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Preservation of Photographic Images for Future Generations: New Opportunities for Prints and Photo Books with a Conservator's Perspective

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Abstract

Upon discovering the 120 year old object in their grandparents' attic, most people today would be hard-pressed to play back a recording made on a wax cylinder of the late 1800s. What will people do just 50 years from now with an optical disk or magnetic hard drive? Over time, we have recorded our memories in many ways: letters, post cards, photographs, movies, audio and video recordings are a few examples. In earlier days, interpreting those recordings was independent of the technology used to create them – you could hold and view a hard copy document in your hand. How will future generations deal with those post cards, letters to the family, and photographs that have now been replaced by "Word documents", email, and digital images on the computer? Professional and mass-portrait labs are beginning to recognize the importance of hard copy images, and the value they can provide to the end consumer. However, the end consumer in particular needs to become aware of long-term storage issues that relate to the preservation of the data behind digital photographic images. Longer-term issues beyond routine backup and migration of data need to be considered, and preservation via human-readable hardcopy images is a key option. As conservators we need to be aware that hard copy photographic images using various imaging technologies will continue to be present in the future, especially if the photographic market is successful in its efforts to expand printing of digital images. Conservators can also be a part of the educational process to help spread the word on the importance of preserving photographic images. This can be done both by publically showcasing restored works from the past as well as using images from the past to promote the value of hard copy photographs into the future.

Introduction

As our world of photographs becomes more and more digital, there is an ever-growing concern over long-term storage and the preservation of these images, especially as it relates to the general public. While the photographic printing industry is certainly aware of this concern, the general public is not. Earlier papers by this author on the subject of long-term preservation (LaBarca 2007, 2010) have dealt with digital photographic images and the use of film as a technology-independent storage medium while a more recent paper (LaBarca 2011) focused on documents of all kinds, including digital files of letters, emails, as well as photographs. The focus of this paper is long term preservation of the "best of the best" of consumers' photo images through hard copy output products from the photo printing industry and to make conservators aware of, and supportive to, industry efforts to preserve digital images through printing. The goal of this paper is to reinforce to conservators the issues surrounding the long-term preservation of digital photographic images with the hope that conservators can help spread the word on the importance of hard copy photographic images, both from the past and into the

future. Ultimately, this will help insure that the next generation of photographic conservators actually have hard copy photographs to conserve.

Current State

As personal computers, notebook/"tablet" computers, and smartphones continue to grow in use, digital imaging, email, and social media become more and more popular as the primary mode of documenting our lives. This creates an ever-growing concern over long-term storage and the preservation of these memories and documents. While some, perhaps many, of these files do not need to be preserved for the long term, some do. Unfortunately, consumers often do not recognize the importance of many of their images; for example, it may not be until a photograph is "rediscovered" 20 to 30 years later that people realize how valuable it is. In the digital world, without proper attention now, digital documents of all kinds will simply not be available 100, 50, or perhaps even 30 years in the future.

Despite efforts by photo industry trade organizations, the average consumer continues to be generally unaware that there is an underlying risk associated with information storage on computer hard drives, digital devices, optical media, or even storage "in the cloud". In many cases, because it is digital, the consumer actually feels that the information and images are safely preserved. Museums, conservators, and archivists, on the other hand recognize the problem of digital image storage. Relative to preservation strategies for large institutions, research and other published works are available on the topic (Gschwind et al 2004, Kriegsman and Mandell 2004, Miyata 2004). These strategies, however, are based on shorter-term storage with an associated longer-term migration plan. While some risk is mitigated, much remains.

Key Issue: Formats

Most people today would be hard-pressed to play back a recording made on a wax cylinder of the late 1800s. What will people 100 years from now do with an optical disk or magnetic hard drive? Wax cylinders were replaced by gramophone disk recordings in the early 1900s, (what we call "phonograph records" or simply "records"). They were a more robust and longer-lived technology, but eventually even records were replaced by new technology – CDs. Now CDs are being superseded by flash media in compressed MP3 format, and the whole concept of iTunes® and "cloud storage" could eventually replace device storage media all together. The eventual replacement of technology is inevitable. Just as one would have difficulty finding the equipment to play a wax cylinder from the late 1800s, or the equipment (turntable and stylus) to play back a 78-RPM record made in the mid 1920s, so too are people having difficulty finding the equipment to render a letter or document recorded on a 5.25-inch floppy disk just 30 years ago. Why would we think it will be any different in another 30-50 years when our children and grandchildren want to render a photographic image recorded on an optical or magnetic disk?

