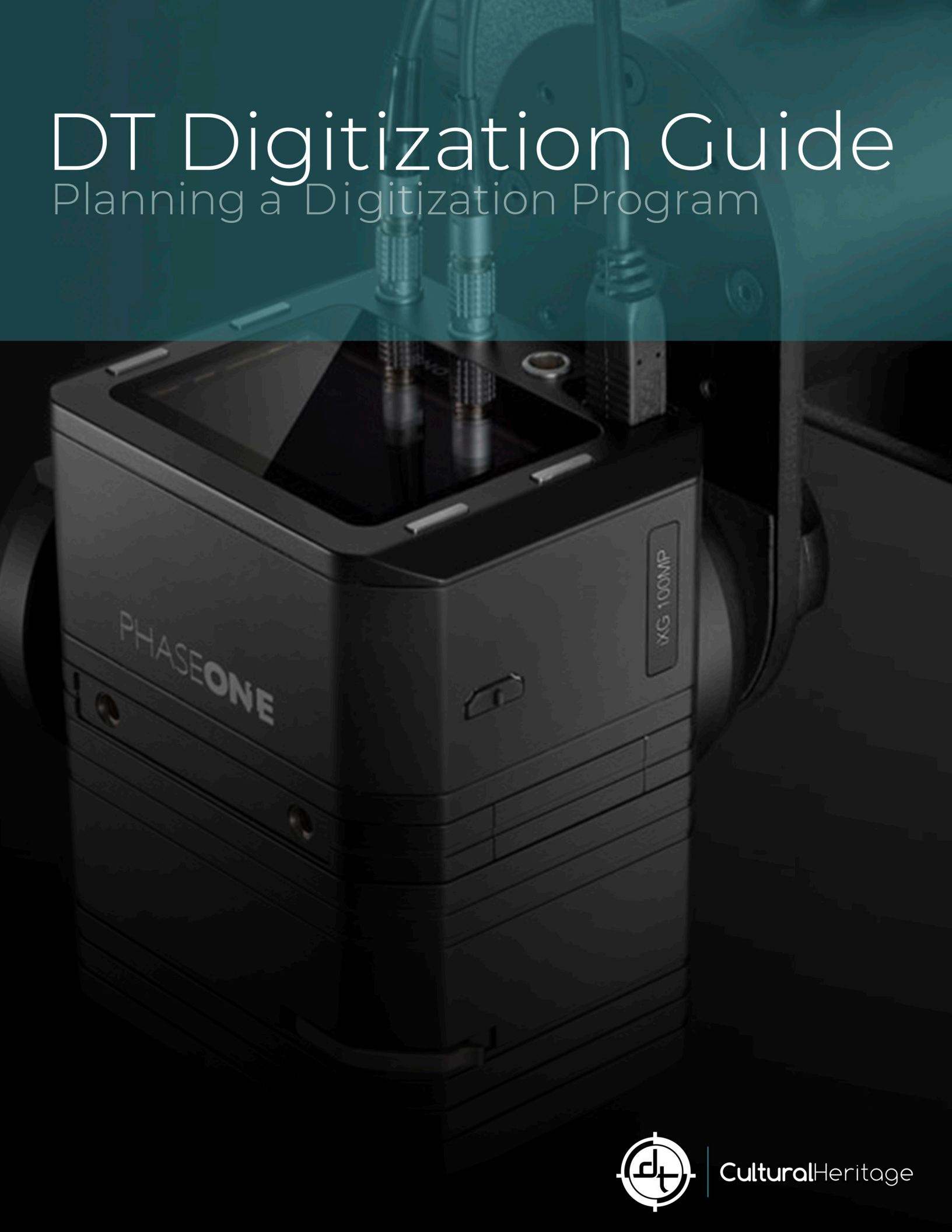
DT Digitization Guide

Planning a Digitization Program



CulturalHeritage

Imaging for the Future

Digitization Program Planning

A Comprehensive & Practical Overview of Cultural Heritage Digitization

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Foreword

I. Contributors

The Digital Transitions Division of Cultural Heritage (DTDCH) is deeply grateful for contributions from an extensive group of individuals and institutions. Since the earliest days of digitization there has been a strong tradition of collaboration within the Cultural Heritage community; we have great clients and industry partners, and their participation in the creation of this document was an invaluable and greatly appreciated continuation of this tradition.

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II. Why Another Guide?

In our experience most Cultural Heritage Imaging documentation falls into one of two categories:

- **Oversimplified:** Basic step-by-step instructions which only explain "how" not "why."
- **Over-elaborated:** Technical manifestos like the Federal Agencies Digitization Guidelines Initiative (FADGI) are very lengthy and heavy on math and theory, but light on practical methodology.

Most of the over-elaborated guides lack practical methodology because they were written from a completely equipment-agnostic point of view. This equipment neutrality was vital to their intention as they were written by committees and organizations that have policies against recommending any particular brand or solution even if they had a strong preference. The Cultural Heritage community benefits from having such technical guidelines written independent of any make/model of equipment. This approach, however, leaves any given institution at a loss for exactly what methods/workflows to follow to achieve these guidelines using their specific equipment.

We wanted to provide something in between these two extremes: a comprehensive, but practical, treatise on Cultural Heritage

Digitization made specifically for those using DTDCH hardware and software. This is not, and cannot be, a how-to guide; every institution has different guidelines to meet. Instead, the goal of this document is to be a reference guide for most of the topics that require consideration when organizing, reorganizing, or evaluating a digitization program.

Our team, the Digital Transitions Division of Cultural Heritage specializes in hardware, software, and workflows for digitization. Because of this we've had the pleasure of working with a large quantity and variety of institutions of Cultural Heritage during the planning and production of a digitization program. We work in this field because we believe the preservation of our shared cultural heritage is a sacred duty owed to future generations. Above all else, we hope that this document, springing from our experience, and the input of our many valued customers, can contribute, in some small way, to that noble goal.

Please Note: This document is designed as a framework to allow for continual contributions, to ensure it will not become obsolete. To contribute, offer a correction, or suggest an addition please contact DTDCH Director, Peter Siegel, at pes@digitaltransitions.com.

III. Where's the Metadata?

We have chosen not to include an in-depth discussion of metadata in the scope of this document. However, this does not indicate its lack of importance. In fact, the opposite is true; metadata is fundamental to a Preservation Digital Object. Proper selection of metadata sets, metadata vocabulary, and metadata workflows are so vital to a successful digitization program that these topics could easily justify their own stand-alone document of equal length. The broad and essential topic of metadata is simply too broad and important to be included in the scope of this document.

> "Embarking upon a full scale digitization effort without any provision for metadata is irresponsible at best."
>
> —Bradley Daigle, University of Virginia, Director of Digital Curation Services

IV. For Whom is this Document Written?

This document is intended for those who are involved with or interact with digitization programs in Cultural Heritage institutions. Specifically the focus of this document is on still imaging of real world objects. It does not cover the related fields of born-digital images, nor does it cover audio or video digitization.

We have made every effort to make sure it is useful and informative regardless of the equipment utilized. However, it is especially helpful for those who are using or are considering DTDCH digitization solutions. Specifically we believe that this document will be useful to Program Directors, and other administrators in charge of digitization based on still-imaging. That said, it is our experience that curators, archivists, program directors, and conservationists can benefit enormously from a deeper understanding of the theory and practice of imaging. However, it is our hope that a broader audience will consider investing the time to digest and provide feedback on this treatise.

1. Benefits of Digitization (aka Scanning)

A properly digitized collection broadens access, protects the safety of the original material and provides new options for research. One of humanity's responsibilities is to ensure that we properly preserve our Cultural Heritage for future generations. Good digitization and dissemination of the resulting Preservation Digital Objects is essential to our role as stewards of our history and culture. Digitization is not a buzz-word or fad; it is a fundamental shift in the way collections are accessed and protected.

1.1 Broader Access

1.1.1 Democratization of Data

Digitization profoundly broadens access by lowering the barrier to entry for discovering and examining Cultural Heritage collections. In the past, only a narrow demographic of the population had the time and resources to travel for the sole purpose of viewing a collection at a particular institution. Now, anyone with Internet access at their home, school, work, or local library can access a digital collection.

> "One of the prized pieces of our collection is the Guttenberg Bible. That completely changed the dissemination of knowledge in its time. Digitization allows a similar dissemination, so a similar revolution is going on now. It breaks down the walls of time and space and now it's accessible to the entire world."
>
> — Graham Haber, Photographer, The Morgan Library & Museum

> "There are very few books written in Haitian Creole, and many Haitian schoolchildren don't have access to books because they are so hard to find in the country, and surprisingly expensive to ship. Our nonprofit organization has built a cloud-based digital library, which allows students in Haiti to access thousands of books on low-cost devices like Android tablets that are made in Haiti. Digitization allows us to fill our library with quality children's books in Creole, helping to support education and literacy for thousands of students."
>
> — Nicole Comforto, Director of Educational Resources, Library for All

Moreover, the ability to access an entire collection of material culture that has not been curated for general audiences truly opens the possibility for new interpretations. Digitizing/Scanning entire collections allows new insights and discoveries from any viewer, not just the select few with physical access to the originals.

1.1.2 Remote Access

For researchers, having digital access to an object can save days of travel and thousands of dollars in expenses. This is especially true for collections which are spread out across multiple institutions. As a result researchers are more likely to cite the institution in their research [See 1.4 - Marketing, Branding, Reach & Politics].

> "Some of [our] books are not widely available. They might be in one or two libraries in the entire world… so researchers, particularly those in the developing world wouldn't have had access to this information, and suddenly here it is on the Internet to read, download for later, and they can do full text searching -- it has transformed the way they do their research. It has given them access to material they didn't even know they needed access to."
>
> — Keri Thompson, Digital Projects Librarian, Smithsonian Libraries

1.2 Safeguarding the Physical Collection

No matter how carefully an institution cares for and protects its physical collections, they will still degrade due to physical handling and environmental factors. Some do so slowly, others quite quickly. However, at some point, *every* collection will be lost to the tidal forces of time. Proper digitization can both directly reduce degradation of the original physical collection, and provide for the survival of the content of a collection in the case of any physical loss.

1.2.1 A Digital Copy Does Not Degrade

In contrast to a physical object, a Preservation Digital Object (PDO), correctly archived, can completely retain its fidelity over time. Every PDO is comprised of a discrete, countable number of bits which can be verified and audited to ensure fidelity. An unlimited number of exact copies or lower-quality derivatives can be made for redundant backup or dissemination, without any loss of fidelity to the master PDO. Correct management of a large digital collection is neither simple nor inexpensive, but it offers complete resistance to degradation. If the PDO is properly formed and maintained, it can retain its faithfulness to the original physical object, and serve as a visual record of that object when it was imaged, thus also providing a time marker of that object's state.

1.2.2 Reduced Material Handling Protects our Cultural Heritage

No matter what handling procedures are put in place, physical handling of an object always causes degradation of its condition. If care is taken to digitize with preservation grade image quality [see 5.1 - FADGI & METAMORFOZE], future handling can be entirely eliminated for entire categories of access, and greatly reduced for others. We believe strongly in the "do it once, do it right" model, which calls for digitizing *all* material to meet or exceed industry standards to ensure adequate quality (resolution, color fidelity, tonal accuracy, etc) is available for any foreseeable future use.

Digitization reduces the amount of future physical handling a collection will undergo, but it's still important to minimize the handling required by the digitization process itself. A proper digitization program makes use of hardware, software, and workflow which prioritizes the safety of the material and reduces the handling to the absolute minimum required. For instance, when using the DT BC100 Book Capture System, bound materials are opened to only a 100 degree angle, and both sides of a spread are imaged simultaneously so that the material only needs to be opened to a particular spread once.

> "When you're digitizing rare books image quality is really important. You want to digitize it once and not have to bring that material out again."
>
> — Eric Philcox, CEO, Pixel Acuity

> "The most important thing as a Cultural Heritage Institution is preserving the rare material. Only a certain number of people can look at a 700-year old manuscript without creating a lot of damage to that manuscript, but by having very high quality imaging, the need for handling is greatly reduced."
>
> — Graham Haber, Photographer, The Morgan Library & Museum

> "Parts of our collection are too brittle to handle without loss of text and have been withdrawn from public use. Having a digital capture system allows us to gently handle one last time, tuck the original away for rare use, and provide the researcher with high quality images."
>
> — Nancy Kraft, Preservation Librarian, University of Iowa Libraries

1.2.3 Digital Phoenix: Rising From the Ashes of Catastrophe

The history of Cultural Heritage Preservation is full of tragic tales of enormous loss. Such losses undo the countless hours dedicated to protect these collections. Natural disasters such as wildfire, flood, earthquake, tornado, hurricane, blizzards, avalanches, mudslides, ice storms, tsunami, volcanic eruption can all threaten the safety, and sometimes very existence, of

Cultural Heritage collections. It is not just the scale of these disasters but also their unpredictable nature which create such an ongoing danger.

> "[During Hurricane Katrina] the worst damage to our physical collections and buildings occurred at the Old U.S. Mint location at 400 Esplanade Ave. The hurricane winds tore off the copper roof of the building, allowing a great deal of rain to enter. There was damage to some collections… All digital assets were backed up and copies were stored off-site. There was no loss of digitized materials."
>
> — Jeff Rubin, IT Director at Louisiana State Museum during Hurricane Katrina

Finally, theft, vandalism, war, famine, nuclear incidents, fire, systematic mismanagement, or extreme changes in budget environments can result in massive losses. These threats can seem remote to those in developed nations, but the time horizon of cultural heritage preservation is millennia, and few places on earth have escaped significant strife for a millenia. From the Library of Alexandria and Hurricane Katrina to the losses of fine art under Nazi Europe and the ongoing losses of Cultural Heritage sites in Iraq and Syria, history teaches us that no state or institution lasts forever.

There is no shortage of dangers to the integrity of our Cultural Heritage collections, and preparing emergency responses to the above described threats is beyond the scope of this document. What is clear is that digitization can play a vital role in salvaging value from a collection which is otherwise lost. While nothing can completely replace a damaged or destroyed object a Preservation Digital Object can act as a surrogate in the event of complete loss; in any event, it's the best failsafe option available and a critical part of disaster planning.

1.2.4 Counterfeit Detection and Defacement Identification

A high quality digitization program can provide a forensic record against which to compare for the identification of counterfeits or defacement of the true original. This can be especially useful in the case that an item is stolen and thought to have been recovered. For famous and well-known pieces it is likely specialists could identify counterfeits or defacement by a variety of means, but for many items in a collection a Preservation Digital Object may be especially important in this process.

> "A Preservation Digital Object (PDO) digitally fingerprints the physical object it records. It precisely records imperfections in handmade paper and inconsistencies in handpress printing. In the event a book is stolen and later recovered, it can be conclusively authenticated by comparing it to the PDO. This theft-resistance does not require physical alteration to the object (e.g. library stamp) and is therefore invisible to the thief. Such security is virtually undefeatable, since these imperfections are scattered throughout every page of a book, sometimes many to a page. Effacing all the individual distinctive features would be virtually impossible."
>
> -- James R. Voelkel, Curator of Rare Books, Othmer Library of Chemical History

1.3 Content Elaboration & Content Discovery

1.3.1 Better Detail than with the Naked Eye

A Preservation Digital Object (PDO) provides extraordinary detail. The resolution and ease of magnification in a digital viewer allows easy holistic examination of an object, from the full view of even a very large object to a small feature. It is not uncommon for this to result in a viewing experience that exceeds the quality of an in-person examination.

