image, a process that cannot be automated. Quality is influenced by many factors—such as the source material from which the image was scanned, the devices used to create the image, any subsequent processing done to the image, compression, and the overall intended use of the image. Although the data dictionary includes information regarding the analog source material and the scanning environment in which the image was created, we are uncertain whether this information is detailed enough to be of use to administrators, curators, and others who will need to make decisions regarding the value and potential use of digital still images. The value of metadata correlates directly with the future use of the metadata. It seems that most technical metadata specified in the NISO data dictionary is meant to be automatically captured from imaging devices and software and intended to be used by systems to render and process the file, not necessarily used by humans to make decisions regarding the value of the file. The metadata can make no guarantee about the quality of the data. Even if files appear to have a full complement of metadata and meet the recommended technical specifications as outlined in these *Technical Guidelines*, there may still be problems with the image file that cannot be assessed without some kind of visual inspection.

The notion of an image quality assessment was partly inspired by the National Library of Medicine Permanence Ratings (see <http://www.nlm.nih.gov/pubs/reports/permanence.pdf> and <http://www.rlg.org/events/pres-2000/byrnes.html>), a rating for resource permanence or whether the content of a resource is anticipated to change over time. However, we focused instead on evaluating image quality and this led to the development of a simplified rating system that would: indicate a quality level for the suitability of the image as a production master file (its suitability for multiple uses or outputs), and serve as a potential metric that could be used in making preservation decisions about whether an image is worth maintaining over time. If multiple digital versions of a single record exist, then the image quality assessment rating may be helpful for deciding which version(s) to keep.

The rating is linked to image defects introduced in the creation of intermediates and/or introduced during digitization and image processing, and to the nature and severity of the defects based on evaluating the digital

images on-screen at different magnifications. In essence, a “good” rating for image files implies an appropriate level of image quality that warrants the effort to maintain them over time.

The image quality assessment takes into account the attributes that influence specifications for scanning a production master image file: format, size, intended use, significant characteristics of the original that should be maintained in the scan, and the quality and characteristics of the source material being scanned. This rating system could later be expanded to take into account other qualities such as object completeness (are all pages or only parts of the resource scanned?); the source of the scan (created in-house or externally provided?); temporal inconsistencies (scanned at different times, scanned on different scanners, scan of object is pre- or post-conservation treatment?), and enhancements applied to the image for specific purposes (for exhibits, cosmetic changes among others).

This rating is not meant to be a full technical assessment of the image, but rather an easy way to provide information that supplements existing metadata about the format, intent, and use of the image, all of which could help determine preservation services that could be guaranteed and associated risks based on the properties of the image. We anticipate a preservation assessment will to be carried out later in the object’s lifecycle based on many factors, including the image quality assessment.

Image quality rating metadata is meant to be captured at the time of scanning, during processing, and even at the time of ingest into a repository. When bringing batches or groups of multiple image files into a repository that do not have individual image quality assessment ratings, we recommend visually evaluating a random sample of images and applying the corresponding rating to all files in appropriate groups of files (such as all images produced on the same model scanner or all images for a specific project).

Record whether the image quality assessment rating was applied as an individual rating or as a batch rating. If a batch rating, then record how the files were grouped.

Image Quality Assessment Ratings

Rating	Description	Use	Defect Identification
2	<ul style="list-style-type: none"> No obvious visible defects in image when evaluating the histogram and when viewed on-screen, including individual color channels, at: <p>100% or 1:1 pixel display (micro) and actual size (1"=1") and full image (global)</p>	Generally, image suitable as production master file.	
1	<ul style="list-style-type: none"> No obvious visible defects in image when evaluating the histogram and when viewed on-screen, including individual color channels, at: <p>actual size (1"=1") and full image (global)</p> <ul style="list-style-type: none"> Minor defects visible at: <p>100% or 1:1 pixel display (micro)</p>	Image suitable for less critical applications (e.g., suitable for output on typical inkjet and photo printers) or for specific intents (e.g., for access images, uses where these defects will not be critical).	<p>Identify and record the defects relating to intermediates and the digital images – illustrative examples:</p> <p>Intermediates-</p> <ul style="list-style-type: none"> out of focus copy negative scratched microfilm surface dirt etc. <p>Digital images-</p> <ul style="list-style-type: none"> oversharpened image excessive noise posterization and quantization artifacts compression artifacts color channel misregistration color fringing around text etc.
0	<ul style="list-style-type: none"> Obvious visible defects when evaluating the histogram and when viewed on-screen, including individual color channels, at: <p>100% or 1:1 pixel display (micro) and/or actual size (1"=1") and/or full image (global)</p>	<p>Image unsuitable for most applications.</p> <p>In some cases, despite the low rating, image may warrant long-term retention if-</p> <ul style="list-style-type: none"> image is the "best copy available" known to have been produced for a very specific output 	<p>Identify and record the defects relating to intermediates and the digital images - illustrative examples:</p> <p>Intermediates-</p> <ul style="list-style-type: none"> all defects listed above uneven illumination during photography under- or over-exposed copy transparencies reflections in encapsulation etc. <p>Digital images-</p> <ul style="list-style-type: none"> all defects listed above clipped highlight and/or clipped shadow detail uneven illumination during scanning reflections in encapsulation image cropped etc.

As stated earlier, image quality assessment rating is applied to the digital image but is also linked to information regarding the source material from which it was scanned. Metadata about the image files includes a placeholder for information regarding source material, which includes a description of whether the analog source is the original or an intermediate, and if so, what kind of intermediate (copy, dupe, microfilm, photocopy, etc.) as well as the source format. Knowledge of deficiencies in the source material (beyond identifying the record type and format) helps to inform image quality assessment as well.

The practicality of implementing this kind of assessment has not yet been tested, especially since it necessitates a review of images at the file level. Until this conceptual approach gains broader acceptance and consistent implementation within the community, quality assessment metadata may only be useful for local preservation decisions. As the assessment is inherently technical in nature, a basic foundation in photography and imaging is

helpful in order to accurately evaluate technical aspects of the file, as well as to provide a degree of trustworthiness in the reviewer and in the rating that is applied.

Records management/recordkeeping-

Another type of metadata, relevant to the digitization of federal records in particular, is records management metadata. Records management metadata is aligned with administrative-type metadata in that its function is to assist in the management of records over time; this information typically includes descriptive (and, more recently, preservation) metadata as a subset of the information necessary to both find and manage records. Records management metadata is usually discussed in the context of the systems or domains in which it is created and maintained, such as Records Management Application (RMA) systems. □ This includes metadata about the records as well as the organizations, activities, and systems that create them. □ The most influential standard in the United States on records management metadata is the Department of Defense's Design Criteria Standard for Electronic Records Management Software Applications (DOD 5015.2) at <http://www.dtic.mil/whs/directives/corres/html/50152std.htm>. This standard focuses on minimum metadata elements a RMA should capture and maintain, defines a set of metadata elements at the file plan, folder, and record levels, and generally discusses the functionality that an RMA should have as well as the management, tracking, and integration of metadata that is held in RMAs. □

Records Management metadata should document whether digital images are designated as permanent records, new records, temporary records, reference copies, or are accorded a status such as "indefinite retention." A determination of the status of digital images in a records management context should be made upfront at the point of creation of the image, as this may have an effect on the level and detail of metadata that will be gathered for a digital object to maintain its significant properties and functionality over the long term. Official designation of the status of the digital images will be an important piece of metadata to have as digital assets are brought into a managed system, such as NARA's Electronic Records Archive (ERA), which will have extensive records management capabilities. □

In addition to a permanent or temporary designation, records management metadata should also include documentation on any access and/or usage restrictions for the image files. Metadata documenting restrictions that apply to the images could become essential if both unrestricted and restricted materials and their metadata are stored and managed together in the same system, as these files will possess different maintenance, use and access requirements. Even if restricted files are stored on a physically separate system for security purposes, metadata about these files may not be segregated and should therefore include information on restrictions.

For digitization projects done under NARA 816 guidance, we assume classified, privacy restricted, and any records with other restrictions will not be selected for digitization. However, records management metadata should still include documentation on access and usage restrictions - even unrestricted records should be identified as "unrestricted." This may be important metadata to express at the system level as well, as controls over access to and use of digital resources might be built directly into a delivery or access system. □

In the future, documentation on access and use restrictions relevant to NARA holdings might include information such as: "classified" (which should be qualified by level of classification); "unclassified" or "unrestricted;" "declassified;" and "restricted," (which should be qualified by a description of the restrictions, i.e., specific donor-imposed restrictions), for example. Classification designation will have an impact on factors such as physical storage (files may be physically or virtually stored separately), who has access to these resources, and different maintenance strategies.

Basic records management metadata about the image files will facilitate bringing them into a formal system and will inform functions such as scheduling retention timeframes, how the files are managed within a system, what types or levels of preservation services can be performed, or how they are distributed and used by researchers, for example.

Tracking-

Tracking metadata is used to control or facilitate the particular workflow of an imaging project during different stages of production. Elements might reflect the status of digital images as they go through different stages of the workflow (batch information and automation processes, capture, processing parameters, quality control, archiving, identification of where/media on which files are stored); this is primarily internally-defined metadata that serves as documentation of the project and may also serve also serve as a statistical source of information to track and report on progress of image files. Tracking metadata may exist in a database or via a directory/folder system.

Meta-metadata-

Although this information is difficult to codify, it usually refers to metadata that describes the metadata record itself, rather than the object it is describing, or to high-level information about metadata “policy” and procedures, most often on the project level. Meta-metadata documents information such as who records the metadata, when and how it gets recorded, where it is located, what standards are followed, and who is responsible for modification of metadata and under what circumstances.

It is important to note that metadata files yield “master” records as well. These non-image assets are subject to the same rigor of quality control and storage as master image files. Provisions should be made for the appropriate storage and management of the metadata files over the long term.

Assessment of Metadata Needs for Imaging Projects:

Before beginning any scanning, it is important to conduct an assessment both of existing metadata and metadata that will be needed in order to develop data sets that fit the needs of the project. The following questions frame some of the issues to consider:

- *Does metadata already exist in other systems (database, finding aid, on item itself) or structured formats (Dublin Core, local database)?*

If metadata already exists, can it be automatically derived from these systems, pointed to from new metadata gathered during scanning, or does it require manual input? Efforts to incorporate existing metadata should be pursued. It is also extremely beneficial if existing metadata in other systems can be exported to populate a production database prior to scanning. This can be used as base information needed in production tracking, or to link item level information collected at the time of scanning to metadata describing the content of the resource. An evaluation of the completeness and quality of existing metadata may need to be made to make it useful (e.g., what are the characteristics of the data content, how is it structured, can it be easily transformed?)

It is likely that different data sets with different functions will be developed, and these sets will exist in different systems. However, efforts to link together metadata in disparate systems should be made so that it can be reassembled into something like a METS document, an Archival XML file for preservation, or a Presentation XML file for display, depending on what is needed. Metadata about digital images should be integrated into peer systems that already contain metadata about both digital and analog materials. By their nature, digital collections should not be viewed as something separate from non-digital collections. Access should be promoted across existing systems rather than building a separate stand-alone system.

- *Who will capture metadata?*

Metadata is captured by systems or by humans and is intended for system or for human use. For example, certain preservation metadata might be generated by system-level activities such as data backup or copying. Certain technical metadata is used by applications to accurately render an image. In determining the function of metadata elements, it is important to establish whether this information is important for use by machines or by people. If it is information that is used and/or generated by systems, is it necessary to explicitly record it as metadata? What form of metadata is most useful for people? Most metadata element sets include less structured, note or comment-type fields that are intended for use by administrators and curators as data necessary for assessment of the provenance, risk of obsolescence, and value inherent to a particular class of objects. Any data, whether generated by systems or people, that is necessary to understand a digital object, should be considered as metadata that may be necessary to formally record. But because of the high costs of manually generating metadata and tracking system-level information, the use and function of metadata elements should be carefully considered. Although some metadata can be automatically captured, there is no guarantee that this data will be valuable over the long term.

- *How will metadata be captured?*

Metadata capture will likely involve a mix of manual and automated entry. Descriptive and structural metadata creation is largely manual; some may be automatically generated through OCR processes to create indexes or full text; some technical metadata may be captured automatically from imaging software and devices; more sophisticated technical metadata, such as image quality assessment metadata used to inform preservation decisions, will require visual analysis and manual input.

An easy-to-use and customizable database or asset management system with a graphical and intuitive front end, preferably structured to mimic a project’s particular metadata workflow, is desirable and will make for more efficient metadata creation.

○ *When will metadata be collected?*

Metadata is usually collected incrementally during the scanning process and will likely be modified over time. At least, start with a minimal element set that is known to be needed and add additional elements later, if necessary.

Assignment of unique identifier or naming scheme should occur upfront. We also recommend that descriptive metadata be gathered prior to capture to help streamline the scanning process. It is usually much more difficult to add new metadata later on, without consultation of the originals. The unique file identifier can then be associated with a descriptive record identifier, if necessary.

A determination of what structural metadata elements to record should also occur prior to capture, preferably during the preparation of materials for capture or during collation of individual items. Information about the hierarchy of the collection, the object types, and the physical structure of the objects should be recorded in a production database prior to scanning. The structural parts of the object can be linked to actual content files during capture. Most technical metadata is gathered at the time of scanning. Preservation metadata is likely to be recorded later on, upon ingest into a repository.

○ *Where will the metadata be stored?*

Metadata can be embedded within the resource (such as an image header or file name) or can reside in a system external to the resource (such as a database) or both. Metadata can be also encapsulated with the file itself, such as with the Metadata Encoded Transmission Standard (METS). The choice of location of metadata should encourage optimal functionality and long-term management of the data.

Header data consists of information necessary to decode the image, and has somewhat limited flexibility in terms of data values that can be put into the fields. Header information accommodates more technical than descriptive metadata (but richer sets of header data can be defined depending on the image file format). The advantage is that metadata remains with the file, which may result in more streamlined management of content and metadata over time. Several tags are saved automatically as part of the header during processing, such as dimensions, date, and color profile information, which can serve as base-level technical metadata requirements. However, methods for storing information in file format headers are very format-specific and data may be lost in conversions from one format to another. Also, not all applications may be able to read the data in headers. Information in headers should be manually checked to see if data has transferred correctly or has not been overwritten during processing. Just because data exists in headers does not guarantee that it has not been altered or has been used as intended. Information in headers should be evaluated to determine if it has value. Data from image headers can be extracted and imported into a database; a relationship between the metadata and the image must then be established and maintained.

Storing metadata externally to the image in a database provides more flexibility in managing, using, and transforming it and also supports multi-user access to the data, advanced indexing, sorting, filtering, and querying. It can better accommodate hierarchical descriptive information and structural information about multi-page or complex objects, as well as importing, exporting, and harvesting of data to external systems or other formats, such as XML. Because metadata records are resources that need to be managed in their own right, there is certainly benefit to maintaining metadata separately from file content in a managed system. Usually a unique identifier or the image file name is used to link metadata in an external system to image files in a directory.

We recommend that metadata be stored both in image headers as well as in an external database to facilitate migration and repurposing of the metadata. References between the metadata and the image files can be maintained via persistent identifiers. A procedure for synchronization of changes to metadata in both locations is also recommended, especially for any duplicated fields. This approach allows for metadata redundancy in different locations and at different levels of the digital object for ease of use (image file would not have to be accessed to get information; most header information would be extracted and added into an external system). Not all metadata should be duplicated in both places (internal and external to the file). Specific metadata is required in the header so that applications can interpret and render the file; additionally, minimal descriptive metadata such as a unique identifier or short description of the content of the file should be embedded in header information in case the file becomes disassociated from the tracking system or repository. Some applications and file formats offer a means to store metadata within the file in an intellectually structured manner, or allow the referencing of standardized schemes, such as Adobe XMP or the XML metadata boxes in the JPEG 2000 format. Otherwise, most metadata will reside in external databases, systems, or registries.

○ *How will the metadata be stored?*

Metadata schemes and data dictionaries define the content rules for metadata creation, but not the format in which metadata should be stored. Format may partially be determined by where the metadata is stored (file headers,

relational databases, spreadsheets) as well as the intended use of the metadata—does it need to be human-readable, or indexed, searched, shared, and managed by machines? How the metadata is stored or encoded is usually a local decision. Metadata might be stored in a relational database or encoded in XML, such as in a METS document, for example. Guidelines for implementing Dublin Core in XML are also available at: <http://dublincore.org/documents/2002/09/09/dc-xml-guidelines/>.

Adobe's Extensible Metadata Platform (XMP) is another emerging, standardized format for describing where metadata can be stored and how it can be encoded, thus facilitating exchange of metadata across applications. The XMP specification provides both a data model and a storage model. Metadata can be embedded in the file in header information or stored in XML "packets" (these describe how the metadata is embedded in the file). XMP supports the capture of (primarily technical) metadata during content creation and modification and embeds this information in the file, which can then be extracted later into a digital asset management system or database or as an XML file. If an application is XMP enabled or aware (most Adobe products are), this information can be retained across multiple applications and workflows. XMP supports customization of metadata to allow for local field implementation using their Custom File Info Panels application. XMP supports a number of internal schemas, such as Dublin Core and EXIF (a metadata standard used for image files, particularly by digital cameras), as well as a number of external extension schemas. The RLG initiative, "*Automatic Exposure: Capturing Technical Metadata for Digital Still Images*," mentioned earlier is considering the use of XMP to embed technical metadata in image files during capture and is developing a Custom File Info Panel for NISO Z39.87 technical metadata. XMP does not guarantee the automatic entry of all necessary metadata (several fields will still require manual entry, especially local fields), but allows for more complete customized, and accessible metadata about the file.

See <http://www.adobe.com/products/xmp/main.html> for more detailed information on the XMP specification and other related documents.

○ *Will the metadata need to interact or be exchanged with other systems?*

This requirement reinforces the need for standardized ways of recording metadata so that it will meet the requirements of other systems. Mapping from an element in one scheme to an analogous element in another scheme will require that the meaning and structure of the data is shareable between the two schemes, in order to ensure usability of the converted metadata. Metadata will also have to be stored in or assembled into a document format, such as XML, that promotes easy exchange of data. METS-compliant digital objects, for example, promote interoperability by virtue of their standardized, "packaged" format.

○ *At what level of granularity will the metadata be recorded?*

Will metadata be collected at the collection level, the series level, the imaging project level, the item (object) level, or file level? Although the need for more precise description of digital resources exists so that they can be searched and identified, for many large-scale digitization projects, this is not realistic. Most collections at NARA are neither organized around nor described at the individual item level, and cannot be without significant investment of time and cost. Detailed description of records materials is often limited by the amount of information known about each item, which may require significant research into identification of subject matter of a photograph, for example, or even what generation of media format is selected for scanning. Metadata will likely be derived from and exist on a variety of levels, both logical and file, although not all levels will be relevant for all materials. Certain information required for preservation management of the files will be necessary at the individual file level. An element indicating level of aggregation (e.g., item, file, series, collection) at which metadata applies can be incorporated, or the relational design of the database may reflect the hierarchical structure of the materials being described.

○ *Adherence to agreed-upon conventions and terminology?*

We recommend that standards, if they exist and apply, be followed for the use of data elements, data values, and data encoding. Attention should be paid to how data is entered into fields and whether controlled vocabularies have been used, in case transformation is necessary to normalize the data.

Local Implementation:

Because most of what we scan comes to the Imaging Lab on an item-by-item basis, we are capturing minimal descriptive and technical metadata at the item level only during the image capture and processing stage. Until a structure into which we can record hierarchical information both about the objects being scanned and their higher-level collection information is in place, we are entering basic metadata in files using Adobe Photoshop. Information about the file is added to the IPTC (International Press Telecommunications Council) fields in Photoshop in anticipation of mapping these values to an external database. The IPTC fields are used as placeholder fields only. This information is embedded in the file using Adobe XMP (Extensible Metadata Platform: <http://www.adobe.com/products/xmp/main.html>). Primary identifier is automatically imported into the "File

Info” function in Photoshop from our scanning software. We anticipate implementing the Custom Panel Description File Format feature available in XMP to define our own metadata set and then exporting this data into an asset management system, since the data will be stored in easily migratable XML packets.

The following tables outline minimal descriptive, technical, and structural metadata that we are currently capturing at the file level (table indicates the elements that logically apply at the object level):

Descriptive/Structural Placeholder Fields – Logical and/or File Attributes

Element Name	Note	Level (Object, File) of Metadata
Primary Identifier	Unique identifier (numerical string) of the digital image. This identifier also serves as the identifier for an associated descriptive metadata record in an external database. May be derived from an existing scheme. This identifier is currently “manually” assigned. We anticipate a “machine” assigned unique identifier to be associated with each image as it is ingested into a local repository system; this will be more like a “persistent identifier.” Since multiple identifiers are associated with one file, it is likely that this persistent identifier will be the cardinal identifier for the image.	Object, File
Secondary Identifier(s)	Other unique identifier(s) associated with the original	Object, File
Title	Title [informal or assigned] or caption associated with the resource	Object
Record Group ID	Record Group Identifier (if known)	Object
Record Group Descriptor	Title of Record Group (if known)	Object
Series	Title of Series (if known)	Object
Box or Location	Box Number or Location (if known)	Object
Structural view or page (sequence)	Description of view, page number, or file number	File
Publisher	Owner or Producer of image. Default is “U.S. National Archives”	Object
Source*	Text	Generation Media
	Film	Generation Format Color Mode Media Creation Date
	Photo Print	Color Mode Media
	Digital Photo	Not yet determined; may include Generation; Dimensions; Capture Mode/Settings; Quality Level; Compression Level, etc.
		Object

*Describes physical attributes of the source material that may assist in interpretation of image quality; describes capture and processing decisions; or indicates known problems with the original media that may affect the quality of the scan. A controlled vocabulary is used for these fields. We feel that it is important to record source object information in technical metadata. Knowledge of the source material will inform image quality assessment and future preservation decisions. For images derived from another digital image, source information will be described in a relationship field, most likely from a set of typed relationships (e.g., “derived from”).

Technical metadata is currently entered into an external project database to describe specific derivative files. We anticipate that this information will map up to attributes of the production master files. The following table describes suggested minimum technical metadata fields for production masters.

Example technical metadata – File Attributes (some generated by file header) – All elements apply at file level -

Element Name	Note
Copy	“Role,” “function,” or “class” of the image (e.g., production master, delivery, or print-optimized derivative). Currently this functional designation is also embedded in the file identifier. This element may serve to indicate level of preservation service required.
File format type/Version	(e.g., TIFF, JPEG)
Location	Pointer to local file directory where image is stored
Image creation date	YYYY-MM-DD format
Photographer/Operator	Producer of image (name of scanner operator)
Compression Type/Level	Type and Level of compression applied (Adobe Photoshop-specific setting)
Color Mode	(e.g., RGB, Grayscale)
Gamma Correction	Default value is 2.2
Color Calibration	ICC Profile. Default value is AdobeRGB 1998 for RGB images and Grayscale 2.2 for grayscale images.
Pixel Array	Pixel width x height
Spatial Resolution	Expressed in ppi (e.g., 300)
Image quality*	Uses controlled values from authority table. Documents image quality characteristics that may influence future decisions on image value.
File Name	Primary identifier (uniqueID_scanyear_componentpart_imagerole)
Source Information	Describes characteristics of the immediate analog source (original or intermediary) from which the digital image was made (see “Source” in table above)

*See “Image Quality Assessment” discussion above.

Structural metadata is currently embedded into the file name in a sequential numbering scheme for multi-part items and is reflected in working file directory structures. We anticipate that the file name, which follows the scheme: unique ID_scan year_component part_image role.format extension, can be parsed so that component parts of a digital resource can be logically related together. We also record minimal structural metadata in the header information, such as “front” and “back” for double-sided items or “cover,” “page 1,” “page 2,” “double-page spread” etc. for multi-page items or multi-views. “Component part” is strictly a file sequence number and does not reflect actual page numbers. This metadata is currently recorded as text since the data is not intended to feed into any kind of display or navigation application at the moment.

Relationships-

Currently there is no utility to record basic relationships among multi-page or multi-part image files beyond documenting relationships in file names. Until a digital asset management system is in place, our practice is to capture as much metadata as possible in the surrounding file structure (names, directories, headers). However, we consider that simple labels or names for file identifiers coupled with more sophisticated metadata describing relationships across files are the preferred way forward to link files together. This metadata would include file identifiers and metadata record identifiers and a codified or typed set of relationships that would help define the associations between image files and between different representations of the same resource. (Relationships between the digital object and the analog source object or the place of the digital object in a larger collection hierarchy would be documented elsewhere in descriptive metadata). Possible relationship types include identification of principal or authoritative version (for production master file); derivation relationships indicating what files come from what files; whether the images were created in the lab or come from another source; structural relationships (for multi-page or –part objects); sibling relationships (images of the same intellectual resource, but perhaps scanned from different source formats). We intend to further refine our work on relationships in the coming months, and start to define metadata that is specific to aggregations of files.

Batch level metadata-

Currently, data common to all files produced in the Imaging Lab (such as byte order, file format, etc.) is not recorded at the logical level at this time, but we anticipate integrating this kind of information into the construction of a digital asset management system. We are continuing discussions on how to formalize “Lab common

knowledge,” such as details about the hardware and software configurations used to scan and process digital images, target information, and capture and image processing methodologies into our technical metadata specifications.

Permanent and temporary metadata-

When planning for a digital imaging project, it may not be necessary to save all metadata created and used during the digitization phase of the project. For example, some tracking data may not be needed once all quality control and redo work has been completed. It may not be desirable, or necessary, to bring all metadata into a digital repository. For NARA’s pilot Electronic Access Project, metadata fields that were calculated from other fields, such as square area of a document (used during the pre-scan planning phase to determine scanning resolution and size of access file derivatives), were not saved in the final database since they could be recalculated in the future. Also, it may not be desirable or necessary to provide access to all metadata that is maintained within a system to all users. Most administrative and technical metadata will need to be accessible to administrative users to facilitate managing the digital assets, but does not need to be made available to general users searching the digital collections.

III. TECHNICAL OVERVIEW

Raster Image Characteristics:

Spatial Resolution-

Spatial resolution determines the amount of information in a raster image file in terms of the number of picture elements or pixels per unit measurement, but it does not define or guarantee the quality of the information. Spatial resolution defines how finely or widely spaced the individual pixels are from each other. The higher the spatial resolution the more finely spaced and the larger number of pixels overall. The lower the spatial resolution the more widely spaced the pixels and the fewer number of pixels overall.

Spatial resolution is measured as pixels per inch or PPI, also pixels per millimeter or pixels per centimeter are used. Resolution is often referred to as dots per inch or DPI, in common usage the terms PPI and DPI are used interchangeably. Since raster image files are composed of pixels, technically PPI is a more accurate term and is used in this document (one example in support of using the PPI term is that Adobe Photoshop software uses the pixels per inch terminology). DPI is the appropriate term for describing printer resolution (actual dots vs. pixels); however, DPI is used often in scanning and image processing software to refer to spatial resolution and this usage is an understandable convention.

The spatial resolution and the image dimensions determine the total number of pixels in the image; an 8”x10” photograph scanned at 100 ppi produces an image that has 800 pixels by 1000 pixels or a total of 800,000 pixels. The numbers of rows and columns of pixels, or the height and width of the image in pixels as described in the previous sentence, is known as the pixel array. When specifying a desired file size, it is always necessary to provide both the resolution and the image dimensions; ex. 300 ppi at 8”x10” or even 300 ppi at original size.