Digital technology adds several additional layers of complexities. Consider a 5.25-inch disk. To render a digitally stored image presents four distinct hurdles: 1) media format, as mentioned; 2) interfacing to a modern computer; 3) file format; 4) data integrity.

Media format: because the 5.25-inch media format has been superseded by three successive generations (3.5 inch magnetic, optical CD and optical DVD), finding a 5.25 inch disk drive may be very difficult.

Interface format: with the advent and proliferation of the Universal Serial Bus (USB) interface in the mid and late 1990s connecting an older 5.25-inch drive will pose problems. Most

drives will have an external serial or parallel connection and, connecting to modern computers will not be possible. Some drives may be found, however, with a USB connection. If the drive is an internal drive it likely has an Integrated Drive Electronics (IDE) architecture which can still be found in many recent computers.

File format: file formats change. For example, early word processors from various companies (Wang®, Multimate®, Wordperfect®, etc.) each had unique file formats. As Microsoft Word became a defacto industry standard, MS Word provided some capability to translate from those formats. Today, however, due to the age of these formats, this capability is not included in recent MS Word versions. An internet search, however, can provide software or companies that do provide translator software (for a charge) to an early version of Word, which can then be retranslated by current versions. In the early days of digital photography Microsoft created a proprietary ".MIX" file format for its "Photo Draw" and "Picture It!" software, both used for consumer photo archives, which was later abandoned without any means of doing batch conversions. Images stored in this file format are essentially lost forever.

Data integrity: is the digital data still there and readable or not? Passing this final hurdle will depend on media quality and storage conditions. Today there is a plethora of low quality, very inexpensive optical media with highly doubtful long-term storage capability. There are also high quality optical media with claimed longevity of 300 years (for CDs, 100 years for DVDs). Even if the media last that long, the likelihood of passing the first three hurdles after 300 years, or even 100 years, is highly doubtful.

Format Hurdles: An Example

Consider the discovery of a 5.25 magnetic floppy disk from 1985 containing family history information. In this example we'll make it easy: the disk was in a labeled jacket containing the file name, and we also know it was created with Multimate® word processing software. Given the relatively low storage capacities and the fact that 5.25-inch floppy disks were stored in a jacket, a human readable hard copy print out of an index of the contents of the disk were often included inside the jacket. This enables us to more easily locate a document and perhaps know its file type. None-the-less, the four hurdles remain. Not only does this example illustrate the physical format and computer interface challenges, it also illustrates the file format challenge. Not all ".doc" files are the same, nor can they be read interchangeably. Even within a company like Microsoft their Office software products evolve. Long term MS Office file formats like DOC, PPT, and XLS have recently been updated to DOCX, etc. The "X" files cannot be read by earlier versions of Office software without add-in updates. Clearly, file format is a very serious concern for long-term preservation.

Finally, it also needs to be noted that the huge challenges of restoring the information in this example occurred with the passage of only 25 years. Imagine the challenges facing a consumer finding digital family photographs after two or three generations.

Technology Always Advances

For both physical and software formats, change is driven by ever-advancing technology. Consumers began "burning" CDs when laser writing technology became inexpensive enough to drive the price of CD writers down. Then the same thing happened with DVD writers. While consumers are now burning DVDs, there is a new, incompatible DVD format from the entertainment industry, with the Blue-ray DVD format having won out over the HD DVD

format. How long a particular format persists depends on many factors, including economics. An additional risk factor is the breadth of usage of a particular format, which can have both positive and negative consequences on the risk of obsolescence. CDs have been well established for many years by the music industry and could therefore be considered a long-surviving, low-risk format. However, unanticipated technology changes occur that can increase risk and shorten longevity. Music CDs are now under direct challenge from flash memory in MP3 players and smartphones. Will there be a full-scale format change? Eventually there will be. Consider VHS tape. It also became well established and actually rendered the Beta format obsolete. In 1990 it would have seemed likely that VHS was sufficiently well established by virtue of the motion picture industry that it would be at low risk for a format change. Today, of course, VHS has become obsolete by DVD technology, driven by the same industry. So risk is always present and usually cannot be predicted far in advance of a format change.

Just as media format changes are hard to predict, technology advances around file structure and format will inevitably change as well, and these improvements eventually render older technology obsolete. DVDs offered many significant improvements over VHS tape. Flash memory in MP3 players offers many advantages over mechanically driven CD players. Technology of file formats and structures continues to advance as well. With this in mind, why would we expect today's popular photo encoding format (JPEG) to endure? JPEG2000 already offers many improvements in compression over JPEG. The Windows Media Photo file format, later renamed HDPhoto, was announced in 2006 and shipped with the Windows VISTA operating system. With some fine tuning by the JPEG committee, HDPhoto has become JPEG XR and in mid-2009 became a published ISO standard (ISO/IEC 29199-2). With its improved compression algorithms, improvements in color reproduction accuracy, and support for High Dynamic Range (HDR) imaging, it is only a matter of time before camera manufacturers begin to abandon JPEG. Will JPEG file formats be readable in 2033? 2033 is only 20 years away.