> "There are things that the camera can see that the eye can't see. Often, when I'm photographing objects and working with the conservation team, we'll see things that they didn't realize were happening."
>
> — Graham Haber, Photographer, The Morgan Library & Museum

1.3.2 Better Methods of Examination, Search & Comparison

Using a PDO allows side-by-side comparison between different areas of one object or of two different objects, without being limited by the sizes or locations of the original physical objects. Such comparisons are essentially impossible with physical objects without violating preservation handling protocols. Consider an analysis of three Van Gogh paintings held at three institutions in three different continents. By placing the three PDOs at any desired magnification or area of interest next to each other on one screen the brush strokes and color palettes can be compared. Such options may seem trivially obvious, but sadly, many institutions have not followed the strict preservation-grade image quality guidelines required to make such direct comparisons meaningful. Color, tone, and texture can only be compared between three separately digitized paintings if each institution digitized their collection within preservation-level tolerances. This requires at least FADGI 4-Star or METAMORFOZE-Strict image quality [see 5.1 - FADGI and METAMOROFOZE], which few digitization systems can achieve, in practice. Moreover PDOs can be manually transcribed or run through OCR software to allow text searches and statistics.

> “One of our work streams is called ‘Do-it-Yourself History’ where we put the captured image up on the web for the public to transcribe which we can then OCR. In addition to being able to view material online, the OCR work allows people to search by keyword, giving even greater access to our material than if a researcher just worked with the original material.”
>
> — Nancy Kraft, Preservation Librarian, University of Iowa Libraries

Similar challenges are posed by collections that are so large, or are under such stringent handling protocols, that the physical handling of the original materials obscures their wholistic meaning as a collection. In such a case, researching using a set of Preservation Digital Objects can provide a different understanding of the collection as a whole than physically handling the individual originals.

> "There are times when there are so many of something, a negative, a group of prints, pages in a manuscript, that handling the physical objects can be overwhelming and sometimes impossible. But the process of digitization allows you to control, to organize, to move through that material in an efficient and organized way. So the digitization can allow a type of access that the physical objects prevent.
>
> [One example of this is the “Big Book”.] W. Eugene Smith towards the end of his life wanted to create a Magnum Opus, a publication that would capture his life's work and bring together images from all kinds of different projects. So he created a book maquette, which is frequently referred to as the "Big Book". We have that original maquette here at the Center for Creative Photography, but it's very fragile and it's very light sensitive. So when you handle that original object you have to do it with tremendous care. In fact, the fragility of it makes the process of looking at it very awkward, very uncomfortable. So we were able to digitize the "Big Book" and create a facsimile which allows you to move through it with a flow and a speed that allows you to begin to see the way that he was thinking about the sequencing and bringing together of images. Only through the digitization process were we able to get a good understanding of his original intent, even though we have the original maquette"
>
> — Becky Senf, Norton Family Curator, Center for Creative Photography

1.3.3 Textural and Contrast Enhancement, Otherwise Not Possible

PDOs allow enhancement to the viewing of the subject matter in ways that are not possible when viewing the physical original. Material which is faded can be viewed under strongly increased contrast, increasing legibility in some cases and providing for the discovery of content otherwise entirely obscured in other cases. The hue contrast of subtle variations of color can be increased making small differences easy to identify. With some objects, raking illumination brings forward textural detail and dimensional features which are barely or not at all visible in even illumination. However, viewing the physical object under such raking light is highly problematic, as the light will always fall off across the object (the parts of the object that are further from

the light will be less brightly illuminated). Using Capture One CH Edition, light fall-off can be mapped and completely corrected, allowing the textural enhancement of raking asymmetrical lighting without the expected loss of tonal consistency across the object.

1.3.4 Multispectral Analysis

Digitization allows capture outside of the visible spectrum. This can be used to shoot through overpainting, or to reveal the content in damaged/burned/moldy areas of an object. Multispectral capture requires specialized versions of capture equipment such as the DT Multispectra Camera, which can image in both infrared and UV spectra.

1.3.5 Comparison over Time

In many areas of research and conservation, it is important to track changes to an object over time. If an institution follows preservation-quality guidelines and includes an object level target [see 5.4.3 - Object Level Target (OLT)], an object can be imaged at different times and compared. The tight tolerances and practical verification allow for even very small changes to be detected. This also requires at least FADGI 4-Star or METAMORFOZE image quality, a guideline few digitization systems can achieve in practice.

1.4 Marketing, Branding, Reach & Politics

1.4.1 A Tale of Two Pressures

Non-profit institutions must live in two worlds: philanthropic and political. Fortunately, digitization is a strong tool in both worlds. Philanthropically, a preservation-grade digitization program provides better stewardship of collections, reduces handling, aids

research, and broadens access. Politically, a preservation-grade digitization program provides a boost to the marketing reach, fundraising abilities, and brand quality of an institution.

1.4.2 Enticing Collection Acquisition

Preservation grade imaging can be used to entice holders of valued collections to bequeath those collections to a particular collection. When an individual or organization looks to donate a valuable collection to a non-profit, they may be motivated by a variety of goals. In most cases providing public and researcher access to the collection and the protection of the collection are high priorities. An institution with the capacity and track record of providing preservation grade digitization can offer strong assurance of both access to and protection of the collection.

1.4.3 You Can’t Cite What You Can’t Access

A researcher who finds potentially useful physical documents/objects spread across several institutions will tend to choose to visit those institutions which have the broadest potentially relevant collections, as their travel is often restricted by time and cost. So even if a majority of relevant material is distributed across several smaller institutions, their holdings will often be overlooked.

Digitization completely changes this equation. Institutions that allow specialized and generic search engines to locate material in their digital collections and participate in cross-library access efforts like Digital Public Library of America will have their results listed on equal-footing with institutions like the Library of Congress. Since the “cost” to “visit” smaller institutions is only

a few seconds, rather than a long flight and hotel room, researchers are significantly more likely to examine and cite those collections in their research.

Moreover, it is becoming increasingly common for scholarly research to begin and end with a digital-only search. When a properly formed search can return a deluge of relevant digitized collections it is difficult to justify a significantly more costly (in terms of both time and expense) search through physical archives. As the world’s holdings are digitized this trend is likely to continue, relegating to obscurity those collections which have not been properly digitized.

1.4.4 Quantifiably Equal Quality of Presentation

Smaller institutions following tight imaging guidelines such as FADGI 4-Star [see 5.1 - FADGI & METAMORFOZE] can provide

PDOs of quantifiably equal quality to those of The Getty Research Institute, The Smithsonian Institution, the Library of Congress, and other marquee institutions. Using the high-end equipment and workflows designed to meet and exceed these standards ensures that resulting PDO can be reused far into the future and stand side-by-side with those from any institution in the world.

Small institutions often have the world's leading collections of niche topics, and can leverage digitization of these collections to increase their reach globally. With larger institutions a researcher often starts with the institution and discovers and learns about a particular collection as a result. But the opposite is often the case with smaller institution; a researcher finds a collection and then learns about the institutions as a result. Digitization of such niche collections simultaneously fulfills the philanthropic goal of enriching community access to that collection and, as a result, increases the visibility of the institution itself, bringing tangible, world-wide recognition.

1.4.5 The Social Media Value of Immediate & Deep Content

Digitization is the perfect companion to social media. A Tweet about a specific person's physical visit to a physical institution is rarely reshared outside of their immediate friends. It lacks context and depth; there isn't any way for the audience to immediately engage. The reader may add "visit this museum" to a crowded mental to-do list, but without depth, it's more than likely the post will be forgotten moments later. In contrast, a social media post about a release of a digital collection provides deep and meaningful content to immediately dive into. This social value also incentivises traditional media coverage. For instance, Engadget, The Verge, and others covered the release of full-resolution downloadable images from the New York Public Library's special collection of maps. The release, and the coverage surrounding it, created strong engagement and public awareness, as exhibited by thousands of likes and retweets on Twitter.

> "This is absolutely incredible!!!!! As a teacher these maps are invaluable!! Thank you so much for doing this!"
>
> — Aleta Boddy, commenting on the Open Access Maps Program of the New York Public Library, which garnered nearly 10,000 likes on Facebook, and 3000+ retweets on Twitter.

1.4.6 Branding and Brand Consistency

Digital reproductions of collection items are one of the most common points of interaction between a Cultural Heritage Institution and the public. The images might be viewed directly on the institution's website, in a newspaper article, in a magazine feature, or in an academic publication. In all cases, they will, quite literally, inform the viewer's image of the institution. In the world of marketing this is called "brand interaction" and is critical in the creation and maintenance of positive high-quality branding. Therefore it is essential that institutions take care in the quality of digital assets they make available which might contribute to their brand. Digital images which are anything less than preservation quality can become a pandora's box of mediocre imagery; once a digital asset is released in any public form it can be nearly impossible to recall or control. The sensible recourse is to digitize only at high quality, ensuring that all digital assets an institution creates will help, rather than hurt, their brand.

> "The visual branding of the Philadelphia Museum is intricately tied to the quality of the photographs that are used to represent the objects in the collection, Museum events and its numerous activities. In an era when the phone cameras most visitors have are capable of capturing a 12-megapixel image, we feel that it is crucial that the quality and technical standards of the images produced by the PMA photographers be heads and shoulders above the crowd.
>
> We have found that it is far too easy for images taken with inferior equipment by well meaning but undiscerning amateurs to somehow become mixed into our archive, alongside professional photographs that we have worked hard to create. We work hard to prevent these inferior quality images from accidentally becoming part of the stock used to communicate the PMA brand.

> This is why a set workflow that starts with a detailed and color correct image, clearly defined labeling, and processing standards becomes crucial. The quality of such files along with their embedded file data helps us to identify and track the use of images that are produced with our brand in mind. While we can't always prevent less than ideal images from surfacing throughout the various channels that use images, it does help us identify and remove these problem files from circulation."
>
> — Justyna Badach, Photography Studio Manager, Philadelphia Museum of Art

1.4.7 First-Mover Advantage

Early in the digitization movement, few institutions of Cultural Heritage could digitize more than a menial fraction of their collection per year. Operating at the slow pace of multi-shot or scanning systems, the completion of digitization seemed more of a fanciful concept than an attainable goal. With the advent of rapid capture solutions built around high-resolution single-shot digital backs and high-speed workflow software like Capture One Cultural Heritage Edition, this pace has quickened by orders of magnitude.

Today's modern systems and the following of preservation-grade industry standards ensure that the day will come, sooner rather than later, that most institutions have the majority or entirety of their collections online. At that point, the publicity and interest surrounding *yet another* institution reaching such a milestone will be quite low. For now, however, there is a distinct first-mover advantage for those institutions completing digitization in the next few years. Thus, it is crucial that institutions that wish to use digitization as a market differentiator adopt a digitization program that includes sufficient quality to maintain a consistent and professional brand, with sufficient planning and equipment to achieve the digitization goals in a timely fashion.

> "We've reached an important milestone at the Freer |Sackler, an effort we're calling Digital Zero. As of this writing, we've become the first Smithsonian museum to digitize their collections. This is a great opportunity for scholars and researchers as well as our everyday virtual visitors to have 24/7 access to our works of art.
>
> What exactly is Digital Zero? For the Freer|Sackler, it means that we've photographed and uploaded our entire collection into a digital asset management system — more than 40,000 objects and almost twice as many images, from Whistler's Peacock Room to the tiniest unnamed ceramic sherd. We have examined the rights information on every object and marked them appropriately. We have reviewed records, both complete and incomplete, and deemed them acceptable to make public."
>
> — Courtney O'Callaghan, Chief Digital Officer, Freer|Sackler, The Smithsonian Institution

2. The Preservation Digital Object

2.1 What is a Preservation Digital Object (PDO)?

The Cultural Heritage Community does not need an education in how quickly information can become obfuscated, obliterated, or impractical without proper preservation curation and migration - it is the very impetus for the existence of the community. The age of microfilm was a short blip on the historical timeline of Cultural Heritage Preservation, and already, much of the work done during this period is languishing in storage, inaccessible by its target audience with their modern expectations. Moreover, much of the work done on microfilm is now considered insufficient quality to be considered Preservation Grade.

Scanning an image and saving to a hard drive is trivially easy; creating a Preservation Digital Object (PDO) requires careful consideration and continuous vigilance. Technology rapidly evolves, especially those technologies which control how digital information is created, stored, and retrieved. The goal of a PDO is to capture, wrap, and describe data in such a way that enables migration between storage systems, with the specific ability to be indexed and deciphered by future access systems.

2.1.1 The PDO Itself: Elements Within the PDO

- **Content** is the abstract information that warrants creating the PDO in the first place. In Cultural Heritage, the content is a photographic representation of a real world object which can replace the original object for most types of access. To qualify as a PDO the content must adhere strictly to preservation-grade image quality guidelines such as FADGI 4-star. An extensive discussion of this can be found in 5 - The PDO Content: Image Quality.
- **Container** is the digital format, or the set of rules that dictates how the content is digitally represented. To qualify as a PDO the file format must be one widely acknowledged as preservation friendly (e.g. TIFF) and the data within the container must conform precisely and strictly to the rules of that format (i.e. passes validation using JHOVE). An extensive discussion of this can be found in 6 - The PDO Container: File Fidelity.
- **Metadata** describes the content and the container with respect to any relevant characteristics (e.g. size, type, identifier of original physical object). To qualify as a PDO the metadata must accurately link to the real world object it represents, and must contain sufficient metadata to aid in the discovery of the digital object within the collection and provide for understanding it within its context.

2.1.2 The PDO Substrate: External Elements the PDO relies on

- **Access** is the means by which the Content is viewed. Modern access to a PDO containing a TIFF file could be provided by programs like Adobe Photoshop, Preview, GIMP, or a home-brewed image reader. It may also be converted on the fly to a JPG derivative for access via an online portal.
- **Storage** is the digital media the PDO resides on (e.g. an on-site server or “cloud” storage solution).

It can be easily assumed that the PDO substrate (access and storage) will be in a near constant state of flux. Therefore, the PDO itself (content, container, and metadata) must be created in such a way that they are not dependent on any given type of access or storage.

2.1.3 The Ultimate Goal: Digital Surrogacy

A PDO is not just a digital copy of the original object. It is a complete package ready to function as a digital surrogate for the original physical object in as many use-cases as possible. A PDO is well structured, easy to access and understand, is well described, and contains high quality content. This means that a requesting entity (patron, researcher, administrator, marketing agent) who wishes to have access to the original object can be instead be offered access to the PDO, with no noticeable difference in value to that entity.

For further discussion of the PDO please see 5 - The PDO Content: Image Quality and 6 - The PDO Container: File Fidelity.

3. Digitization Program Planning

3.1 Types of Digitization: Programmatic, On Demand, Forensic

Generally, digitization falls into three categories:

- **On-Demand Digitization (aka Ad Hoc Digitization):** Objects (or parts of objects) are digitized when a stakeholder (e.g. patron, researcher, curator), requests it
- **Programmatic Digitization (aka Systematic Digitization):** Collections are digitized in their entirety, in a planned manner.
- **Forensic Digitization:** an object is digitized before, during, and/or after some event such as a conservation repair/cleaning process, or an external loan.