The image file size, in terms of data storage, is proportional to the spatial resolution (the higher the resolution, the larger the file size for a set document size) and to the size of the document being scanned (the larger the document, the larger the file size for a set spatial resolution). Increasing resolution increases the total number of pixels resulting in a larger image file. Scanning larger documents produces more pixels resulting in larger image files.

Higher spatial resolution provides more pixels, and generally will render more fine detail of the original in the digital image, but not always. The actual rendition of fine detail is more dependent on the spatial frequency response of the scanner or digital camera (see Quantifying Scanner/Digital Camera Performance below), the image processing applied, and the characteristics of the item being scanned. Also, depending on the intended usage of the production master files, there may be a practical limit to how much fine detail is actually needed.

Signal Resolution-

Bit-depth or signal resolution, sometimes called tonal resolution, defines the maximum number of shades and/or colors in a digital image file, but does not define or guarantee the quality of the information.

In a 1-bit file each pixel is represented by a single binary digit (either a 0 or 1), so the pixel can be either black or white. There are only two possible combinations or $2^1 = 2$.

The common standard for grayscale and color images is to use 8-bits (eight binary digits representing each pixel) of data per channel and this provides a maximum of 256 shades per channel ranging from black to white; $2^8 = 256$ possible combinations of zeroes and ones.

High-bit or 16-bits (16 binary digits representing each pixel) per channel images can have a greater number of shades compared to 8-bit per channel images, a maximum of over 65,000 shades vs. 256 shades; $2^{16} = 65,536$ possible combinations of zeroes and ones.

Well done 8-bits per channel imaging will meet most needs; with a limited ability for major corrections, transformations, and re-purposing because gross corrections of 8-bit per channel images may cause shades to drop out of the image, creating a posterization effect, due to the limited number of shades.

High-bit images can match the effective shading and density range of photographic originals (assuming the scanner is actually able to capture the information), and, due to the greater shading (compared to 8-bits per channel), may be beneficial when re-purposing images and when working with images that need major or excessive adjustments to the tone distribution and/or color balance. However, at this time, monitors for viewing images and output devices for printing images all render high-bit images at 8-bits per pixel, so there is limited practical benefit to saving high-bit images and no way to verify the accuracy and quality of high-bit images. Also, it is best to do a good job during digitization to ensure accurate tone and color reproduction, rather than relying on post-scan correction of high-bit images. Poorly done high-bit imaging has no benefit.

Color Mode-

Grayscale image files consist of a single channel, commonly either 8-bits (256 levels) or 16-bits (65,536 levels) per pixel with the tonal values ranging from black to white. Color images consist of three or more grayscale channels that represent color and brightness information, common color modes include RGB (red, green, blue), CMYK (cyan, magenta, yellow, black), and LAB (lightness, red-green, blue-yellow). The channels in color files may be either 8-bits (256 levels) or 16-bits (65,536 levels). Display and output devices mathematically combine the numeric values from the multiple channels to form full color pixels, ranging from black to white and to full colors.

RGB represents an additive color process- red, green and blue light are combined to form white light. This is the approach commonly used by computer monitors and televisions, film recorders that image onto photographic film, and digital printers/enlargers that print to photographic paper. RGB files have three color channels: 3 channels x 8-bits = 24-bit color file or 3 channels x 16-bits = 48-bit color. All scanners and digital cameras create RGB files, by sampling for each pixel the amount of light passing through red, green and blue filters that is reflected or transmitted by the item or scene being digitized. Black is represented by combined RGB levels of 0-0-0, and white is represented by combined RGB levels of 255-255-255. This is based on 8-bit imaging and 256 levels from 0 to 255; this convention is used for 16-bit imaging as well, despite the greater number of shades. All neutral colors have equal levels in all three color channels. A pure red color is represented by levels of 255-0-0, pure green by 0-255-0, and pure blue by 0-0-255.

CMYK files are an electronic representation of a subtractive process- cyan (C), magenta (M) and yellow (Y) are combined to form black. CMYK mode files are used for prepress work and include a fourth channel representing black ink (K). The subtractive color approach is used in printing presses (four color printing), color inkjet and laser printers (four color inks, many photo inkjet printers now have more colors), and almost all traditional color photographic processes (red, green and blue sensitive layers that form cyan, magenta and yellow dyes).

LAB color mode is a device independent color space that is matched to human perception- three channels representing lightness (L, equivalent to a grayscale version of the image), red and green information (A), and blue and yellow information (B). LAB mode benefits would include the matching to human perception and they do not require color profiles (see section on color management), disadvantages include the potential loss of information in the conversion from the RGB mode files from scanners and digital cameras, need to have high-bit data, and few applications and file formats support the mode.

Avoid saving files in CMYK mode, CMYK files have a significantly reduced color gamut (see section on color management) and are not suitable for production master image files for digital imaging projects involving holdings/collections in cultural institutions. While theoretically LAB may have benefits, at this time we feel that RGB files produced to the color and tone reproduction described in these guidelines and saved with an Adobe RGB 1998 color profile are the most practical option for production master files and are relatively device independent. We acknowledge our workflow to produce RGB production master files may incur some level of loss of data, however we believe the benefits of using RGB files brought to a common rendering outweigh the minor loss.

Digitization Environment:

Our recommendations and the ISO standards referred to below are based on using CRT monitors. Most LCD monitors we have tested do not compare in quality to the better CRTs in rendering fine detail and smooth gradients. Also, LCD monitors may have artifacts that make it difficult to distinguish image quality problems in the image files, and the appearance of colors and monitor brightness shift with the viewing angle of the LCD panel. This is changing rapidly and the image quality of current high-end LCD monitors is very close to the quality of better CRT monitors. If used, LCD monitors should meet the criteria specified below.

Viewing conditions-

A variety of factors will affect the appearance of images, whether displayed or printed on reflective, transmissive or emissive devices or media. Those factors that can be quantified must be controlled to assure proper representation of an image.

We recommend following the guidance in the following standards-

- ISO 3664 *Viewing Conditions- For Graphic Technology and Photography*

Provides specifications governing viewing images on reflective and transmissive media, as well as images displayed on a computer monitor without direct comparison to any form of the originals.
- ISO 12646 *Graphic Technology – Displays for Colour Proofing – Characteristics and Viewing Conditions* (currently a draft international standard or DIS)

Provides specific requirements for monitors and their surrounds for direct comparison of images on a computer monitor with originals (known as softproofing).

NOTE- The following are common parameters controlled by users, however refer to the standards for complete requirements and test methods. In particular, ISO 12646 specifies additional hardware requirements for monitors to ensure a reasonable quality level necessary for comparison to hardcopy.

Monitor settings, light boxes, and viewing booths-

We assume the assessment of many digital images will be made in comparison to the originals that have been digitized, therefore ISO 12646 should be followed where it supplements or differs from ISO 3664.

We recommend digital images be viewed on a computer monitor set to 24 bits (millions of colors) or greater, and calibrated to a gamma of 2.2.

ISO 12646 recommends the color temperature of the monitor also be set to 5000K (D50 illuminant) to match the white point of the illumination used for viewing the originals.

Monitor luminance level must be at least 85 cd/m², and should be 120 cd/m² or higher.

The computer/monitor desktop should be set to a neutral gray background (avoid images, patterns, and/or strong colors), preferably no more than 10% of the maximum luminance of the screen.

For viewing originals, we recommend using color correct light boxes or viewing booths that have a color temperature of 5000K (D50 illuminant), as specified in ISO 3664.

ISO 3664 provides two luminance levels for viewing originals, ISO 12646 recommends using the lower levels (P2 and T2) when comparing to the image on screen.

The actual illumination level on originals should be adjusted so the perceived brightness of white in the originals matches the brightness of white on the monitor.

The room-

The viewing environment should be painted/decorated a neutral, matte gray with a 60% reflectance or less to minimize flare and perceptual biases.

Monitors should be positioned to avoid reflections and direct illumination on the screen.

ISO 12646 requires the room illumination be less than 32 lux when measured anywhere between the monitor and the observer, and the light a color temperature of approximately 5000K.

Practical experience-

In practice, we have found a tolerable range of deviation from the measurements required in the ISO standards. When the ambient room lighting is kept below the limit set in ISO 12646, its color temperature can be lower than 5000K, as long as it is less than the monitor color temperature.

To compensate for environments that may not meet the ISO standards, as well as difficulties comparing analog originals to images on a monitor, the color temperature may need to be set higher than 5000K so that the range of grays from white to black appears neutral when viewed in the actual working environment. The higher color temperature may also be necessary for older monitors to reach an appropriate brightness, as long as neutrals don't appear too blue when compared to neutral hardcopy under the specified illumination.

Monitor calibration-

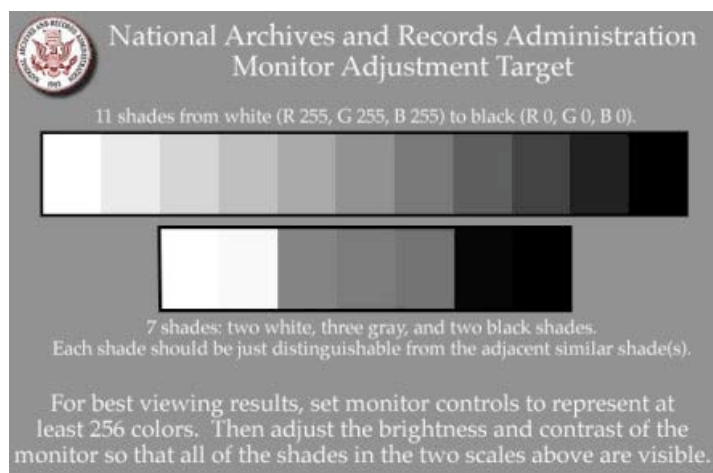
In order to meet and maintain the monitor settings summarized above, we recommend using CRT monitors designed for the graphic arts, photography, or multimedia markets.

A photosensor-based color calibrator and appropriate software (either bundled with the monitor or a third party application) should be used to calibrate the monitor to the aims discussed above. This is to ensure desired color temperature, luminance level, neutral color balance, and linearity of the red, green, and blue representation on the monitor are achieved.

If using an ICC color managed workflow (see section on color management), an ICC profile should be created after monitor calibration for correct rendering of images.

The monitor should be checked regularly and recalibrated when necessary.

Using a photosensor-based monitor calibrator, however, does not always ensure monitors are calibrated well. Ten years of practical experience has shown calibrators and calibration software may not work accurately or consistently. After calibration, it is important to assess the monitor visually, to make sure the monitor is adjusted appropriately. Assess overall contrast, brightness, and color neutrality of the gray desktop. Also, evaluate both color neutrality and detail rendering in white and black areas. This can be done using an image target of neutral patches ranging from black to white and saved in LAB color mode (since LAB does not require an ICC profile and can be viewed independently of the color managed process). In addition, it may be helpful to evaluate sample images or scans of targets – such as the *NARA Monitor Adjustment Target* (shown below) and/or a known image such as a scan of a Kodak grayscale adjusted to the aimpoints (8-8-8 / 105-105-105 / 247-247-247) described below.



When the monitor is adjusted and calibrated appropriately, the *NARA Monitor Adjustment Target* (shown at left) and/or an adjusted image of a Kodak gray scale will look reasonably accurate. Images with ICC color profiles will display accurately within color managed applications, and sRGB profiled images should display reasonably accurately outside color managed applications as well. The *NARA Monitor Adjustment Target* and the gray scale aimpoints are based on an empirical evaluation of a large number of monitors, on both Windows and Macintosh computers, and represent the average of the group. Over the last six years calibrating and adjusting monitors in this manner, we have found the onscreen representation to be very good on a wide variety of monitors and computers.

Quantifying Scanner/Digital Camera Performance:

Much effort has gone into quantifying the performance of scanners and digital cameras in an objective manner. The following tests are used to check the capabilities of digitization equipment, and provide information on how to best use the equipment.

Even when digitization equipment is assessed as described below, it is still necessary to have knowledgeable and experienced staff to evaluate images visually. At this time, it is not possible to rely entirely on the objective test measurements to ensure optimum image quality. It is still necessary to have staff with the visual literacy and technical expertise to do a good job with digitization and to perform quality control for digital images. This is true for the digitization of all types of archival records, but very critical for the digitization of photographic images.

Also, these tests are useful when evaluating and comparing scanners and digital cameras prior to purchase. Ask manufacturers and vendors for actual test results, rather than relying on the specifications provided in product literature, some performance claims in product literature are often overstated. If test results are not available, then try to scan test targets during a demonstration and consider having the analyses performed by a contract service.

During digitization projects, tests should be performed on a routine basis to ensure scanners and digital cameras/copy systems are performing optimally. Again, if it is not possible to analyze the tests in-house, then consider having a service perform the analyses on the resulting image files.

The following standards either are available or are in development, these test methods can be used for objective assessment of scanner or digital camera/copy system performance-

Terminology	ISO 12231
Opto-electronic Conversion Function	ISO 14524
Resolution: Still Picture Cameras	ISO 12233
Resolution: Print Scanners	ISO 16067-1
Resolution: Film Scanners	ISO 16067-2
Noise: Still Picture Cameras	ISO 15739
Dynamic Range: Film Scanners	ISO 21550

These standards can be purchased from ISO at <http://www.iso.ch> or from IHS Global at <http://global.ihs.com>. At this time, test methods and standards do not exist for all testing and device combinations. However, many tests are applicable across the range of capture device types and are cited in the existing standards as normative references.

Other test methods may be used to quantify scanner/digital camera performance. We anticipate there will be additional standards and improved test methods developed by the group working on the above standards. Unfortunately, at this time image analysis software is expensive and complex making it difficult to perform all the tests needed to properly quantify scanner/digital camera performance. Also, there is a range of test targets needed for these tests and they can be expensive to purchase.

The following requirements for performance criteria are based on measurements of the variety of actual scanners and digital cameras used in the NWTs Digital Imaging Lab. Where limits are specified, the limits are based on the performance of equipment we consider subjectively acceptable. This subjective acceptability is based on many years combined staff experience in the fields of photography, of photographic reformatting and duplication of a variety of archival records, and of digital imaging and digitization of a variety of archival records.

No digitization equipment or system is perfect, they all have trade-offs in regards to image quality, speed, and cost. The engineering of scanners and digital cameras represents a compromise, and for many markets image quality is sacrificed for higher speed and lower cost of equipment. Many document and book scanners, office scanners (particularly inexpensive ones), and high-speed scanners (all types) may not meet the limits specified, particularly for properties like image noise. Also, many office and document scanners are set at the default to force the paper of the original document to pure white in the image, clipping all the texture and detail in the paper (not desirable for most originals in collections of cultural institutions). These scanners will not be able to meet the desired tone reproduction without recalibration (which may not be possible), without changing the scanner settings (which may not overcome the problem), or without modification of the scanner and/or software (not easily done).

Test Frequency and Equipment Variability:

After equipment installation and familiarization with the hardware and software, an initial performance capability evaluation should be conducted to establish a baseline for each specific digitization device. At a minimum, this benchmark assessment would include for example-

- resolution performance for common sampling rates (e.g. 300, 400, 600, and 800 ppi for reflection scanning)
- OECF and noise characterization for different gamma settings
- lighting and image uniformity

Many scanners can be used both with the software/device drivers provided by the manufacturer and with third-party software/device drivers, characterize the device using the specific software/device drivers to be used for production digitization. Also, performance can change dramatically (and not always for the better) when software/device drivers are updated, characterize the device after every update.

A full suite of tests should be conducted to quantify the performance of digitization systems. Some tests probably only need to be redone on an infrequent basis, while others will need to be done on a routine basis. Depending on the performance consistency of equipment, consider performing tests using production settings on a weekly basis or for each batch of originals, whichever comes first. You may want to perform appropriate tests at the beginning of each batch and at the end of each batch to confirm digitization was consistent for the entire batch.

Scanner/digital camera performance will vary based on actual operational settings. Tests can be used to optimize scanner/camera settings. The performance of individual scanners and digital cameras will vary over time (see test frequency above). Also, the performance of different units of the same model scanner/camera will vary. Test every individual scanner/camera with the specific software/device driver combination(s) used for production. Perform appropriate test(s) any time there is an indication of a problem. Compare these results to past performance through a cumulative database. If large variability is noted from one session to the next for given scanner/camera settings, attempt to rule out operator error first.

Tests:

Opto-electronic conversion function (OECF) – for grayscale and color imaging–

- Follow ISO 14524.
- Perform OECF analysis for both grayscale and color imaging.
- Perform separate tests and analyses for both reflection and transmission scanning/digitization.
- Run tests at the manufacturer's standard/default settings and at actual production settings.
- Guidance – If these technical guidelines are followed, the actual or final OECF for the production master files is defined by our aimpoints.
- Variability – Limits for acceptable variability are unknown at this time.

Dynamic range – for grayscale and color imaging–

- Follow ISO 14524 and ISO 21550.
- Perform dynamic range analysis for both grayscale and color imaging.
- Perform separate tests and analyses for both reflection and transmission scanning/digitization.
- Guidance – Use of dynamic range analysis –
 - Do not rely on manufacturers' claims regarding the ability of scanners/digital cameras to capture large density ranges as a guide for what originals can be scanned with a particular scanner/camera. Most claims are only based on the sampling bit-depth and not on actual measured performance. Also, the performance of different units of the same model scanner/camera will vary, as well as the performance of individual units will vary over time. Performance will vary based on actual operational settings as well.
 - Do not scan originals that have larger density ranges than the measured dynamic range for a particular scanner/camera and mode (reflection vs. transmission). So, if the measured dynamic range for transmission scanning is 3.2, do not that scanner to scan a color transparency with a density range of greater than 3.2.
- Variability – Limits for acceptable variability are unknown at this time.

Spatial frequency response (SFR) – for grayscale and color imaging–

- Follow ISO 12233, ISO 16067-1, and ISO 16067-2.
- Perform SFR analysis for both grayscale and color imaging.
- Perform separate tests and analyses for both reflection and transmission scanning/digitization.
- Slant edge or sinusoidal targets and corresponding analyses should be used. Generally, do not use character based or line-pair based targets for SFR or resolution analysis.
- For reflection tests – scan targets at a resolution of at least 50% increase from desired resolution (if you plan to save 400 ppi files, then use at least 600 ppi for this test; $400 \text{ ppi} \times 1.5 = 600 \text{ ppi}$), test scans at 100% increase from desired resolution are preferable (if you plan to save 400 ppi, then use at least 800 ppi for testing; $400 \text{ ppi} \times 2 = 800 \text{ ppi}$). Alternative – scan targets at the maximum optical resolution cited by the manufacturer, be aware that depending on the scanner and given the size of the target, this can produce very large test files.
- For transmission tests – scan targets at the maximum resolution cited by the manufacturer, generally it is not necessary to scan at higher interpolated resolutions.
- Guidance – Use of MTF (modulation transfer function) analysis for SFR-
 - Do not rely on manufacturers' claims regarding the resolution of scanners/digital cameras, even optical resolution specifications are not a guarantee the appropriate level of image detail will be captured. Most

claims are over-rated in regards to resolution, and resolution is not the best measure of spatial frequency response (modulation transfer function is the best measurement).

- Evaluation of the MTF curve will provide the maximum resolution a scanner/digital camera system is actually achieving. Use this measured performance (perhaps an appropriate term would be system limited resolution) as a guide. If your scan resolution requirement exceeds the measured performance (system limited resolution), then generally we would not recommend using the scanner for that digitization work.
- The following formula can be used to assist with determining when it is appropriate to use a scanner/digital camera-
 - Scan resolution = desired output resolution x magnification factor.
 - For all items scanned at original size, the magnification factor is one and the scan resolution is the same as your desired output resolution.
 - For images that need to be enlarged, such as scanning a copy transparency or negative and scanning the image to original size, then multiply the desired output resolution by the magnification factor to determine the actual scan resolution – as an example, the desired output resolution is 400 ppi while scanning an image on a 4"x5" copy negative that needs to be enlarged 300% in the scanning software to match original size, the actual scan resolution is $400 \text{ ppi} \times 3 = 1,200 \text{ ppi}$.
- Variability – Limits for acceptable variability are unknown at this time.

Noise – for grayscale and color imaging–

- Follow ISO 15739.
- Perform noise measurement for both grayscale and color imaging.
- Perform separate tests and analyses for both reflection and transmission scanning/digitization.
- Limits –
 - For textual documents and other non-photographic originals with low maximum densities, less than 2.0 visual density-
 - Not to exceed 1.0 counts, out of 255
 - Lower is better
 - For photographs and originals with higher maximum densities, higher than 2.0 visual density
 - Not to exceed 0.7 counts, out of 255
 - Lower is better
- Variability – Limits for acceptable variability are unknown at this time.

Channel registration – for color imaging–

- Perform color channel registration measurement for color imaging.
- Perform separate tests and analyses for both reflection and transmission scanning/digitization.
- Limits –
 - For all types of originals-
 - Not to exceed 0.5 pixel misregistration.
- Guidance – Lower is better. Good channel registration is particularly important when digitizing textual documents and other line based originals in color; misregistration is very obvious as color halos around monochrome text and lines.
- Variability – Limits for acceptable variability are unknown at this time.

Uniformity – illumination, color, lens coverage, etc. – for grayscale and color imaging–

- Evaluate uniformity for both grayscale and color imaging.
- Perform separate tests and analyses for both reflection and transmission scanning/digitization.
- The following provides a simple visual method of evaluating brightness and color uniformity, and assists with identifying areas of unevenness and the severity of unevenness-
 - Scan the entire platen or copy board using typical settings for production work. For the reflection test - scan a Kodak photographic gray scale in the middle of the platen/copy board backed with an opaque sheet of white paper that covers the entire platen/copy board; for scanners ensure good contact between the paper and the entire surface of the platen. For the transmission test – scan a Kodak black-and-white film step tablet in the middle of the platen and ensure the rest of the platen is clear. The gray scale and step tablet are included in the scan to ensure auto ranging functions work properly. Scan the gray scale and step tablet, each image should show the scale centered in an entirely white image.
 - For image brightness variability - Evaluate the images using the “Threshold” tool in Adobe Photoshop. Observe the histogram in the Threshold dialog box and look for any clipping of the highlight tones of the image. Move the Threshold slider to higher threshold values and observe when the first portion of the white background turns black and note the numeric level. Continue adjusting the threshold higher until almost the entire image turns black (leaving small areas of white is OK) and note the numeric level (if the highlights have been clipped the background will not turn entirely black even at the highest threshold level of 255 – if

this is the case, use 255 for the numeric value and note the clipping). Subtract the lower threshold value from the higher threshold value. The difference represents the range of brightness levels of the areas of non-uniformity. With a perfectly uniform image, the threshold would turn the entire image black within a range of only 1 to 2 levels. Observe the areas that initially turn black as the threshold is adjusted, if possible avoid these areas of the platen/copy board when scanning. These most frequently occur near the edge of the platen or field of view.

- For color variability - Evaluate the images using the "Levels" tool in Adobe Photoshop. Move the white-point slider lower while holding the Option (Macs)/Alternate (Windows) key to see the clipping point. Observe when the first pixels in the highlight areas turn from black to any color and note the numeric level for the white-point. Continue shifting the white-point lower until almost the entire image turns white (leaving small areas of black or color is OK) and note the numeric level. Subtract the lower white-point value from the higher white-point value, the difference represents the range of color levels of the areas of non-uniformity. With a perfectly uniform image the threshold would turn the entire image white within a range of only 1 to 2 levels.
- Guidance - Make every effort to produce uniform images and to minimize variation. Avoid placing originals being scanned on areas of the platen/copy board that exhibit significant unevenness. Brightness and color variability ranges of 8 levels or less for RGB (3% or less for grayscale) are preferred. Achieving complete field uniformity may be difficult. Some scanners/digital cameras perform a normalization function to compensate for non-uniformity, many do not. It is possible, but very time consuming, to manually compensate for non-uniformity. Conceptually, this uses a low-resolution (50 ppi) grayscale image record of the uniformity performance along with the OECF conditions. In the future effective automated image processing functions may exist to compensate for unevenness in images, this should be done as part of the immediate post-capture image processing workflow.
- Variability - Limits for acceptable variability are unknown at this time.

Dimensional accuracy - for 1-bit, grayscale, and color imaging-

- For all types of imaging, including 1-bit, grayscale and color.
- Perform separate tests and analyses for reflection and transmission scanning/digitization.
- The following provides a simple approach to assessing dimensional accuracy and consistency-
 - Overall dimensional accuracy-
 - For reflection scanning- scan an Applied Image QA-2 (280mm x 356mm or 11"x14") or IEEE Std 167A-1995 facsimile test target (216mm x 280mm or 8.5"x11") at the resolution to be used for originals. Use target closest in size to the platen size or copy board size.
 - For transmission scanning- Consider scanning thin, clear plastic drafting scales/rulers. If these are too thick, create a ruler in a drafting/drawing application (black lines only on a white background) and print the ruler onto overhead transparency film on a laser printer using the highest possible resolution setting of the printer (1,200 ppi minimum). Compare printed scales to an accurate engineering ruler or tape measure to verify accuracy. Size the scales to match the originals being scanned, shorter and smaller scales for smaller originals. Scan scales at the resolution to be used for originals.
 - Dimensional consistency - for reflection and transmission scanning- scan a measured grid of equally spaced black lines creating 1" squares (2.54 cm) at the resolution that originals are to be scanned. Grids can be produced using a drafting/drawing application and printed on an accurate printer (tabloid or 11"x17" laser printer is preferred, but a good quality inkjet printer can be used and will have to be for larger grids). Reflection grids should be printed on a heavy-weight, dimensionally stable, opaque, white paper. Transmission grids should be printed onto overhead transparency film. Measure grid, both overall and individual squares, with an accurate engineering ruler or tape measure to ensure it is accurate prior to using as a target.
 - Determine the overall dimensional accuracy (as measured when viewed at 200% or 2:1 pixel ratio) for both horizontal and vertical dimensions, and determine dimensional consistency (on the grid each square is 1" or 2.54 cm) across both directions over the full scan area.
- Guidance -
 - Images should be consistent dimensionally in both the horizontal and vertical directions. Overall dimensions of scans should be accurate on the order of 1/10th of an inch or 2.45 mm, accuracy of 1/100th of an inch or 0.245 mm is preferred. Grids should not vary in square size across both directions of the entire platen or scan area compared to the grid that was scanned.
 - Aerial photography, engineering plans, and other similar originals may require a greater degree of accuracy.
- Variability - Limits for acceptable variability are unknown at this time.

Other artifacts or imaging problems-

- Note any other problems that are identified while performing all the above assessments.
 - Examples - streaking in blue channel, blur in fast direction.

- Unusual noise or grain patterns that vary spatially across the field.
- One dimensional streaks, and single or clustered pixel dropouts – sometimes these are best detected by visual inspection of individual color channels.
- Color misregistration that changes with position – this is frequently observed along high contrast slant edges.

Reference Targets:

We recommend including reference targets in each image of originals being scanned, including, at a minimum, a photographic gray scale as a tone and color reference and an accurate dimensional scale. If a target is included in each image, you may want to consider making access derivatives from the production masters that have the reference target(s) cropped out. This will reduce file size for the access files and present an uncluttered appearance to the images presented.