Historic Perspectives

In the days of photographic film, it was pretty much a given that a hard copy print would be made. In the world of digital photography and display devices this is not the case. Digital photography has enabled the capture of multitudes more images than with film. Industry estimates indicate that nearly 380 billion images were captured in 2012 (Zeev 2013). While many, if not most, of these images do not need to be preserved, some do. For those images, long-term storage of the digital information is tentative at best, especially when it is up to the end consumer to manage the files.

Many studies are available on the long-term storage of digital information (Wilson 2005). The work has been driven largely by libraries, museums, and governmental institutions, and addresses the threats associated with computer-dependent systems. There is recognition of the need for ongoing data migration as hardware, software, file formats, and operating systems evolve. Because the quantity of information for these large institutions is huge, high-capacity systems are needed. Alternatives to these types of rapid access, computer-dependent systems have been studied where the ability to have rapid access is reduced in exchange for a reduction in the need for data migration. Examples that have been discussed in the literature make use of photographic film as the preservation medium (Normand et al 2005).

The use of film for preservation is not new, as it has been done extensively in the motion picture and document industries for many years. Polyester-based, black-and-white silver separation films enabled the creation of separate red, green, and blue records of color motion

pictures that could last over 200 years in controlled, room-temperature storage. The viability of this process has been demonstrated repeatedly in recent years with successful restorations of many classic films. With their ongoing transition to digital (both capture and projection) there is still a recognition by the industry of the importance of film as a technology independent medium for long-term storage and preservation. Today an additional option to silver separation film is available with a new offering from Eastman Kodak Company – KODAK Color Asset Protection Film 2332. The importance of a systems approach to preservation in the motion picture industry was emphasized at the 2013 IS&T Archiving Conference in Washington DC (Fitzgerald and Rutter 2013).

Black-and-white microfilm provides stability up to and beyond 500 years at room temperature with good storage efficiency. Compression of documents in the order of 25 to 45 times is possible. New hybrid document imaging systems enable the use of film with scannable metadata for enablement of automated search and retrieval functions (Hofmann et al 2005). For additional information on film usage in this application, where longevity estimates of 100-500 and more years are possible, see the technical papers referenced earlier. In addition, methods and a patent on film for preservation schemes are available in the literature (Willaims 1996, Williams and Burns 2004, Burns et al 2005).

Preservation of photographs in the home has historically centered on hard copy prints in albums, scrapbooks, and shoeboxes. In photography, there has been significant growth in digitally generated scrapbooks, photo albums and photo books in the last several years, and growth of these products is expected to continue. A hard copy print is human readable and therefore requires no system architecture to be put into use. Longevity of various photographic print media will be discussed later in this paper.

As consumer imaging continues its rapid advance to the digital world, preservation remains erratic or non-existent. There has been little to no thought by consumers for long-term preservation of their images. It seems they are taking for granted the automatic, "built-in" preservation that came with the traditional analog negative and resulting print that was available for many decades. Today, digital files of all documents, including images, tend to be loosely organized on hard drives, CDs, DVDs and social media sites. But, often, there is no organization and little to no awareness of the vulnerability to loss of the image from the format and integrity issues mentioned earlier. All of these impacts result in the need for continual long-term migration of the digital data of an ever-growing digital image collection. Unfortunately, consumers in general are totally unaware of this need.

Long Term Archiving

As mentioned above, archiving of digital files requires an ongoing commitment to manage records to keep them intact and ahead of any type of time-dependent changes. Considering that consumers want at least some of their images to last for many generations, if not a lifetime or more, this requires a very long-term commitment. Migration cycles need to be short because of the rapid and ongoing advancement of the computer and associated systems and the short life cycle of the media. So how do we preserve for the long term, for many generations?

TIP: Technology Independent Preservation

Technology independent preservation takes a long-term perspective and eliminates the need for short-cycle migration of digital information. The digital information (images, documents,

email) is rendered to a hard copy, human readable output. Once done, a computer (today or in the future) is no longer needed to access and use the information. Once the document is rendered, elimination of the dependency on the computer has a positive impact on migration cycle time and allows for a preservation system that needs infrequent attention other than maintaining proper environmental storage conditions. The migration cycle is dependent only on the long-term stability of the output media. The key is to move from a digital storage format to a human-readable format using media that are very stable. This is echoed by industry analyst InfoTrends, which, in their publication "Road Map 2013: Photo Printing Trends", believe that "…strong growth in printing will take place because it is the best way to insure that important photos will be easily accessible and viewable well into the future".