The practical requirement to provide On Demand Digitization is obvious to anyone who has run a digitization program. Most stakeholders cannot wait for a particular object's turn in a programmatic schedule, especially when the scale of the collection means the programmatic schedule is projected out many years (or even decades). A digitization program must provide for procedures and workflows to provide On Demand Digitization with turnaround time that will sufficiently meet the needs of their stakeholders.

The benefits of systematic digitization are obvious, but the scale of this benefit may not be. When it comes to digitizing a Cultural Heritage collection, the whole is often greater than the sum of its parts. By completing an entire collection, the stakeholders are provided a complete deliverable digital collection rather than piecemeal elements of one. Moreover, the pre-planning and efficiency in programmatic digitization can *radically* reduce the per-object cost of digitization provided high quality hardware and software are used [see 3.5.2 - Collating By Required Capture Window].

> "Before we adopted the BC100 we were capturing around 10 plates per hour. Using the BC100 we now capture around 300 per hour. This allows us to digitize entire books (editors note: this is Programmatic Digitization), rather than just a few plates from each (editors note: this is On Demand Digitization), as we did with our previous slower system. Just as importantly, the BC100 captures a higher level of detail, which is important because our natural history plates have lots of small detail, important to the understanding of the object. With the images from the BC100 the viewer can zoom in to examine details, such as an insect, the coloring of a bird's wings, botanical drawings, or a huge foldout map. Increasing both speed and quality has been a boon to our digitization program and to the users of our digital collections."
>
> — David Holbert, Imaging Specialist, Smithsonian Libraries

> "To facilitate digitization of historical records it is imperative that all disciplines within a cultural heritage are represented in the development of digitization workflows. The Church History Library developed a 'Digital Highway' to facilitate effective digitization of historical records. A coordinator works with all disciplines to ensure records are reviewed according to access policies, metadata and finding aids are created and that the records properly handled. This has allowed the Church History Library to fulfill digitization requests in days rather than weeks or months."
>
> — Chad S. Barker, Manager, Preservation Planning & Operations, Church History Library

3.2 Pre-Planning

3.2.1 Scope Analysis: Material Type, Size, State

Before undertaking digitization, it is important to survey the variety of material present in the collection. Efforts to create universal conventions for breaking down a collection are in progress at The Getty Research Institute in the form of the Cultural Objects Name Authority. Such canonical hierarchies may be useful for planning a digitization program. They were not explicitly created for this purpose, however, and more utility may be gleaned by a purpose-made breakdown that is customized to a specific institution. The example below is well suited as a starting point for planning a digitization program, and can be made with any standard spreadsheet program using a rough estimate of quantities to help guide the process. Here, we have broken it down by type, size, and state, taking cues from which collection attributes call for special digitization considerations.

- **Type:**
  - **Works on Paper:** drawings, sketches, paintings, diaries, field notes, scrapbooks, ledgers, maps, blueprints, posters
  - **Works on Other Substrates:** engravings, etchings, multimedia
  - **Reflective Photomechanical:** silver prints, cyanotypes, tintypes, calotypes, moon print
  - **Transmissive Photomechanical:** lantern slides, x rays, cyanotypes, glass plates
  - **Spaces:** installations, architecture, scenics
  - **3D Items:** sculptures, fossils, material culture
  - **Organics:** people, biological specimens

- **Size:**
  - **Macro:** anything smaller than A8, including 35mm film, microfilm, stamps, coins
  - **Normal:** anything larger than A8 and smaller than A3
  - **Oversized:** anything A3 or larger
- **State:**
  - **Binding:** loose (unbound), T-Binding, bound, stapled
  - **Stability:** stable, rapidly deteriorating
  - **Handling Risk:** robust, fragile, very fragile, consumption
  - **Hazardous:** mold, arsenic, lead, radioactive

Establishing the scope of the collection to be digitized is essential for both the prioritization of digitization and the proper selection of the hardware and workflows that will be used. For instance, a collection which contains 3D materials is ill suited to systematic digitization via a flatbed scanner. Ideally, the hardware and workflow software that can digitize the majority of the collection should be selected. It is imperative for institutions to examine their holdings and look for a solution that is versatile and accommodate the particular needs of their collections. For example, the same high-resolution digital back and raw workflow software can be used to digitize any of the above categorized material types. The ability to use the same hardware and software across a broad collection reduces the institutional training requirements involved, and consolidates hardware cost outlays.

It is especially important to make careful note of the type and quantity of “problem children.” These are the outliers of a collection which will require extraordinary time or effort to digitize. This could be because of size (e.g. in a bound material collection there may be a small number of especially over-sized manuscripts) or condition (e.g. fire-damaged or extremely fragile materials).

> “We have handscrolls, we have prints, small paintaints, large oil paintings, hanging scrolls, six-fold screens; we also have quite an extensive collection of 3D material: bronzes, sculptures, metals of all types. We have a mandate to photograph our entire collection and put it online... by the end of 2014.”
>
> — John Tsantes, Freer|Sackler, The Smithsonian Institution

3.2.2 Leveraging Existing Collections Management Systems

One should never underestimate the amount of “housekeeping” required to maintain, curate, and provide long-term access to the tremendous quantity of files created during digitization projects. Perpetually maintaining digital objects require a range of ongoing expenses such as on-site storage, off-site redundant backups, electricity, maintenance, and migration costs. The use of Preservation Digital Objects more easily justify this ongoing cost than those of digital objects that do not meet, or have not been verified to meet, preservation standards.

Organizational systems such as an electronic collections catalogue, collections management system, and/or digital asset management system will help optimize workflow by providing structure to the materials to be imaged and can also help track which collections have been digitized. The ability to assemble collections by likeness and size tremendously increase the efficiency of digitization program and greatly enhance the conversion of collections into Preservation Digital Objects. If the collections catalogue has a digital asset management component, one can characterize the quality of the digital objects using FADGI type guidelines, and segregate images that are true Preservation Digital Objects from lower-quality images. This can help guide which digital assets are worth the costs of maintaining.

3.2.3 Long Term Preservation of and Access to the Digital Collection

The result of a digitization program is the creation of Preservation Digital Objects. These PDOs become part of the collection of the institution and must be preserved and properly cared for. When planning a digitization program this obligation and its ramifications must be considered.

The most obvious implication of an expanded collection of PDOs is the need for more digital storage. Every PDO requires digital storage space, so more PDOs means larger pools of storage are required. Less obvious is that a larger digital collection usually implies more digital traffic in the form of visitors to an institution's website or collections portal. Handling this increased bandwidth of online visitors may require upgraded servers or a more expensive website hosting plan. Also, those visitors may require more sophisticated tools (e.g. better filtering, searching, browsing) as the online collection grows; manually browsing through a few hundred thumbnails is tedious but practical, while manually browsing through a few million thumbnails is not practical. Adding such tools to a web platform, or switching to a more sophisticated platform which includes them can be a lengthy and expensive process.

3.3 Digitization Prioritization

3.3.1 Digitization Return on Investment (ROI): Benefit/Cost

Often, the total size of a collection is monumental, even when measured at the pace of a rapid mass digitization program. In nearly all cases, the collection will have to be segmented and prioritized, as comprehensive digitization may take years or decades. Both the costs of digitization (in terms of hardware, personnel, storage outlays, and time spent) and its benefits must be considered, resulting in a traditional Return on Investment (ROI) calculation.

> “Image quality has been paramount throughout the history of our digitization program. We select projects carefully according to agreed upon criteria. These include our current level of access to the material, whether digitization will help promote the preservation of the current state of the material, the quality of digital surrogate we can produce, the research value of the content, the practicality of the project's scope, the state of the cataloging records for a collection, handling considerations for the materials, the perceived audience for the resulting Preservation Digital Objects, and whether the project will build on projects previously completed. We measure these factors against the investment required for the project.”
>
> — Julie Ainsworth, Head, Photography and Digital Imaging, Folger Shakespeare Library

3.3.2 Integration with Other Activities

It is often possible, with proper planning, to coordinate the digitization of a collection with other required activities or initiatives. One of the most common is to combine the rehousing, cataloging of a collection, or conservation treatments with its digitization. This can not only save time and resources, but also reduces the net handling that a collection experiences. Digitization which is integrated with other activities has an inherently reduced cost/investment and therefore an inherently higher ROI.

> "Digitization is a great motivator for bringing special collections material through the conservation lab. When items or collections come up to the lab for digitization we can take care of both conservation treatment and digitization concurrently. This way the items are only coming into the preservation and conservation department once."
>
> — Bethany Davis, Digital Processing Coordinator Librarian, University of Iowa Libraries

3.3.3 Provenance, Copyright, Location

Provenance, copyright status, and storage location of the collections impact its digitization ROI. Provenance can affect whether digitization is a contractual obligation or restriction. For instance, many collections are donated on the condition that they will be made available to the public, sometimes with specific riders that they be made available publicly via an online portal or within a specified period of time. Any implicit or explicit commitment that an institution has to digitize a particular collection should be strongly considered in its prioritization.

Copyright status can legally limit the creation of and use of digital copies of a collection in ways that are different than access to the physical originals. For example, contemporary works are generally under copyright and the capture of and use of digital reproductions of the work may require specific release. If an institution has two collections that are of similar overall value and condition but one has passed into the public domain, it may be reasonable to prioritize the digitization of the public domain collection, as the derivatives of this collection will be easier to use.

Location can pose obvious logistical challenges. For instance, digitization may be more costly (in terms of time and money) if the target collection is held at a branch or satellite collection away from the main digitization lab. It may be sensible to prioritize the digitization of collections that do not present logistical complications.

3.3.4 Uniqueness of the Collection

Collections that are not duplicated at other institutions can be considered to have a higher ROI for digitization. For instance, circulation material that is already available in publicly accessible digital collections provide minimal ROI for duplicate digitization. In contrast, a one-of-a-kind document which has no peers or equivalents, or is in better condition at one institution than at another, provides obvious research value.

3.3.5 Suitability to Today's Technology

Today's technology can achieve rapid digitization at preservation-grade standards for many, but not all objects. For instance, an A1 size map can be captured in a single capture, allowing rapid digitization of a collection of that size, while an A0 sized map requires resolution only available by stitching or by using slower scanning or multi-shot approaches. Digitization of such oversized material today is certainly possible, but comes at a significantly higher time cost than digitization of smaller material.

Given the constant advancement of technology, it may make sense for some institutions to prioritize digitization of those parts of a collection that can be done rapidly with today's technology. If prioritized accordingly, technology may be available to digitize the larger material without requiring the higher time-cost.

Consider that in early 2015 the highest resolution single-shot digital back available was the 80mp series of digital backs from Team Phase One, allowing a maximum object-length of 37" for preservation-grade imaging (assuming 300ppi @ 93% sampling efficiency). Any object larger than 37" on the long side currently requires multiple captures, multi shot, or scanning-capture - all of which are significantly more time consuming and error-prone than a standard single-shot capture. If an institution had two collections, one being a large set of 20"x30" posters and another a large set of 30"x40" posters, it may make sense to prioritize the systematic digitization of the 20"x30" collection since the cost (in time and cost per item digitized)

will be significantly lower since they can all be captured with single-shots. In the future, when higher resolution backs become available (e.g. 100mp), the institution could upgrade their digital back and digitize the 30”x40” posters at a similar low per-object cost.

- Example 1:
    - Ten thousand 20”x30” posters are digitized with 80mp single captures in 2015. Rate is 100 per day.
    - Ten thousand 30”x40” posters are digitized with 100mp single captures in 2016. Rate is 100 per day.
        - Total project time is 200 days.
- Example 2:
    - Ten thousand 30”x40” posters are digitized with stitched 80mp captures in 2015. Rate is 20 per day.
    - Ten thousand 20”x30” posters are digitized with 80mp single captures in 2017. Rate is 100 per day.
        - Total project time is 600 days.

In both of the above examples the the institution has successfully created 20,000 Preservation Digital Objects from their poster collection. However, in Example 1 they have reduced 400 days of labor and overhead by prioritizing their digitization program based on the suitability of the collection to today’s technology and then upgrading their digital back using tomorrow’s technology for the sake of efficiency.

3.3.6 Temporal Relevance

Often a collection will vary in relevance to researchers and the public based on anniversaries or a relationship with current events. For instance, the centennial anniversary of the First World War in 2014 created heightened activity around collections from that period. Likewise, the ongoing destruction of sites of Cultural Heritage significance in Syria might change the ROI of collections from that region.

In addition, collections can often have limited periods of relevancy; such was the case with military personnel service records at the National Archives of the United States (NARA). This collection has a hybrid of cultural and practical value, but the latter is fading away as the individuals referenced in the records pass away.

> “We are responsible for preserving millions of fire-affected Military Service record documents that were damaged in a fire in 1973 at our St. Louis, Missouri facility. These records are of immediate concern to aging veterans seeking proof-of-service for access to veterans' benefits. NARA is currently imaging the most heavily damaged and fragile subset of these records with the DT Multispectra Camera; creating digitized versions of these records that reveal lost content from charred areas of documents. Before working with Digital Transitions, NARA tested a number of other imaging systems but could not get the project off the ground due to the lack of quality and information recovery effect in the IR images produced. The DT Multispectra Camera was the only system that met our production requirements of rapidly capturing high quality images, straight from the camera, in both visible and IR. Without the engagement of Digital Transitions in solving this problem, the NARA project would not have proceeded.”
>
> — Noah Durham, Supervisory Imaging Specialist, National Archives of the United States

3.3.7 Political Factors

In an ideal world, political factors could be entirely ignored in deference to the substantive value of a collection. However, the practical reality is that benefactors, grant controllers, and the public will not view the digitization of all collections as equally valuable. The PR and fundraising value of digitizing a collection may be worth considering as part of the ROI calculations when prioritizing digitization initiatives [see 1.4 - Marketing, Branding, Reach, & Politics]. This is especially true with collections that are controversial in nature. For instance, some funding entities may have ideological objections that discourage them from funding digitization of a collection related to the science of evolution or the history of transgendered individuals thereby potentially raising the cost (e.g. more time required to find grant sources). However, broadening access for such collections may relate to institutional goals such as public education and may influence the prioritization of digitization regardless.

Many, including the authors of this paper, would prefer Cultural Heritage institutions entirely transcend politics and cultural

sensitivities in their digitization ROI analysis. Institutional missions such as preserving and presenting unbiased and accurate historical records should not take a back seat to realpolitik. We include the topic here since it is clearly part of the conversation that must be had during the planning of a digitization program. If high-grade controversy is likely to arise from the digitization of a particular collection the appropriate stakeholders should be made aware in advance (e.g. Public Relations and Legal Affairs departments) so they may be appropriately prepared.

3.3.8 Physical State of the Collection & Risk of Future Degradation

Some collections are in excellent condition and are inherently stable. Stone statues in good condition, properly stored in a preservation environment, are at very low risk of future degradation. Unfortunately, this is not typical of every collection – sometimes, objects in a collection are already in a poor physical state or are inherently unstable, and are likely to deteriorate further. It is sensible that these at-risk collections receive priority in the planning of a digitization program.