In a high production environment, it may be more efficient to scan targets separately and do it once for each batch of originals. The one target per batch approach is acceptable as long as all settings and operation of the equipment remains consistent for the entire batch and any image processing is applied consistently to all the images. For scanners and digital cameras that have an “auto range” function, the single target per batch approach may not work because the tone and color settings will vary due to the auto range function, depending on the density and color of each original.

All targets should be positioned close to but clearly separated from the originals being scanned. There should be enough separation to allow easy cropping of the image of the original to remove the target(s) if desired, but not so much separation between the original and target(s) that it dramatically increases the file size. If it fits, orient the target(s) along the short dimension of originals, this will produce smaller file sizes compared to having the target(s) along the long dimension (for the same document, a more rectangular shaped image file is smaller than a squarer image). Smaller versions of targets can be created by cutting down the full-size targets. Do not make the tone and color targets so small that it is difficult to see and use the target during scanning (this is particularly important when viewing and working with low resolution image previews within scanning software).

Make sure the illumination on the targets is uniform in comparison to the lighting of the item being scanned (avoid hot spots and/or shadows on the targets). Position targets to avoid reflections.

If the originals are digitized under glass, place the tone and color reference targets under the glass as well. If originals are encapsulated or sleeved with polyester film, place the tone and color reference targets into a polyester sleeve.

For digital copy photography set-ups using digital cameras, when digitizing items that have depth, it is important to make sure all reference targets are on the same level as the image plane – for example, when digitizing a page in a thick book, make sure the reference targets are at the same height/level as the page being scanned.

All types of tone and color targets will probably need to be replaced on a routine basis. As the targets are used they will accumulate dirt, scratches, and other surface marks that reduce their usability. It is best to replace the targets sooner, rather than using old targets for a longer period of time.

Scale and dimensional references-

Use an accurate dimensional scale as a reference for the size of original documents.

For reflection scanning, scales printed on photographic paper are very practical given the thinness of the paper and the dimensional accuracy that can be achieved during printing. Consider purchasing IEEE Std 167A-1995 facsimile test targets and using the ruler portion of the target along the left-hand edge. Due to the relatively small platen size of most scanners, you may need to trim the ruler off the rest of the target. Different length scales can be created to match the size of various originals. The Kodak Q-13 (8” long) or Q-14 (14” long) color bars have a ruler along the top edge and can be used as a dimensional reference; however, while these are commonly used, they are not very accurate.

For transmission scanning, consider using thin, clear plastic drafting scales/rulers. If these are too thick, create a ruler in a drafting/drawing application (black lines only on a white background) and print the ruler onto overhead transparency film on a laser printer using the highest possible resolution setting of the printer (600 ppi minimum). Compare printed scales to an accurate engineering ruler or tape measure to verify accuracy prior to using as a target. Again, different length scales can be created to match the size of various originals.

Targets for tone and color reproduction-

Reference targets can be used to assist with adjusting scanners and image files to achieve objectively “good images” in terms of tone and color reproduction. This is particularly true with reflection scanning. Copy negatives and copy transparencies should be produced with targets, gray scales and color bars, so they can be printed or scanned to match the original. Unfortunately, scanning original negatives is much more subjective, and this is also the case for copy negatives and copy transparencies that do not contain targets.

Reflection scanning-

We recommend including a Kodak Q-13 (8” long) or Q-14 (14” long) Gray Scale (20 steps, 0.10 density increments, and density range from approximately 0.05 to 1.95) within the area scanned. The Kodak gray scales are made of black-and-white photographic paper and have proven to work well as a reference target, including:

- Good consistency from gray scale to gray scale
- Good color neutrality
- Reasonably high visual density of approximately 1.95
- Provide the ability to quantify color and tone for the full range of values from black-point up to white-point
- The spectral response of the photographic paper has been a reasonable match for a wide variety of originals being scanned on a wide variety of scanners/digital cameras, few problems with metamerism
- The semi-matte surface tends to minimize problems with reflections and is less susceptible to scratching

The Kodak Color Control Patches (commonly referred to as color bars) from the Q-13 and Q-14 should only be used as a supplement to the gray scale, and never as the only target. The color bars are produced on a printing press and are not consistent. Also, the color bars do not provide the ability to assess color and tone reproduction for the full range of values from black-point to white-point.

Other gray scales produced on black-and-white photographic papers could be used. However, many have a glossy surface that will tend to scratch easily and cause more problems with reflections. Also, while being monochrome, some gray scales are not neutral enough to be used as a target.

IT8 color input targets (ex. Kodak Q-60) should not be used as scanning reference targets. IT8 targets are used for producing custom color profiles for scanning specific photographic papers, and therefore are produced on modern color photographic paper. Often, the neutral patches on IT8 targets are not neutral and the spectral response of the color photographic paper is not likely to match the response of most materials being scanned, therefore IT8 targets will not work well as a scanning reference. Also, there is little consistency from one IT8 target to another, even when printed on the same color photo paper.

Consider using a calibrated densitometer or colorimeter to measure the actual visual density or L*A*B* values of each step of the gray scales used as reference targets. Then use a laser printer to print the actual densities and/or L*A*B* values (small font, white text on a gray background) and tape the information above the gray scale so the corresponding values are above each step; for the Kodak gray scales you may need to reprint the identifying numbers and letters for each step. This provides a quick visual reference within the digital image to the actual densities.

Transmission scanning – positives–

Generally, when scanning transmissive positives, like original color transparencies and color slides, a tone and color reference target is usually not necessary. Most scanners are reasonably well calibrated for scanning color transparencies and slides (usually they are not so well calibrated for scanning negatives).

Transparencies and slides have the highest density range of photographic materials routinely scanned. You may need to include within the scan area both a maximum density area of the transparency (typically an unexposed border) and a portion of empty platen to ensure proper auto ranging. Mounted slides can present problems, it is easy to include a portion of the mount as a maximum density area, but since it may not be easy to include a clear area in the scan, you should check highlight levels in the digital image to ensure no detail was clipped.

Ideally, copy transparencies and slides were produced with a gray scale and color bars in the image along with the original. The gray scale in the image should be used for making tone and color adjustments. Caution, carefully evaluate using the gray scales in copy transparencies and slides to make sure that the illumination was even, there are no reflections on the gray scale, and the film was properly processed with no color cross-overs (the highlights and shadows have very different color casts). If any problems exist, you may have problems using the gray scale in the image, as tone and color adjustments will have to be done without relying on the gray scale.

For the best results with transmission scanning, it is necessary to control extraneous light known as flare. It may be necessary to mask the scanner platen or light box down to the just the area of the item being scanned or digitized.

Generally, photographic step tablets on black-and-white film (see discussion on scanning negatives below) are not good as tone and color reference targets for color scanning.

Transmission scanning – negatives–

We recommend including an uncalibrated Kodak Photographic Step Tablet (21 steps, 0.15 density increments, and density range of approximately 0.05 to 3.05), No. 2 (5" long) or No. 3 (10" long), within the scan area. The standard density range of a step tablet exceeds the density range of most originals that would be scanned, and the scanner can auto-range on the step tablet minimizing loss of detail in the highlight and/or shadow areas of the image.

For production masters, we recommend the brightness range be optimized or matched to the density range of the originals. It may be necessary to have several step tablets, each with a different density range to approximately match the density range of the items being scanned; it is preferable the density range of the step tablet just exceeds the density range of the original. These adjusted step tablets can be produced by cutting off the higher density steps of standard step tablets. If originals have a very short or limited density range compared to the reference targets, this may result in quantization errors or unwanted posterization effects when the brightness range of the digital image is adjusted; this is particularly true for images from low-bit or 8-bit per channel scanners compared to high-bit scanners/cameras.

Ideally, copy negatives were produced with a gray scale and/or color bars in the image along with the original. The gray scale in the image should be used for making tone and/or color adjustments. Caution, carefully evaluate using the gray scales in copy negatives to make sure that the illumination was even, there are no reflections on the gray scale, and for color film the film was properly processed with no color cross-overs (the highlights and shadows have very different color casts). If any problems exist with the quality of the copy negatives, you may have problems using the gray scale in the image, as tone and/or color adjustments will have to be done without relying on the gray scale.

For the best results with transmission scanning, it is necessary to control extraneous light known as flare. It may be necessary to mask the scanner platen or light box down to the just the area of the item being scanned or digitized. This is also true for step tablets being scanned as reference targets. Also, due to the progressive nature of the step tablet, with the densities increasing along the length, it may be desirable to cut the step tablet into shorter sections and mount them out of sequence in an opaque mask; this will minimize flare from the low density areas influencing the high density areas.

Consider using a calibrated densitometer to measure the actual visual and color density of each step of the step tablets used as reference targets. Use a laser printer to print the density values as gray letters against a black background and print onto overhead transparency film, size and space the characters to fit adjacent to the step tablet. Consider mounting the step tablet (or a smaller portion of the step tablet) into an opaque mask with the printed density values aligned with the corresponding steps. This provides a quick visual reference within the digital image to the actual densities.

IV. IMAGING WORKFLOW

Adjusting Image Files:

There is a common misconception that image files saved directly from a scanner or digital camera are pristine or unmolested in terms of the image processing. For almost all image files this is simply untrue. Only "raw" files from scanners or digital cameras are unadjusted, all other digital image files have a range of image processing applied during scanning and prior to saving in order to produce digital images with good image quality.

Because of this misconception, many people argue you should not perform any post-scan or post-capture adjustments on image files because the image quality might be degraded. We disagree. The only time we would recommend saving unadjusted files is if they meet the exact tone and color reproduction, sharpness, and other image quality parameters that you require. Otherwise, we recommend doing minor post-scan adjustment to optimize image quality and bring all images to a common rendition. Adjusting production master files to a common rendition provides significant benefits in terms of being able to batch process and treat all images in the same manner. Well designed and calibrated scanners and digital cameras can produce image files that require little

or no adjustment, however, based on our practical experience, there are very few scanners/cameras that are this well designed and calibrated.

Also, some people suggest it is best to save raw image files, because no “bad” image processing has been applied. This assumes you can do a better job adjusting for the deficiencies of a scanner or digital camera than the manufacturer, and that you have a lot of time to adjust each image. Raw image files will not look good on screen, nor will they match the appearance of originals. Raw image files cannot be used easily; this is true for inaccurate unadjusted files as well. Every image, or batch of images, will have to be evaluated and adjusted individually. This level of effort will be significant, making both raw files and inaccurate unadjusted files inappropriate for production master files.

We believe the benefits of adjusting images to produce the most accurate visual representation of the original outweigh the insignificant data loss (when processed appropriately), and this avoids leaving images in a raw unedited state. If an unadjusted/raw scan is saved, future image processing can be hindered by unavailability of the original for comparison. If more than one version is saved (unadjusted/raw and adjusted), storage costs may be prohibitive for some organizations, and additional metadata elements would be needed. In the future, unadjusted or raw images will need to be processed to be used and to achieve an accurate representation of the originals and this will be difficult to do.

Overview:

We recommend using the scanner/camera controls to produce the most accurate digital images possible for a specific scanner or digital camera. Minor post-scan/post-capture adjustments are acceptable using an appropriate image processing workflow that will not significantly degrade image quality.

We feel the following goals and tools are listed in priority order of importance-

- . 1. Accurate imaging - use scanner controls and reference targets to create grayscale and color images that are:
 - . i. Reasonably accurate in terms of tone and color reproduction, if possible without relying on color management.
 - . ii. Consistent in terms of tone and color reproduction, both image to image consistency and batch to batch consistency.
 - . iii. Reasonably matched to an appropriate use-neutral common rendering for all images.
- . 2. Color management – as a supplement to accurate imaging, use color management to compensate for differences between devices and color spaces:
 - . i. If needed to achieve best accuracy in terms of tone, color, and saturation - use custom profiles for capture devices and convert images to a common wide-gamut color space to be used as the working space for final image adjustment.
 - . ii. Color transformation can be performed at time of digitization or as a post scan/digitization adjustment.
- . 3. Post scan/digitization adjustment - use appropriate image processing tools to:
 - . i. Achieve final color balance and eliminate color biases (color images).
 - . ii. Achieve desired tone distribution (grayscale and color images).
 - . iii. Sharpen images to match appearance of the originals, compensate for variations in originals and the digitization process (grayscale and color images).

The following sections address various types of image adjustments that we feel are often needed and are appropriate. The amount of adjustment needed to bring images to a common rendition will vary depending on the original, on the scanner/digital camera used, and on the image processing applied during digitization (the specific scanner or camera settings).

Scanning aimpoints-

One approach for ensuring accurate tone reproduction (the appropriate distribution of the tones) for digital images is to place selected densities on a gray scale reference target at specific digital levels or aimpoints. Also, for color images it is possible to improve overall color accuracy of the image by neutralizing or eliminating color biases of the same steps of the gray scale used for the tone reproduction aimpoints.

This approach is based on working in a gray-balanced color space, independent of whether it is an ICC color managed workflow or not.

In a digital image, the white point is the lightest spot (highest RGB levels for color files and lowest % black for grayscale files) within the image, the black point is the darkest spot (lowest RGB levels for color files and highest % black for grayscale files), and a mid-point refers to a spot with RGB levels or % black in the middle of the range.

Generally, but not always, the three aimpoints correspond to the white-point, a mid-point, and the black-point within a digital image, and they correspond to the lightest patch, a mid-density patch, and the darkest patch on the reference gray scale within the digital image. This assumes the photographic gray scale has a larger density range than the original being scanned. In addition to adjusting the distribution of the tones, the three aimpoints can be used for a three point neutralization of the image to eliminate color biases in the white-point, a mid-point, and the black-point.

The aimpoints cited in this section are guidelines only. Often it is necessary to vary from the guidelines and use different values to prevent clipping of image detail or to provide accurate tone and color reproduction.



The above images illustrate the importance of controlling the image tones so detail or information is not clipped or lost. The top images have been carefully adjusted using aimpoints and a reference target so all image detail is visible and distinct. The bottom images have been adjusted so the highlight detail in the photograph on the left and the light shades (for the Red channel) in the document on the right have been clipped or rendered at the maximum brightness value (measured as percent gray for the grayscale image and RGB levels for the color image). Clipping or loss of image detail can happen in the shadow detail or dark shades as well, with the pixels being rendered at the lowest brightness value or black. The loss of detail and texture is obvious in the magnified close-up details. Looking at the overall images, the difference in appearance is subtle, but the loss of information is apparent. [photograph on left- President Harry S. Truman, 7/3/1947, NARA – Harry S. Truman Library; document on right- 11th Amendment, RG 11 General Records of the United States Government, NARA Old Military and Civil LICON]

Since the aimpoints rely on a photographic gray scale target, they are only applicable when a gray scale is used as a reference. If no gray scale is available (either scanned with the original or in a copy transparency/negative), the Kodak Color Control Patches (color bars) can be used and alternative aimpoints for the color bars are provided. We recommend using a photographic gray scale and not relying on the color bars as the sole target.

Many image processing applications have automatic and manual “place white-point” and “place black-point” controls that adjust the selected areas to be the lightest and darkest portions of the image, and that will neutralize the color in these areas as well as. Also, most have a “neutralize mid-point” control, but usually the tonal adjustment for brightness has to be done separately with a “curves”, “levels”, “tone curve”, etc, control. The better applications will let you set the specific RGB or % black levels for the default operation of the place white-point, place black-point, and neutralize mid-point controls.

Typically, both the brightness placement (for tone reproduction) and color neutralization to adjust the color balance (for color reproduction) should be done in the scanning step and/or as a post-scan adjustment using image processing software. A typical manual workflow in Adobe Photoshop is black-point placement and neutralization

(done as a single step, control set to desired neutral level prior to use), white-point placement and neutralization (done as a single step, control set to desired neutral level prior to use), mid-point neutralization (control set to neutral value prior to use), and a gamma correction to adjust the brightness of the mid point (using levels or curves). For grayscale images the mid-point neutralization step is not needed. The tools in scanner software and other image processing software should allow for a similar approach, the sequence of steps may need to be varied to achieve best results.

The three point tone adjustment and color neutralization approach does not guarantee accurate tone and color reproduction. It works best with most scanners with reflection scanning, but it can be difficult to achieve good tone and color balance when scanning copy negatives/transparencies. It can be very difficult to produce an accurate digital image reproduction from color copy negatives/transparencies that exhibit color cross-over or other defects such as under/over exposure or a strong color cast. The three point neutralization approach will help minimize these biases, but may not eliminate the problems entirely.

If the overall color balance of an image is accurate, using the three point neutralization to adjust the color reproduction may cause the color balance of the shades lighter and darker than the mid-point to shift away from being neutral. For accurate color images that need to have just the tone distribution adjusted, apply levels or curves adjustments to the luminosity information only, otherwise the overall color balance is likely to shift.

When scanning photographic prints it is important to be careful about placing the black point, in some cases the print being scanned will have a higher density than the darkest step of the photographic gray scale. In these cases, you should use a lighter aimpoint for the darkest step of the gray scale so the darkest portion of the image area is placed at the normal aimpoint value (for RGB scans, the shadow area on the print may not be neutral in color and the darkest channel should be placed at the normal aimpoint).

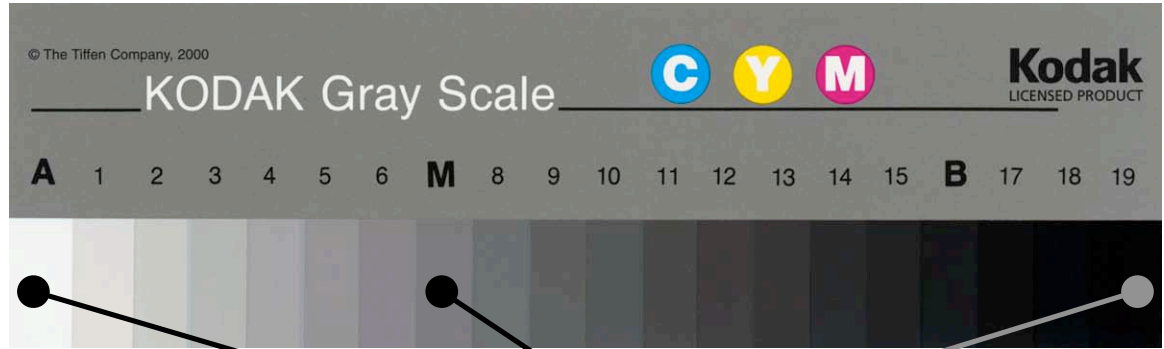
Occasionally, objects being scanned may have a lighter value than the lightest step of the photographic gray scale, usually very bright modern office papers or modern photo papers with a bright-white base. In these cases, you should use a darker aimpoint for the lightest step of the gray scale so the lightest portion of the image area is placed at the normal aimpoint value (for RGB scans, the lightest area of the object being scanned may not be neutral in color and the lightest channel should be placed at the normal aimpoint).

Aimpoints may need to be altered not only for original highlight or shadow values outside the range of the gray scale, but also deficiencies in lighting, especially when scanning photographic intermediates. Excessive flare, reflections, or uneven lighting may need to be accounted for by selecting an alternate value for a patch, or selecting a different patch altogether. At no point should any of the values in any of the color channels of the properly illuminated original fall outside the minimum or maximum values indicated below for scanning without a gray scale.

The aimpoints recommended in the 1998 NARA guidelines have proven to be appropriate for monitor display and for printed output on a variety of printers. The following table provides slightly modified aimpoints to minimize potential problems when printing the image files; the aimpoints described below create a slightly compressed tonal scale compared to the aimpoints in the 1998 guidelines.

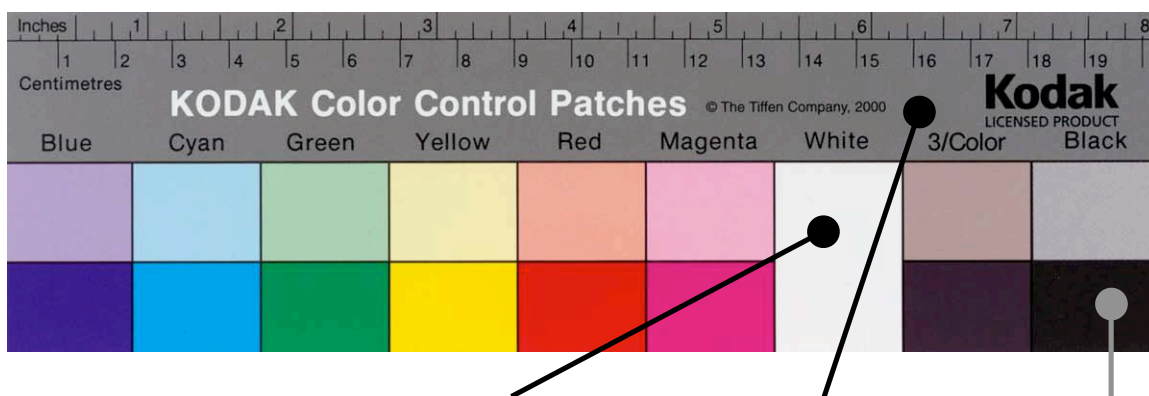
All aimpoint measurements and adjustments should be made using either a 5x5 pixel (25 pixels total) or 3x3 pixel (9 pixels total) sample. Avoid using a point-sample or single pixel measurement.

Aimpoints for Photographic Gray Scales -



		Neutralized White Point	Neutralized Mid Point*	Neutralized Black Point	Alternative Neutralized Black Point**
Step or Density	Kodak Q-13/Q-14	A	M	19	B
	Visual Density	0.05 to 0.10	0.75 to 0.85	1.95 to 2.05	1.65 to 1.75
Aimpoint	RGB Levels	242-242-242	104-104-104	12-12-12	24-24-24
	% Black	5%	59%	95%	91%
Acceptable Range for Aimpoint	RGB Level	239 to 247	100 to 108	8 to 16	20 to 28
	% Black	3% to 6%	58% to 61%	94% to 97%	89% to 92%
<p>*When using the recommended black point, step 19, the aimpoint for mid point (MP) to be calculated from actual values for white point (WP) and step 19 black point (BP) using the following formula: $MP = WP - 0.60(WP - BP)$</p> <p>**Sometimes there may be problems when trying to use the darkest step of the gray scale - such as excessive flare, reflections, or uneven lighting - and it may be better to use the B-step as the black point. When using the alternative black point, B-step, the aimpoint for mid point (MP) to be calculated from actual values for white point (WP) and step B black point (BP) using the following formula: $MP = WP - 0.63(WP - BP)$</p>					

Alternative Aimpoints for Kodak Color Control Patches (color bars) -



		Neutralized White Point	Neutralized Mid Point*	Neutralized Black Point
Color Patch / Area		White	Gray Background	Single Color Black
Aimpoint	RGB Levels	237-237-237	102-102-102	23-23-23
	% Black	7%	60%	91%
Acceptable Range for Aimpoint	RGB Level	233 to 241	98 to 106	19 to 27
	% Black	5% to 9%	58% to 62%	89% to 93%
*Aimpoint for mid point (MP) to be calculated from actual values for white point (WP) and black point (BP) using the following formula: $MP = WP - 0.63(WP - BP)$				

Aimpoint variability-

For the three points that have been neutralized and placed at the aimpoint values: no more than +/- 3 RGB level variance from aimpoints and no more than 3 RGB level difference in the individual channels within a patch for RGB scanning and no more than +/- 1% level variance from the aimpoints in % black for grayscale scanning. Again, the image sampler (in Adobe Photoshop or other image processing software) should be set to measure an average of either 5x5 pixels or 3x3 pixels when making these measurements, point sample or single pixel measurements should not be used.

Other steps on the gray scale may, and often will, exhibit a higher degree of variation. Scanner calibration, approaches to scanning / image processing workflow, color management, and variation in the target itself can all influence the variability of the other steps and should be used / configured to minimize the variability for the other steps of the gray scale. Usually the other steps of the gray scale will be relatively consistent for reflection scanning, and significantly less consistent when scanning copy negatives and copy transparencies.

Minimum and maximum levels-

The minimum and maximum RGB or % black levels when scanning materials with no reference gray scale or color patches, such as original photographic negatives:

- For RGB scanning the highlight not to go above RGB levels of 247 - 247 - 247 and shadow not to go below RGB levels of 8 - 8 - 8.
- For grayscale scanning the highlight not to go below % black of 3 % and shadow not to go above % black of 97%.

Color Management Background:

Digitization is the conversion of analog color and brightness values to discrete numeric values. A number, or set of numbers, designates the color and brightness of each pixel in a raster image. The rendering of these numerical

values, however, is very dependent on the device used for capture, display or printing. Color management provides a context for objective interpretation of these numeric values, and helps to compensate for differences between devices in their ability to render or display these values, within the many limitations inherent in the reproduction of color and tone.

Color management does not guarantee the accuracy of tone and color reproduction. We recommend color management not be used to compensate for poor imaging and/or improper device calibration. As described above, it is most suitable to correct for color rendering differences from device to device.

Every effort should be made to calibrate imaging devices and to adjust scanner/digital camera controls to produce the most accurate images possible in regard to tone and color reproduction (there are techniques for rescuing poorly captured images that make use of profile selection, particularly synthesized profiles, that will not be discussed here. For further information see the writings of Dan Margulis and Michael Kieran). Calibration will not only improve accuracy of capture, but will also ensure the consistency required for color management systems to function by bringing a device to a stable, optimal state. Methods for calibrating hardware vary from device to device, and are beyond the scope of this guidance.

International Color Consortium (ICC) color management system-

Currently, ICC-based color management is the most widely implemented approach. It consists of four components that are integrated into software (both the operating system and applications):

- PCS (Profile Connection Space)
 - Typically, end users have little direct interaction with the PCS; it is one of two device-independent measuring systems for describing color based on human vision and is usually determined automatically by the source profile. The PCS will not be discussed further.
- Profile
 - A profile defines how the numeric values that describe the pixels in images are to be interpreted, by describing the behavior of a device or the shape and size of a color space.
- Rendering intent
 - Rendering intents determine how out-of-gamut colors will be treated in color space transformations.
- CMM (Color Management Module)
 - The CMM performs the calculations that transform color descriptions between color spaces.

Profiles-

Profiles are sets of numbers, either a matrix or look up table (LUT), that describe a color space (the continuous spectrum of colors within the gamut, or outer limits, of the colors available to a device) by relating color descriptions specific to that color space to a PCS.

Although files can be saved with any ICC-compliant profile that describes an input device, output device or color space (or with no profile at all), it is best practice to adjust the color and tone of an image to achieve an accurate rendition of the original in a common, well-described, standard color space. This minimizes future effort needed to transform collections of images, as well as streamlines the workflow for repurposing images by promoting consistency. Although there may be working spaces that match more efficiently with the gamut of a particular original, maintaining a single universal working space that covers most input and output devices has additional benefits. Should the profile tag be lost from an image or set of images, the proper profile can be correctly assumed within the digitizing organization, and outside the digitizing organization it can be reasonably found through trial and error testing of the small set of standard workspaces.

Some have argued saving unedited image files in the input device space (profile of the capture device) provides the least compromised data and allows a wide range of processing options in the future, but these files may not be immediately usable and may require individual or small batch transformations. The data available from the scanner has often undergone some amount of adjusting beyond the operator's control, and may not be the best representation of the original. We recommend the creation of production master image files using a standard color space that will be accurate in terms of color and tone reproduction when compared to the original.