Preservation by Consumers Today

The first and simplest way is to make hard copy prints of the most valuable images, and media of various technologies exist today to provide over 100 years of storage life at room-temperature conditions. Printing is easily accomplished at home using photographic-quality 4 × 6 or page-sized printers, at retail locations using self-service kiosks or a retailer-operated digital minilab, or online. Online options are best for larger volumes of images. Many online sources are available providing prints, photo books, and photo albums and include many high quality professional labs or consumer oriented image sharing sites. The first page or so of a Goolge® search on "professional photographic printing" provides many sources of high quality printing. With all of the long-term concerns that have already been discussed, printing of the consumer's "best of the best" images is the simplest and most reliable means of storage for multiple generations.

Digital storage, however, does have its merits including access and sorting capabilities. Online storage is becoming ever more prevalent at reasonable costs and photo sharing sites such as Snapfish, or SmugMug are popular and provide storage of the full, high resolution file. So are social media sites such as Facebook ® although many sites do not store the full resolution file. Significant compression is often done resulting in a significant loss of quality if a print were to be made from this compressed file. In addition, the consumer needs to be aware that some companies sponsoring these sites have gone bankrupt and shut the sites down with little or no notice, resulting in a total loss of the stored files. A second, self-managed option for digital storage is to use multiple magnetic hard drives with redundant backup. This option requires a disciplined approach and gets complicated as the collection of images grows in size. RAID (redundant array of independent disks) systems provide automatic redundant backup and storage and require minimal attention by the consumer. Another, higher complexity and less desirable storage option is to routinely move images to optical media such as CDs or DVDs. One critical concern in this option, in addition to the media format, file format and data integrity concerns applicable to all digital storage as discussed above, is the media longevity. While CD and DVD optical media is available with advertised longevity of 100 years and higher, there is a large amount of anecdotal evidence that low-cost CD media lasts for two years or less. Any short-term plan by the end consumer to use optical media should center on high-quality, higher-cost media only. An additional storage option to consider are the many services today that will automatically backup files and store them "in the cloud" for a nominal service fee. As mentioned before, the long-term viability of the service provider is a potential concern here as well. Additionally, cloud storage does not address the inevitable long-term changes in file formats.

Stability of Materials Used for Preservation

A key issue for conservators as hard copy "photographs" move from traditional black and white and color silver halide materials to the wider range of digital technologies is identification. These newer digital output technologies include thermal dye transfer (often mistakenly called "dye sub"), electrophotographic/toner technologies (including both dry and liquid toners), and inkjet materials. Inkjet materials contain the widest range of component types including swellable and porous media and dye-based and pigment-based inks. An excellent resource for conservators to aid in the identification of print materials is the Digital Print Preservation Portal (DP3) from the Image Permanence Institute at Rochester Institute of Technology. The DP3 website includes information on identification of various output technologies as well as degradation pathways and illustrations.

The section below provides longevity information on various technologies used for hard copy output. A reflection medium has the advantage of being excellent for human readability but has variable longevity, which depends on the output technology chosen making careful choice by the consumer very important. Regardless, a hardcopy print is a human-readable, technology-independent record of the digital file.

Table 1 below discusses the longevity of various reflection technologies and provides specific examples and longevity information for Kodak media (ISO 18909:2005, Bugner et al 2004). Longevity of similar technology materials from other manufacturers may or may not be as stable so careful comparison, using common test methods and interpretations, is called for. With one noted exception, the lifetime estimates in these tables use a new endpoint criterion that is more conservative than that typically used for consumer images (Oldfield and Segur 2004, Oldfield and Twist 2004). Because the application is for long-term storage, these predictions are based on dark keeping applications, and they include the effects of heat, humidity, and atmospheric pollutants, but they do not include effects of light.

Media Type	**Media Name**	**Estimated Longevity**	**Comments**
Thermal Dye Diffusion Transfer	*Kodak Professional Ektatherm XtraLife* media	80–100 years for 5% dye loss[2]	Virtually no sensitivity to humidity or ozone
Inkjet/Porous Media	*Kodak Ultra* Premium photo paper	50 to over 75 years	Using high-quality pigmented inks
Silver Halide	*Kodak Professional Endura* papers	Over 150 years	Virtually no sensitivity to humidity or ozone; greatest longevity of any silver halide paper
Electrophotographic	*Kodak* NexPress Digital Production Color Presses with *Kodak Professional Endura* EP-D paper	Over 100 years[3]	Virtually no sensitivity to ozone; physical damage can occur in high humidity environments so storage conditions need to be carefully controlled

Table 1. Stability of reflection media for long-term storage applications.[1]

[1] Using much tighter dye loss criteria of 15%; room-temperature storage conditions of 23ºC and 50% RH and pollutant-free air; lower storage temperatures can provide significantly longer longevity.
[2] Time for 15% dye loss has not been determined due to the extremely high thermal stability; actual time will be well beyond 100 years.
[3] Estimated based on longevity of the various components; testing on current products in progress.