3.3.9 Collection Preparedness & Curatorial Understanding

The creation of a proper digital collection is reliant on an understanding of the meaning and context of the physical collection. Preliminary curatorial research can often reveal aspects of a collection that influence details of its digitization protocols. For example, a curator might, after research, find that a particular painter used unusual substrates which featured interesting textural properties that added to the meaning of the subject matter; knowing this the curator might recommend the paintings receive both standard and texture-enhanced digitization.

It is generally expected that the materials in a collection slated for digitization are stable, organized in a manner that optimizes preparatory processing, and have a supportive collections records to help facilitate collections processing workflows. If a collection is not physically ready, adequately organized and documented, or sufficiently understood, digitization should be delayed, regardless of priority status. The surest path to an inefficient digitization program is needless duplication of effort; “do it once, and do it right."

3.4 Setting High Image Quality Guidelines

3.4.1 Unforeseen Costs of Imaging for Short Term Needs

Unfortunately, many digitization programs are built around short-term needs. Items are often scanned on a flatbed or photographed with general-purpose cameras (e.g. Canon/Nikon) and planetary devices without any verification of the resulting image quality beyond a cursory visual comparison. Worse yet, the quality claims of a hardware manufacturer are often taken at face value, and are not assessed by the institution. The institution justifies using these lower-quality solutions because they meet the requirements of a particular immediate use; they are “good enough.” This philosophy has two main sources of unforeseen cost: the myriad costs of inevitable re-imaging and the cost of maintaining the Preservation Digital Object (PDO).

3.4.2 Cost of Re-Imaging: Cost, Time, Condition Degradation

If, at any point after creation, the image quality of a PDO is found to be insufficient for a new initiative, the object must be re-imaged. This requires that most of the Digitization Chain must be repeated as well: object retrieval, object prep, digitization, QC, object return. An even greater concern is the inherent risk of degradation of the object’s condition from additional handling. The additional internal resources required of the institution and the longer period of time during which the object is unavailable to other interested parties (patrons, researchers, conservation staff, etc.) must also be considered. Moreover, it’s likely both versions (the non-preservation first-pass and the PDO from the preservation grade re-imaging) will be maintained, increasing the cost of maintaining the digital collection. When examining the costs of re-imaging, it generally makes sense to “do it once, and do it right.” It’s safer for the object, it’s more cost and time efficient, and it’s a simpler approach.

> “There is so much to image at most libraries and museums that the chance to re-image an object is small, and the opportunity cost to do so is high. Therefore it is only logical to ensure that all digitization is done appropriately.”
>
> — Ian Bogus, MacDonald Curator of Preservation, University of Pennsylvania Libraries

3.4.3 Cost of Maintaining a Preservation Digital Object

A PDO is meant to be kept indefinitely. However, the cost of maintaining and migrating the PDO Substrate [see: 2.1.2 - The PDO Substrate] is high, especially when you sum this cost up over decades or longer. Maintaining a non-preservation digital asset with limited applicability (e.g., only good enough for patron web access, but not adequate for research needs) costs the same as a PDO created for broad scope-of-use both now and in the future. When considering all of these factors, it can be said that the only type of digital asset worth creating (and indefinitely maintaining) is a PDO that achieves the image quality standards that were formulated specifically for preservation-grade cultural heritage digitization.

> There is no advantage in taking the short-sighted view of a "once and done" digital imaging project – it is a waste of time and assets. It is imperative that all stakeholders, especially those who are further removed from the day-to-day work of the project, but perhaps have more authority over allocation of funds, are in agreement and fully understand that a long-term commitment is necessary for the all-important and never-ending responsibility of file storage, organization and access. In comparison, the actual digital capture of the object is the "easy" part of the project!
>
> — Barbara Katus, Manager of Imaging Services, Pennsylvania Academy of the Fine Arts

3.4.4 The Minimal Cost of Imaging in the Full Digitization Chain

Imaging collections is a Herculean task in terms of labor, costs, and mindshare. Many departments are involved in the Digitization Chain. This includes the executive arm of the institute, preservation conservation teams, cataloguing personal, imaging specialists, and information technologies departments. The scope is so wide and the chain so long that the overwhelming majority of the time and resources spent in the Digitization Chain are not related to the actual imaging. The preponderance of the time and costs are spent on administrative planning, internal communication and project organization, object retrieval, metadata entry, quality control, object return, and file management. For example, a single technician could image more than 10,000 photographic prints in one shift using a DT RG3040 Reprographic System provided that was the only step in the digitization process. In reality, the imaging technician is only one part of the total Digitization Chain, and will spend more time retrieving, organizing, and returning the boxes/containers of prints than actively imaging.

It's also important to consider that beyond the initial Digitization Chain, there is a commitment to maintain the image file in perpetuity. Even with a decreasing cost of storage, there is still a recurring cost associated with storage and providing organization of, and access to, digital archives. Taking into account the entire Digitization Chain and the life span of the resulting assets, the difference in cost to create and maintain a true Preservation Digital Object versus a mediocre image is negligible.

Imagine opening a restaurant in the middle of Manhattan: designing an elegant menu with a well-researched flavor palate, filling the dining area with the finest decor, and spending the going rate for top-notch staff. Now, imagine installing Easy Bake Ovens in the kitchens of this restaurant. The core product, the meals served, will now be mediocre, despite the rest of the efforts to create a high-end restaurant. While an industrial-grade oven may be significantly more expensive than an Easy Bake Oven, it represents only a fraction of a cost of running the restaurant, and is worth the investment

> "Thinking about the value of the [Keith Albee] collection and the value of the staff provided by the [NEH] grant… we're investing a lot of time money and effort and we didn't want the imaging hardware to hold us back. We invested in Digital Transitions solutions in order to get a great end product."
>
> — Bethany Davis, Digital Processing Coordinator Librarian, University of Iowa Libraries

Keeping in mind the cost of the entire Digitization Chain, it is imperative to execute the imaging itself at the best possible quality, which requires the best imaging hardware and software. Otherwise, the rest of the institutional resources involved in the Digitization Chain will have been squandered.

> “The percentage of overall cost of digitization at NYPL represented by capture and processing probably falls somewhere between 20 and 30%. This is an extremely rough estimate based on an estimated average salary and factoring in an estimate of average annual equipment cost.”
>
> — Eric Shows, Assistant Manager, Digital Imaging Unit, New York Public Library

> “High quality images do not have to cost much more if the equipment is already available. Much of the real costs are human, so the time required to retrieve an item, prepare it, shoot it, process the images and reshelve it can be up to 80-90% of all costs incurred. Even when investing in high-end hardware and software these costs make up only 10-20% of all costs incurred as long as the equipment is consistently used.”
>
> — Ian Bogus, MacDonald Curator of Preservation, University of Pennsylvania Libraries

3.4.5 No Need to Compromise in the First Place

In years past, slow scanning systems and multi-shot systems meant that high-quality images took significantly more time to produce. Increasing resolution and quality with these legacy systems required a direct compromise on capture speed. As a result, a slow workflow was, for many years, the only viable way to accomplish high-resolution, high color-fidelity, sharp PDOs. However, in the last several years, the advent of high-resolution single-shot capture systems has revolutionized digital capture; now it takes the same time to digitize with preservation-grade image quality standards as it does to produce lower quality images that are only suitable for access and patrons.

For instance, a DT BC100 Book Capture System can digitize bound material up to an A2 page spread at 600ppi with FADGI 4-Star sharpness; its capture rate of approximately 24 pages per minute is the same whether capturing an A2@600ppi@FADGI-4 or an A2@150ppi@FADGI-2. There is no longer a need to compromise between high-quality and high-productivity.

> "The SRLF Preservation Imaging team is committed to providing quality digital images of collections held at the UCLA Library. We work with a range of materials including rare manuscripts, photographs, maps, artifacts, and other sensitive materials. The ability to achieve high resolution capture and an efficient throughput with the Phase 645DF and Digital Transitions’ RCam has allowed us to meet the mission of the University while consistently providing access to collections and continuing their preservation as digital images."
>
> — Colleen A Carlton, Director, Southern Regional Library Facility, UCLA

3.5 Planning Collection Pulls

Before a digitization program begins, clear procedures must be in place for how objects will be pulled from the collection and then returned to the collection after digitization. Along with the usual logistical considerations for retrieving an item from the collection (intra-institutional communication, scheduling systems, tracking systems, and logs), which are outside of the scope of this document and common to other collection-pulls such as patron requests, there are special considerations for pulling items specifically for digitization.

3.5.1 Length of Pull vis a vis Quality Control

The Standard Raw Digitization Workflow [see 4.1 - Standard Raw Digitization Workflow] calls for a Final Quality Control Stage executed by an individual who has access to the original object. Therefore, it is important that the object remains available to the digitization team not only during the Capture and Initial Quality Control stages, but through the end of the Final Quality Control Stage.

Moreover, the Standard Raw Digitization Workflow is built around efficiency, which is often increased by completing a large batch of Production Capture before proceeding to the post-production and Final Quality Control. For example, here is an

example of a simplified breakdown of the Standard Raw Workflow when digitizing 100 boxes, each of which contain 40 envelopes:

1. Production: Technician preps and captures all envelopes from all ten boxes, creating 40,000 raw files. Initial Quality Control is executed during this capture stage.
2. Post-Production: Technician uses Capture One CH 8 workflow software tools like Auto Crop on the 40,000 raw files. Final Quality Control is executed at this stage.
3. Processing: Technician processes the 40,000 raw files to TIFFs and places them into the Archive/DAM system.

With a rapid capture system using a 80mp digital back and the DT RCam Reprographic Camera with Capture One CH 8 Software, one could expect a reasonable rate of production of 600 envelopes per hour - quite impressive, especially given that the result will be true PDOs. However, with a collection of this size, it is expected that there will be a two week gap between capture of the first box of envelopes and the Final Quality control for that box. If the boxes are not kept locally available for physical reference, then issues discovered during Final Quality Control may require re-pulling the item. Even a technician with a 99.9% rate of success will have 40 errors during the Final Quality Control stage. If 10% of those 40 errors require re-imaging the object (as opposed to recropping or adjusting the raw file), then 4 envelopes will need to be pulled again from storage, resulting in a significant delay for the completion of the project. For this reason, where institutionally feasible, a large window should be granted between Object Pull and Object Return, commensurate with the size of the pull.

3.5.2 Collating By Required Capture Window (PPI & Object Size)

In the Standard Raw Digitization Workflow, very large gains in productivity can be achieved by minimizing PPI-Changeover time. Consider if there are one hundred objects to be digitized: 50% are A2-size that require a 300ppi capture and 50% are A4-size that require a 600ppi capture. In this case it is most efficient to digitize all of the A2 objects, and then all of the A4 objects. The least efficient method would be to switch between sizes on every capture. The table below illustrates the total time for digitization if the PPI-changeover time was 3 minutes, and the object handling/capture/initial-QC time was 30 seconds.

Workflows	**Object Handling, Capture, and Initial QC**	**PPI Changeover Time**	**Total Time**
Collated Workflow (all A4, then all A2)	30 sec * 100 objects	3 min * 2 PPI change	56 minutes
Uncollated Workflow (A4, A2, A4, A2, A4, A2…)	30 sec * 100 objects	3 min * 100 PPI changes	350 minutes

In the extreme example above, a collated workflow reduces capture time by 84%! Put in different terms, the capture rate accomplished in the “collated” workflow above would capture 750 objects per 8-hour shift, while the uncollated workflow would capture only 120. That is a massive increase in productivity without any reduction in quality and with fewer opportunities for human error.

Many collections are not stored in a collated form, and it would be presumptuous of the digitization program to dictate or even influence the manner in which these collections are stored. However, the gains of digitizing in a collated workflow are so significant it can make sense to temporarily collate the structure of the collection prior to digitization and then restore the original structure prior to returning the items to storage. However, these additional steps in the workflow will increase physical handling and increases the possibility to misplace collection items. These drawbacks must be evaluated alongside the potentially significant increase in overall efficiency.

Consider that the results need not be so extreme to make significant (>10%) changes to productivity. The digitization technician is at the mercy of the program manager and institutional stakeholders; they can only collate within the items delivered in a particular batch. It is essential, therefore, that maximizing collation and other streamlining operations be incorporated into the scheduling of the digitization program from the onset and at the highest levels of organization. However, administrators and other stakeholders are often unaware of the drastic difference collation can make. It can be useful for those

involved in planning collection pulls to see a brief demonstration of the practical steps required to prepare to digitize a particular type/size of object as compared to the minimal time required to digitize additional similar objects. The change in productivity is so massive that the internal cost to digitize additional homogeneous objects in a collated workflow is nearly free in comparison to additional objects in an entirely uncollated workflow. Proper collation can drastically improve the math behind determining an object's Digitization ROI.

> "it makes very good sense in organizing digitization to pull objects of like size, even if they are not of the highest importance in the overall collection. If the goal is to digitize the entire collection, it will certainly be more efficient to shoot similarly sized objects in "one go", as it were, rather than prioritizing by order of relevance and constantly changing capture settings."
>
> — Barbara Katus, Manager of Imaging Services, Pennsylvania Academy of the Fine Arts

3.6 Establishing Handling & Presentation Protocols

3.6.1 Cross Pollination of the Conservation & Digitization Team

Every item in a Cultural Heritage collection is unique and demands particular handling. Consider a collection of fragile bound volumes from medieval France that may have significant variation in binding fidelity, and require individual assessment and handling to prevent damage to those bindings. Nonetheless, establishing uniform baseline handling protocols can help keep all team members and stakeholders on the same page regarding how particular collections should be handled and what special considerations to account for when evaluating individual items from that collection. This must be done in close consultation with the conservation team of the institution, drawing on their expertise and experience in the proper handling of Cultural Heritage items.

This interaction between the conservation team and digitization team should be collaborative. Digitization teams often have only cursory educations and backgrounds in conservation, and conservation teams often have only cursory understandings of the digitization process. When mass-digitization is an institutional goal, there must be a concerted effort to promote cross-pollination between the two teams. Not only will the digitization team develop a better understanding of material handling, but the conservation team will learn the practical effects of certain handling restrictions. In some cases, a minor handling accommodation can profoundly impact the utility and speed of digitization. For instance the quality and speed of digitizing a manuscript collection can be increased by allowing it to be digitized by a PSI-limited operator-controlled gentle contact with a glass platen; such a system can greatly increase the readability of the digital object created by providing a partial flattening of the page, and increase the capture rate by 10X or more (e.g. simultaneous capture of both pages in one pass using a DT BC100 Book Capture System vs. focus stacking on a general-purpose non-contact copy stand).

> "At the University of Illinois at Urbana-Champaign Library the communication between digitization and conservation is really developing into a robust two-way conversation where we are educating each other. Conservation is always working with the digitization team to tell them about physical limitations due to bindings or other restrictive formats, what we can and can't fix, and making them understand why we can't fix something. Digitization staff have also become more confident of their judgement during the digitization process – they know when to know to stop and call conservation. Likewise it's helping us go in and look at their cameras and understand their workflow, how are they handling materials, how are they propping the books open, what sorts of straps and weights they are using, and how those tools react with the object so we can better work to conserve our materials anticipating that sort of use."
>
> — Jennifer Hain Teper, Head of Preservation Services, University of Illinois at Urbana-Champaign

The purpose of such interaction is not to pressure the conservation team to provide more liberal object handling protocols than they are comfortable with. Indeed, this would be anathema to the primary goal of a cultural heritage institution; the safety of the collection must always come first. Instead, this cross-pollination should seek to provide both teams with greater knowledge,

such that the conservation team can provide handling protocols that keep the collection safe without being needlessly restrictive, and the digitization team can understand the protocols themselves, as well as the underlying reasons for their details.