The RGB color space for production master files should be gray-balanced, perceptually uniform, and sufficiently large to encompass most input and output devices, while not wasting bits on unnecessary color descriptions. Color spaces that describe neutral gray with equal amounts of red, green and blue are considered to be gray-balanced. A gamma of 2.2 is considered perceptually uniform because it approximates the human visual response to stimuli.

The Adobe RGB 1998 color space profile adequately meets these criteria and is recommended for storing RGB image files. Adobe RGB 1998 has a reasonably large color gamut, sufficient for most purposes when saving files as 24-bit RGB files (low-bit files or 8-bits per channel). Using larger gamut color spaces with low-bit files can cause quantization errors, therefore wide gamut color spaces are more appropriate when saving high-bit or 48-bit RGB files. Gray Gamma 2.2 (available in Adobe products) is recommended for grayscale images.

An ideal workflow would be to scan originals with a calibrated and characterized device, assign the profile of that device to the image file, and convert the file to the chosen workspace (Adobe RGB 1998 for color or Gray Gamma 2.2 for grayscale). Not all hardware and software combinations produce the same color and tonal conversion, and even this workflow will not always produce the best results possible for a particular device or original. Different scanning, image processing and printing applications have their own interpretation of the ICC color management system, and have varying controls that produce different levels of quality. It may be necessary to deviate from the normal, simple color managed workflow to achieve the best results. There are many options possible to achieve the desired results, many of which are not discussed here because they depend on the hardware and software available.

Rendering intents-

When converting images from one color space to another, one of four rendering intents must be designated to indicate how the mismatch of size and shape of source and destination color spaces is to be resolved during color transformations - perceptual, saturation, relative colorimetric, or absolute colorimetric. Of the four, perceptual and relative colorimetric intents are most appropriate for creation of production master files and their derivatives. In general, we have found that perceptual intent works best for photographic images, while relative colorimetric works best for images of text documents and graphic originals. It may be necessary to try both rendering intents to determine which will work best for a specific image or group of images.

When perceptual intent is selected during a color transformation, the visual relationships between colors are maintained in a manner that looks natural, but the appearance of specific colors are not necessarily maintained. As an example, when printing, the software will adjust all colors described by the source color space to fit within a smaller destination space (printing spaces are smaller than most source or working spaces). For images with significant colors that are out of the gamut of the destination space (usually highly saturated colors), perceptual rendering intent often works best.

Relative colorimetric intent attempts to maintain the appearance of all colors that fall within the destination space, and to adjust out-of-gamut colors to close, in-gamut replacements. In contrast to absolute colorimetric, relative colorimetric intent includes a comparison of the white points of the source and destination spaces and shifts all colors accordingly to match the brightness ranges while maintaining the color appearance of all in-gamut colors. This can minimize the loss of detail that may occur with absolute colorimetric in saturated colors if two different colors are mapped to the same location in the destination space. For images that do not contain significant out of gamut colors (such as near-neutral images of historic paper documents), relative colorimetric intent usually works best.

Color Management Modules-

The CMM uses the source and destination profiles and the rendering intent to transform individual color descriptions between color spaces. There are several CMMs from which to select, and each can interact differently with profiles generated from different manufacturers' software packages. Because profiles cannot provide an individual translation between every possible color, the CMM interpolates values using algorithms determined by the CMM manufacturer and each will give varying results.

Profiles can contain a preference for the CMM to be used by default. Some operating systems allow users to designate a CMM to be used for all color transformations that will override the profile tag. Both methods can be superseded by choosing a CMM in the image processing application at the time of conversion. We recommend that you choose a CMM that produces acceptable results for project-specific imaging requirements, and switch only when unexpected transformations occur.

Image Processing:

After capture and transformation into one of the recommended color spaces (referred to as a "working space" at this point in the digitization process), most images require at least some image processing to produce the best digital rendition of the original. The most significant adjustments are color correction, tonal adjustment and sharpening. These processes involve data loss and should be undertaken carefully since they are irreversible once

the file is saved. Images should initially be captured as accurately as possible; image processing should be reserved for optimizing an image, rather than for overcoming poor imaging.

Color correction and tonal adjustments-

Many tools exist within numerous applications for correcting image color and adjusting the tonal scale. The actual techniques of using them are described in many excellent texts entirely devoted to the subject. There are, however, some general principles that should be followed.

- As much as possible, depending on hardware and software available, images should be captured and color corrected in high bit depth.
- Images should be adjusted to render correct highlights and shadows--usually neutral (but not always), of appropriate brightness, and without clipping detail. Also, other neutral colors in the image should not have a color cast (see Aimpoint discussion above).
- Avoid tools with less control that act globally, such as brightness and contrast, and that are more likely to compromise data, such as clipping tones.
- Use tools with more control and numeric feedback, such as levels and curves.
- Despite the desire and all technological efforts to base adjustments on objective measurements, some amount of subjective evaluation may be necessary and will depend upon operator skill and experience.
- Do not rely on "auto correct" features. Most automatic color correction tools are designed to work with color photographic images and the programmers assumed a standard tone and color distribution that is not likely to match your images (this is particularly true for scans of text documents, maps, plans, etc.).

Sharpening-

Digitization utilizes optics in the capture process and the sharpness of different imaging systems varies. Most scans will require some amount of sharpening to reproduce the apparent sharpness of the original. Generally, the higher the spatial resolution, the less sharpening that will be needed. As the spatial resolution reaches a level that renders fine image detail, such as image grain in a photograph, the large features of an image will appear sharp and will not require additional sharpening. Conversely, lower resolution images will almost always need some level of sharpening to match the appearance of the original.

Sharpening tools available from manufacturers use different controls, but all are based on increasing contrast on either side of a defined brightness difference in one or more channels. Sharpening exaggerates the brightness relationship between neighboring pixels with different values, and this process improves the perception of sharpness.

Sharpening of the production master image files should be done conservatively and judiciously; generally it is better to under-sharpen than to over-sharpen. Over-sharpening is irreversible and should be avoided, but it is not objectively measurable. Often over-sharpening will appear as a lighter halo between areas of light and dark.

We recommend using unsharp mask algorithms, rather than other sharpening tools, because they provide the best visual results and usually give greater control over the sharpening parameters. Also-

- Sharpening must be evaluated at an appropriate magnification (1:1 or 100%) and the amount of sharpening is contingent on image pixel dimensions and subject matter.
- Sharpening settings for one image or magnification may be inappropriate for another.
- In order to avoid color artifacts, or fringing, appropriate options or techniques should be used to limit sharpening only to the combined channel brightness.
- The appropriate amount of sharpening will vary depending on the original, the scanner/digital camera used, and the control settings used during digitization.

Sample Image Processing Workflow:

The following provides a general approach to image processing that should help minimize potential image quality defects due to various digital image processing limitations and errors. Depending on the scanner/digital camera, scan/capture software, scanner/digital camera calibration, and image processing software used for post-scan adjustment and/or correction, not all steps may be required and the sequence may need to be modified.

Fewer steps may be used in a high-volume scanning environment to enhance productivity, although this may result in less accurate tone and color reproduction. You can scan a target, adjust controls based on the scan of the target, and then use the same settings for all scans - this approach should work reasonably well for reflection

scanning, but will be much harder to do when scanning copy negatives, copy transparencies, original negatives, and original slides/transparencies.

Consider working in high-bit mode (48-bit RGB or 16-bit grayscale) for as much of the workflow as possible, if the scanner/digital camera and software is high-bit capable and your computer has enough memory and speed to work with the larger files. Conversion to 24-bit RGB or 8-bit grayscale should be done at the end of the sequence.

The post-scan sequence is based on using Adobe Photoshop 7 software.

WORKFLOW

Scanning:

Adjust size, scaling, and spatial resolution.

Color correction and tone adjustment-

- Follow aimpoint guidance - remember there are always exceptions and you may need to deviate from the recommended aimpoints, or to adjust image based on a visual assessment and operator judgement.
- Recommended – use precision controls in conjunction with color management to achieve the most accurate capture in terms of tone and color reproduction
- Alternative – if only global controls are available, adjust overall color balance and compress tonal scale to minimize clipping.

Saturation adjustment for color scans.

No sharpening or minimal sharpening (unsharp mask, applied to luminosity preferred).

Color profile conversion (might not be possible at this point, depends on scanner and software)–

- Convert from scanner space to Adobe RGB 1998 for color images or Gray Gamma 2.2 for grayscale images.
- Generally, for color image profile conversion – use relative colorimetric rendering intent for near-neutral images (like most text documents) and perceptual rendering intent for photographic and other wide-gamut, high-saturation images.

Check accuracy of scan. You may need to adjust scanner calibration and control settings through trial-and-error testing to achieve best results.

Post-Scan Adjustment / Correction:

Color profile assignment or conversion (if not done during scanning)–

- Either assign desired color space or convert from scanner space; use approach that provides best color and tone accuracy.
 - Adobe RGB 1998 for color images or Gray Gamma 2.2 for grayscale images.
- Generally, for color image profile conversion – use relative colorimetric rendering intent for near-neutral images (like most text documents) and perceptual rendering intent for photographic and other wide-gamut, high-saturation images.

Color correction-

- Follow aimpoint guidance - remember there are always exceptions and you may need to deviate from the recommended aimpoints, or to adjust image based on a visual assessment and operator judgment.
- Recommended - use precision controls (levels recommended, curves alternative) to place and neutralize the black-point, place and neutralize the white-point, and to neutralize mid-point. When color correcting photographic images, levels and curves may both be used.
- Alternative – try auto-correct function within levels and curves (adjust options, including algorithm, targets, and clipping) and assess results. If auto-correct does a reasonable job, then use manual controls for minor adjustments.
- Alternative – if only global controls are available, adjust overall color balance.

Tone adjustment, for color files apply correction to luminosity information only-

- Recommended - use precision controls (levels recommended, curves alternative) to adjust all three aimpoints in iterative process - remember there are always exceptions and you may need to deviate from the recommended aimpoints - or to adjust image based on a visual assessment and operator judgment.
- Alternative – try auto-correct function within levels and curves (adjust options, including algorithm, targets, and clipping) and assess results. If auto-correct does a reasonable job, then use manual controls for minor adjustments.
- Alternative – if only global controls are available, adjust contrast and brightness.

Crop and/or deskew.

Check image dimensions and resize.

Convert to 8-bits per channel – either 24-bit RGB or 8-bit grayscale.

Sharpen – Unsharp mask algorithm, applied to approximate appearance of original. For color files, apply unsharp mask to luminosity information only. Version CS (8) of Photoshop has the ability to apply unsharp mask to luminosity in high-bit mode, in this case sharpening should be done prior to the final conversion to 8-bits per channel.

Manual clean up of dust and other artifacts, such as surface marks or dirt on copy negatives or transparencies, introduced during the scanning step. If clean up is done earlier in the image processing workflow prior to sharpening, it is a good idea to check a second time after sharpening since minor flaws will be more obvious after sharpening.

Save file.

Again, the actual image processing workflow will depend on the originals being digitized, the equipment and software being used, the desired image parameters, and the desired productivity. Adjust the image processing workflow for each specific digitization project.

V. DIGITIZATION SPECIFICATIONS FOR RECORD TYPES

The intent of the following tables is to present recommendations for scanning a variety of original materials in a range of formats and sizes. The tables are broken down into six main categories: textual documents (including graphic illustrations/artworks/originals, maps, plans, and oversized documents); reflective photographic formats (prints); transmissive photographic formats (negatives, slides, transparencies); reflective aerial photographic formats (prints); transmissive aerial photographic formats (negatives, positives); graphic materials (graphic illustrations, drawings, posters); and objects and artifacts.

Because there are far too many formats and document characteristics for comprehensive discussion in these guidelines, the tables below provide scanning recommendations for the most typical or common document types and photographic formats found in most cultural institutions. The table for textual documents is organized around physical characteristics of documents which influence capture decisions. The recommended scanning specifications for text support the production of a scan that can be reproduced as a legible facsimile at the same size as the original (at 1:1, the smallest significant character should be legible). For photographic materials, the tables are organized around a range of formats and sizes that influence capture decisions.

NOTE: We recommend digitizing to the original size of the records following the resolution requirements cited in the tables (i.e. no magnification, unless scanning from various intermediates). Be aware, many Windows applications will read the resolution of image files as 72 ppi by default and the image dimensions will be incorrect.

Workflow requirements, actual usage needs for the image files, and equipment limitations will all be influential factors for decisions regarding how records should be digitized. The recommendations cited in the following section and charts, may not always be appropriate. Again, the intent for these *Technical Guidelines* is to offer a range of options and actual approaches for digitizing records may need to be varied.

Cleanliness of work area, digitization equipment, and originals-

Keep work area clean. Scanners, platens, and copy boards will have to be cleaned on a routine basis to eliminate the introduction of extraneous dirt and dust to the digital images. Many old documents tend to be dirty and will leave dirt in the work area and on scanning equipment.

See sample handling guidelines, Appendix E, Records Handling for Digitization, for safe and appropriate handling of original records. Photographic originals may need to be carefully dusted with a lint-free, soft-bristle brush to minimize extraneous dust (just as is done in a traditional darkroom or for copy photography).

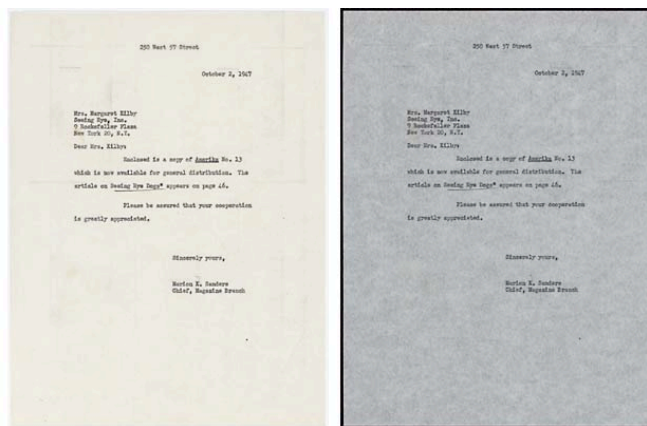
Cropping-

We recommend the entire document be scanned, no cropping allowed. A small border should be visible around the entire document or photographic image. Careful placement of documents on flatbed scanners may require the originals to be away from platen edge to avoid cropping.

For photographic records - If there is important information on a mount or in the border of a negative, then scan the entire mount and the entire negative including the full border. Otherwise, scan photographs so there is only a small border around just the image area.

Backing reflection originals-

We recommend backing all originals with a bright white opaque paper (such as a smooth finish cover stock), occasionally, an off-white or cream-colored paper may complement the original document and should be used. For most documents, the bright white backing will provide a lighter shade for scanner auto-ranging and minimize clipping of detail in the paper of the original being scanned. In the graphic arts and photography fields, traditionally items being copied to produce line negatives (somewhat equivalent to 1-bit scanning) have been backed with black to minimize bleed-through from the back. However, this can create very low contrast and/or grayed-out digital images when the paper of the original document is not opaque and when scanning in 8-bit grayscale or 24-bit RGB color. Backing with white paper maximizes the paper brightness of originals and the white border around the originals is much less distracting.



The above document, a carbon copy on thin translucent paper, was scanned and backed with white paper on the left and with black paper on the right. Using a white backing enhances text contrast and allows the scanner to auto-range on the light background, this helps minimize clipping of the tones in the paper of the document. A black backing may minimize bleed-through of text from the back of the page (a technique that may only work well with 1-bit images), but will significantly lower the overall image contrast, gray-out the document image, and show significant paper texture.

Scanning encapsulated or sleeved originals-

Scanning/digitizing originals that have been encapsulated or sleeved in polyester film can present problems- the visual appearance is changed and the polyester film can cause Newton's rings and other interference patterns.

The polyester film changes the visual appearance of the originals, increasing the visual density. You can compensate for the increase by placing the tone and color reference target (photographic gray scale) into a polyester sleeve (this will increase the visual density of the reference target by the same amount) and scan using the normal aimpoints.

Interference patterns known as Newton's rings are common when two very smooth surfaces are placed in contact, such as placing encapsulated or sleeved documents onto the glass platen of a flatbed scanner; the susceptibility and severity of Newton's rings varies with the glass used, with coatings on the glass, and with humidity in the work area. These patterns will show up in the digital image as multi-colored concentric patterns of various shapes and sizes. Also, we have seen similar interference patterns when digitizing encapsulated documents on a digital copy stand using a scanning camera back, even when there is nothing in contact with the encapsulation. Given the complex nature of these interference patterns, it is not practical to scan and then try to clean-up the image. Some scanners use special glass, known as anti-Newton's ring glass, with a slightly wavy surface to prevent Newton's rings from forming.

To prevent interference patterns, use scanners that have anti-Newton's ring glass and avoid scanning documents in polyester film whenever practical and possible. Some originals may be too fragile to be handled directly and will have to be scanned in the polyester encapsulation or sleeve. One option is to photograph the encapsulated/sleeved document first and then scan the photographic intermediate; generally this approach works well, although we have seen examples of interference patterns on copy transparencies (to a much lesser degree compared to direct digitization).

Embossed seals-

Some documents have embossed seals, such as notarized documents, or wax seals that are an intrinsic legal aspect of the documents. Most scanners are designed with lighting to minimize the three dimensional aspects of the original documents being scanned, in order to emphasize the legibility of the text or writing. In most cases, embossed seals or the imprint on a wax seal will not be visible and/or legible in digital images from these scanners, and this raises questions about the authenticity of the digital representation of the documents. Some scanners have a more directed and/or angled lighting configuration that will do a better job reproducing embossed seals. With a few scanners, the operator has the control to turn off one light and scan using lighting from only one direction, this approach will work best for documents with embossed or wax seals. Similarly, when using a digital copy stand, the lighting can be set up for raking light from one direction (make sure the light is still even across the entire document). When working with unidirectional lighting, remember to orient the document so the shadows fall at the bottom of the embossment/seal and of the document.



The close-up on the left shows an embossed seal when scanned on a flatbed scanner with two lights and very even illumination, while the close-up on the right shows the seal from the same document scanned on a flatbed scanner set to use one directional light.

Compensating for minor deficiencies-

Scanning at higher than the desired resolution and resampling to the final resolution can minimize certain types of minor imaging deficiencies, such as minor color channel misregistration, minor chromatic aberration, and low to moderate levels of image noise. Conceptually, the idea is to bury the defects in the fine detail of the higher resolution scan, which are then averaged out when the pixels are resampled to a lower resolution. This approach should not be used as a panacea for poorly performing scanners/digital cameras, generally it is better to invest in higher quality digitization equipment. Before using this approach in production, you should run tests to determine there is sufficient improvement in the final image quality to justify the extra time and effort. Generally, we recommend over-scanning at 1.5 times the desired final resolution, as an example- 400 ppi final \times 1.5 = 600 ppi scan resolution.

Scanning text-

Guidelines have been established in the digital library community that address the most basic requirements for preservation digitization of text-based materials, this level of reproduction is defined as a "faithful rendering of the underlying source document" as long as the images meet certain criteria. These criteria include completeness, image quality (tonality and color), and the ability to reproduce pages in their correct (original) sequence. As a faithful rendering, a digital master will also support production of a printed page facsimile that is a legible facsimile when produced in the same size as the original (that is 1:1). See the Digital Library Federation's *Benchmark for Faithful Digital Reproductions of Monographs and Serials* at <http://www.diglib.org/standards/bmarkfin.htm> for a detailed discussion.

The Quality Index (QI) measurement was designed for printed text where character height represents the measure of detail. Cornell University has developed a formula for QI based on translating the Quality Index method developed for preservation microfilming standards to the digital world. The QI formula for scanning text relates quality (QI) to character size (h) in mm and resolution (dpi). As in the preservation microfilming standard, the digital QI formula forecasts levels of image quality: barely legible (3.0), marginal (3.6), good (5.0), and excellent (8.0). However, manuscripts and other non-textual material representing distinct edge-based graphics, such as maps, sketches, and engravings, offer no equivalent fixed metric. For many such documents, a better representation of detail would be the width of the finest line, stroke, or marking that must be captured in the digital surrogate. To fully represent such a detail, at least 2 pixels should cover it. (From *Moving Theory into Practice*:

Digital Imaging for Libraries and Archives, Anne R. Kenney and Oya Y. Rieger, editors and principal authors. Research Libraries Group, Mountain View, CA: 2000).

Optical character recognition, the process of converting a raster image of text into searchable ASCII data, is not addressed in this document. Digital images should be created to a quality level that will facilitate OCR conversion to a specified accuracy level. This should not, however, compromise the quality of the images to meet the quality index as stated in this document.

Scanning oversized-

Scanning oversized originals can produce very large file sizes. It is important to evaluate the need for legibility of small significant characters in comparison to the overall file size when determining the appropriate scanning resolution for oversized originals.

Scanning photographs-

The intent in scanning photographs is to maintain the smallest significant details. Resolution requirements for photographs are often difficult to determine because there is no obvious fixed metric for measuring detail, such as quality index. Additionally, accurate tone and color reproduction in the scan play an equal, if not more, important role in assessing the quality of a scan of a photograph. At this time, we do not feel that there is a valid counterpart for photographic materials to the DLF benchmarks for preservation digitization of text materials.

The recommended scanning specifications for photographs support the capture of an appropriate level of detail from the format, and, in general, support the reproduction, at a minimum, of a high-quality 8"x10" print of the photograph. For photographic formats in particular, it is important to carefully analyze the material prior to scanning, especially if it is not a camera original format. Because every generation of photographic copying involves some quality loss, using intermediates, duplicates, or copies inherently implies some decrease in quality and may also be accompanied by other problems (such as improper orientation, low or high contrast, uneven lighting, etc.).

For original color transparencies, the tonal scale and color balance of the digital image should match the original transparency being scanned to provide accurate representation of the image.

Original photographic negatives are much more difficult to scan compared to positive originals (prints, transparencies, slides, etc.), with positives there is an obvious reference image that can be matched and for negatives there is not. When scanning negatives, for production master files the tonal orientation should be inverted to produce a positive image. The resulting image will need to be adjusted to produce a visually pleasing representation. Digitizing negatives is very analogous to printing negatives in a darkroom and it is very dependent on the photographer's/technician's skill and visual literacy to produce a good image. There are few objective metrics for evaluating the overall representation of digital images produced from negatives.

When working with scans from negatives, care is needed to avoid clipping image detail and to maintain highlight and shadow detail. The actual brightness range and levels for images from negatives are very subject dependent, and images may or may not have a full tonal range.

Often it is better to scan negatives in positive mode (to produce an initial image that appears negative) because frequently scanners are not well calibrated for scanning negatives and detail is clipped in either the highlights and/or the shadows. After scanning, the image can be inverted to produce a positive image. Also, often it is better to scan older black-and-white negatives in color (to produce an initial RGB image) because negatives frequently have staining, discolored film base, retouching, intensification, or other discolorations (both intentional and the result of deterioration) that can be minimized by scanning in color and performing an appropriate conversion to grayscale. Evaluate each color channel individually to determine the channel which minimizes the appearance of any deterioration and optimizes the monochrome image quality, use that channel for the conversion to a grayscale image.

Scanning intermediates-

Adjust scaling and scan resolution to produce image files that are sized to the original document at the appropriate resolution, or matched to the required QI (legibility of the digital file may be limited due to loss of legibility during the photographic copying process) for text documents.

For copy negatives (B&W and color), if the copy negative has a Kodak gray scale in the image, adjust the scanner settings using the image of the gray scale to meet the above requirements. If there is no gray scale, the scanner software should be used to match the tonal scale of the digital image to the density range of the specific negative

being scanned to provide an image adjusted for monitor representation.

For color copy transparencies and color microfilm, if the color intermediate has a Kodak gray scale in the image, adjust the scanner settings using the image of the gray scale to meet the above requirements. If there is no gray scale, the scanner software should be used to match the tonal scale and color balance of the digital image to the specific transparency being scanned to provide an accurate monitor representation of the image on the transparency.

There are more specific details regarding scanning photographic images from intermediates in the notes following the photo scanning tables.

Generally, for-

- 35mm color copy slides or negatives, a 24-bit RGB digital file of approximately 20 MB would capture the limited information on the film for this small format.
- Approximate maximum scan sizes from color film, 24-bit RGB files (8-bit per channel).²

<u>Original Color Film</u>		<u>Duplicate Color Film</u>	
35mm	50 MB	35mm	17 MB
120 square	80 MB	120 square	27 MB
120 6x4.5	60 MB	120 6x4.5	20 MB
120 6x9	90 MB	120 6x9	30 MB
4x5	135 MB	4x5	45 MB
8x10	240 MB	8x10	80 MB

Scanning microfilm-

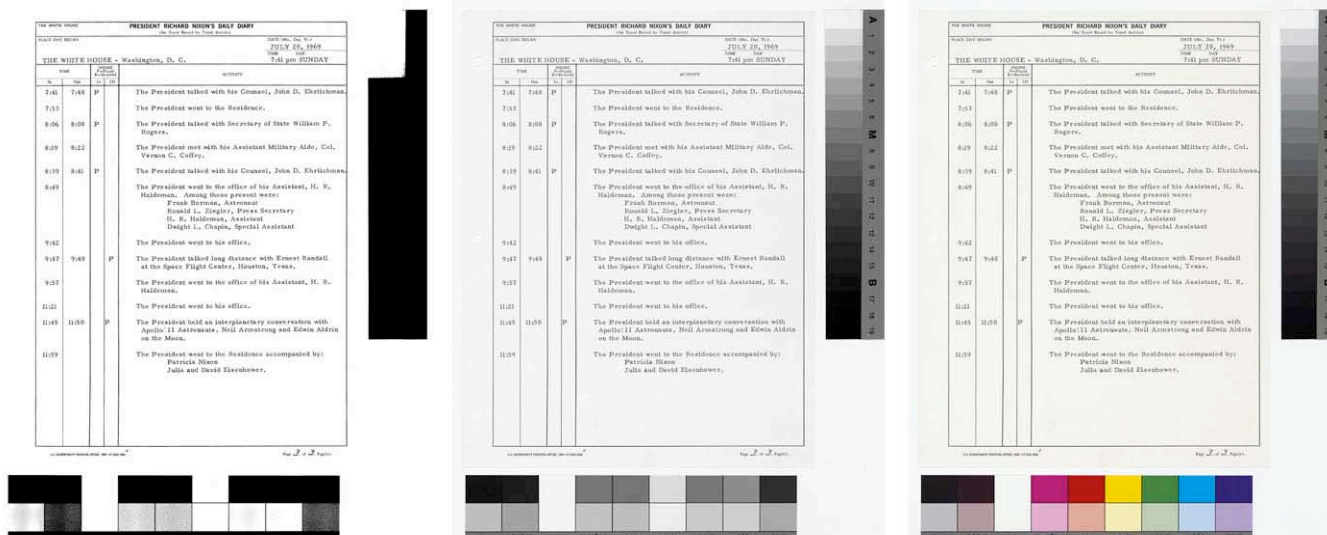
When scanning microfilm, often the desire is to produce images with legible text. Due to photographic limitations of microfilm and the variable quality of older microfilm, it may not be possible to produce what would normally be considered reproduction quality image files. Your scanning approach may vary from the recommendations cited here for textual records and may be more focused on creating digital images with reasonable legibility.