Table 1 clearly shows there is a wide range of high quality reflection printing technologies that can be used for long-term preservation. Properly stored, hard copy prints are certainly usable for long-term preservation of the consumer's "best of the best" images. The photographic industry needs to encourage people to make prints as preservation records of their images so future generations will easily be able to find and enjoy these records of people's lives without dependence on a possibly obsolete digital technology from a generation or more prior.

Image Permanence Standards

As mentioned previously, a preservation strategy requires good information on media dark stability. This includes more than just thermal stability, which had been sufficient for printing technologies using silver halide materials. For the newer technologies such as inkjet, standardized stability information should include gas pollutants and humidity as well. The ISO technical committee on photography (TC42) has recently published three new standards on measuring image degradation due to heat, atmospheric pollutants and humidity (ISO 18941:2011, ISO 18946:2011, ISO 18936:2012,) and a similar standard for degradation due to light is close to being published. Work is also underway on measurements of durability of photo books. Protocols for predicting life estimates are also needed, however, and these must include all four of the environmental factors (heat, humidity, pollutants, and light), and they need to be relevant to the specific application and end user. As mentioned in Table 1, tighter degradation criteria are needed for the application of preservation compared to normal consumer home and display predictions. The longevity estimates included here are 50% tighter (allowing for only half the colorant loss) than those generally in use for consumer/home longevity predictions, which can be found in the ISO Image-life parameters table of illustrative endpoint criteria contained in the silver halide stability standard (ISO 18909:2005). These tighter criteria would yield a net change that would be considered close to a just-noticeable difference (JND). For this application of long-term preservation, that level of change is about the maximum tolerable.

A Call to Action

With digital now in the mainstream for imaging, much more education is needed to make the general public/consumer aware of the risks of image loss from not having a preservation plan. Memories preservation is important, and consumers have done this historically through photo albums and scrap books. The initiative that was announced in 2007 and supported for several years by the International Imaging Industry Association (I3A) on consumer photo preservation was a start to creating this awareness among retailers and consumers (I3A 2006). The "SaveMyMemories.org" website, also launched in 2007, received positive response initially and during its first couple of years, but is no longer available. There needs to be further promotion to a broader audience, especially the consumer, and these efforts need support from the entire

photographic industry. At the image creation end this includes imaging manufacturers, including camera and output media suppliers, as well as the photo fulfillment industry. At the image preservation end this includes conservators. Photographers and their associated printing labs, along with online photo fulfillment sites, mass portrait and school finishing labs, have the closest connection to the end consumer and therefore have the best chance of driving this message home. Conservators can help spread the message by publically highlighting historical preservation they have done in the past and promoting the importance of these works to future generations. Creating the awareness at the consumer level will help create the demand and stimulate the business for various high-volume photo fulfillment systems to address the consumers' need for image preservation and maintain a stream of important images for conservators of the future to maintain and restore.

Conclusions: Path Forward – Reaching the Consumer

This paper has described the risks associated with storage of digital data and why those risks are so high. We have also presented a solution using high quality hard copy output to create a long-term solution that will last for multiple generations. Additionally, this paper has reviewed both traditional (silver halide), and newer (inkjet, thermal) media for storage as hardcopy prints. Electrophotographic media, such as that used for on-line generation of photo albums, photo books, and scrapbooks is also included and is especially important given the growth in these products. A simple solution, however, does not help if the consumer is not even aware that the risks are present.

Educating the consumer is the near-term issue that needs to be solved and a broad, far-reaching effort is needed. To make consumers aware immediately, digital camera manufacturers should take a lead role by providing educational information when a camera is sold. The photo fulfillment industry can reinforce this message to further educate the consumer while simultaneously growing revenue from photo output products. Educational outreach by conservators will be helpful in highlighting the importance of hard copy images from the past and emphasizing that this will still be important with today's images 30, 50, or more years into the future. Finally, a goal of Pixel Preservation International, in conjunction with industry sponsorship, is to reach out to the general public to educate, through examples such as those included in this paper, on the need for technology independent storage.

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