> "Our students found a journal with pretty wallpaper samples that they were touching and admiring. They wondered what we should do with the book, after it had been disbound and digitized, because it was considered non-unique. I suggested they consult with the Head of Conservation. The Head of Conservation read the article title, 'The Dangers of Arsenic in Wallpaper' - arsenic was used to make vibrant, colorfast inks in the Edwardian/Victorian era - and she advised the students to wash their hands."
>
> — Lawrence Wentzel, Associate Librarian, University of Michigan

Some institutions may not have a staffed conservation position. In that case it may be helpful to explore the possibilities of reciprocal site visits with a neighboring or associated institution that does, paid outside consulting, or attendance at an relevant conferences. Any effort to foster cross-pollination with individuals or groups with conservation experience is likely to be rewarding.

3.6.2 Contact vs Non-Contact Scanner

As a matter of definition, Contact Scanning means any type of digitization that requires, at any stage in the process, something to come in contact with the object with the exception of using hands (gloved or ungloved) for the basic handling of the object. This includes glass platens, straps, magnets, bars, and corner holders.

There are two types of contact scanners:

- **No PSI Limit (aka Uncontrolled Contact):** In most systems, the amount of pressure exerted during contact is not measured and there is no method to hard-limit this pressure. For example, when using a spring-based cradle the amount of pressure exerted on the object will vary depending on how thick the object is. An item with a 4" binding will compress the spring more than an item with a 2" binding, and will thereby experience more pressure since springs increase in force the further they are compressed.
- **PSI Limited (aka PSI Controlled Contact):** Some systems provide a built-in or optional add-on provision for hard-limiting the pressure of any contact with the object. For instance, the DT BC100 Book Capture System [see BC100] has an optional pneumatic cradle used to raise a bound material against a statically positioned glass V platen. An adjustable valve limits the maximum amount of pressure that can be exerted upward during this raising motion, and a self-correcting lateral sliding mechanism and in-cradle object cushion ensure this pressure is spread evenly over the object. Such a limit does not inherently eliminate the potential of damaging an object, but it does give the technician and curatorial staff an objective method to measure and limit the pressure exerted, offering some level of protection.

When using a No PSI Limit system, it is especially important for the conservation team and digitization technician work closely together. The technician should demonstrate potential ways the system can be used, and received immediate feedback from the conservation team as to which variations conform to the required handling protocols for a particular collection.

In the case of PSI Limited systems, an institution-wide objective maximum can be set for different classes of collections. The request to digitize a particular collection or object can be accompanied by a specific and relevant PSI limit which can then be objectively followed by the digitization team. Such objective limitations are also useful when outsourcing digitization to a third party vendor.

The exact manner in which a contact system operates is also be critical in determining what materials it can safely handle. Ideally, contact should be entirely technician-controlled; robotic and automatic handling are not able to adapt to changing conditions in the same way that a trained technician is. For instance, in a bound object, there may be an isolated page which is damaged or torn which requires more careful handling. Such a case is easily identified and handled by a human operator but is potentially vexing for a robotic system.

Contact systems which use a pivot point are not as desirable, as the contact will roll unevenly across the object.Contact should be homogeneous across the surface of the object instead, as is the case with the RGC180 and BC100.

3.6.3 Vacuum Tables

The use of a vacuum system has both pros and cons.

- Benefits: Objects which are flexible but tend to curl, roll, or otherwise deform can be held in a flatter state by means of vacuum. The vacuum table will not visually obfuscate the object, unlike systems using weights, magnets, or restraining belts/bars.
- Disadvantages: Some material is sufficiently breathable that air from the vacuum will pass through the object itself, dragging with it any dust and other undesirable particulates. These risks can be mitigated by adding an appropriately sized air filter to the room, and shortening the time the vacuum is on. For example, a policy that the vacuum is only engaged immediately prior to the final capture would limit these exposures. More problematically, some materials are not pliable enough to be usefully flattened by a vacuum, as vacuum pressure is limited by nature to 15 psi.

3.6.4 Heat / UV from Lighting

The desire to keep collections at their native storage temperature is nearly absolute across institutions. This should not change during digitization. Scanning/digitization hardware should not expose the object to meaningful heat (or temperature changes in either direction for that matter). In modern reflective digitization, this is not problematic, as the industry-wide movement to strobe and LED lighting has eliminated the enormous heat generation of tungsten-based lighting. Furthermore, most professional strobe systems include strong UV filtration, which greatly reduces concerns about UV damage; a handheld UV meter can be used to confirm that a given light source is safe, or lighting can be purchased from a company that specializes in cultural heritage imaging and understands these considerations.

Selection of a system for digitization of transmissive materials is constrained by desire for both high CRI lights and a continuous light source in close proximity to the object to provide guidance for object handling. Many institutions shoot transmissive materials directly on a lightbox, exposing the material to heat. Instead, it is desirable to raise the transmissive materials away from the lighting surface. This is the approach taken with the DT Film Positioning System, which ensures the object is exposed to only minimally raised temperatures while providing rapid preservation handling.

3.6.5 Cropping & Inclusiveness

Guidelines need to be developed regarding the cropping and inclusion of the object, before digitization commences. The most common guidance in Cultural Heritage imaging is to be quite conservative in both regards, a standard which can be referred to as “full object inclusion.” For cropping, this means all four edges of a rectangle (or all edges of a non-rectangular object) are included in the capture, even when there is no meaningful content at or near the edge of the object. For inclusiveness, this means imaging every object in a group regardless of content. For instance, shooting every page of a bound material, even when the page is blank or is a duplicate of another page.

Many institutions also include an Object Level Target [see 5.4.3 - Object Level Target (OLT)] within the frame. When possible, these Object Level Targets should be included in the PDO, even if other non preservation derivatives (aka access copies, presentation version, etc.) crop them out. Sophisticated workflow software, such as Capture One CH, can be used to automate the process of creating both types of output with their respective crops.

3.6.6 Object Background

The background against which an object is captured is important for several reasons: visual perception, workflow, and transparency handling.

The background against which an object is viewed has a strong influence on the way the viewer visually perceives the object. This is a topic far too broad to discuss in this document, but should be carefully considered. While it is possible to remove an object from the background digitally, it is a time consuming and imperfect process that is not broadly accepted in the Cultural Heritage Community. Therefore, it is very important to consider what background is used prior to the initiation of digitization.

In a workflow including automatic cropping such as in Capture One CH, it can be useful to ensure contrast between the object and background. Workflow considerations like this should never supersede the more important questions of correct visual

presentation and other curatorial considerations. However, when all else is equal, a background which has higher contrast with the outer edge of the subject will work more easily with autocropping. For example, shooting a white document on a gray or black background will require fewer manual corrections when autocropping.

As some objects are not fully opaque, consideration should be given for what background such transparency should show through to. For instance, digitizing a single layer of carbon copy paper against a black background rather than a white background may significantly increase legibility of the writing. This is also true when digitizing bound material; a thin page may “leak” part of the next page’s content unless a blank sheet of paper is inserted as backing.

3.7 Staffing Structure: Roles, Skills & Efficiency

3.7.1 Administrators, Technicians & Operators

Within any digitization project there are many roles that need to be filled. It's critical to consider the relationship between these roles, and the skill/experience required to effectively fill them. There is no community-wide definition of these roles, and moreover the exact needs and structure of each institution will vary. In many smaller institutions one person will play more than one role. For the discussions in this document we use the terminology as defined below:

Role Name	General Responsibilities	Required Technical Experience	Required Management Experience	Role in Guidelines	Alternative Terminology
Project Manager	Administrative Planner. Establishes overall plans for digitization program. Interfaces with other departments and stakeholders to prioritize the digitization of candidate collections. Allocates department resources, makes staffing decisions, and applies for grants. Tracks productivity metrics and delegates projects.	Moderate. Should have general familiarity with digitization process and the capabilities and limitations of various hardware and software therein.	High	Creates Guidelines	Program Administrator
Technical Manager	Technical Planner and Overseer. Helps translate overall plans into specific workflows. Writes documents like Standard Operating Procedures. Manages the Quality and Control processes and handles calibration and maintenance tasks. Trains technicians and operators.	High. Should have experience as a power-user and formal technical training in digitization.	Moderate	Creates Guidelines	Lead Technician Technical Lead Technical Planner
Technician	Responsible for the actual digitization. Is comfortable setting up for new projects and seeing them through to completion with minimal input and guidance from the Technical Manager. Understands the underlying principles that are informing the decisions of the Technical Manager and Project Manager.	Moderate. Ideally should have functioned in previous projects as an operator and/or received training in digitization.	Low	Understands Reasoning Behind Guidelines	High-Level User Power User Skilled Operator
Operator	Responsible for the actual digitization. Is comfortable operating a digitization system once a Technical Manager sets it up and provides specific step by step instructions.	Basic. Ideally should be given moderate training and detailed guidelines and operating procedures.	None	Follows Guidelines	Student Worker
Assistant	Provides an additional set of hands. Helps with tasks like transporting collections from storage to the digitization area, loading/unloading film carriers, and organizing items in the digitization queue.	None. Should receive training regarding internal procedures and basic terminology.	None	Follows Guidelines	Runner Production Assistant Intern

3.7.2 Operators Compared to Technicians

As we've defined above, a Technician has significant technical skill/experience and can be given autonomy over day-to-day operations. Their experience enables them to not only follow guidelines and procedures, but to understand their underlying rationales. This understanding allows them to adapt when faced with novel challenges. In contrast, an Operator has limited technical skill/experience. They are comfortable following specific documented procedures in a step-by-step manner but are not familiar with the underlying reasons why these procedures should be followed.

An Operator that is given additional training and accumulates sufficient experience becomes a Technician. Many institutions choose to use, or are limited by administrative policy to use, Operators in the form of student labor or temporary workers for mass digitization programs, which generally precludes their progress from Operator to Technician. Student labor or temporary workers have one main advantage and several disadvantages. The advantage is that they are less expensive in direct compensation. However, they are rarely invested in the outcome of the project they are working on and may require extensive training to adequately fulfill the duties entailed by an operator-level employee. Full-time, long-term employees have better technical preparation and are more strongly incentivized to ensure relevant guidelines for quality are closely followed, such that errors are minimized, and are caught and corrected when they do occur.

The hard costs of an Operator are usually quite low compared to a Technician, making their use seemingly attractive. Often, however, the hidden costs associated with their use can add up. Student labor is often provided on a revolving basis, with new students rotating in every 4-18 months. This requires overhead of training and management, often consuming a significant percentage of the total project time. It also implies a higher rate of error and a lower rate of productivity, as these two metrics typically improve with the experience and training of an operator. It is often the case that a student becomes especially proficient and self-sufficient only in their last few months of service.

Such cycles of short-term training and retraining, as well as lower underlying technical proficiency, often lead to a variation in the quality of the work-product of a digitization program. It also competes with resources (e.g. time) that could otherwise improve technical institutional memory and overall institutional capabilities (e.g. continually evaluating and improving internal processes, training of long-term staff, inter-institutional academic research). The acquisition of talented full-time, long-term technicians reduces the time spent training new staff and will increase productivity in almost all cases. The most important asset in any digitization program is its people, and many institutions have found that the increased productivity, lower error rates, lower training burden, and high quality of work more than justifies the salary of professional long-term staff.

> "Having staff that have real photography experience is invaluable. The process is much more than just clicking a button; it is easy to for someone who is trying to be helpful, but does not really understand what they are doing, to create hard to detect, problems from someone who is trying to be helpful but does not really understand what they are doing. There should be at least one photographer available at all times to help keep images accurate and the equipment running smoothly.
>
> Free and student labor can be more trouble than they are worth, especially if the work is mostly project based. Not only might there be attendance issues, but turnover is often high. Finding new staff and retraining require much higher management costs. Handling and security are a major concerns in libraries and museums. It is easy to give a primer on what to do, but complex objects like books require a lot of hands on experience to fully understand what an object can really take."
>
> — Ian Bogus, MacDonald Curator of Preservation, University of Pennsylvania Libraries

> "When an institution commits to embarking on a digitization project by purchasing the best equipment available for the task (such as the products available through Digital Transitions), the same standard should prevail when it comes to staffing, not only for the short term, but more importantly, for the long term"
>
> — Barbara Katus, Manager of Imaging Services, Pennsylvania Academy of the Fine Arts

3.7.3 Continuing Education

Digitization is a nascent and rapidly evolving field. Therefore, continuing education for digitization technicians, administrators, and managers is essential.

Several conferences each year provide paper presentations and panel discussions on the topic of digitization. These are held at staggered times throughout the year and in different cities, simplifying the logistics of attending at least one conference per year. Several such conferences that are widely attended in the United States include:

- The American Library Association (ALA) Annual Conference
- The Society of American Archivists (SAA) Annual Meeting
- The Museum Computer Network (MCN) Annual Conference

In addition, more formal training can be provided by industry vendors. The Digital Transitions Division of Cultural Heritage (DTDCH) includes training and calibration services with every hardware package, and also offers half-day to multi-day training and consultation options on an à la carte basis. In the last several years, the technology for remote training has also improved, allowing DTDCH to provide webinars and remote video conferences to supplement in-person training.

Finally, there exists within each institution the opportunity to implement mentor and peer-to-peer training programs. When carrying out such a program, the Project Manager and/or Technical Administrator should formalize the curriculum to avoid propagating bad habits. The creation of an internal Standard Operating Procedures document (outlining step-by-step procedures and policies for different workflows) can help with such formalization, as can comprehensive digitization-program documents such as this one.

> "To keep up with this rapidly evolving field I take online courses related to my position and specialty, attend workshops and conferences, train on new equipment and software, have attained the certified digital preservation and curation trainer status from the Library of Congress, and serve on numerous committees at my Library that maintain a handle on digital assets management and migration."
>
> — Marge Thompson, Manager of Digital Photographic Services, Rasmuson Library, University of Alaska

3.8 Hardware Ergonomics

When digitization expands beyond small quantities, it becomes very important to consider the ergonomics of repetition. A mass digitization program and a factory assembly line have much in common, including the potential peril of prolonged poor ergonomics. Many technicians will use digitization hardware more than a thousand hours each year, so ergonomics can have a profound impact on both their personal well being and the quality and consistency of their work product.

3.8.1 Types of Releases, Triggers & Actuators

Anything the technician repeatedly clutches or pushes needs to be examined. Repeated motions which require even modest strain should be avoided wherever possible. If there is a locking or lifting mechanism, it needs to open/close with minimal force. When possible, a foot pedal should take the place of hand-operated triggers/switches, as this improves ergonomics, encourages active posture, and frees the hands for object handling and other mechanically complex tasks. When using hand triggers, it is preferable to use the base of the palm rather than a clutching or grabbing motion, as this is a lower tension activity and is less likely to cause repetitive stress discomfort or injuries. When any repetitive lifting must be accomplished (e.g. to raise/lower a glass platen), it is far preferable in long-term use to utilize a system that has power-assisted movements rather than rely on the manual force of the technician. This is an obvious consideration for heavy items as the consequences are quickly manifest, but it is also true for light loads (e.g. small platens) over long term use.