For B&W microfilm, scanner software should be used to match the tonal scale of the digital image to the density range of the specific negative or positive microfilm being scanned. Example: the minimum density of negative microfilm placed at a maximum % black value of 97% and the high density placed at a minimum % black value of 3%.

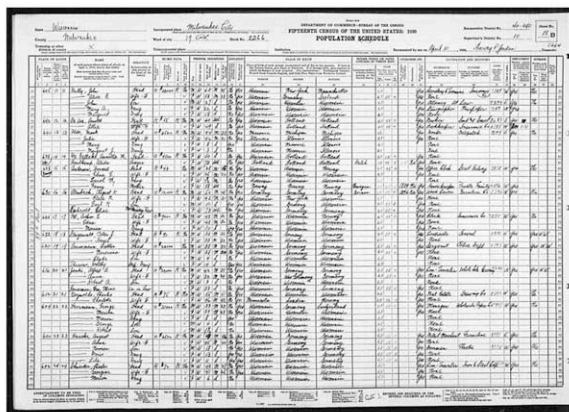
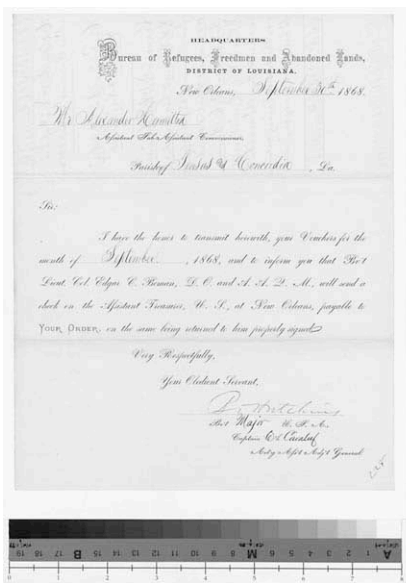
² From - Digital and Photographic Imaging Services Price Book, Rieger Communications Inc, Gaithersburg, MD, 2001- "In our opinion and experience, you will not achieve better results...than can be obtained from the scan sizes listed....Due to the nature of pixel capture, scanning larger does make a difference if the scan is to be used in very high magnification enlargements. Scan size should not be allowed to fall below 100 DPI at final magnification for quality results in very large prints."

Illustrations of Record Types:

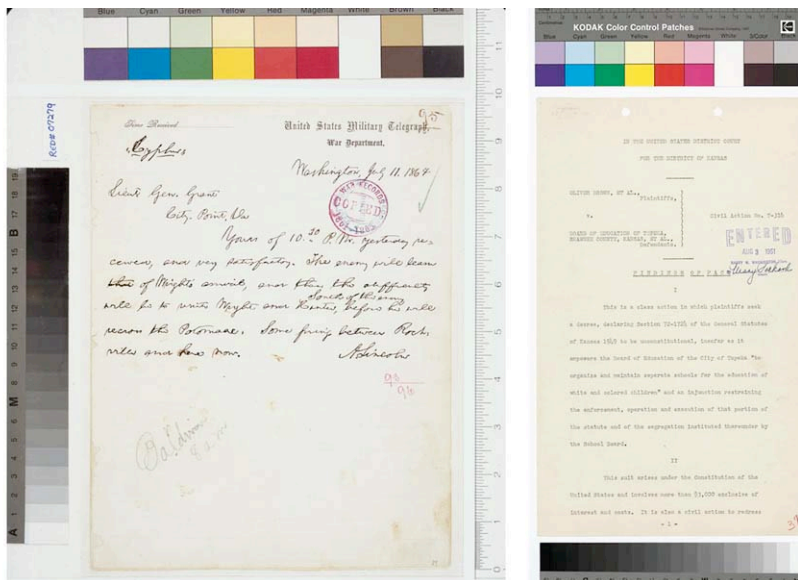
Textual documents-



Documents with well defined printed type (e.g. typeset, typed, laser printed, etc.), with high inherent contrast between the ink of the text and the paper background, with clean paper (no staining or discoloration), and no low contrast annotations (such as pencil writing) can be digitized either as a 1-bit file (shown on left) with just black and white pixels (no paper texture is rendered), as an 8-bit grayscale file (shown in the center) with gray tones ranging from black to white, or as a 24-bit RGB color image file (shown on right) with a full range of both tones and colors (notice the paper of the original document is an off-white color). [document- President Nixon's Daily Diary, page 3, 7/20/1969, NARA – Presidential Libraries - Nixon Presidential Materials Staff]

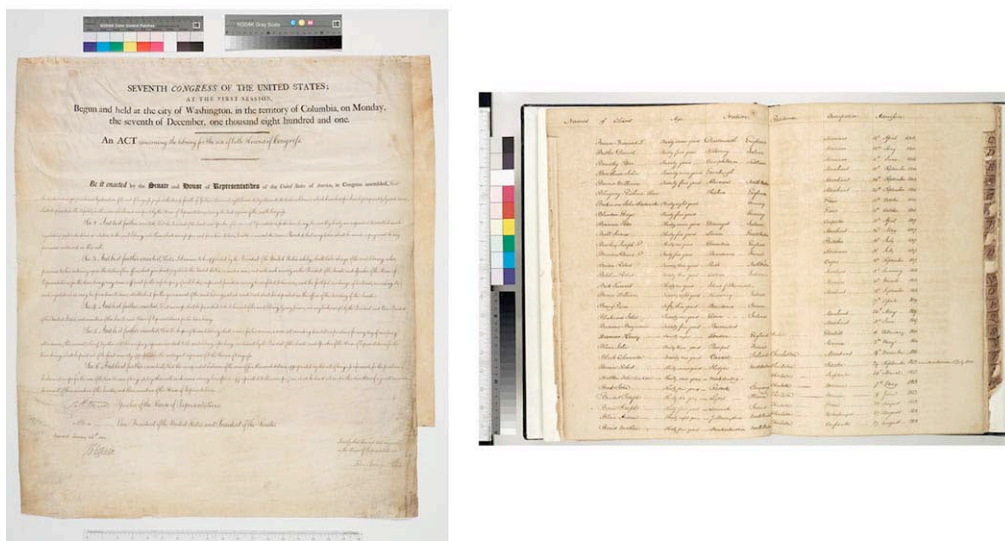


Often grayscale imaging works best for older documents with poor legibility or diffuse characters (e.g. carbon copies, Thermofax/Verifax, etc.), with handwritten annotations or other markings, with low inherent contrast between the text and the paper background, with staining or fading, and with halftone illustrations or photographs included as part of the documents. Many textual documents do not have significant color information and grayscale images will be smaller to store compared to color image files. The document above on the left was scanned directly using a book scanner and the document on the right was scanned from 35mm microfilm using a grayscale microfilm scanner. [document on left- from RG 105, Records of the Bureau of Refugees, Freedmen, and Abandoned Lands, NARA – Old Military and Civil LICON; document on the right- 1930 Census Population Schedule, Milwaukee City, WI, Microfilm Publication T626, Roll 2594, sheet 18B]



For textual documents where color is important to the interpretation of the information or content, or there is a desire to produce the most accurate representation, then scanning in color is the most appropriate approach. The document above on the left was scanned from a 4"x5" color copy transparency using a film scanner and the document on the right was scanned directly on a flatbed scanner. [document on left- Telegram from President Lincoln to General Grant, 07/11/1864, RG 107 Records of the Office of the Secretary of War, NARA – Old Military and Civil LICON; document on the right- Brown v. Board, Findings of Fact, 8/3/1951, RG 21 Records of the District Courts of the United States, NARA – Central Plains Region (Kansas City)]

Oversized records-

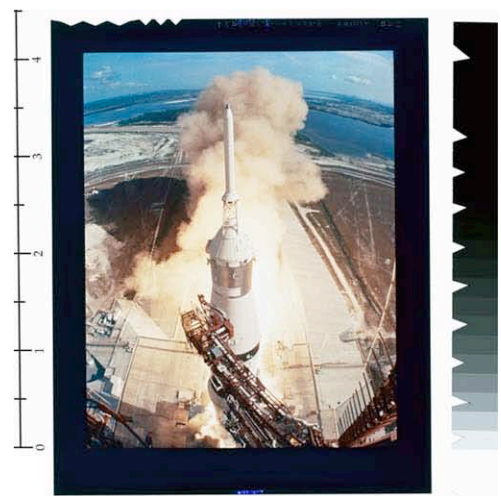


Generally, oversized refers to documents of any type that do not fit easily onto a standard flatbed scanner. The above parchment document on the left and the large book on the right were digitized using a copy stand with a large-format camera and a scanning digital camera back. Books and other bound materials can be difficult to digitize and often require appropriate types of book cradles to prevent damaging the books. [document on the left- Act Concerning the Library for the Use of both Houses of Congress, Seventh Congress of the US, NARA – Center for Legislative Archives; document on the right- Lists of Aliens Admitted to Citizenship 1790-1860, US Circuit and District Courts, District of South Carolina, Charleston, NARA – Southeast Region (Atlanta)]



Maps, architectural plans, engineering plans, etc. are often oversized. Both of the above documents were scanned using a digital copy stand. [document on left- Map of Illinois, 1836, RG 233 Records of the U.S. House of Representatives, NARA – Center for Legislative Archives; document on right- The Mall and Vicinity, Washington, Sheet # 35-23, RG 79 Records of the National Capitol Parks Commission, NARA – Special Media Archives Services Division]

Photographs-



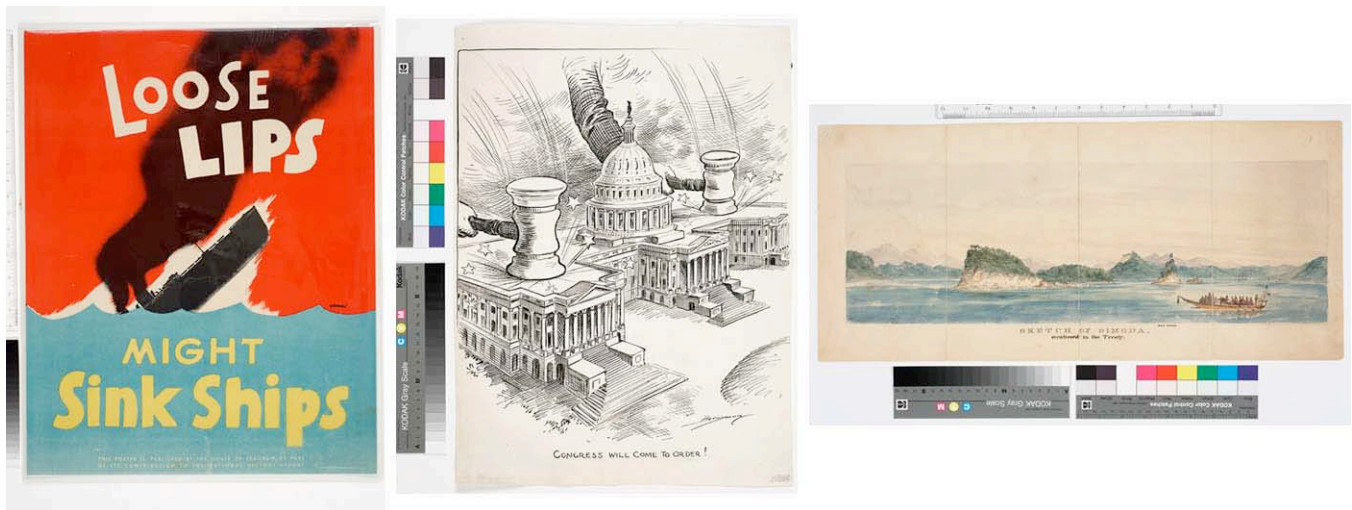
There is a wide variety of photographic originals and different types will require different approaches to digitizing. Above on the left is a scan of a modern preservation-quality film duplicate negative of a Mathew Brady collodion wet-plate negative. Since the modern duplicate negative is in good condition and has a neutral image tone, the negative was scanned as a grayscale image on a flatbed scanner. The photograph in the center is a monochrome print from the 1940s that was scanned in color on a flatbed scanner because the image tone is very warm and there is some staining on the print; many older "black-and-white" prints have image tone and it may be more appropriate to scan these monochrome prints in color. The photo on the right is a 4"x5" duplicate color transparency and was scanned in color using a flatbed scanner. [photograph on left- Gen. Edward O.C. Ord and family, ca. 1860-ca. 1865, 111-B-5091, RG 111 Records of the Office of the Chief Signal Officer, NARA – Special Media Archives Services Division; photograph in center- Alonzo Bankston, electric furnace operator, Wilson Nitrate Plant, Muscle Shoals, Alabama, 1943, RG 142 Records of the Tennessee Valley Authority, NARA – Southeast Region (Atlanta); photograph on right- Launch of the Apollo 11 Mission, 306-AP-A11-5H-69-H-1176, RG 306 Records of the U.S. Information Agency, NARA – Special Media Archives Services Division]

Aerial photographs-



Aerial photographs have a lot of fine detail, often require a high degree of enlargement, and may require a higher degree of precision regarding the dimensional accuracy of the scans (compared to textual documents or other types of photographs). The above two grayscale images were produced by scanning film duplicates of the original aerial negatives using a flatbed scanner. The original negative for the image on the left was deteriorated with heavy staining and discoloration, if the original was to be scanned one option would be to scan in color and then to convert to grayscale from an individual color channel that minimizes the appearance of the staining. [photograph on left- Roosevelt Inauguration, 01 /1941, ON27740, RG373 Records of the Defense Intelligence Agency, NARA – Special Media Archives Services Division; photograph on the right- New Orleans, LA, French Quarter, 12-15-1952, ON367261 /10280628, RG 145 Records of the Farm Service Agency, NARA – Special Media Archives Services Division]

Graphic illustrations/artwork/originals-



Some originals have graphic content, and will often have some text information as well. The above examples, a poster on the left, a political cartoon in the center, and an artist’s rendition on the right all fall into this category. The most appropriate equipment to digitize these types of records will vary, and will depend on the size of the originals and their physical condition. [document on left- “Loose Lips Might Sink Ships”, 44-PA-82, RG 44 Records of the Office of Government Reports, NARA – Special Media Archives Services Division; document in center- “Congress Comes to Order” by Clifford K. Berryman, 12/2/1912, Washington Evening Star, D-021, U.S. Senate Collection, NARA – Center for Legislative Archives; document on right- Sketch of Simoda (Treaty of Kanagawa, TS 183 AO, RG 11 General Records of the United States Government, NARA - Old Military and Civil Records LICON]

Objects and artifacts-



Objects and artifacts can be photographed using either film or a digital camera. If film is used, then the negatives, slides/transparencies, or prints can be digitized. The images on the left were produced using a digital camera and the image on the right was produced by digitizing a 4"x5" color transparency. [objects on top left- Sword and scabbard, Gift from King of Siam, RG 59 General Records of the Department of State, NARA – Civilian Records LICON; object on bottom left- from Buttons Commemorating the Launch of New Ships at Philadelphia Navy Yard, RG 181 Records of the Naval Districts and Shore Establishments, NARA – Mid Atlantic Region (Center City Philadelphia); objects on right- Chap Stick tubes with hidden microphones, RG 460 Records of the Watergate Special Prosecution Force, NARA – Special Access/FOIA LICON]

Textual documents, graphic illustrations/artwork/originals, maps, plans, and oversized:

Document Character - Original	Recommended Image Parameters	Alternative Minimum
<p>Clean, high-contrast documents with printed type (e.g. laser printed or typeset)</p>	<p>1-bit bitonal mode or 8-bit grayscale - adjust scan resolution to produce a QI of 8 for smallest significant character</p> <p style="text-align: center;">or</p> <p>1-bit bitonal mode - 600 ppi* for documents with smallest significant character of 1.0 mm or larger</p> <p style="text-align: center;">or</p> <p>8-bit grayscale mode – 400 ppi for documents with smallest significant character of 1.0 mm or larger</p> <p>NOTE: Regardless of approach used, adjust scan resolution to produce a minimum pixel measurement across the long dimension of 6,000 lines for 1-bit files and 4,000 lines for 8-bit files</p> <p style="text-align: center;">*The 600 ppi 1-bit files can be produced via scanning or created / derived from 400 ppi, 8-bit grayscale images.</p>	<p>1-bit bitonal mode - 300 ppi* for documents with smallest significant character of 2.0 mm or larger</p> <p style="text-align: center;">or</p> <p>8-bit grayscale mode - 300 ppi for documents with smallest significant character of 1.5 mm or larger</p> <p style="text-align: right;">*The 300 ppi 1-bit files can be produced via scanning or created / derived from 300 ppi, 8-bit grayscale images.</p>
<p>Documents with poor legibility or diffuse characters (e.g. carbon copies, Thermofax/Verifax, etc.), handwritten annotations or other markings, low inherent contrast, staining, fading, halftone illustrations, or photographs</p>	<p>8-bit grayscale mode - adjust scan resolution to produce a QI of 8 for smallest significant character</p> <p style="text-align: center;">or</p> <p>8-bit grayscale mode - 400 ppi for documents with smallest significant character of 1.0 mm or larger</p> <p>NOTE: Regardless of approach used, adjust scan resolution to produce a minimum pixel measurement across the long dimension of 4,000 lines for 8-bit files</p>	<p>8-bit grayscale mode - 300 ppi for documents with smallest significant character of 1.5 mm or larger</p>
<p>Documents as described for grayscale scanning and/or where color is important to the interpretation of the information or content, or desire to produce the most accurate representation</p>	<p>24-bit color mode - adjust scan resolution to produce a QI of 8 for smallest significant character</p> <p style="text-align: center;">or</p> <p>24-bit RGB mode - 400 ppi for documents with smallest significant character of 1.0 mm or larger</p> <p>NOTE: Regardless of approach used, adjust scan resolution to produce a minimum pixel measurement across the long dimension of 4,000 lines for 24-bit files</p>	<p>24-bit RGB mode - 300 ppi for documents with smallest significant character of 1.5 mm or larger</p>

Photographs - film / camera originals - black-and-white and color - transmission scanning:

Format - Original	Recommended Image Parameters	Alternative Minimum
<p><i>Format range:</i></p> <ul style="list-style-type: none"> ○ 35 mm and medium-format, up to 4"x5" <p><i>Size range:</i></p> <ul style="list-style-type: none"> ○ Smaller than 20 square inches 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> ○ 4000 pixels across long dimension of image area, excluding mounts and borders <p><i>Resolution:</i></p> <ul style="list-style-type: none"> ○ Scan resolution to be calculated from actual image dimensions - approx. 2800 ppi for 35mm originals and ranging down to approx. 800 ppi for originals approaching 4"x5" <p><i>Dimensions:</i></p> <ul style="list-style-type: none"> ○ Sized to match original, no magnification or reduction <p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> ○ 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file ○ 24-bit RGB mode for color and monochrome (e.g. collodion wet-plate negative, pyro developed negatives, stained negatives, etc.), can be produced from a 48-bit RGB file 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> ○ 3000 pixels across long dimension for all rectangular formats and sizes ○ 2700 pixels by 2700 pixels for square formats regardless of size <p><i>Resolution:</i></p> <ul style="list-style-type: none"> ○ Scan resolution calculated from actual image dimensions – approx. 2100 ppi for 35mm originals and ranging down to the appropriate resolution to produce the desired size file from larger originals, approx. 600 ppi for 4"x5" and 300 ppi for 8"x10" originals
<p><i>Format range:</i></p> <ul style="list-style-type: none"> ○ 4"x5" and up to 8"x10" <p><i>Size range:</i></p> <ul style="list-style-type: none"> ○ Equal to 20 square inches and smaller than 80 square inches 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> ○ 6000 pixels across long dimension of image area, excluding mounts and borders <p><i>Resolution:</i></p> <ul style="list-style-type: none"> ○ Scan resolution to be calculated from actual image dimensions – approx. 1200 ppi for 4"x5" originals and ranging down to approx. 600 ppi for 8"x10" originals <p><i>Dimensions:</i></p> <ul style="list-style-type: none"> ○ Sized to match original, no magnification or reduction <p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> ○ 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file ○ 24-bit RGB mode for color and monochrome (e.g. collodion wet-plate negative, pyro developed negatives, stained negatives, etc.), can be produced from a 48-bit RGB file 	<p><i>Dimension:</i></p> <ul style="list-style-type: none"> ○ File dimensions set to 10" across long dimension at 300 ppi for rectangular formats and to 9"x9" at 300 ppi for square formats
<p><i>Format range:</i></p> <ul style="list-style-type: none"> ○ 8"x10" and larger <p><i>Size range:</i></p> <ul style="list-style-type: none"> ○ Larger than or equal to 80 square inches 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> ○ 8000 pixels across long dimension of image area, excluding mounts and borders <p><i>Resolution:</i></p> <ul style="list-style-type: none"> ○ Scan resolution to be calculated from actual image dimensions – approx. 800 ppi for originals approx. 8"x10" and ranging down to the appropriate resolution to produce the desired size file from larger originals <p><i>Dimensions:</i></p> <ul style="list-style-type: none"> ○ Sized to match original, no magnification or reduction <p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> ○ 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file ○ 24-bit RGB mode for color and monochrome (e.g. collodion wet-plate negative, pyro developed negatives, stained negatives, etc.), can be produced from a 48-bit RGB file 	<p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> ○ 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file ○ 24-bit RGB mode for color and monochrome (e.g. collodion wet-plate negative, pyro developed negatives, stained negatives, etc.), can be produced from a 48-bit RGB file

Duplicate negatives and copy negatives can introduce problems in recommending scanning specifications, particularly if there is no indication of original size. Any reduction or enlargement in size must be taken into account, if possible. In all cases, reproduction to original size is ideal. For copy negatives or

transparencies of prints, use the specifications for that print size. For duplicates (negatives, slides, transparencies), match the original size. However, if original size is not known, the following recommendations are supplied:

- For a copy negative or transparency, scan at a resolution to achieve 4000 pixels across the long dimension.
- For duplicates, follow the scanning recommendations for the size that matches the actual physical dimensions of the duplicate.

For scanning negatives with multiple images on a single negative, see the section on scanning stereographs below. If a ruler has been included in the scan, use it to verify that the image has not been reduced or enlarged before calculating appropriate resolution.

Although many scanning workflows accommodate capturing in 24-bit color, we do not see any benefit at this time to saving the master files of scans produced from modern black-and-white copy negatives and duplicates in RGB. These master scans can be reduced to grayscale in the scanning software or during post-processing editing. However, master scans of camera originals may be kept in RGB, and specifically recommend RGB for any negatives that contain color information as a result of staining, degradation, or intentional color casts.

Scanning Negatives: Often photographic negatives are the most difficult originals to scan. Unlike scanning positives, reflection prints and transparencies/slides, there are no reference images to which to compare scans. Scanning negatives is very much like printing in the darkroom, it is up to the photographer/technician to adjust brightness and contrast to get a good image. Scanning negatives is a very subjective process that is very dependent on the skill of the photographer/technician. Also, most scanners are not as well calibrated for scanning negatives compared to scanning positives.

Often to minimize loss of detail, it is necessary to scan negatives as positives (the image on screen is negative), to invert the images in Photoshop, and then to adjust the images.

If black-and-white negatives are stained or discolored, we recommend making color RGB scans of the negatives and using the channel which minimizes the appearance of the staining/discoloration when viewed as a positive. The image can then be converted to a grayscale image.



On the left is an image of a historic black-and-white film negative that was scanned in color with a positive tonal orientation (the digital image appears the same as the original negative), this represents a reasonably accurate rendition of the original negative. The middle grayscale image shows a direct inversion of the tones, and as shown here, often a direct inversion of a scan of a negative will not produce a well-rendered photographic image. The image on the right illustrates an adjusted version where the brightness and contrast of the image has been optimized (using "Curves" and "Levels" in Adobe Photoshop software) to produce a reasonable representation of the photographic image, these adjustments are very similar to how a photographer prints a negative in the darkroom. [photograph- NRCA-142-INFO01-3169D, RG 142 Records of the TVA, NARA – Southeast Region (Atlanta)]

Photographs - prints - black-and-white, monochrome, and color - reflection scanning:

Format - Original	Recommended Image Parameters	Alternative Minimum
<p><i>Format range:</i></p> <ul style="list-style-type: none"> ○ 8"x10" or smaller <p><i>Size range:</i></p> <ul style="list-style-type: none"> ○ Smaller than or equal to 80 square inches 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> ○ 4000 pixels across long dimension of image area, excluding mounts and borders <p><i>Resolution:</i></p> <ul style="list-style-type: none"> ○ Scan resolution to be calculated from actual image dimensions – approx. 400 ppi for 8"x10" originals and ranging up to the appropriate resolution to produce the desired size file from smaller originals, approx. 570 ppi for 5"x7" and 800 ppi for 4"x5" or 3.5"x5" originals <p><i>Dimensions:</i></p> <ul style="list-style-type: none"> ○ Sized to match the original, no magnification or reduction <p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> ○ 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file ○ 24-bit RGB mode for color and monochrome (e.g. albumen prints or other historic print processes), can be produced from a 48-bit RGB file 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> ○ 3000 pixels across long dimension for all rectangular formats and sizes ○ 2700 pixels by 2700 pixels for square formats regardless of size <p><i>Resolution:</i></p> <ul style="list-style-type: none"> ○ Scan resolution calculated from actual image dimensions – approx. 2100 ppi for 35mm originals and ranging down to the appropriate resolution to produce the desired size file from larger originals, approx. 600 ppi for 4"x5" and 300 ppi for 8"x10" originals
<p><i>Format range:</i></p> <ul style="list-style-type: none"> ○ Larger than 8"x10" and up to 11"x14" <p><i>Size range:</i></p> <ul style="list-style-type: none"> ○ Larger than 80 square inches and smaller than 154 square inches 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> ○ 6000 pixels across long dimension of image area, excluding mounts and borders <p><i>Resolution:</i></p> <ul style="list-style-type: none"> ○ Scan resolution to be calculated from actual image dimensions – approx. 600 ppi for originals approx. 8"x10" and ranging down to approx. 430 ppi for 11"x14" originals <p><i>Dimensions:</i></p> <ul style="list-style-type: none"> ○ Sized to match the original, no magnification or reduction <p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> ○ 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file ○ 24-bit RGB mode for color and monochrome (e.g. albumen prints or other historic print processes), can be produced from a 48-bit RGB file 	<p><i>Dimension:</i></p> <ul style="list-style-type: none"> ○ File dimensions set to 10" across long dimension at 300 ppi for rectangular formats and to 9"x9" at 300 ppi for square formats
<p><i>Format range:</i></p> <ul style="list-style-type: none"> ○ Larger than 11"x14" <p><i>Size range:</i></p> <ul style="list-style-type: none"> ○ Equal to or larger than 154 square inches 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> ○ 8000 pixels across long dimension of image area, excluding mounts and borders <p><i>Resolution:</i></p> <ul style="list-style-type: none"> ○ Scan resolution to be calculated from actual image dimensions – approx. 570 ppi for originals approx. 11"x14" and ranging down to the appropriate resolution to produce the desired size file from larger originals <p><i>Dimensions:</i></p> <ul style="list-style-type: none"> ○ Sized to match the original, no magnification or reduction <p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> ○ 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file ○ 24-bit RGB mode for color and monochrome (e.g. albumen prints or other historic print processes), can be produced from a 48-bit RGB file 	<p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> ○ 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file ○ 24-bit RGB mode for color and monochrome (e.g. collodion wet-plate negative, pyro developed negatives, stained negatives, etc.), can be produced from a 48-bit RGB file

For stereograph images and other multiple image prints, modified recommended scanning specifications are to scan to original size (length of both photos and mount) and add 2000 pixels to the long dimension, in the event that only one of the photographs is requested for high-quality reproduction. For example, if the stereograph is 8" on the long dimension, a resolution of 500 ppi would be required to achieve 4000 pixels across the long dimension for that size format; in this case, adding 2000 pixels to the long dimension would require that the stereograph be scanned at 750 ppi to achieve the desired 6000 pixels across the long dimension.

For photographic prints, size measurements for determining appropriate resolution are based on the size of the image area only, excluding any borders, frames, or mounts. However, in order to show that the entire record has been captured, it is good practice to capture the border area in the master scan file. In cases where a small image is mounted on a large board (particularly where large file sizes may be an issue), it may be desirable to scan the image area only at the appropriate resolution for its size, and then scan the entire mount at a resolution that achieves 4000 pixels across the long dimension.

Aerial - transmission scanning:

Format - Original	Recommended Image Parameters*	Alternative Minimum
<p><i>Format range:</i></p> <ul style="list-style-type: none"> ○ 70mm wide and medium format roll film <p><i>Size range:</i></p> <ul style="list-style-type: none"> ○ Smaller than 10 square inches 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> ○ 6000 pixels across long dimension of image area, excluding borders <p><i>Resolution:</i></p> <ul style="list-style-type: none"> ○ Scan resolution to be calculated from actual image dimensions – approx. 2700 ppi for 70mm originals and ranging down to the appropriate resolution to produce the desired size file from larger originals <p><i>Dimensions:</i></p> <ul style="list-style-type: none"> ○ Sized to match original, no magnification or reduction <p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> ○ 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file ○ 24-bit RGB mode for color and monochrome (stained negatives), can be produced from a 48-bit RGB file 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> ○ 4000 pixels across long dimension of image area <p><i>Resolution:</i></p> <ul style="list-style-type: none"> ○ Scan resolution calculated from actual image dimensions – approx. 1800 ppi for 6cm x 6cm originals and ranging down to the appropriate resolution to produce the desired size file from larger originals, approx. 800 ppi for 4"x5" and 400 ppi for 8"x10" originals
<p><i>Format range:</i></p> <ul style="list-style-type: none"> ○ 127mm wide roll film, 4"x5" and up to 5"x7" sheet film <p><i>Size range:</i></p> <ul style="list-style-type: none"> ○ Equal to 10 square inches and up to 35 square inches 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> ○ 8000 pixels across long dimension of image area, excluding borders <p><i>Resolution:</i></p> <ul style="list-style-type: none"> ○ Scan resolution to be calculated from actual image dimensions – approx. 1600 ppi for 4"x5" originals and ranging down to approx. 1100 ppi for 5"x7" originals <p><i>Dimensions:</i></p> <ul style="list-style-type: none"> ○ Sized to match original, no magnification or reduction <p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> ○ 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file ○ 24-bit RGB mode for color and monochrome (stained negatives), can be produced from a 48-bit RGB file 	<p><i>Dimension:</i></p> <ul style="list-style-type: none"> ○ File dimensions set to 10" across long dimension at 400 ppi for all formats
<p><i>Format range:</i></p> <ul style="list-style-type: none"> ○ Larger than 127mm wide roll film and larger than 5"x7" sheet film <p><i>Size range:</i></p> <ul style="list-style-type: none"> ○ Larger than 35 square inches 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> ○ 10000 pixels across long dimension of image area, excluding borders <p><i>Resolution:</i></p> <ul style="list-style-type: none"> ○ Scan resolution to be calculated from actual image dimensions – approx. 2000 ppi for 5"x5" originals and ranging down to the appropriate resolution to produce the desired size file from larger originals <p><i>Dimensions:</i></p> <ul style="list-style-type: none"> ○ Sized to match original, no magnification or reduction <p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> ○ 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file ○ 24-bit RGB mode for color and monochrome (e.g. stained negatives), can be produced from a 48-bit RGB file 	<p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> ○ 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file ○ 24-bit RGB mode for color and monochrome (e.g. stained negatives), can be produced from a 48-bit RGB file

*If scans of aerial photography will be used for oversized reproduction, follow the scanning recommendations for the next largest format (e.g., if your original is 70mm wide, follow the specifications for 127mm wide roll film to achieve 8000 pixels across the long dimensions.

Aerial - reflection scanning:

Format - Original	Recommended Image Parameters*	Alternative Minimum
<p><i>Format range:</i></p> <ul style="list-style-type: none"> Smaller than 8"x10" <p><i>Size range:</i></p> <ul style="list-style-type: none"> Smaller than 80 square inches 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> 4000 pixels across long dimension of image area, excluding mounts and borders <p><i>Resolution:</i></p> <ul style="list-style-type: none"> Scan resolution to be calculated from actual image dimensions – approx. 400 ppi for originals approx. 8"x10" and ranging up to the appropriate resolution to produce the desired size file from smaller originals, approx. 570 ppi for 5"x7" and 800 ppi for 4"x5" originals <p><i>Dimensions:</i></p> <ul style="list-style-type: none"> Sized to match the original, no magnification or reduction <p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file 24-bit RGB mode for color and monochrome (e.g. discolored prints), can be produced from a 48-bit RGB file 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> 3000 pixels across long dimension of image area <p><i>Resolution:</i></p> <ul style="list-style-type: none"> Scan resolution to be calculated from actual image dimensions – approx. 300 ppi for 8"x10" originals and ranging up to the appropriate resolution to produce the desired size file from smaller originals, approx. 570 ppi for 5"x7" and 800 ppi for 4"x5" or 3.5"x5" originals <p><i>Dimensions:</i></p> <ul style="list-style-type: none"> Sized to match the original, no magnification or reduction <p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file 24-bit RGB mode for color and monochrome (e.g. discolored prints), can be produced from a 48-bit RGB file
<p><i>Format range:</i></p> <ul style="list-style-type: none"> 8"x10" and up to 11"x14" <p><i>Size range:</i></p> <ul style="list-style-type: none"> Equal to 80 square inches and up to 154 square inches 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> 6000 pixels across long dimension of image area, excluding mounts and borders <p><i>Resolution:</i></p> <ul style="list-style-type: none"> Scan resolution to be calculated from actual image dimensions – approx. 600 ppi for 8"x10" originals and ranging down to approx. 430 ppi for 11"x14" originals <p><i>Dimensions:</i></p> <ul style="list-style-type: none"> Sized to match the original, no magnification or reduction <p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file 24-bit RGB mode for color and monochrome (e.g. discolored prints), can be produced from a 48-bit RGB file 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> 6000 pixels across long dimension of image area, excluding mounts and borders <p><i>Resolution:</i></p> <ul style="list-style-type: none"> Scan resolution to be calculated from actual image dimensions – approx. 600 ppi for 8"x10" originals and ranging down to approx. 430 ppi for 11"x14" originals <p><i>Dimensions:</i></p> <ul style="list-style-type: none"> Sized to match the original, no magnification or reduction <p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file 24-bit RGB mode for color and monochrome (e.g. discolored prints), can be produced from a 48-bit RGB file
<p><i>Format range:</i></p> <ul style="list-style-type: none"> Larger than 11"x14" <p><i>Size range:</i></p> <ul style="list-style-type: none"> Larger than 154 square inches 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> 8000 pixels across long dimension of image area, excluding mounts and borders <p><i>Resolution:</i></p> <ul style="list-style-type: none"> Scan resolution to be calculated from actual image dimensions – approx. 570 ppi for 11"x14" originals and ranging down to the appropriate resolution to produce the desired size file from larger originals <p><i>Dimensions:</i></p> <ul style="list-style-type: none"> Sized to match the original, no magnification or reduction <p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file 24-bit RGB mode for color and monochrome (e.g. discolored prints), can be produced from a 48-bit RGB file 	<p><i>Pixel Array:</i></p> <ul style="list-style-type: none"> 8000 pixels across long dimension of image area, excluding mounts and borders <p><i>Resolution:</i></p> <ul style="list-style-type: none"> Scan resolution to be calculated from actual image dimensions – approx. 570 ppi for 11"x14" originals and ranging down to the appropriate resolution to produce the desired size file from larger originals <p><i>Dimensions:</i></p> <ul style="list-style-type: none"> Sized to match the original, no magnification or reduction <p><i>Bit Depth:</i></p> <ul style="list-style-type: none"> 8-bit grayscale mode for black-and-white, can be produced from a 16-bit grayscale file 24-bit RGB mode for color and monochrome (e.g. discolored prints), can be produced from a 48-bit RGB file

*If scans of aerial photography will be used for oversized reproduction, follow the scanning recommendations for the next largest format (e.g., if your original is 8"x10", follow the specifications for formats larger than 8"x10" to achieve 6000 pixels across the long dimensions.

Objects and artifacts:

Recommended Image Parameters	Alternative Minimum
<p>10 to 16 megapixel 24-bit RGB mode image, can be produced from a 48-bit RGB file.</p> <p>If scanning photographic copies of objects and artifacts, see recommended requirements in the appropriate photo charts above.</p>	<p>6 megapixel 24-bit RGB mode image, can be produced from a 48-bit RGB file.</p> <p>If scanning photographic copies of objects and artifacts, see minimum requirements in the appropriate photo charts above.</p>

High resolution digital photography requirements:

- Images equivalent to 35mm film photography (6 megapixels to 14 megapixels), to medium format film photography (12 megapixels to 22 megapixels), or to large format film photography (18 megapixels to 200 megapixels).
- Images for photo quality prints and printed reproductions with magazine quality halftones, with maximum image quality at a variety of sizes.
- “Megapixel” is millions of pixels, the megapixel measurement is calculated by multiplying the pixel array values: image width in pixels x image height in pixels.

Actual pixel dimensions and aspect ratio will vary depending on digital camera - illustrative sizes, dimensions, and proportions are:

- 35mm equivalent - Minimum pixel array of 3,000 pixels by 2,000 pixels (6 megapixels, usual default resolution of 72 ppi at 41.7” by 27.8” or equivalent such as 300 ppi at 10” by 6.7”). Pixel array up to 4,500 pixels by 3,100 pixels (14 megapixels, usual default resolution of 72 ppi at 62.5” by 43” or equivalent such as 300 ppi at 15” by 10.3”).
- Medium format equivalent - Minimum pixel array of 4,000 pixels by 3,000 pixels (12 megapixels, usual default resolution of 72 ppi at 55.6” by 41.7” or equivalent such as 300 ppi at 13.3” by 10”). Pixel array up to 5,200 pixels by 4,200 pixels (22 megapixels, usual default resolution of 72 ppi at 72.2” by 58.3” or equivalent such as 300 ppi at 17.3” by 14”).
- Large format equivalent - Minimum pixel array of 4,800 pixels by 3,700 pixels (18 megapixels, usual default resolution of 72 ppi at 66.7” by 51.4” or equivalent such as 300 ppi at 16” by 12.5”). Pixel array up to 16,000 pixels by 12,500 pixels (200 megapixels, usual default resolution of 72 ppi at 222.2” by 173.6” or equivalent such as 300 ppi at 53.3” by 41.7”).

File Formats – Image files shall be saved using the following formats:

- Uncompressed TIFF (.tif, sometimes called a raw digital camera file) or LZW compressed TIFF preferred for medium and high resolution requirements.
- JPEG File Interchange Format (JFIF, JPEG, or .jpg) at highest quality (least compressed setting) acceptable for medium and high resolution requirements.
- JPEG Interchange Format (JFIF, JPEG, or .jpg) at any compression setting acceptable for low resolution requirements, depending on the subject matter of the photograph.
- Using the TIFF format and JFIF/JPEG format with high-quality low compression will result in relatively large image file sizes. Consider using larger memory cards, such as 128 MB or larger, or connecting the camera directly to a computer. Select digital cameras that use common or popular memory card formats.

Image Quality - Digital cameras shall produce high quality image files, including:

- No clipping of image detail in the highlights and shadows for a variety of lighting conditions.
- Accurate color and tone reproduction and color saturation for a variety of lighting conditions.
- Image files may be adjusted after photography using image processing software, such as Adobe Photoshop or JASC Paint Shop Pro. It is desirable to get a good image directly from the camera and to do as little adjustment after photography.
- Digital images shall have minimal image noise and other artifacts that degrade image quality.

- Subject of the photographs shall be in focus, using either auto or manual focus.
- Use of digital zoom feature may have a detrimental effect on the image quality, a smaller portion of the overall image is interpolated to a larger file (effectively lowering resolution).

White Balance – Digital cameras shall be used on automatic white balance or the white balance shall be selected manually to match the light source.

Color Profile – Image files saved with a custom ICC image profile (done in camera or profile produced after photography using profiling software) or a standard color space like sRGB should be converted to a standard wide-gamut color space like Adobe RGB 1998.

Header Data – If camera supports EXIF header data, data in all tags shall be saved.

Image Stitching - Some cameras and many software applications will stitch multiple images into a single image, such as stitching several photographs together to create a composite or a panorama. The stitching process identifies common features within overlapping images and merges the images along the areas of overlap. This process may cause some image degradation. Consider saving and maintaining both the individual source files and the stitched file.

VI. STORAGE

File Formats:

We recommend the Tagged Image File Format or TIFF for production master files. Use TIFF version 6, with Intel (Windows) byte order. For additional information on file formats for production masters, see Appendix D, File Format Comparison.

Uncompressed files are recommended, particularly if files are not actively managed, such as storage on CD-ROM or DVD-ROM. If files are actively managed in a digital repository, then you may want to consider using either LZW or ZIP lossless compression for the TIFF files. Do not use JPEG compression within the TIFF format.

File Naming:

A file naming scheme should be established prior to capture. The development of a file naming system should take into account whether the identifier requires machine- or human-indexing (or both—in which case, the image may have multiple identifiers). File names can either be meaningful (such as the adoption of an existing identification scheme which correlates the digital file with the source material), or non-descriptive (such as a sequential numerical string). Meaningful file names contain metadata that is self-referencing; non-descriptive file names are associated with metadata stored elsewhere that serves to identify the file. In general, smaller-scale projects may design descriptive file names that facilitate browsing and retrieval; large-scale projects may use machine-generated names and rely on the database for sophisticated searching and retrieval of associated metadata.

In general, we recommend that file names-

- Are unique.
- Are consistently structured.
- Take into account the maximum number of items to be scanned and reflect that in the number of digits used (if following a numerical scheme).
- Use leading 0's to facilitate sorting in numerical order (if following a numerical scheme).
- Do not use an overly complex or lengthy naming scheme that is susceptible to human error during manual input.
- Use lowercase characters and file extensions.
- Use numbers and/or letters but not characters such as symbols or spaces that could cause complications across operating platforms.
- Record metadata embedded in file names (such as scan date, page number, etc.) in another location in addition to the file name. This provides a safety net for moving files across systems in the future, in the event that they must be renamed.
- In particular, sequencing information and major structural divisions of multi-part objects should be explicitly recorded in the structural metadata and not only embedded in filenames.
- Although it is not recommended to embed too much information into the file name, a certain amount of information can serve as minimal descriptive metadata for the file, as an economical alternative to the provision of richer data elsewhere.
- Alternatively, if meaning is judged to be temporal, it may be more practical to use a simple numbering system. An intellectually meaningful name will then have to be correlated with the digital resource in the database.

Directory structure-

Regardless of file name, files will likely be organized in some kind of file directory system that will link to metadata stored elsewhere in a database. Production master files might be stored separately from derivative files, or directories may have their own organization independent of the image files, such as folders arranged by date or record group number, or they may replicate the physical or logical organization of the originals being scanned.

The files themselves can also be organized solely by directory structure and folders rather than embedding meaning in the file name. This approach generally works well for multi-page items. Images are uniquely identified and aggregated at the level of the logical object (i.e., a book, a chapter, an issue, etc.), which requires that the folders or directories be named descriptively. The file names of the individual images themselves are unique only within each directory, but not across directories. For example, book 0001 contains image files 001.tif, 002.tif, 003.tif, etc. Book 0002 contains image files 001.tif, 002.tif, 003.tif. The danger with this approach is that if individual images are separated from their parent directory, they will be indistinguishable from images in a different directory.

In the absence of a formal directory structure, we are currently using meaningful file names. The item being scanned is assigned a 5-digit unique identifier (assigned at the logical level). This identifier has no meaning in the scanning process, but does carry meaning in a system that links the image file(s) to descriptive information. Also embedded in the file name is the year the file was scanned as well as a 3-digit sequential number that indicates multiple pages. This number simply records the number of files belonging to an object; it does not correlate with actual page numbers. The organization is: logical item ID_scan year_page or file number_role of image.tif; e.g., 00001_2003_001_MA.tif.

Versioning-

For various reasons, a single scanned object may have multiple but differing versions associated with it (for example, the same image prepped for different output intents, versions with additional edits, layers, or alpha channels that are worth saving, versions scanned on different scanners, scanned from different original media, scanned at different times by different scanner operators, etc.). Ideally, the description and intent of different versions should be reflected in the metadata; but if the naming convention is consistent, distinguishing versions in the file name will allow for quick identification of a particular image. Like derivative files, this usually implies the application of a qualifier to part of the file name. The reason to use qualifiers rather than entirely new names is to keep all versions associated with a logical object under the same identifier. An approach to naming versions should be well thought out; adding 001, 002, etc. to the base file name to indicate different versions is an option; however, if 001 and 002 already denote page numbers, a different approach will be required.

Naming derivative files-

The file naming system should also take into account the creation of derivative image files made from the production master files. In general, derivative file names are inherited from the production masters, usually with a qualifier added on to distinguish the role of the derivative from other files (i.e., "pr" for printing version, "t" for thumbnail, etc.) Derived files usually imply a change in image dimensions, image resolution, and/or file format from the production master. Derivative file names do not have to be descriptive as long as they can be linked back to the production master file.

For derivative files intended primarily for Web display, one consideration for naming is that images may need to be cited by users in order to retrieve other higher-quality versions. If so, the derivative file name should contain enough descriptive or numerical meaning to allow for easy retrieval of the original or other digital versions.

Storage Recommendations:

We recommend that production master image files be stored on hard drive systems with a level of data redundancy, such as RAID drives, rather than on optical media, such as CD-R. An additional set of images with metadata stored on an open standard tape format (such as LTO) is recommended (CD-R as backup is a less desirable option), and a backup copy should be stored offsite. Regular backups of the images onto tape from the RAID drives is also recommended. A checksum should be generated and should be stored with the image files.

Currently, we use CD-ROMs for distribution of images to external sources, not as a long-term storage medium. However, if images are stored on CD-ROMs, we recommend using high quality or "archival" quality CD-Rs (such as Mitsui Gold Archive CD-Rs). The term "archival" indicates the materials used to manufacture the CD-R (usually the dye layer where the data is recording, a protective gold layer to prevent pollutants from attacking the dye, or a physically durable top-coat to protect the surface of the disk) are reasonably stable and have good durability, but this will not guarantee the longevity of the media itself. All disks need to be stored and handled properly. We have found files stored on brand name CD-Rs that we have not been able to open less than a year after they have been written to the media. We recommend not using inexpensive or non-brand name CD-Rs, because generally they will be less stable, less durable, and more prone to recording problems. Two (or more) copies should be made; one copy should not be handled and should be stored offsite. Most importantly, a procedure for migration of the files off of the CD-ROMs should be in place. In addition, all copies of the CD-ROMs should be periodically checked using a metric such as a CRC (cyclic redundancy checksum) for data integrity. For large-scale projects or for projects that create very large image files, the limited capacity of CD-R storage will be problematic. DVD-Rs may be considered for large projects, however, DVD formats are not as standardized as the lower-capacity CD-ROM formats, and compatibility and obsolescence in the near future is likely to be a problem.

Digital repositories and the long-term management of files and metadata-

Digitization of archival records and creation of metadata represent a significant investment in terms of time and money. Is it important to realize the protection of these investments will require the active management of both the

image files and the associated metadata. Storing files to CD-R or DVD-R and putting them on a shelf will not ensure the long-term viability of the digital images or the continuing access to them.

We recommend digital image files and associated metadata be stored and managed in a digital repository, see www.rlg.org/longterm, www.nla.gov.au/padi/, and www.dpconline.org/. The Open Archival Information System (OAIS) reference model standard describes the functionality of a digital repository- see www.rlg.org/longterm/oais.html and <http://ssdoo.gsfc.nasa.gov/nost/isoas/overview.html>.

NARA is working to develop a large scale IT infrastructure for the management of, preservation of, and access to electronic records, the Electronic Records Archive (ERA) project. Information is available at http://www.archives.gov/electronic_records_archives/index.html. ERA will be an appropriate repository for managing and providing access to digital copies of physical records.

VII. QUALITY CONTROL

Quality control (QC) and quality assurance (QA) are the processes used to ensure digitization and metadata creation are done properly. QC/QA plans and procedures should address issues relating to the image files, the associated metadata, and the storage of both (file transfer, data integrity). Also, QC/QA plans should address accuracy requirements for and acceptable error rates for all aspects evaluated. For large digitization projects it may be appropriate to use a statistically valid sampling procedure to inspect files and metadata. In most situations QC/QA are done in a 2-step process- the scanning technician will do initial quality checks during production and this is followed by a second check by another person.

A quality control program should be initiated, documented, and maintained throughout all phases of digital conversion. The quality control plan should address all specifications and reporting requirements associated with each phase of the conversion project.

Completeness-

We recommend verification that 100% of the required images files and associated metadata have been completed or provided.

Inspection of digital image files-

The overall quality of the digital images and metadata will be evaluated using the following procedures. The visual evaluation of the images shall be conducted while viewing the images at a 1 to 1 pixel ratio or 100% magnification on the monitor.

We recommend, at a minimum, 10 images or 10 % of each batch of digital images, whichever quantity is larger, should be inspected for compliance with the digital imaging specifications and for defects in the following areas:

File Related-

- Files open and display
- Proper format
 - TIFF
- Compression
 - Compressed if desired
 - Proper encoding (LZW, ZIP)
- Color mode
 - RGB
 - Grayscale
 - Bitonal
- Bit depth
 - 24-bits or 48-bits for RGB
 - 8-bits or 16-bits for grayscale
 - 1-bit for bitonal
- Color profile (missing or incorrect)
- Paths, channels, and layers (present if desired)

Original/Document Related-

- Correct dimensions
- Spatial resolution
 - Correct resolution

- Correct units (inches or cm)
- Orientation
 - Document- portrait/vertical, landscape/horizontal
 - Image- horizontally or vertically flipped
- Proportions/Distortion
 - Distortion of the aspect ratio
 - Distortion of or within individual channels
- Image skew
- Cropping
 - Image completeness
 - Targets included
- Scale reference (if present, such as engineering scale or ruler)
- Missing pages or images

Metadata Related - see below for additional inspection requirements relating to metadata-

- Named properly
- Data in header tags (complete and accurate)
- Descriptive metadata (complete and accurate)
- Technical metadata (complete and accurate)
- Administrative metadata (complete and accurate)

Image Quality Related-

- Tone
 - Brightness
 - Contrast
 - Target assessment – aimpoints
 - Clipping – detail lost in high values (highlights) or dark values (shadows) – not applicable to 1-bit images
- Color
 - Accuracy
 - Target assessment – aimpoints
 - Clipping – detail lost in individual color channels
- Aimpoint variability
- Saturation
- Channel registration
 - Misregistration
 - Inconsistencies within individual channels
- Quantization errors
 - Banding
 - Posterization
- Noise
 - Overall
 - In individual channels
 - In areas that correspond to the high density areas of the original
 - In images produced using specific scanner or camera modes
- Artifacts
 - Defects
 - Dust
 - Newton’s rings
 - Missing scan lines, discontinuities, or dropped-out pixels
- Detail
 - Loss of fine detail
 - Loss of texture
- Sharpness
 - Lack of sharpness
 - Over-sharpened
 - Inconsistent sharpness
- Flare
- Evenness of tonal values, of illumination, and vignetting or lens fall-off (with digital cameras)

This list has been provided as a starting point, it should not be considered comprehensive.

Quality control of metadata-

Quality control of metadata should be integrated into the workflow of any digital imaging project. Because metadata is critical to the identification, discovery, management, access, preservation, and use of digital resources, it should be subject to quality control procedures similar to those used for verifying the quality of digital images. Since metadata is often created and modified at many points during an image's life cycle, metadata review should be an ongoing process that extends across all phases of an imaging project and beyond.

As with image quality control, a formal review process should also be designed for metadata. The same questions should be asked regarding who will review the metadata, the scope of the review, and how great a tolerance is allowed for errors.

Practical approaches to metadata review may depend on how and where the metadata is stored, as well as the extent of metadata recorded. It is less likely that automated techniques will be as effective in assessing the accuracy, completeness, and utility of metadata *content* (depending on its complexity), which will require some level of manual analysis. Metadata quality assessment will likely require skilled human evaluation rather than machine evaluation. However, some aspects of managing metadata stored within a system can be monitored using automated system tools (for example, a digital asset management system might handle verification of relationships between different versions of an image, produce transaction logs of changes to data, produce derivative images and record information about the conversion process, run error detection routines, etc.). Tools such as checksums (for example, the MD5 Message-Digest Algorithm) can be used to assist in the verification of data that is transferred or archived.

Although there are no clearly defined metrics for evaluating metadata quality, the areas listed below can serve as a starting point for metadata review. Good practice is to review metadata at the time of image quality review. In general, we consider:

- *Adherence to standards set by institutional policy or by the requirements of the imaging project.*

Conformance to a recognized standard, such as Dublin Core for descriptive metadata and the *NISO Data Dictionary – Technical Metadata for Digital Still Images* for technical and production metadata, is recommended and will allow for better exchange of files and more straightforward interpretation of the data. Metadata stored in encoded schemes such as XML can be parsed and validated using automated tools; however, these tools do not verify accuracy of the content, only accurate syntax. We recommend the use of controlled vocabulary fields or authority files whenever possible to eliminate ambiguous terms; or the use of a locally created standardized terms list.

- *Procedures for accommodating images with incomplete metadata.*

Often images obtained from various sources are represented among the digital images that NARA manages. Procedures for dealing with images with incomplete metadata should be in place. The minimal amount of metadata that is acceptable for managing images (such as a unique identifier, or a brief descriptive title or caption, etc.) should be determined. If there is no metadata associated with an image, would this preclude the image from being maintained over time?

- *Relevancy and accuracy of metadata.*

How are data input errors handled? Poor quality metadata means that a resource is essentially invisible and cannot be tracked or used. Check for correct grammar, spelling, and punctuation, especially for manually keyed data.

- *Consistency in the creation of metadata and in interpretation of metadata.*

Data should conform to the data constraints of header or database fields, which should be well-defined. Values entered into fields should not be ambiguous. Limit the number of free text fields. Documentation such as a data dictionary can provide further clarification on acceptable field values.

- *Consistency and completeness in the level at which metadata is applied.*

Metadata is collected on many hierarchical levels (file, series, collection, record group, etc.), across many versions (format, size, quality), and applies to different logical parts (item or document level, page level, etc.). Information may be mandatory at some levels and not at others. Data constants can be applied at higher levels and inherited down if they apply to all images in a set.