3.8.2 Chairs

If a technician sits during digitization, their chair is of paramount importance. In particular DTDCH has found the HAG Capisco Ergonomic Chair [see our DTDCH Accessories Page] to be especially useful in a mixed digitization environment, as it can be used forward or backward. The armrests provided in the backward position can be conducive to a resting position for some

types of digitization. However, there is no ‘golden’ chair that is perfect for everyone. The right chair for any given technician is the one they find comfortable while maintaining good posture and low strain during the movements required by their role in the digitization process.

> “Ergonomics is incredibly important. The biggest impact to us is the chairs we use. We like the Trooper task chair (armless) high back TR-HAM and mid-back TR-MAM.”
>
> — Marge Thompson, Manager of Digital Photographic Services, Rasmuson Library, University of Alaska

3.8.3 Standing vs. Sitting Desks

Some institutions have begun experimenting in recent years with standing desks, usually with models which allow conversion between a standing height and a sitting height. This allows the technician to vary their posture, and may help some technicians avoid fatigue, back pain, and boredom. Program Managers for mass digitization efforts should consider the minor added cost of a standing desk, as comfort of the technician (and injury/fatigue) is paramount in maintaining consistent preservation-grade results.

> “The staging area at our large-format workstation is just over 14" high (editor's note: this is not a DTDCH station), which is an unbelievably awkward height for working on just about anything. It also necessitates the need to be up on one's feet, so bending over to look at a screen between shots adds insult to injury. The Assistant Director of our department sent over a standing desk that wasn't being used, which gave us an opportunity to test out the ergonomic impact before going all in. Needless to say, our Collections Photographer loved the new desk. We ended up ordering 3 more, settling on The Uplift 900 from The Human Solution. I'm sure there are many other comparable solutions out there, but we liked the design/impact/simplicity to price ratio. I have since had the opportunity myself to work with the desk and our ridiculously low large-format staging area, and I enjoy the combination quite a bit. CH Imaging is much more enjoyable on one's feet and with a little music on.”
>
> — Eric Shows, Assistant Manager, Digital Imaging Unit, New York Public Library

3.8.4 Flash vs. Continuous Lighting

Digitization programs vary wildly in number of captures in a day. For special collections, such as rare and fragile paintings, it may only be possible to make a handful of total captures. In such cases, a flash-based solution is entirely non-problematic. On the other end of the spectrum, a digitization program consisting of bound materials using a DT BC100 Book Capture System might reasonably create 3,000 captures per day; digitizing homogeneous 4x6 photo prints might reasonably create 6,000 captures per day. In such high-volume scenarios, the use of strobe lighting will strain the technician.

There is no hard limit to the number of flashes per day that is still considered comfortable for the operator. It will vary greatly based on the person, the brightness of the strobe, the ambient illumination, and where the light is relative to the technician. As a general rule of thumb,continuous lighting should be strongly considered anytime a technician will be expected to produce more than a few hundred captures in a shift. Since the technician plays a considerable role in this equation, we suggest they be included in the decision making process. We also advise selecting a modular digitization system that allows for switching between strobes and ambient light; the needs and limitations of the technician and the institution may change and such flexibility means the lighting can be changed rather than requiring switching to an entirely different digitization system.

3.8.5 Light Shielding

Whether using continuous or flash illumination, it is preferable to set up the lighting and physical space in a way that allows the technician to be largely shielded from looking directly into a bright light. Solutions for this can include dedicated hardware ranging from as high-end grid accessories to a simple flag made of gaffer tape and black matteboard. Alternatively, a hat or visor may reduce eye stress when the light source is positioned above the technician.

3.9 The Mental Factor

3.9.1 Boredom: Break Frequency & Variety

Digitization of our Cultural Heritage is a sacred duty, and is vital to humanity's self-exploration, but the process can also be very tedious, even boring. The technicians responsible for consistently and carefully carrying out the responsibilities of the digitization process need to be strongly considered in the setup of a digitization program. It is tempting to assume the greatest total output is accomplished by minimizing breaks, but many institutions have found in practice that their total productivity goes up and errors decrease when breaks are planned and enforced, even when on tight deadlines. Since repetitive tasks in digitization are similar to many areas of industrial production, additional reading on Human Factors Engineering or consultation with an expert in this field may be informative in fine-tuning a digitization program's procedures and policies.

3.9.2 External Distraction: the Enemy of Efficiency & Consistency

The modern culture of always-on communication, and the tendency, especially of younger technicians, to need to feel connected at all times has led to a situation where administrators need to be especially mindful of distracted technicians. It is both reasonable and productive for technicians to have breaks that include the freedom to use email/texting/social-media and the like during those breaks. However, the introduction of interruptions during active digitization can be especially disruptive and greatly increase the rate of errors. When engaged in rapid imaging, as in digitizing a several-hundred-page bound volume, a single mistake can cause significant loss of productivity. If an operator answers a text message mid-book and a page is skipped, the error may only be noticed during later QC, and the item may need to be recalled from storage to correct it.

We recommend against cell phone use during digitization. Moreover, on the systems being used for digitization, we recommend the administrator make use of free programs like Self Control or other admin-level blocking utilities to block access to non-work sites like Facebook, Twitter, Youtube, and common email sites like Yahoo Mail.

Many technicians underestimate the increase in errors created by distraction because those error rates are still quite low. For instance a distracted, technician might make mistakes on 0.3% of captures, while a careful technician might only make mistakes on 0.1% of captures. While it's true that 99.7% is still a seemingly good rate of error-free operation, it still represents a tripling of errors. Since each error offsets the productivity of many error-free captures, the effect on net productivity can be quite high even though the absolute error-rate is quite low.

3.9.3 In-House Distractions

Distraction can also be created by other technicians, managers, or internal communication. When possible, we recommend fostering an internal understanding that specific hours are reserved for continuous, uninterrupted digitization and non-urgent communication with technicians is actively discouraged at these times.

Many institutions allow the technician to wear headphones or play music at their station, both for entertainment and to reduce distractions from noise/conversation nearby. In considering this, project planners should research whether any important errors or warnings on any of the relevant digitization equipment are provided in audio-form only. In the case that headphones cannot be worn, it may be worthwhile to consider sound-reduction panels or providing overhead music in the overall digitization area.

With this in mind, we recommend making technicians stakeholders in their productivity, and the productivity of the total team. A system that objectively tracks image quality over time can help technicians realize the practical implications of their raw throughput, error rates, and net productivity. Performance bonuses (whether monetary, time off, or flexible schedules) and team goals can help foster a productive environment.

> "Imaging or processing all day can be tedious, and boredom can cause major problems. We allow people to listen but not to watch. Music, books or podcasts can help people get into the zone and actually increase productivity with fewer errors, though it can sometimes be a fine line between someone finding a balance and getting lost in the

> distraction. Music in the room can be a good compromise. Staff aren't plugged in and isolated and they can actually feel more part of a team."
>
> — Ian Bogus, MacDonald Curator of Preservation, University of Pennsylvania Libraries

3.9.4 The Four-Day Weekend Effect

When Object-Level Targets (OLT) are present in every frame digitized, the metrics can be extracted from a set of images using software like the GoldenThread software package from Image Science Associates (ISA) [see 5.4 - Numerically Evaluating Image Quality]. These metrics can be traced over time to evaluate the practical effect of any operational changes in ongoing digitization efforts. These metrics can also provide illumination on any number of phenomena.

Don Williams of Image Science Associates, an independent image-scientist and creator of GoldenThread, reports that an examination of long-term data at an unnamed major institution showed a significant and consistent downtick in objective image quality on the workday following a four-day weekend. While such study cannot completely isolate correlation/coincidence from causality, it seems obvious that a groggy employee is one more likely to make minor mistakes (e.g. slight misfocusing), degrading the quality of the digitization process.

We propose that the solution to such problematic findings is not to eliminate four-day weekends, nor to chastise employees for being a bit off their game following an overly exuberant Independence Day celebration. Instead, we suggest to incorporate such realities into the planning of the digitization program; potentially problematic work days could be days reserved for office organization and cleanup or non-detail-oriented administrative paperwork. Preservation digitization requires an alert, careful, mindful technician, and it is important to address the practicalities of life beyond the digitization lab.

> "Transitions and disruptions in workflows of ongoing digitization projects are the largest cause of unintended imaging performance changes, sometimes for the better, sometimes for the worse. More importantly, the message is that such inconsistencies make such projects difficult to manage. A classic case of this was demonstrated after a four day holiday weekend when digitization operations were discontinued. Upon start-up afterwards, there was a significant change (~1 stop) in exposure compared to an otherwise stable exposure history previous to the holiday. This was detected with simple day-today control chart tracking of highlight and mid-tone gray patches of an imaged Device level target at the beginning of each day's sessions."
>
> — Don Williams, Image Science Associates

4. The Standard Raw Digitization Workflow

4.1 Stages & Steps of The Standard Raw Digitization Workflow

For the purposes of this document, the Standard Raw Digitization Workflow begins when the technician has objects prepared and ready for digitization and ends when a final PDO (usually in the form of a TIFF) is delivered to the next stage in the workflow. The below basic outline can help to standardize conversations about workflow. These same terms are used in the workspaces of Capture One CH.

1. **Pre-Flight Stage**
    a. Establishing PPI (camera distance, lens selection, focus)
    b. Calibration (LCC, exposure, white balance)
2. **Production Stage**
    a. Object Handling (aka staging)
    b. Capture (naming, capture)
    c. Initial Quality Control (object completeness, organic exclusion, focus)
    d. Process Control (neutrality, exposure)
3. **Processing Stage**
    a. Cropping (auto or manual)
    b. Final Quality Control (set completeness, cropping, consistency)
    c. Processing PDOs (TIFF or JPG2000)

4.2 Where's the Metadata?

Metadata entry is not explicitly mentioned in the Standard Raw Digitization Workflow listed above. This is because the ideal time to enter metadata is highly dependent on the scope of the metadata an institution wishes to add to the PDO, and how unique or shared this metadata will be within a particular production run. When digitizing bound material it is common that each page will received the same metadata. In this instance, it is most efficient to enter the metadata in bulk. In contrast, when digitizing a collection of European paintings it is likely that most of the metadata fields will be different for each capture, and it is more logical to enter the metadata at the same time as capture. In institutions where a parallel workflow is used to apply metadata to the digital collection, it is possible that only a UUID is entered during the Standard Raw Digitization Workflow.

4.3 Advantages of the Standard Raw Digitization Workflow

Digitization systems that leverage the Standard Raw Digitization Workflow increase efficiency in mass digitization programs. These systems use raw files for preflight, capture, image transfer, editing, and quality control. This establishes a much faster workflow than the direct-to-TIFF model used by many scanning systems.

4.3.1 Fast Capture & Image Transfer

The Standard Raw Digitization Workflow captures a losslessly compressed raw file, resulting in a working file which is much smaller than a 16-bit TIFF. Counterintuitively, this raw file actually contains *more* information than its bloated TIFF counterpart as it represents exactly what the capture device captured without any translation or reduction. The small size of this raw file means that transfer of the capture from the capture device to the computer is much faster than possible with a direct-to-TIFF system. This speed disparity is further exaggerated when using a raw capture system with a modern connection like USB3 rather than the legacy FW400 and USB2 connections that are prevalent in scanning systems. A Phase One IQ280, for example, using its USB3 connection in the Standard Raw Digitization Workflow can capture and transfer the equivalent of a 480MB TIFF scan in about two seconds.

The increased transfer speed in this workflow also provides the technician immediate feedback so that Initial Quality Control (object completeness, organic exclusion, focus) can be completed at the time of capture. For instance, if the technician's hand was in the frame they will see it right away and it will only take another two seconds to recapture the frame.

4.3.2 Fast, Non-Destructive Batch Editing

Working with raw files means that settings like white balance, deskewing, crop (automatic or manual), level adjustments, and sharpening can be made without making permanent destructive changes to the underlying data. For example, a technician may want sharpening to be applied during the capture/edit/QC stage because it's easier to differentiate between pretty-good focus and excellent focus with some sharpening applied. In a direct-to-TIFF workflow that "evaluation" sharpening would be destructively/irreversibly applied to the underlying data. In the Standard Raw Digitization Workflow the sharpening is simply a setting that can be changed at any time. In fact, in Capture One Cultural Heritage (CH) 8 Edition, there is a dedicated check box for "disable sharpening" which can be included on a specific recipe, saving the step of changing the sharpening setting when generating final TIFF/JPG2000 files.

4.3.3 No Open/Save/Close Required

Moreover, in Capture One CH 8 batch editing can be applied to huge numbers of captures with nearly instant results. A common editing-stage operation would be to make two versions of each capture, one which includes the Object Level Target [see 5.4.3 - Object Level Target] and one which crops the Object Level Target out. Capture One CH 8 can sync a crop across two thousand Phase One IQ280 raw files in about five seconds, approximately the same time as it takes in Photoshop to open/crop/save/close a *single* 480MB TIFF.

4.3.4 Quality Control Before It's Too Late

In a direct-to-TIFF workflow, most Quality Control failures require rescanning the original material. For instance, if the TIFF was cropped, had its black point over adjusted, or was incorrectly sharpened, then the TIFF cannot be "reset" - the changes are baked into the output. In a Standard Raw Digitization Workflow, the quality control for such issues takes place before the captures are processed to TIFFs/JPG2000.

The ability to do quality control at the raw stage is especially useful when using the AutoCrop function of Capture One CH 8. No automatic cropping tool can ever be 100% accurate; the results will always need to be quality controlled. But, since the AutoCrop sets a crop as an adjustment to the raw file, rather than making an irreversible change to a TIFF, occasional errors in automatic cropping can be caught and corrected during the Final QC stage without the need to repeat the digitization process. If a crop is slightly uneven, the technician can simply drag the crop to the correct position. Since the raw has not yet been processed, the correction does not require reprocessing or otherwise going backwards through the workflow.

4.3.5 Separation of Capture & Processing

Raw files must be processed into TIFFs or JPG2000 files, but in the Standard Raw Digitization Workflow, this step is offloaded to avoid using valuable technician time or monopolizing the capture station. In the case of Capture One Pro, the processing can be queued throughout the day and then set to run overnight, or the entire processing job can be offloaded to another station. Either way, the digitization of new/additional material can continue unabated.

In Capture One, a job/batch of scans are put into a "session" that is self-contained and portable. All adjustments to the raw files can be bundled into the raw files themselves (EIP Format) so that moving, uploading, renaming, or reorganizing the raw files does not break the workflow.

4.3.6 Case Study of Speed Improvements

Let's compare the technician labor time for each of these methods. Object handling time will vary significantly based on the condition of the drawings, their manner of storage, and handling protocols in place for that material, so the numbers here are rough estimates. Given the requirement to open and close the scanner top, we'll add two seconds for the scanner.

	Handling	**Capture**	**Applying One Crop**	**Total Technician Time**
Non-Raw Workflow (e.g. Scanner)	10 seconds / drawing = 333 minutes	20 seconds / drawing = 667 minutes	3 seconds / drawing = 100 minutes	18 hours
Standard Raw Digitization Workflow (e.g. Phase One IQ280 on DT RCam)	8 seconds / drawing = 267 minutes	2 seconds / drawing = 63 minutes	3 seconds *total* = 3 sec	6 hours

The above example assumes that a static crop will suffice for all captures in the production run - thus the "Applying One Crop" is listed as 3 seconds per drawing; approximately the time for a batch script to open/crop/save/close a particular file in Adobe Photoshop. If intelligent per-image cropping is required (e.g. each drawing is a different size), the speed disparity grows, since the Auto Cropping function of Capture One CH 8 requires only a few seconds of technician time (total) regardless of the number of images being cropped or whether the crop varies from one capture to the next. In contrast, manual cropping requires additional technician time for every drawing captured.