- *Evaluation of the usefulness of the metadata being collected.*

Is the information being recorded useful for resource discovery or management of image files over time? This is an ongoing process that should allow for new metadata to be collected as necessary.

○ *Synchronization of metadata stored in more than one location.*

Procedures should be in place to make sure metadata is updated across more than one location. Information related to the image might be stored in the TIFF header, the digital asset management system, and other databases, for example.

○ *Representation of different types of metadata.*

Has sufficient descriptive, technical, and administrative metadata been provided? All types must be present to ensure preservation of and access to a resource. All mandatory fields should be complete.

○ *Mechanics of the metadata review process.*

A system to track the review process itself is helpful; this could be tracked using a database or a folder system that indicates status.

Specifically, we consider:

○ *Verifying accuracy of file identifier.*

File names should consistently and uniquely identify both the digital resource and the metadata record (if it exists independently of the file). File identifiers will likely exist for the metadata record itself in addition to identifiers for the digitized resource, which may embed information such as page or piece number, date, project or institution identifier, among others. Information embedded in file identifiers for the resource should parallel metadata stored in a database record or header. Identifiers often serve as the link from the file to information stored in other databases and must be accurate to bring together distributed metadata about a resource. Verification of identifiers across metadata in disparate locations should be made.

○ *Verifying accuracy and completeness of information in image header tags.*

The file browser tool in Adobe Photoshop 7.0 can be used to display some of the default TIFF header fields and IPTC fields for quick review of data in the header; however, the tool does not allow for the creation or editing of header information. Special software is required for editing TIFF header tags.

○ *Verifying the correct sequence and completeness of multi-page items.*

Pages should be in the correct order with no missing pages. If significant components of the resource are recorded in the metadata, such as chapter headings or other intellectual divisions of a resource, they should match up with the actual image files. For complex items such as folded pamphlets or multiple views of an item (a double page spread, each individual page, and a close-up section of a page, for example), a convention for describing these views should be followed and should match with the actual image files.

○ *Adherence to agreed-upon conventions and terminology.*

Descriptions of components of multi-page pieces (i.e., is “front” and “back” or “recto” and “verso” used?) or descriptions of source material, for example, should follow a pre-defined, shared vocabulary.

Documentation-

Quality control data (such as logs, reports, decisions) should be captured in a formal system and should become an integral part of the image metadata at the file or the project level. This data may have long-term value that could have an impact on future preservation decisions.

Testing results and acceptance/rejection-

If more than 1% of the total number of images and associated metadata in a batch, based on the randomly selected sampling, are found to be defective for any of the reasons listed above, the entire batch should be re-inspected. Any specific errors found in the random sampling and any additional errors found in the re-inspection should be corrected. If less than 1% of the batch is found to be defective, then only the specific defective images and metadata that are found should be redone.

APPENDIX A: Digitizing for Preservation vs. Production Masters:

In order to consider using digitization as a method of preservation reformatting it will be necessary to specify much more about the characteristics and quality of the digital images than just specifying spatial resolution.

The following chart provides a comparison of image characteristics for preservation master image files and production master image files-

	Preservation Master Files	Production Master Files
Tone reproduction	<p>We need to use well defined, conceptually valid, and agreed upon approaches to tone reproduction that inform current and future users about the nature of the originals that were digitized. At this point in time, no approaches to tone reproduction have been agreed upon as appropriate for preservation digitization.</p> <p>If analog preservation reformatting is used as a model, then one analogous conceptual approach to tone reproduction would be to digitize so the density values of the originals are rendered in a linear relationship to the lightness channel in the LAB color mode. The lightness channel should be correlated to specified density ranges appropriate for different types of originals- as examples, for most reflection scanning a range of 2.0 to 2.2, for transmission scanning of most older photographic negatives a range of 2.0 to 2.2, and for transmission scanning of color transparencies /slides a range of 3.2 to 3.8.</p> <p>Many tone reproduction approaches that tell us about the nature of the originals are likely to produce master image files that are not directly usable on-screen or for printing without adjustment. It will be necessary to make production master derivative files brought to a common rendition to facilitate use. For many types of master files this will be a very manual process (like images from photographic negatives) and will not lend itself to automation.</p> <p>The need for a known rendering in regards to originals argues against saving raw and unadjusted files as preservation masters.</p> <p>For some types of originals, a tone reproduction based upon average or generic monitor display (as described in these <i>Technical Guidelines</i>) may be appropriate for preservation master files.</p>	<p>Images adjusted to achieve a common rendering and to facilitate the use of the files and batch processing.</p> <p>Tone reproduction matched to generic representation – tones distributed in a non-linear fashion.</p>
Tonal Orientation	<p>For preservation digitization the tonal orientation (positive or negative) for master files should be the same as the originals. This approach informs users about the nature of the originals, the images of positive originals appear positive and the images of photographic negatives appear negative. This approach would require production master image files be produced of images of negatives and the tonal orientation inverted to positive images. The master image files of photographic negatives will not be directly usable.</p>	<p>All images have positive tonal orientation.</p>

Color reproduction

We need to use well defined, conceptually valid, and agreed upon approaches to color reproduction that inform current and future users about the nature of the originals that were digitized. At this point in time, no approaches to color reproduction have been agreed upon as appropriate for preservation digitization.

Device independence and independence from current technical approaches that may change over time (such as ICC color management) are desirable.

Conceptually, LAB color mode may be more appropriate than RGB mode. Although, since scanners/digital cameras all capture in RGB, the images have to be converted to LAB and this process does entail potential loss of image quality. Also, LAB master files would have to be converted back to RGB to be used, another transformation and potential loss of image quality.

Also, the imaging field is looking at multi-spectral imaging to provide the best color reproduction and to eliminate problems like metamerisms. At this time, standard computer software is not capable of dealing with multi-spectral data. Also, depending on the number of bands of wavelengths sampled, the amount of data generated is significantly more than standard 3-channel color digitization. If multi-spectral imaging was feasible from a technical perspective, it would be preferable for preservation digitization. However, at this time there is no simple raster image format that could be used for storing multi-spectral data. The JPEG 2000 file format could be used, but this is a high-encoded wavelet based format that does not save the raster data (it does not save the actual bits that represent the pixels, instead it recreates the data representing the pixels). To use a simple raster image format like TIFF it would probably be necessary to convert the multi-spectral data to 3-channel RGB data; hopefully this would produce a very accurate RGB file, but the multi-spectral data would not be saved.

Images adjusted to achieve a common rendering and to facilitate the use of the files and batch processing.

Color reproduction matched to generic RGB color space. Intent is to be able to use files both within and outside of current ICC color managed process.

Bit depth

High bit-depth digitization is preferred, either 16-bit grayscale images or 48-bit RGB color images.

Standard 8-bit per channel imaging has only 256 levels of shading per channel, while 16-bit per channel imaging has thousands of shades per channel making them more like the analog originals.

High bit-depth necessary for standard 3-channel color digitization to achieve the widest gamut color reproduction.

Currently, it is difficult to verify the quality of high-bit image files.

Traditional 8-bit grayscale and 24-bit RGB files produced to an appropriate quality level are sufficient.

Resolution

Requires sufficient resolution to capture all the significant detail in originals.

Currently the digital library community seems to be reaching a consensus on appropriate resolution levels for preservation digitization of text based originals – generally 400 ppi for grayscale and color digitization is considered sufficient as long as a QI of 8 is maintained for all significant text. This approach is

Generally, current approaches are acceptable (see requirements in these *Technical Guidelines*).

based on typical legibility achieved on 35mm microfilm (the current standard for preservation reformatting of text-based originals), and studies of human perception indicate this is a reasonable threshold in regards to the level of detail perceived by the naked eye (without magnification). Certainly all originals have extremely fine detail that is not accurately rendered at 400 ppi. Also, for some reproduction requirements this resolution level may be too low, although the need for very large reproduction is infrequent.

Unlike text-based originals, it is very difficult to determine appropriate resolution levels for preservation digitization of many types of photographic originals. For analog photographic preservation duplication, the common approach is to use photographic films that have finer grain and higher resolution than the majority of originals being duplicated. The analogous approach in the digital environment would be to digitize all photographic camera originals at a resolution of 3,000 ppi to 4,000 ppi regardless of size. Desired resolution levels may be difficult to achieve given limitations of current scanners.

File size

The combination of both high bit-depth and high resolution digitization will result in large to extremely large image files. These files will be both difficult and expensive to manage and maintain.

Moderate to large files sizes.

If multi-spectral image is used, file sizes will be even larger. Although, generally it is assumed a compressed format like JPEG 2000 would be used and would compensate for some of the larger amount of data.

Other image quality parameters

Preservation master images should be produced on equipment that meets the appropriate levels for the following image quality parameters at a minimum:

- Ability to capture and render large dynamic ranges for all originals.
- Appropriate spatial frequency response to capture accurately fine detail at desired scanning resolutions.
- Low image noise over entire tonal range and for both reflective and transmissive originals.
- Accurate channel registration for originals digitized in color.
- Uniform images without tone and color variation due to deficiencies of the scanner or digitization set-up.
- Dimensionally accurate and consistent images.
- Free from all obvious imaging defects.

We need to use well defined, conceptually valid, and agreed upon approaches to these image quality parameters. At this point in time, no approaches have been agreed upon as appropriate for preservation digitization.

Generally, current equipment and approaches are acceptable (see requirements in these *Technical Guidelines*).

Three dimensional and other physical aspects of documents

We need to acknowledge digitization is a process that converts three-dimensional objects (most of which are very flat, but are three-dimensional nonetheless) into two-dimensional images or representations. Most scanners are designed with lighting to minimize the three dimensional aspects of the original documents being scanned, in order to emphasize the legibility of the text or writing. So not all of the three-dimensional aspects of the documents are recorded well and in many cases are not recorded at all; including properties and features like paper texture and fibers, paper watermarks and laid lines, folds and/or creases, embossed seals, etc. Loss of three-dimensional information may influence a range of archival/curatorial concerns regarding preservation reformatting.

These concerns are not unique to digital reformatting, traditional approaches to preservation reformatting, such as microfilming, photocopying (electrophotographic copying on archival bond), and photographic copying/duplication have the same limitations – they produce two-dimensional representations of three-dimensional originals.

One example of a concern about rendering three-dimensional aspects of documents that has legal implications is documents with embossed seals and questions about the authenticity of the digital representation of the documents when the seals are not visible and/or legible in the digital images (a common problem, see Digitization Specifications for Record Types for a short discussion of lighting techniques to improve legibility of embossed seals).

Other issues that may need to be considered and appropriate approaches defined prior to starting any reformatting include, but limited to, the following:

- Digitize front and/or back of each document or page – even if no information is on one side.
- Reflection and/or transmission scanning for all materials – to record watermarks, laid lines, paper structure and texture, any damage to the paper, etc.
- Use of diffuse and/or raking light – digitize using diffuse light to render text and/or writing accurately, and/or digitize using raking light to render the three-dimensionality of the document (folds, creases, embossed seals, etc.).
- Digitize documents folded and/or unfolded.
- Digitize documents with attachments in place and/or detached as separate documents.
- Digitize documents bound and/or unbound.

The question that needs to be answered, and there will probably not be a single answer, is how many representations are needed for preservation reformatting to accurately document the original records? The digital library community needs to discuss these issues and arrive at appropriate approaches for different types of originals. One additional comment, originals for which it is considered appropriate to have multiple representations in order to be considered preservation reformatting probably warrant preservation in original form.

Generally, digitization limited to one version without consideration of the representation of three-dimensional aspects of the original records.

APPENDIX B: Derivative Files

The parameters for access files will vary depending on the types of materials being digitized and the needs of the users of the images. There is no set size or resolution for creating derivative access files. The following charts provide some general recommendations regarding image size, resolution, and file formats for the creation of derivative images from production master image files.

From a technical perspective, records that need similar derivatives have been grouped together-

- textual records and graphic illustrations/artwork/originals
- photographs and objects/artifacts
- maps/plans/oversized and aerial photography

The charts have been divided into sections representing two different approaches to web delivery of the derivatives-

- fixed-sized image files for static access via a web browser
- dynamic access via a web browser

JPEG compression was designed for photographic images and sacrifices fine detail to save space when stored, while preserving the large features of an image. JPEG compression creates artifacts around text when used with digital images of text documents at moderate to high compression levels. Also, JPEG files will be either 24-bit RGB images or 8-bit grayscale, they can not have lower bit depths.

GIF files use LZW compression (typical compression ratio is 2:1, or the file will be half original size), which is lossless and does not create image artifacts; therefore, GIF files may be more suitable for access derivatives of text documents. The GIF format supports 8-bit (256 colors), or lower, color files and 8-bit, or lower, grayscale files. All color GIF files and grayscale GIF files with bit-depths less than 8-bits are usually dithered (the distribution of pixels of different shades in areas of another shade to simulate additional shading). Well dithered images using an adaptive palette and diffusion dither will visually have a very good appearance, including when used on photographic images. In many cases a well produced GIF file will look better, or no worse, than a highly compressed JPEG file (due to the JPEG artifacts and loss of image sharpness), and for textual records the appearance of a GIF format derivative is often significantly better than a comparable JPEG file.

The following table compares the uncompressed and compressed file sizes for the same image when using GIF format vs. JPEG format:

For an 800x600 pixel access file, assumes 2:1 compression for GIF and 20:1 for JPEG-

	Color Image		Grayscale Image	
	GIF 8-bit	JPEG 24-bit	GIF 4-bit	JPEG 8-bit
Open File Size	480 KB	1.44 MB (3 times larger than open GIF)	240 KB	480 KB (2 times larger than open GIF)
Stored File Size	240 KB (3 times larger stored JPEG)	72 KB	120 KB (5 times larger than stored JPEG)	24 KB

As you can see, when the files are open the GIF file will be smaller due to the lower bit-depth and when stored the JPEG will be smaller due to the higher compression ratio. GIF files will take longer to download, but will decompress quicker and put less demand on the end user's CPU in terms of memory and processor speed. JPEG files will download quicker, but will take longer to decompress putting a greater demand on the end user's CPU. Practical tests have shown a full page of GIF images generally will download, decompress, and display more quickly than the same page full of JPEG versions of the images.

The newer JPEG 2000 compression algorithm is a wavelet compression, and can be used to compress images to higher compression ratios with less loss of image quality compared to the older JPEG algorithm. Generally, JPEG 2000 will not produce the same severity of artifacts around text that the original JPEG algorithm produces.

Access Approach and Derivative File Type		Record Types	
		Textual Records*	Graphic Illustrations/ Artwork/ Originals**
Fixed-Sized Image Files for Static Access via a Web Browser			
Thumbnail*		<ul style="list-style-type: none"> ○ File Format: GIF (adaptive/perceptual palette, diffusion/noise dither) or JPG (low to medium quality compression, sRGB profile for color and Gamma 2.2 profile for grayscale) ○ Pixel Array: not to exceed an array of 200x200 pixels ○ Resolution: 72 ppi 	
Access – requirements for access files will vary depending on the size of the originals, text legibility, and the size of the smallest significant text characters.	Minimum	<ul style="list-style-type: none"> ○ File Format: GIF (for smaller originals, adaptive/perceptual palette, diffusion/noise dither) or JPG (for larger originals, low to medium quality compression, sRGB profile for color and Gamma 2.2 for grayscale) ○ Image Size: original size ○ Resolution: 72 ppi to 90 ppi 	
	Recommended	<ul style="list-style-type: none"> ○ File Format: GIF (for smaller originals, adaptive/perceptual palette, diffusion/noise dither) or JPG (for larger originals, medium to high quality compression, sRGB profile for color and Gamma 2.2 for grayscale) ○ Image Size: original size ○ Resolution: 90 ppi to 120 ppi 	
	Larger Alternative	<ul style="list-style-type: none"> ○ File Format: GIF (for smaller originals, adaptive/perceptual palette, diffusion/noise dither) or JPG (for larger originals, medium to high quality compression, sRGB profile for color and Gamma 2.2 for grayscale) ○ Image Size: original size ○ Resolution: 120 ppi to 200 ppi 	
Printing and Reproduction – for printing full page images from within a web browser and for magazine quality reproduction at approx. 8.5"x11"		<ul style="list-style-type: none"> ○ File Format: PDF (JPEG compression at high quality, Adobe 1998 profile for color and Gamma 2.2 for grayscale) ○ Image Size: fit within and not to exceed dimensions of 8"x10.5" (portrait or landscape orientation) ○ Resolution: 300 ppi 	
Alternative – Dynamic Access via a Web Browser			
Access – High Resolution – requires special server software and allows zooming, panning, and download of high resolution images.		<ul style="list-style-type: none"> ○ File Format: JPEG 2000 (wavelet encoding) or traditional raster file formats like TIFF or JPEG (lossy compression at high quality, Adobe 1998 profile for color and Gamma 2.2 for grayscale) ○ Image Size: original size ○ Resolution: same resolution as production master file 	

*Many digitization projects do not make thumbnail files for textual records - the text is not legible and most documents look alike when the images are this small, so thumbnails may have limited usefulness. However, thumbnail images may be needed for a variety of web uses or within a database, so many projects do create thumbnails from textual documents.

**Includes posters, artwork, illustrations, etc., generally would include any item that is graphic in nature and may have text as well.

Access Approach and Derivative File Type		Record Types	
		Photographs	Objects and Artifacts
Fixed-Sized Image Files for Static Access via a Web Browser			
Thumbnail		<ul style="list-style-type: none"> ○ File Format: GIF (adaptive/perceptual palette, diffusion/noise dither) or JPG (low to medium quality compression, sRGB profile for color and Gamma 2.2 profile for grayscale) ○ Pixel Array: not to exceed an array of 200x200 pixels ○ Resolution: 72 ppi 	
Access –	Minimum	<ul style="list-style-type: none"> ○ File Format: GIF (for smaller originals, adaptive/perceptual palette, diffusion/noise dither) or JPG (for larger originals, low to medium quality compression, sRGB profile for color and Gamma 2.2 for grayscale) ○ Pixel Array: array fit within 600x600 pixels at a minimum and up to 800x800 pixels ○ Resolution: 72 ppi 	
	Recommended	<ul style="list-style-type: none"> ○ File Format: GIF (for smaller originals, adaptive/perceptual palette, diffusion/noise dither) or JPG (for larger originals, medium to high quality compression, sRGB profile for color and Gamma 2.2 for grayscale) ○ Pixel Array: array fit within 800x800 pixels at a minimum and up to 1200x1200 pixels ○ Resolution: 72 ppi 	
	Larger Alternative	<ul style="list-style-type: none"> ○ File Format: GIF (for smaller originals, adaptive/perceptual palette, diffusion/noise dither) or JPG (for larger originals, medium to high quality compression, sRGB profile for color and Gamma 2.2 for grayscale) ○ Pixel Array: array fit within 1200x1200 pixels at a minimum and up to 2000x2000 pixels ○ Resolution: 72 ppi, or up to 200 ppi 	
Printing and Reproduction – for printing full page images from within a web browser and for magazine quality reproduction at approx. 8.5"x11"		<ul style="list-style-type: none"> ○ File Format: PDF (JPEG compression at high quality, Adobe 1998 profile for color and Gamma 2.2 for grayscale) ○ Image Size: fit within and not to exceed dimensions of 8"x10.5" (portrait or landscape orientation) ○ Resolution: 300 ppi 	
Alternative – Dynamic Access via a Web Browser			
Access – High Resolution – requires special server software and allows zooming, panning, and download of high resolution images.		<ul style="list-style-type: none"> ○ File Format: JPEG 2000 (wavelet encoding) or traditional raster file formats like TIFF or JPEG (lossy compression at high quality, Adobe 1998 profile for color and Gamma 2.2 for grayscale) ○ Image Size: original size ○ Resolution: same resolution as production master file 	

Access Approach and Derivative File Type		Record Types	
		Maps, Plans, and Oversized	Aerial Photography
Fixed-Sized Image Files for Static Access via a Web Browser			
Thumbnail		<ul style="list-style-type: none"> ○ File Format: GIF (adaptive/perceptual palette, diffusion/noise dither) or JPG (low to medium quality compression, sRGB profile for color and Gamma 2.2 profile for grayscale) ○ Pixel Array: not to exceed an array of 200 pixels by 200 pixels ○ Resolution: 72 ppi 	
Access –	Minimum	<ul style="list-style-type: none"> ○ File Format: GIF (for smaller originals, adaptive/perceptual palette, diffusion/noise dither) or JPG (for larger originals, low to medium quality compression sRGB profile for color and Gamma 2.2 for grayscale) ○ Pixel Array: array fit within 800x800 pixels at a minimum and up to 1200x1200 pixels ○ Resolution: 72 ppi 	
	Recommended	<ul style="list-style-type: none"> ○ File Format: GIF (for smaller originals, adaptive/perceptual palette, diffusion/noise dither) or JPG (for larger originals, medium to high quality compression, sRGB profile for color and Gamma 2.2 for grayscale) ○ Pixel Array: array fit within 1200x1200 pixels at a minimum and up to 2000x2000 pixels ○ Resolution: 72 ppi, or up to 200 ppi 	
	Larger Alternative	<ul style="list-style-type: none"> ○ File Format: GIF (for smaller originals, adaptive/perceptual palette, diffusion/noise dither) or JPG (for larger originals, medium to high quality compression, sRGB profile for color and Gamma 2.2 for grayscale) ○ Pixel Array: array fit within 2000x2000 pixels at a minimum and up to 3000x3000 pixels ○ Resolution: 72 ppi, or up to 300 ppi 	
Printing and Reproduction – for printing full page images from within a web browser and for magazine quality reproduction at approx. 8.5"x11"		<ul style="list-style-type: none"> ○ File Format: PDF (JPEG compression at high quality, Adobe 1998 profile for color and Gamma 2.2 for grayscale) ○ Image Size: fit within and not to exceed dimensions of 8"x10.5" (portrait or landscape orientation) ○ Resolution: 300 ppi 	
Recommended Alternative – Dynamic Access via a Web Browser			
Access – High Resolution – requires special server software and allows zooming, panning, and download of high resolution images.		<ul style="list-style-type: none"> ○ File Format: JPEG 2000 (wavelet encoding) or traditional raster file formats like TIFF or JPEG (lossy compression at high quality, Adobe 1998 profile for color and Gamma 2.2 for grayscale) ○ Image Size: original size ○ Resolution: same resolution as production master file 	

**APPENDIX C: Mapping of LCDRG Elements to Unqualified Dublin Core
(Mandatory Metadata Elements excerpted from the Lifecycle Data Requirements Guide [LCDRG]³)**

Mandatory Elements for Record Groups and Collections

Record Group	Collection	Dublin Core	LCDRG Notes
Title	Title	Title	May be an assigned name that differs from the original name
	Collection Identifier	Identifier	
Record Group Number		Identifier	
Inclusive Start Date	Inclusive Start Date	Date	
Inclusive End Date	Inclusive End Date	Date	
Description Type	Description Type		Level of aggregation

Mandatory Elements for Series, File Units, and Items

Series	File Unit	Item	Dublin Core	LCDRG Notes
Title	Title	Title	Title	
Function and Use	<input type="checkbox"/>	<input type="checkbox"/>	Description	Only mandatory for newly created descriptions of organizational records
Inclusive Start Date	<input type="checkbox"/>	<input type="checkbox"/>	Date	Inclusive Start Date for File Unit and Item inherited from Series description
Inclusive End Date	<input type="checkbox"/>	<input type="checkbox"/>	Date	Inclusive End Date for File Unit and Item inherited from Series description
General Records Type	General Records Type	General Records Type	Type	Uses NARA-controlled values
Access Restriction Status	Access Restriction Status	Access Restriction Status	Rights	
Specific Access Restrictions	Specific Access Restrictions	Specific Access Restrictions	Rights	Mandatory if value is present in Access Restriction Status

³ Lifecycle Data Requirements Guide. Second Revision, January 18, 2002

http://www.nara-at-work.gov/archives_and_records_mgmt/archives_and_activities/accessioning_processing_description/lifecycle/mandatoryelements.html

Series (cont.)	File Unit (cont.)	Item (cont.)	Dublin Core (cont.)	LCDRG Notes (cont.)
Security Classification	Security Classification	Security Classification	Rights	
Use Restriction Status	Use Restriction Status	Use Restriction Status	Rights	
Specific Use Restrictions	Specific Use Restrictions	Specific Use Restrictions	Rights	Mandatory if value is present in Use Restriction Access
Creating Individual	<input type="checkbox"/>	<input type="checkbox"/>	Creator	Creators at the File Unit and the Item level are inherited from Series description
Creating Individual Type	<input type="checkbox"/>	<input type="checkbox"/>		Most Recent/Predecessor
Creating Organization	<input type="checkbox"/>	<input type="checkbox"/>	Creator	Creators at the File Unit and the Item level are inherited from Series description
Creating Organization Type	<input type="checkbox"/>	<input type="checkbox"/>		Most Recent/Predecessor
Description Type	Description Type	Description Type		Level of Aggregation
Copy Status	Copy Status	Copy Status		Role or purpose of physical occurrence
Extent	<input type="checkbox"/>	<input type="checkbox"/>	Coverage	
GPRA Indicator	<input type="checkbox"/>	<input type="checkbox"/>		
Holdings Measurement Type	<input type="checkbox"/>	<input type="checkbox"/>		Unit by which archival materials are physically counted
Holdings Measurement Count	<input type="checkbox"/>	<input type="checkbox"/>		Numeric value. Quantity of archival materials
Location Facility	Location Facility	Location Facility	Publisher	
Reference Unit	Reference Unit	Reference Unit	Publisher	
Media Type	Media Type	Media Type	Format	Describes both physical occurrence and individual media occurrences

Mandatory Elements for Archival Creators

Organization Elements	Person Elements	Dublin Core	LCDRG Notes
Organization Name	Name	Title	
Abolish Date	<input type="checkbox"/>	Date	
Establish Date	<input type="checkbox"/>	Date	

Note: Many of the LCDRG elements above use authority lists for data values that may not necessarily map into recommended Dublin Core Metadata Initiative typology for vocabulary terms, data values, and syntax or vocabulary encoding schemes. Please consult the LCDRG for acceptable data values.

This table suggests a simple mapping only. It is evident that Dublin Core elements are extracted from a much richer descriptive set outlined in the LCDRG framework. Dublin Core elements are repeatable to accommodate multiple LCDRG fields; however, repeatability of fields is not equivalent to the complex structure of archival collections that the LCDRG attempts to capture. As a result, mapping to Dublin Core may result in a loss of information specificity and/or meaning in an archival context. A more detailed analysis of how LCDRG values are being implemented in Dublin Core will be necessary.

APPENDIX D: File Format Comparison

As stated earlier, the choice of file format has a direct affect on the performance of the digital image as well as implications for long term management of the image. Future preservation policy decisions, such as what level of preservation service to apply, are often made on a format-specific basis*. A selection of file formats commonly used for digital still raster images are listed below. The first table lists general technical characteristics to consider when choosing an appropriate file format as well as a statement on their recommended use in imaging projects. Generally, these are all well-established formats that do not pose a big risk to the preservation of content information; however, it is advised that an assessment of the potential longevity and future functionality of these formats be undertaken for any digital imaging project. The second table attempts to summarize some of these concerns.

File Format	Technical Considerations	Recommended Use
TIFF	<ul style="list-style-type: none"> -“De facto” raster image format used for master files -Simply encoded raster-based format -Accommodates internal technical metadata in header/ extensible and customizable header tags -Supports Adobe’s XMP (Extensible Metadata Platform) -Accommodates large number of color spaces and profiles -Supports device independent color space (CIE L*a*b) -Uncompressed; lossless compression (Supports multiple compression types for 1-bit files). JPEG compression not recommended in TIFF file -High-bit compatible -Can support layers, alpha channels -Accommodates large file sizes -Anticipate greater preservation support in repository settings; preferred raster image format for preservation -Widely supported and used -Long track record (format is over 10 years old) -Potential loss of Adobe support of TIFF in favor of PDF? -Not suitable as access file—no native support in current web browsers 	Preferred format for production master file
PNG	<ul style="list-style-type: none"> -Simple raster format -High-bit compatible -Lossless compression -Supports alpha channels -Not widely adopted by imaging community -Native support available in later web browsers as access file 	Possible format for production master file—not currently widely implemented
JPEG 2000	<ul style="list-style-type: none"> -Not yet widely adopted -More complex model for encoding data (content is not saved as raster data) -Supports multiple resolutions -Extended version supports color profiles -Extended version supports layers -Includes additional compression algorithms to JPEG (wavelet, lossless) -Support for extensive metadata encoded in XML “boxes;” particularly technical, descriptive, and rights metadata. Supports IPTC information; mapping to Dublin Core. 	Possible format for production master file—not currently widely implemented
GIF	<ul style="list-style-type: none"> -Lossy (high color) and lossless compression -Limited color palette -8-bit maximum, color images are dithered -Short decompression time 	Access derivative file use only—recommend for text records

File Format	Technical Considerations	Recommended Use
JFIF/JPEG	<ul style="list-style-type: none"> -Lossy compression, but most software allows for adjustable level of compression -Presence of compression artifacts -Smaller files -High-bit compatible -Longer decompression time -Supports only a limited set of internal technical metadata -Supports a limited number of color spaces -Not suitable format for editing image files—saving, processing, and resaving results in degradation of image quality after about 3 saves 	Access derivative file use only—not recommended for text or line drawings
PDF	<ul style="list-style-type: none"> -Intended to be a highly structured page description language that can contain embedded objects, such as raster images, in their respective formats. -Works better as a container for multiple logical objects that make up a coherent whole or composite document -More complex format due to embedded/externally linked objects -Implements Adobe’s XMP specification for embedding metadata in XML -Can use different compression on different parts of the file; supports multiple compression schemes -Supports a limited number of color spaces 	Not recommended for production master files
[ASCII]	<ul style="list-style-type: none"> -For image files converted to text -Potential loss to look and feel of document/formatting 	N/A
[XML]	<ul style="list-style-type: none"> -For image files converted to text -Hierarchical structure -Good for encoding digital library-like objects or records -Allows for fast and efficient end-user searching for text retrieval -Easily exchanged across platforms/systems 	N/A

* For example, DSpace directly associates various levels of preservation services with file formats—categorized as supported formats, known formats, and unknown formats. See <http://dspace.org/faqs/index.html#preserve>. The Florida Center for Library Automation (FCLA) specifies preferred, acceptable, and bit-level preservation only categories for certain file formats for their digital archive. See <http://www.fcla.edu/digitalArchive/pdfs/recFormats.pdf>.

For additional information on research into file format longevity, see *Digital Formats for Library of Congress Collections: Factors to Consider When Choosing Digital Formats* by Caroline Arms and Carl Fleischhauer at: <http://memory.loc.gov/ammem/techdocs/digform/>, from which many of the considerations below were taken; see also the Global Digital Format Registry (GDFR) at <http://hul.harvard.edu/gdfr/> for discussion of a centralized, trusted registry for information about file formats.

Longevity Considerations

- *Documentation*: For both proprietary and open standard formats, is deep technical documentation publicly and fully available? Is it maintained for older versions of the format?
- *Stability*: Is the format supported by current applications? Is the current version backward-compatible? Are there frequent updates to the format or the specification?
- *Metadata*: Does the format allow for self-documentation? Does the format support extensive embedded metadata beyond what is necessary for normal rendering of a file? Can the file support a basic level of descriptive, technical, administrative, and rights metadata? Can metadata be encoded and stored in XML or other standardized formats? Is metadata easily extracted from the file?
- *Presentation*: Does the format contain embedded objects (e.g. fonts, raster images) and/or link out to external objects? Does the format provide functionality for preserving the layout and structure of document, if this is important?
- *Complexity*: Simple raster formats are preferred. Can the file be easily unpacked? Can content be easily separated from the container? Is "uncompressed" an option for storing data? Does the format incorporate external programs (e.g., Javascript, etc.)? Complexity of format is often associated with risk management—more complex formats are assumed to be harder to decode. However, some formats are by necessity complex based on their purpose and intended functionality. Complex formats should not be avoided solely on the basis that they are forecast to be difficult to preserve, at the expense of using the best format for the use of the data it contains.
- *Adoption*: Is the format widely used by the imaging community in cultural institutions? How is it generally used by these stakeholders—as a master format, a delivery format?
- *Continuity*: How long has the format been in existence? Is the file format mature (most of the image formats in the table above have been in existence for over 10 years).
- *Protection*: Does the format accommodate error detection and correction mechanisms and encryption options? These are related to complexity of the file. In general, encryption and digital signatures may deter full preservation service levels.
- *Compression algorithms*: Does the format use standard algorithms? In general, compression use in files may deter full preservation service levels; however, this may have less to do with file complexity and more to do with patent issues surrounding specific compression algorithms.
- *Interoperability*: Is the format supported by many software applications/ OS platforms or is it linked closely with a specific application? Are there numerous applications that utilize this format? Have useful tools been built up around the format? Are there open source tools available to use and develop the format? Is access functionality improved by native support in web browsers?
- *Dependencies*: Does the format require a plug-in for viewing if appropriate software is not available, or rely on external programs to function?
- *Significant properties*: Does the format accommodate high-bit, high-resolution (detail), color accuracy, multiple compression options? (These are all technical qualities important to master image files).
- *Ease of transformation/preservation*: Is it likely that the format will be supported for full functional preservation in a repository setting, or can guarantees currently only be made at the bitstream (content data) level (where only limited characteristics of the format are maintained)?
- *Packaging formats*: In general, packaging formats such as zip and tar files should be acceptable as transfer mechanisms for image file formats. These are not normally used for storage/archiving.

APPENDIX E: Records Handling for Digitization

All digitization projects should have pre-established handling guidelines. The following provides general guidance on the proper handling of archival materials for digitization projects. This appendix is provided for informational purposes and does not constitute a policy. Handling guidelines may need to be modified for specific projects based on the records being digitized and their condition.

1. Physical Security

As records are received for digitization, they should be logged into the lab area for temporary storage. The log should include-

- o date and time records received
- o job or project title (batch identification if applicable)
- o item count
- o NARA citation/identification (including custodial unit or LICON)
- o media or physical description of the records
- o person dropping off records (archivist/technician/etc. and unit)
- o lab personnel log-in or acceptance of records
- o requested due date
- o special instructions
- o date completed
- o date and time records picked-up
- o person picking up records (archivist/technician/etc. and unit)
- o lab personnel log-out of records

The above list is not intended to be comprehensive, other fields may be required or desirable.

Records should be stored in a secure area that provides appropriate physical protection. Storage areas should meet all NARA requirements and environmental standards for records storage or processing areas - see 36 CFR, Part 1228, Subpart K, Facility Standards for Records Storage Facilities at http://www.archives.gov/about_us/regulations/part_1228_k.html

2. Equipment

- a. Preservation Programs, NWT, shall review and approve all equipment prior to beginning projects.
- b. The unit/partner/contractor shall not use automatic feed devices, drum scanners or other machines that require archival materials to be fed into rollers or wrapped around rollers, that place excessive pressure on archival materials, or require the document to be taped to a cylinder. Motorized transport is acceptable when scanning microfilm.
- c. The unit's/partner's/contractor's equipment shall have platens or copy boards upon which physical items are supported over their entire surface.
- d. The unit/partner/contractor shall not use equipment having devices that exert pressure on or that affix archival materials to any surface. The unit/partner/contractor shall ensure that no equipment comes into contact with archival materials in a manner that causes friction. The unit/partner/contractor shall not affix pressure sensitive adhesive tape, nor any other adhesive substance, to any archival materials.
- e. The unit/partner/contractor shall not use equipment with light sources that raise the surface temperature of the physical item being digitized. The unit/partner/contractor shall filter light sources that generate ultraviolet light. Preservation Programs, NWT shall have the right to review the lighting parameters for digitizing, including the number of times a single item can be scanned, the light intensity, the ultraviolet and infrared content, and the duration of the scan.
- f. The scanning/digitization area shall have sufficient space and flat horizontal work-surfaces (tables, carts, shelves, etc.) to work with and handle the records safely.

3. Procedures

- a. Custodial units shall maintain written records of pulling archival materials for digitization and of the receipt of materials when returned to the custodial units. The unit/partner/contractor shall keep any tracking paperwork with the archival materials and/or their containers.
- b. The unit/partner/contractor shall keep all archival materials in their original order and return them to their original jackets or containers. The unit/partner/contractor shall not leave archival materials unattended or uncovered on digitizing equipment or elsewhere. The unit/partner/contractor shall return archival materials left un-digitized, but needed for the next day's work, to their jackets and containers and place them in the appropriate secure storage areas in the unit's/partner's/contractor's work area. The unit/partner/contractor shall return completed batches of archival materials to NARA staff in the unit's/partner's/contractor's work area.
- c. Review of the condition of the records should take place prior to the beginning of the digitization project and shall be done in consultation with Preservation Programs, NWT. During digitization, the unit/partner/contractor shall report archival materials that are rolled (excluding roll film), folded, or in poor condition and cannot be safely digitized, and seek further guidance from NARA custodial staff and Preservation Programs, NWT, before proceeding.
- d. The unit/partner/contractor shall not remove encapsulated archival materials from their encapsulation or sleeved documents from L-sleeves. The unit/partner/contractor may remove L-sleeves with permission of custodial staff.
- e. The unit/partner/contractor shall place archival materials flat on the platen- rolling, pulling, bending, or folding of archival materials is not permitted, and items shall be supported over their entire surface on the platen- no part of an item shall overhang the platen so that it is unsupported at any time. The unit/partner/contractor shall not place archival materials that may be damaged, such as rolled, folded, warped, curling, or on warped and/or fragile mounts, on the platen. The unit/partner/contractor shall place only one physical item at a time on a surface appropriate for the item's size and format, except when scanning 35mm slides in a batch mode on a flatbed scanner. The unit/partner/contractor shall handle archival materials in bound volumes carefully and not force them open or place them face down. The unit/partner/contractor shall use book cradles to support volumes, and volumes shall be digitized in a face up orientation on cradles.
- f. The unit/partner/contractor shall not place objects such as books, papers, pens, and pencils on archival materials or their containers. The unit/partner/contractor shall not lean on, sit on, or otherwise apply pressure to archival materials or their containers. The unit/partner/contractor shall use only lead pencils as writing implements near archival materials or their containers. The unit/partner/contractor shall not write on or otherwise mark archival materials, jackets, or containers. The unit/partner/contractor shall not use Tacky finger, rubber fingers, or other materials to increase tackiness that may transfer residue to the records.
- g. The unit/partner/contractor shall not smoke, drink, or eat in the room where archival materials or their containers are located. The unit/partner/contractor shall not permit anyone to bring tobacco, liquids, and food into the room where archival materials or their containers are located.
- h. Unit/partner/contractor staff shall clean their hands prior to handling records and avoid the use of hand lotions before working with archival materials. Unit/partner/contractor staff shall wear clean white cotton gloves at all times when handling photographic film materials, such as negatives, color transparencies, aerial film, microfilm, etc. The unit/partner/contractor shall provide gloves. For some types of originals using cotton gloves can inhibit safe handling, such as when working with glass plate negatives.
- i. The unit/partner/contractor shall reinsert all photographic negatives, and other sheet film, removed from jackets in proper orientation with the emulsion side away from the seams. The unit/partner/contractor shall unwind roll film carefully and rewind roll film as soon as the digitizing is finished. The unit/partner/contractor shall rewind any rolls of film with the emulsion side in and with the head/start of the roll out.
- j. NARA custodial staff and Preservation Programs, NWT, shall have the right to inspect, without notice, the unit/partner/contractor work areas and digitizing procedures or to be present at all times when archival materials are being handled. Units/partners/contractors are encouraged to consult with Preservation

Programs, NWT, staff for clarification of these procedures or when any difficulties or problems arise.

4. Training

Training shall be provided by Preservation Programs, NWT, for archival material handling and certification of unit/partner/contractor staff prior to beginning any digitization. Any new unit/partner/contractor staff assigned to this project after the start date shall be trained and certified before handling archival materials.

APPENDIX F: Resources

Scope -

NARA 816 – *Digitization Activities for Enhanced Access*, at http://www.nara-at-work.gov/nara_policies_and_guidance/directives/0800_series/nara816.html (NARA internal link only)

Records Management information on the NARA website - http://www.archives.gov/records_management/index.html and http://www.archives.gov/records_management/initiatives/erm_overview.html

Records transfer guidance for scanned textual documents - http://www.archives.gov/records_management/initiatives/scanned_textual.html

Records transfer guidance for scanned photographs and digital photography image files - http://www.archives.gov/records_management/initiatives/digital_photo_records.html

Code of Federal Regulations at – <http://www.gpoaccess.gov/cfr/index.html>, see 36 CFR 1200

NARA’s Electronic Records Archive project - http://www.archives.gov/electronic_records_archives/index.html

Introduction -

General Resources –

Moving Theory into Practice, Cornell University Library, available at – <http://www.library.cornell.edu/preservation/tutorial/>

HANDBOOK FOR DIGITAL PROJECTS: A Management Tool for Preservation and Access, Northeast Document Conservation Center, available at – <http://www.nedcc.org/digital/dighome.htm>

Guides to Quality in Visual Resource Imaging, Digital Library Federation and Research Libraries Group, July 2000, available at - <http://www.rlg.org/visguides>

The NINCH Guide to Good Practice in the Digital Representation and Management of Cultural Heritage Materials, Humanities Advanced Technology and Information Institute, University of Glasgow, and National Initiative for a Networked Cultural Heritage, available at – <http://www.nyu.edu/its/humanities/ninchguide/index.html>

Project Management Outlines –

“NDLP Project Planning Checklist,” Library of Congress, available at <http://lcweb2.loc.gov/ammem/prjplan.html>

“Considerations for Project Management,” by Stephen Chapman, *HANDBOOK FOR DIGITAL PROJECTS: A Management Tool for Preservation and Access*, Northeast Document Conservation Center, available at – <http://www.nedcc.org/digital/dighome.htm>

“Planning an Imaging Project,” by Linda Serenson Colet, *Guides to Quality in Visual Resource Imaging*, Digital Library Federation and Research Libraries Group, available at - <http://www.rlg.org/visguides/visguide1.html>

Digitization resources, Colorado Digitization Program, available at <http://cdpheritage.org/resource/index.html>

Metadata -

Common Metadata Types -

Dublin Core Metadata Initiative -

<http://dublincore.org/usage/terms/dc/current-elements/>

NARA's Lifecycle Data Requirements Guide (LCDRG), January 2002, (NARA internal link only)

http://www.nara-at-work.gov/archives_and_records_mgmt/archives_and_activities/accessioning_processing_description/lifecycle/

Official EAD site at the Library of Congress -

<http://lcweb.loc.gov/ead/>

Research Library Group's Best Practices Guidelines for EAD -

<http://www.rlg.org/rlgead/eadguides.html>

Harvard University Library's Digital Repository Services (DRS) User Manual for Data Loading, Version 2.04 -

http://hul.harvard.edu/ois/systems/drs/drs_load_manual.pdf

Making of America 2 (MOA2) Digital Object Standard: Metadata, Content, and Encoding -

<http://www.cdlib.org/about/publications/CDLObjectStd-2001.pdf>

Dublin Core initiative for administrative metadata -

<http://metadata.net/admin/draft-iannella-admin-01.txt>

Data Dictionary for Administrative Metadata for Audio, Image, Text, and Video Content to Support the Revision of Extension Schemas for METS -

<http://lcweb.loc.gov/rr/mopic/avprot/extension2.html>

Metadata Encoding and Transmission Standard (METS) rights extension schema available at -

<http://www.loc.gov/standards/rights/METSRights.xsd>

Peter B. Hirtle, "Archives or Assets?" -

<http://techreports.library.cornell.edu:8081/Dienst/UI/1.0/Display/cul.lib/2003-2>

June M. Besek, Copyright Issues Relevant to the Creation of a Digital Archive: A Preliminary Assessment, January 2003 - <http://www.clir.org/pubs/reports/pub112/contents.html>

Adrienne Muir, "Copyright and Licensing for Digital Preservation," -

<http://www.cilip.org.uk/update/issues/jun03/article2june.html>

Karen Coyle, Rights Expression Languages, A Report to the Library of Congress, February 2004, available at - http://www.loc.gov/standards/Coylereport_final1single.pdf

MPEG-21 Overview v.5 contains a discussion on intellectual property and rights at -

<http://www.chiariglione.org/mpeg/standards/mpeg-21/mpeg-21.htm>

Peter Hirtle, "When Works Pass Into the Public Domain in the United States: Copyright Term for Archivists and Librarians," -

http://www.copyright.cornell.edu/training/Hirtle_Public_Domain.htm

Mary Minow, "Library Digitization Projects: Copyrighted Works that have Expired into the Public Domain" - <http://www.librarylaw.com/DigitizationTable.htm>

Mary Minow, *Library Digitization Projects and Copyright* -

<http://www.llrx.com/features/digitization.htm>

NISO Data Dictionary - Technical Metadata for Digital Still Images –
http://www.niso.org/standards/resources/Z39_87_trial_use.pdf.

Metadata for Images in XML (MIX) –
<http://www.loc.gov/standards/mix/>

TIFF 6.0 Specification -
<http://partners.adobe.com/asn/developer/pdfs/tn/TIFF6.pdf>

Digital Imaging Group's DIG 35 metadata element set –
http://www.i3a.org/i_dig35.html

Harvard University Library's Administrative Metadata for Digital Still Images data dictionary -
http://hul.harvard.edu/ldi/resources/ImageMetadata_v2.pdf

Research Library Group's "Automatic Exposure" Initiative -
<http://www.rlg.org/longterm/autotechmetadata.html>

Global Digital Format Registry –
<http://hul.harvard.edu/gdfr/>

Metadata Encoding Transmission Standard (METS) –
<http://www.loc.gov/standards/mets/>

Flexible and Extensible Digital Object Repository Architecture (FEDORA) –
<http://www.fedora.info/documents/master-spec-12.20.02.pdf>

Open Archival Information System (OAIS) -
<http://ssdoo.gsfc.nasa.gov/nost/isoas/overview.html>

A Metadata Framework to Support the Preservation of Digital Objects -
http://www.oclc.org/research/projects/pmwg/pm_framework.pdf

Preservation Metadata for Digital Objects: A Review of the State of the Art -
http://www.oclc.org/research/projects/pmwg/presmeta_wp.pdf

PREMIS (Preservation Metadata Implementation Strategies) -
<http://www.oclc.org/research/projects/pmwg/>

OCLC Digital Archive Metadata –
http://www.oclc.org/support/documentation/pdf/da_metadata_elements.pdf

Florida Center for Library Automation Preservation Metadata –
http://www.fcla.edu/digitalArchive/pdfs/Archive_data_dictionary20030703.pdf

Technical Metadata for the Long-Term Management of Digital Materials -
http://dvl.dtic.mil/metadata_guidelines/TechMetadata_26Mar02_1400.pdf

National Library of New Zealand, Metadata Standard Framework, Preservation Metadata –
http://www.natlib.govt.nz/files/4initiatives_metaschema_revised.pdf

National Library of Medicine Permanence Ratings -
<http://www.nlm.nih.gov/pubs/reports/permanence.pdf>
and <http://www.rlg.org/events/pres-2000/byrnes.html>

Design Criteria Standard for Electronic Records Management Software Applications (DOD 5015.2)
<http://www.dtic.mil/whs/directives/corres/html/50152std.htm>

Assessment of Metadata Needs for Imaging Projects -

Guidelines for implementing Dublin Core in XML -
<http://dublincore.org/documents/2002/09/09/dc-xml-guidelines/>

Adobe's Extensible Metadata Platform (XMP) –
<http://www.adobe.com/products/xmp/main.html>

Local Implementation -

Adobe's Extensible Metadata Platform (XMP) –
<http://www.adobe.com/products/xmp/main.html>

Technical Overview -

Glossaries of Technical Terms –

Technical Advisory Service for Images, available at –
http://www.tasi.ac.uk/glossary/glossary_technical.html

Kodak Digital Learning Center, available at –
<http://www.kodak.com/US/en/digital/dlc/book4/chapter2/index.shtml>

Raster Image Characteristics –

“Introduction to Imaging (Getty Standards Program),” Getty Information Institute, available at –
http://www.getty.edu/research/conducting_research/standards/introimages/homepage.html

“Handbook for Digital Projects – Section VI Technical Primer,” by Steven Puglia, available at –
<http://www.nedcc.org/digital/vi.htm>

Digitization Environment -

Standards-

ISO 3664 *Viewing Conditions- For Graphic Technology and Photography*

ISO 12646 *Graphic Technology – Displays for Colour Proofing – Characteristics and Viewing Conditions* (currently a draft international standard or DIS)

These standards can be purchased from ISO at <http://www.iso.ch> or from IHS Global at <http://global.ihs.com>.

“Digital Imaging Production Services at the Harvard College Library,” by Stephen Chapman and William Comstock, *DigiNews*, Vol. 4, No. 6, Dec. 15, 2000, available at <http://www.rlg.org/legacy/preserv/diginews/diginews4-6.html>

Quantifying Scanner/Digital Camera Performance –

Standards-

ISO 12231 Terminology

ISO 14524 Opto-electronic Conversion Function

ISO 12233 Resolution: Still Picture Cameras

ISO 16067-1 Resolution: Print Scanners

ISO 16067-2 Resolution: Film Scanners

ISO 15739 Noise: Still Picture Cameras

ISO 21550 Dynamic Range: Film Scanners

These standards can be purchased from ISO at <http://www.iso.ch> or from IHS Global at <http://global.ihs.com>.

“Debunking Specsmanship” by Don Williams, Eastman Kodak, in *RLG DigiNews*, Vol. 7, No. 1, Feb. 15, 2003, available at http://www.rlg.org/preserv/diginews/v7_v1_feature1.html

"Image Quality Metrics" by Don Williams, Eastman Kodak, in *RLG DigiNews*, Vol. 4, No. 4, Aug. 15, 2000, available at <http://www.rlg.org/legacy/preserv/diginews/diginews4-4.html#technical1>

"What is an MTF...and Why Should You Care" by Don Williams, Eastman Kodak, in *RLG DigiNews*, Vol. 2, No. 1, Feb. 15, 1998, available at <http://www.rlg.org/preserv/diginews/diginews21.html#technical>

Guides to Quality in Visual Resource Imaging, Digital Library Federation and Research Libraries Group, July 2000, available at <http://www.rlg.org/visguides>

- Guide 2 – "Selecting a Scanner" by Don Williams
- Guide 3 – "Imaging Systems: the Range of Factors Affecting Image Quality" by Donald D'Amato
- Guide 4 – "Measuring Quality of Digital Masters" by Franziska Frey

"Digital Imaging for Photographic Collections" by Franziska Frey and James Reilly, Image Permanence Institute, 1999, available at - http://www.rit.edu/~661www1/sub_pages/digibook.pdf

"Image Capture Beyond 24-bit RGB" by Donald Brown, Eastman Kodak, in *RLG DigiNews*, Vol. 3, No. 5, Oct. 15, 1999, available at <http://www.rlg.org/preserv/diginews/diginews3-5.html#technical>

Color Management –

Real World Color Management, by Bruce Fraser, Chris Murphy, and Fred Bunting, Peachpit Press, Berkeley, CA, 2003 – <http://www.peachpit.com>

Image Processing Workflow –

Adobe Photoshop CS Studio Techniques, by Ben Wilmore, Adobe Press, Berkeley, CA, 2004 – <http://www.digitalmastery.com/book> or <http://www.adobepress.com>

"Digital Imaging for Photographic Collections" by Franziska Frey and James Reilly, Image Permanence Institute, 1999, available at - http://www.rit.edu/~661www1/sub_pages/digibook.pdf

Digitization in Production Environments –

"Imaging Production Systems at Corbis Corporation," by Sabine Süssstrunk, *DigiNews*, Vol. 2, No. 4, August 15, 1998, available at <http://www.rlg.org/legacy/preserv/diginews/diginews2-4.html>

"Imaging Pictorial Collections at the Library of Congress," by John Stokes, *DigiNews*, Vol. 3, No. 2, April 15, 1999, available at <http://www.rlg.org/legacy/preserv/diginews/diginews3-2.html>

Digitization Specifications for Record Types -

Imaging guidelines -

Benchmark for Faithful Digital Reproductions of Monographs and Serials, Digital Library Federation, available at <http://www.diglib.org/standards/bmarkfin.htm>

"Managing Text Digitisation," by Stephen Chapman. *Online Information Review*, Volume 27, Number 1, 2003, pp. 17-27. Available for purchase at: <http://www.emeraldinsight.com/1468-4527.htm>

Library of Congress - <http://memory.loc.gov/ammem/techdocs/index.html> and <http://lcweb2.loc.gov/ammem/formats.html>

Colorado Digitization Program - http://www.cdpheritage.org/resource/scanning/documents/WSDIBP_v1.pdf

California Digital Library - <http://www.cdlib.org/news/pdf/CDLImageStd-2001.pdf>

Imaging Techniques –

Copying and Duplicating: Photographic and Digital Imaging Techniques, Kodak Publication M-1, CAT No. E152 7969, Sterling Publishing, 1996.

Storage and Digital Preservation -

Digital Preservation & Ensured Long-term Access, Research Libraries Group, available at – http://www.rlg.org/en/page.php?Page_ID=552

Digital Preservation Coalition, available at – <http://www.dpconline.org/graphics/index.html>

Preserving Access to Digital Information, available at – <http://www.nla.gov.au/padi/>

National Digital Information Infrastructure and Preservation Program, Library of Congress, available at – <http://www.digitalpreservation.gov/>

NARA's Electronic Records Archive project - http://www.archives.gov/electronic_records_archives/index.html

Digital Preservation, Digital Library Federation, available at – <http://www.diglib.org/preserve.htm>

Open Archival Information System, available at – <http://ssdoo.gsfc.nasa.gov/nost/isoas/overview.html>

"Trusted Digital Repositories: Attributes and Responsibilities," Research Libraries Group and OCLC, May 2002, available at www.rlg.org/longterm/repositories.pdf

Quality Control, Testing Results, and Acceptance/Rejection

Conversion Specifications, American Memory, Library of Congress, available at – <http://memory.loc.gov/ammem/techdocs/conversion.html>

"NDLP Project Planning Checklist," Library of Congress, available at <http://lcweb2.loc.gov/ammem/prjplan.html>