Also consider that the additional 12 hours of production time has not provided any additional benefits. To the contrary, the image quality of the scanner will be *lower*, and the handling of the materials will be *harsher* (since it involves pinch-style two-sided contact).

5. The PDO Content: Image Quality

5.1 Overview of FADGI & METAMORFOZE

The the most highly regarded guidelines to date have been formulated out of a need to create objective requirements for digitization contracted by government entities to 3rd party vendors. The two best known guidelines are from:

- Federal Agency Digitization Guidelines Initiative (FADGI) - a US based interagency government effort
- METAMORFOZE - a venture between the National Library and National Archive of the Netherlands.

These are known, in shorthand, as FADGI and METAMORFOZE. In general, their similarities are much greater than their differences. Many institutions have adopted these guidelines for their own in house digitization and carefully scrutinize hardware, software, and workflows to ensure they meet or exceed the requirements set forth in these guidelines.

Both FADGI and METAMORFOZE describe several tiers of quality. Loose equivalencies of these tiers are shown below.

General Description	FADGI	METAMORFOZE
Very Low Quality	1 Star	No Equivalent
Low Quality	2 Star	Extra Light
Mid Quality	3 Star	Light
Preservation Grade Quality	4 Star	Strict*

*In the official documentation the three tiers are unhelpfully referred to simply as “METAMORFOZE”, “METAMORFOZE LIGHT” AND “METAMORFOZE EXTRA-LIGHT”. Here we are taking the liberty to use “Strict” to refer to denote the “METAMORFOZE” tier.

The purpose of these tiers is not to pass negative judgement on digitization executed at less-than-preservation-grade quality. There are some use-cases where there is no incremental value in accomplishing digitization at a higher quality. For instance, neither color nor tonal-accuracy is critical for patron requests for text-only circulation material; if the patron can read the result clearly, the quality was more than sufficient for the task.

However, as we argued in Unforeseen Costs of Imaging for Short Term Needs we feel strongly that Preservation Grade Quality (METAMORFOZE-Strict or FADGI 4-Star) should be pursued unless it’s eminently clear that such quality will not offer additional value.

> “The principals behind FADGI and Metamorfoze are exactly the same: measurable and standardized guidelines for assessing digital imaging performance. They both use the exact same ISO methods for measuring performance and both use graduated (or tiered) levels of imaging performance specification. The differences lie in the flexibility and choices of those specifications. Metamorfoze was intended for general preservation imaging tasks and the specifications are designed for such a use case with three distinct non-interchangeable categories. FADGI guidelines can also be chosen for preservation but also allow for lesser or greater needs. For instance, color imaging performance in FADGI can be specifically relaxed relative to other performance metrics (i.e. interchangeable) if the use case supports such a choice. There can be a greater variety of performance levels between imaging metrics in FADGI than in Metamorfoze. Generally though, FADGI three star levels are the same as all Metamorfoze specification levels.”
>
> — Don Williams, Image Science Associates

5.2 Technical Specifications of FADGI & METAMORFOZE

5.2.1 Resolution: Beyond "Optical" vs "Interpolated"

Sampling Frequency is the number of pixels (typically measured in ppi, or pixels per inch) used to represent the physical object. This measurement does not represent how much meaningful detail is present; it is unaffected by inherent sharpness or additional sharpening added in post processing.

Imagine that a professor asks his students to write a 20-page essay, and every student in the class turns in an essay that fills 20 pieces of paper. In the strict sense, all students have fulfilled the requirements of the assignment. However, some students use double spacing, others add padding between the letters, and many use filler words and phrases that add no actual detail to their arguments, and only a few actually fill 20-pages with precise and meaningful content.

This example is very similar to the way that many, perhaps even most, digitization systems claim to scan objects at a particular PPI; at closer inspection the amount of precise and meaningful image content is well below that PPI. Worse, over time such marketing misrepresentation of the actual detail level has become better hidden.

For many years, Cultural Heritage Institutions have known to look for "optical resolution" in scanning systems, as scanner manufacturers would often provide non-optical interpolated resolutions in their marketing material and only show their optical resolution deep in technical specification lists. This is the equivalent of double-spacing an essay, and is quite obvious and well-known. Here are more subtle forms of marketing inflation:

- **Theory vs. Measured:** Stating only the resolution of the sensor, which provides a theoretical maximum resolution, rather than the as-measured resolution of the entire system. A 36 megapixel sensor used with a mediocre lens does not record files with anywhere near 36 megapixels of actual subject detail.
- **Center vs. Edge:** Stating the resolution measured in the center of the image, rather than the resolution in the corners or edges. Most general purpose photographic lenses, including even expensive, high-end lenses, are not as sharp in the corners as in the center.
- **One Axis vs. Both Axis:** Stating the resolution measured in one axis, rather than both. Scanning systems (planetary, flatbed, or rotary fed) that move during the capture of the image often have measurably better detail along the axis of the scanning array than along the axis of their motion. In other words, the image is subtly blurry in the direction of the motion.
- **Sharpened vs. Native:** Many systems have excessive sharpening applied automatically or in the background, hiding the native sharpness (or lack thereof) from the user. The resulting image appears visually sharp in the same way an auto-tuned singer sounds on-pitch.

As manufacturers exaggerate resolution in increasingly sophisticated ways, it has become clear that the community needs a foolproof, objective way of measuring resolution. The members of the FADGI Still Image Working Group assessed many proposed measurements for the level of actual subject detail recorded in an image, and settled on Spatial Frequency Response (SFR).

SFR is a fairly complicated mathematical modeling of how well detail is recorded at various feature sizes. It has many features, including the ability to reveal when an image has been over-sharpened, and allows a more holistic analysis of detail than any metric based on a single number. Simplicity, however, is not among its advantages. The formula used to generate a graph, which is then analyzed to provide the final relevant rating number, is available on the Wikipedia article on Optical Resolution. It is unlikely that any institution would undertake manual calculation of SFR. Instead, SFR is almost always calculated by one of the several image-analysis software packages discussed in 5.4 Numerically Evaluating Image Quality.

The bottom line is summarized well at Archives.org:

> "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)."

— (page 33, www.archives.gov/preservation/technical/guidelines.pdf

5.2.2 Tone & Color Accuracy

The ability to compare objects from disparate institutions, digitized at different times, and potentially digitized by different equipment, requires very precise control of tone and color. Both FADGI and METAMORFOZE specify tone and color control by providing tolerances for:

- **Maximum Delta E:** All measured color-errors must be below this value.
- **Average Delta E:** The average color-error cannot exceed this.

FADGI and METAMORFOZE use different formulas:

- **Delta E 1976 | METAMORFOZE:** The original Delta E formulation.
- **Delta E 2000 | FADGI:** A modern revision that weights errors based on how likely it is to see a difference between two colors assuming the intended user of the images is human (as opposed to machine analysis).

The limits for tone and color error are given below:

	FADGI 4-Star (ΔE* 2000)	METAMORFOZE-Strict (ΔE* 1976)
Maximum Error	6	10
Average Error	3	4

5.2.3 Noise

Both FADGI and METAMORFOZE suggest the measurement of noise, but do so in slightly different ways.

- **FADGI:** Standard deviation for each neutral patch plus red, blue, and green patches.
- **METAMORFOZE:** Standard deviation in each patch.

The limits are given below:

	FADGI 4-Star	METAMORFOZE-Strict
Measure	One Standard Deviation	One Standard Deviation
Measured ROI	Every Neutral Patch. Red, Blue, & Green Patch.	Every Neutral Patch
Noise Level	< 2.0 levels	< 4.0 levels

The measurement of noise is especially prone to three complications:

- **Noise Reduction in Software:** Many digitization systems apply noise reduction by default, or in a way that is not transparent to the user.
- **Unclean Targets:** Foreign matter such as hair, dust, or grime will often be read as noise. A very clean target is required for proper analysis of noise.
- **Real-World Variation in the Target:** The assumption in the formulas is that the subject matter is, in reality, 100% homogenous, so any variation at all is a capture error. In practice, however, even the highest-end targets can have minor imperfections.

5.2.4 Illumination Uniformity

Both FADGI and METAMORFOZE provide methodology for evaluating the evenness in which the object is illuminated. This can be accomplished natively or by post processing compensation. The latter technique opens up a host of possibilities, including:

- Allowing for a smaller working area than could otherwise be achieved.
- Allowing for non-even source lighting that enhances texture without compromising uniformity of the subject's brightness.

Major limitations and challenges to measuring or achieving illumination uniformity include:

- **Bound Materials:** When a bound material is imaged at a non-180 degree opening, one page will inevitably bounce light into the facing page; when there is any variation in the density or color of the page (e.g. a heavily illustrated page, a manuscript with gold embellishments, or a blank page) then this will result in a variation of the illumination uniformity. This can make it nearly impossible to achieve FADGI 4-Star illumination uniformity in bound materials, unless a different correction is made and applied to every individual page.
- **Only Luminance is Considered:** Some systems may have slight color biases in one area of the frame. For instance, when illumination is provided by two lights on opposite sides of the object, a slight difference in color temperature between the two light sources will manifest itself most at the outer edges of the frame. If the target patches used to measure color accuracy reside in a small part of the overall frame, then this drift in color will not affect color accuracy, and may not be detected by Luminance Uniformity checks based only on luminance.

5.2.5 Color Registration

Low quality lenses and systems that use motion for capture (e.g.: linear and planetary scanners) can cause misregistration of color. Such misregistration can manifest itself as a ghosting-offset or chromatic aberration, and is more commonly seen as a color alongside hard-edge, high contrast lines. Misregistration of color makes it difficult to judge small, fine details, as it is impossible to know (especially in the context of a future viewer separated from the digitization process) whether such offset was present in the original (e.g. a production run of newspaper where the printing press plates were misaligned) and correctly captured, or whether it was an artifact of the digitization program.

5.3 Visually Evaluating Image Quality

Visual comparison of an object to the digitized version of the object is a practical and common, but surprisingly limited and imprecise way of judging color and tonal accuracy. Whether comparing to monitors or prints inherent limitations in the hardware and limitations of human perception of color make such visual comparison fraught with difficulty.

> "Obtaining an accurate visual match of a complex scene or object under dual-stimulus (i.e. both rendered image and object are at hand and can be compared side by side) is nearly impossible. While a colorimetric match might be possible, differing spectral content (metamerism), human sensitivities and capture/display variabilities are always present. For instance, the term "daylight" illumination is often mentioned as some solid gold standard. In fact it can have several meanings (D50, D55, etc.) and types of spectral content. All of these make it quite difficult to make exact perceptual color matches, especially when multiple people are trying to agree on the match."
>
> — Don Williams, Image Science Associates

5.3.1 Visual Comparison to a Monitor

Visually comparing a digital capture on a monitor to the original object can be useful, provided due consideration is given to the environment in which this comparison is performed. If normal ambient lighting, consumer monitors, or an uncalibrated workflow are included, then visual comparison will be meaningless.

- **Monitor Hardware:** Most computer monitors available for purchase are designed with a relatively low priority assigned to color/tone accuracy. Consumer-grade models produced by companies such as Apple are targeted at consumers who want their monitors to be bright, contrasty, and saturated. There are many technical elements that go into creating a monitor intended for color proofing, which are beyond the scope of this document. In general, it can be said that all engineering is a set of compromises and priorities; a monitor engineered to sell to consumers will not perform as well for color-critical uses as one designed specifically for such use.
- **Monitor Calibration Method:** Normal monitors accomplish “calibration” via software that limits the output of the graphics card. Such software calibration can improve the accuracy of color the monitor displays, but can also lead to artifacts such as banding and gamut instability. Professional color-critical monitors provide hardware calibration where the monitor output itself is calibrated. This allows the full output of the graphics card to be used. Note that using a hardware-calibrated monitor like an Eizo CG series with a software-calibration program like X-Rite i1 Profiler results in a software-calibration. For best results, it is recommended that software allowing for hardware calibration is always used. In the case of an Eizo CG series, the industry standard for color accuracy, Eizo’s Color Navigator software should be used.
- **Monitor Calibration Settings:** A high-quality monitor calibrated carefully to the wrong standards will be very precise, but inaccurate. When comparing a monitor to a physical object, it’s important the brightness and white point are closely matched. Placing an object inside a proofing booth makes this especially straightforward, as the booth will be made to target a specific white point. For example, when using a D50 proofing booth, it would be appropriate to calibrate your monitor to a D50 standard. A D65 standard is appropriate if using a north-facing window while the sun is high in the sky.
- **Ambient Illumination:** The human vision system automatically adapts to the predominant ambient illumination. The most obvious adaptation is the opening and closing of the pupil as the brightness of one’s surroundings shift. More subtle adaptation can be demonstrated based on changing color temperature. For this reason, it is important to measure and control the ambient lighting in a room used for color evaluation.

5.3.2 Visual Assessment as a Safeguard

Visual assessment is especially useful as a guard against user-error or equipment failure. For instance, if a test target is dusty, numerical analysis may indicate there is excessive noise in the image; the software has no way of knowing that the target itself is actually dusty. Likewise, any manner of software or user error can result in numerical evaluations that are grossly incorrect. When numerical analysis shows a significant and sudden change from past results, the first step in troubleshooting is usually to make a visual assessment to determine whether the digital object or the evaluation of the digital object is in error.

5.3.3 Visual Assessment for Subjective Rendering

In some cases, objective accuracy comes at the cost of a rendering that would be generally considered pleasant and representative of the intention of the original artist or the original presentation of the object. This is especially true in the case of transmissive and three-dimensional objects. A skilled technician can bring their visual vocabulary, experience, and understanding of the context and intent of the physical object to bear on the way it is rendered. For example, the imaging technician might need to render the object being imaged relative to the weight of the image content. If one is to image white paper that contains a light graphite drawing the exposure, tone needs to be darker than what the target indicates to make the content readable for the viewer. It is the experienced technician’s job, in consultation with curators and other stakeholders, to ensure that the rendering selected is optimal for the intended purpose.

5.3.4 Visual Comparison to a Print

A carefully calibrated print workflow can be used to compare a digital capture to the original physical object. This method has obvious limitations, namely the increased number of variables to control as the printing workflow itself needs to be done with high quality and meticulously calibrated hardware. This makes it less than ideal for truly critical color evaluation.

There are also significant benefits that cannot be easily achieved using a monitor-only comparison workflow. First and foremost, the print can be transported easily, allowing it to be brought to the object for comparison, if, for instance, the object has been returned to storage or is now located with the restoration team. Less obviously, a print is, like the original physical object, also a reflective object and therefore the disparity in perception between transmissive and reflective objects is not present.

It should never be assumed that because both a print and an object are physical objects that they will match in all lighting conditions. Color is a fickle perception. Changing the light source to one with a different spectral output means different objects that were the same color will appear as different colors, an effect called ‘Metameric Failure’ which limits the utility of print-to-object visual comparisons.

5.4 Numerically Evaluating Image Quality

The unpredictable nature of color has compelled most major cultural heritage institutions to include numerical analysis of image quality into their quality control workflows. There are a variety of ways this can be accomplished, and when properly implemented, can significantly contribute to the creation of consistent and correct PDOs. However, it is critical to avoid blind pursuit of numeric perfection. Numbers are oblivious to intention and context. Each image quality metric (e.g. illumination uniformity, sampling efficiency, etc.) can be analyzed by a machine, but such analysis should not be followed without context and understanding.

5.4.1 Test Targets & Spectral Measurements

There are three ways to confirm that the PDO has accurate color and tone: evaluation of a Device Level Target, evaluation of an Object Level Target, or a direct measurement of the object with a spectrometer.

5.4.2 Device Level Target (DLT)

A Device Level Target fills most or all of the captured scene. This allows measurements to be taken across the entire frame and provide extensive visual features for analysis. For example, a device level target may have dozens, or even hundreds, of color patches, a full grayscale ramp, an inch/cm ruler or other dimensional reference, a slanted edge target, gradually converging lines with annotated cycle rates, and several identical patches spread out across the target (to evaluate various kinds of intra-frame consistency).

However, a device level target, by definition, can only be included in substitution for an object; it is not intended to be imaged alongside an object. Therefore, this type of target is most useful for calibration and process QC, by including one at the beginning and end of a production run, for example. Note that a color chart by itself, such as the X-Rite Color Checker, is not a device level target. Such color charts only contain color patches. Wherever possible, a true Device Level Target like the one produced by Image Science Associates is strongly preferred as it provides a variety of test features beyond color patches.

5.4.3 Object Level Target (OLT)

An OLT is small enough, and of an appropriate narrow aspect ratio, to sit alongside an object during the course of a normal digitization production run. Many institutions mandate that all digitized material include an Object Level Target in-frame.

An Object Level Target usually carries features similar to a Device Level Target. The range of these features is not as large as Device Level Targets because of their smaller size. However, high quality targets like those from Image Science Associates still provide for evaluation of color, tone, DPI, and SFR.

Some institutions are still making use of legacy targets such as the Color Control Patches from Kodak. These sorts of targets were developed primarily for printing-press workflows and color-separation films decades before the advent of modern imaging guidelines like FADGI and METAMORFOZE. The manufacturing tolerances of these targets were not very tight; a patch on a specific copy of these legacy targets may vary considerably from the stated “correct” value of that patch. Modern targets such as those from Image Science Associates are strongly preferred over legacy targets because they were developed for digital image creation and are made to very tight tolerances.

5.4.4 Measurement from the Object

A spectrometer such as the X-Rite i1 can be used to make a spectral measurement of a specific point on a object. This can be useful where the object may contain material which suffers strong metameric failure, or for forensic or scientific analyses. However, it has four significant limitations in mass digitization programs: speed, location specificity, and illumination angle, and the requirement for contact.

Speed: Measurements using a spectrometer are tedious time consuming. Each measurement only takes a moment, but can only be taken after the location has been carefully selected and the spectrometer precisely positioned.

Location Specificity: Each measurement is inherently linked to a specific location on the object, so the exact location on the object must be carefully recorded. Moreover, it's most useful to select an area of homogenous tone since it can be difficult to correlate the location in the PDO with sufficient precision to isolate a particular brush stroke or detail. This eliminates (or at least greatly challenges) use in areas of high frequency detail.

Illumination Angle: Most spectrometers provide illumination which is fixed at 45°. Those with "flexible" angles of illumination are locked to a selection of three or four hard-wired angles (e.g. 30/45/60°). There are systems called goniospectrometers, and allow for a full spectral reading at any arbitrary angle of illumination, but they are incredibly slow to use; they are useful for research, but are not suitable for use in a mass digitization program. In practice, nearly all such measurements made in Cultural Heritage environments are made with a spectrometer that illuminates the object at 45°. This is in stark contrast to the actuality of digitizing real world objects, which often require non 45° illumination to avoid issues like glare and reflections.

Requirement for Contact: Most commercial spectrophotometers require direct contact, or extremely close proximity, with the surface being measured. This limits their applicability for objects where handling protocols may forbid direct contact (or high risk of direct contact). Spectrophotometers capable of taking measurements at a distance are available, but are manufactured for the scientific-research market and carry commensurate price, size, and technical acumen.

5.4.5 Target Analyzers

An Object Level Target or Device Level Target in a PDO must be analyzed to be useful. Several software packages exist which can automate this process, including the GoldenThread software package from Image Science Associates, and the Delt.ae website.

ISA GoldenThread - This software is especially useful for continuing process control, as it provides professional-level traceability and quality auditing for long term digitization projects.The Four-Day Weekend Effect [see 3.9.4 - The Four-Day Weekend Effect] provides an interesting example of what insights such traceability can provide. The author, Don Williams, sits on the Still Image Digitization Advisory Board that created the FADGI Guidelines, and has taken great care to ensure that the exact algorithms and implementations of GoldenThread comply with the spirit and letter of the FADGI Guidelines.

Delt.ae - This website is provided by the European for-profit digitization company Picturae. It is notable as a no-cost solution for basic target evaluation. Development has been sparse since 2012, but basic support is provided for a variety of targets. Certain specifics of their implementation are not ideal, so the results from GoldenThread should be prefered when results between them differ. Since the tool is hosted online, rather than installed locally, it can be limited by the connection speed and network policies of the client. Purchasing GoldenThread ensures perpetual access, whereas there is no guarantee the Delt.ae website will be available indefinitely.

6. The PDO Container: Format & File Fidelity

6.1 File Formats

6.1.1 Raw

The value of raw files in the process of Cultural Heritage Digitization is enormous. As described in the Standard Raw Digitization Workflow, it can significantly increase productivity compared to direct-to-TIFF workflows. However, the raw itself is not generally considered to be a Preservation Digital Object. No two raw processing programs will render a particular raw file identically, and even different versions/generations of the *same* raw processing program will render a particular file with subtle, but non-trivial, differences.

There is often value to maintaining a short/mid term archive of the raw files used to create the PDOs in a collection. For instance, between Capture One v3, v4, v6, v7, and v8, there were significant and continuous improvements to the amount of real detail that could be extracted from a given raw file which yielded tangible increases in numerically measured sampling efficiency and perceived visual fidelity; this improvement was due to improved algorithms in the software. These benefits could only be seen when reprocessing the original raw file, so institutions that only had processed derivatives like TIFFs missed out on this gain in quality.

Given these improvements in raw processing, it makes sense to retain raw files for months or even years. However, a raw file does not stand alone - specific software is required to convert it into a useful image; the same raw file, opened in different (or future) software changes the way the image appears. So in the scope of decades and centuries, the raw file should not be considered a preservation object.

There is also some value to having the raw files in the short-term and mid-term as a low-storage-cost emergency backup of the PDO TIFFs/JPG2000 files.

> “In 2014, six months into a massively expanded digitization effort, we had a significant failure in our primary storage system. Since the expanded digitization program was just ramping up and our off-site emergency backup solution had not yet been finalized, some portion of our work was lost. Fortunately our IT department had provided us with separate storage for a raw file archive; I insisted we carry over the film-era practice of keeping your negatives. Reprocessing these raw files to TIFF meant we did not lose any work. It really saved our bacon.”
>
> — Brad Flowers, Dallas Museum of Art

6.1.2 DNG

Despite misconceptions to the contrary, DNG is NOT a preservation format. It is simply a wrapper for raw files which conform to guidelines provided by, and under constant revision by, Adobe. In the same way a “normal” raw file should not be considered a PDO, neither should DNG. With either a “normal” raw file or a DNG-wrapped raw file the final image depends on both the file and the software (and version thereof) used to open it. A DNG-wrapper improves the likelihood that a file will be easily “opened” but does not guarantee the image it contains will look the same as when it was created.

6.1.3 TIFF

The gold standard of preservation image formats, the Tagged Image File Format or TIFF (aka .TIF or .tif) file is notable for its exceptionally wide adoption, fully documented and transparent format, versatility, and simplicity. It seems likely that commercially available solutions will be available indefinitely to read TIFFs, but with digital technologies, the commonplace can become obscure history with startling speed.

The simplicity of the format itself distinguishes TIFF from other formats more than any other attribute. A programmer with limited experience could create a fully-featured TIFF reader using nothing but the 121-page document outlining its specification; assuming the collection is held as standard TIFFs with LZW compression, this might take an entry-level

programmer one day of work to complete. Thus this format can be easily integrated into future system on new platforms and provide a consistent rendition of the underlying image well into the unknown future.

6.1.4 JPG2000

Years ago, the JPG2000 format was created to be the successor to TIFF for preservation applications. It provides for several major variations, including lossless and lossy wavelet compression. However, wide-spread adoption of JPG2000 has not materialized, and the slow adoption rate warrants concern about its utility as a long term archival format. It is more commonly in use as a service/presentation format than the format for a PDO.

6.1.5 Additional Formats and Considerations: LOC

The Library of Congress run website, www.digitalpreservation.gov, lists seven primary factors used to determine the suitability of a file format to preservation: Disclosure, Adoption, Transparency, Self-documentation, External Dependencies, Impact of Patents, and Technical Protection Mechanisms. Reports are provided for many image formats under these considerations (e.g. TIFF Report).

6.2 JHOVE Validation

6.2.1 Intention & Practical Use

Many institutions use a particular commercial software package to confirm that a file is opening correctly (i.e. no error messages are presented and no obvious visual discrepancies are visible) as part of the Initial Quality Control or Final Quality Control. For instance they may open a file in Adobe Photoshop. However, this is an impartial check of the validity of the file. If there is an issue with the file a commercial software package may ignore it, or attempt to automatically compensate for the error in a way that is not transparent. There is no guarantee that a different software package decades or centuries from now will handle such an error the same way. If a file exactly conforms to the specifications of its file format there is a much greater confidence of trouble-free compatibility with programs built to read that file format based on its specifications.

The JSTOR/Harvard Object Validation Environment (JHOVE) was co-developed by JSTOR and the Harvard University Library to provide institutions a robust and reliable way of evaluating files for adherence to their format. It serves three specific purposes purposes: Identification, Validation, and Characterization. Of these, this document is most concerned with its use for validation. When given a file purporting itself to be a valid example of X file format, JHOVE will check every required attribute of that format for compliance with the specifications of that file format. It then reports on whether the file is well-formed and valid.

In addition to end-users, JHOVE can be used by manufacturers to ensure that their software packages are creating PDOs which strictly adhere to their purported file formats. Phase One uses JHOVE to check the output formats of every release of Capture One CH.

6.3 Metadata

As mentioned in the Foreword, the topic of metadata is not discussed in-depth in this document. However, its complete absence in this section would be conspicuous.

6.3.1 Self-Description

Who has not had the experience of looking through a parents' photo album and finding a potentially interesting photo with a frustrating lack of notes of who is in the photo or when/where it was taken (i.e. metadata)? Metadata is sometimes described as "additional" information, whereas in many cases the metadata is of equal importance to the content itself in the interpretation of the object. An image of a primitive cave painting is of greatly diminished value to someone researching the early origins of artwork if it lacks metadata describing its location and information on any carbon dating.

Perhaps one day in the distant future Artificial Intelligence will advance to the point of reliably analyzing a PDO based on its image content alone. Imagine an algorithm analyzing a photo from a presidential inauguration and identifying each individual based on facial recognition and an automatic search of news accounts and social media posts of that day, or scanning

Picasso's *Guernica* and identifying it as an oil on canvas depicting a scene of human suffering, painted in a cubist style - without manual entry of metadata. Until this fanciful future occurs it falls on the technicians and project managers of Cultural Heritage Institutions to ensure that PDOs have the appropriate metadata to provide context and facilitate a deeper understanding of an object.

6.3.2 Finding Aid

Primarily, metadata is often thought of as a way to provide a viewer additional context to an object. In fact, it is the ability for an object to be *discovered* by a viewer for which metadata is indispensable. Digitization is only useful if the end result, a digital collection, can be efficiently used, and metadata is not just an aid to this use, it is the most important means by which that use will be effected.

As the world's digital collections continue to become increasingly centrally accessible, the total size will be measured with storage prefixes which we are only abstractly aware of, like exabyte, zettabyte, and yottabyte. In such collections there is no ability to search or organize manually - all organizational operations take the form of searches. A PDO without proper metadata in such a collection is like an unlabeled box in an unfathomably massive warehouse. While this guide does not include extensive information about Metadata, it is of unquestioned value to a digitization program.

7. Institutional Policy Worksheets

In this section is a list of areas that a digitization program manager may need to make institutional policies for. It is left blank so it can be filled in as part of the planning stages of a digitization program, or as part of a revamp of an existing program. The particulars of each list item are not discussed in the checklist, but can be found in discussions elsewhere in this document. Consultation within an institution is often required, as many of these policies have impacts well outside the digitization team.

7.1 Material Handling

Handling Procedure	Collections Allowed	Collections Disallowed	Notes / Limits
Gloved Hands			
Ungloved Hands			
Vacuum Tables			
Contact Scanning - PSI Limited (aka PSI Controlled Contact)			
Contact Scanning - No PSI Limit (aka Uncontrolled Contact)			
Contact Scanning - Restraining Belt			
Contact Scanning - Restraining Bar			
Bound Material - Disbind			
Bound Material - Open 180 degrees			
Bound Material - Open 100 degree			
Exposure to Daylite (5 min)			
Exposure to Daylite (30 min)			
Exposure to Low Heat			
Exposure to High Heat			

7.2 Imaging Quality Guidelines

Quality Level	Metrics Used (circle one)	Relevant Collections	Exceptions & Notes
Preservation	FADGI 4 METAMORFOZE Strict		
Below Preservation	FADGI 3 FADGI 2 FADGI 1 METAMORFOZE Strict METAMORFOZE Light METAMORFOZE Extra-Light		

7.3 PDO Checklist

The Digital Object...	Circle One
has been validated (by e.g. Golden Thread) to contain FADGI 4-Star Image Quality	Yes / No
has been validated (by e.g. JHOVE) to contain well-formed and valid data in a format widely acknowledged as preservation friendly (e.g. TIFF)	Yes / No
has metadata to accurately link to the real world object it represents	Yes / No
has metadata to aid in the discovery of the digital object within the collection	Yes / No
has metadata to provide sufficient context to aid the understanding of the object it describes	Yes / No

7.4 Roles

Role Name Per this Document	Role Alternative Terms	Individuals Assigned to These Roles
Project Manager	Program Administrator	
Technical Manager	Lead Technician Technical Lead Technical Planner	
Technician	High-Level User Power User Skilled Operator	
Operator	Student Worker Temp Labor Volunteers	
Assistants	Runner Production Assistant Extra set of Hands	

7.5 Collection Prioritization, ROI Assignment

		Collection 1	Collection 2	Collection 3	Collection 4	Collection 5
	Collection Name					
VALUE	Uniqueness					
	Research Value					
	Provenance Donor Value Obligation					
	Copyright Status Use Allowances					
	Public Value					
	Relevance to Core Mission					
	Temporal Relevance					
	Political Factors					
	Current Physical State, Risk of Degradation					
INVESTMENT	Material Handling Restrictions					
	Location of Collection					
	Suitability to Today's Digitization Technology					
	Current State of Preparedness					
	Return on Investment					

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