The DP3 Project: Digital Print Preservation Portal (PART II)—Evaluations of the Effects of Housing, Handling, and Flood on Modern Digital Prints

PROJECT OVERVIEW

The Image Permanence Institute (IPI), part of the College of Imaging Arts and Sciences at Rochester Institute of Technology (RIT) in Rochester, NY is seeking funding for a major research and development project dealing with the preservation of digitally printed materials: inkjet (IJ), dye diffusion thermal transfer (D2T2), and color electrophotographic (EP). This project will help all conservators, curators, archivists, librarians, and collection managers better understand and care for these objects in their collections.

This project is complementary to a project to be funded by the Andrew W. Mellon Foundation, called the Digital Print Preservation Portal (DP3) Project. The main activities of that project are to perform original research into the stability of digital print materials and publish those findings on a unique website called the *The DP3 Project: Digital Print Preservation Portal*. The Mellon-funded research will consist of evaluating the inherent stability of various digital print technologies when exposed to known environmental stresses: heat, light, air pollution, and extremes of humidity. The resulting website will be a vehicle for the publication of those findings as well as other information on digital printing, such as descriptions of the processes, a glossary, and a bibliography.

This proposal to IMLS outlines a project involving research into several key elements of preservation for digital prints in libraries and museums. The research will focus on the effects of housing and display materials on digital prints, effects of handling, and minimizing the risk of damage due to flood. The final results of the project will be a set of recommendations for housing and displaying digital prints, cautions regarding print handling, and an assessment of the risk of damage to digital prints in the event of flood, all to be published on *The DP3 Project: Digital Print Preservation Portal* website.

While this proposed project is clearly complementary to the project being funded by the Andrew W. Mellon Foundation, and will run concurrently, it can also stand alone. None of the research in the Mellon Foundation project matches or overlaps the work being outlined in this IMLS proposal. Even if the Mellon Foundation project were not funded and carried out, this proposal could be fully completed and provide significant and critical information to the field.

1. ASSESSMENT OF NEED

Virtually all forms of individual scholarly communication and artistic creation of images now depend on a few technologies for creating hard copy output. IJ, EP, and D2T2 materials account for the overwhelming majority of desktop documents and an increasing portion of short-run publications and monographs. The lines between imaging media and document media are disappearing as the quality and speed of digital print media equal or even exceed traditional photographic materials. Documents are becoming a seamless blend of text and image. An enormous volume of digital output media is now entering institutional collections. Professionals need guidance even to determine what portion of the collections has been digitally printed. It is very important that the nature and preservation needs of such materials be understood by collections care professionals and also by scholars and artists. Every new print technology is accompanied by new component materials and—at least potentially—new vulnerabilities to the forces of environment and handling. The technologies addressed in this project have not been systematically studied, and thus a balanced overview of their preservation strengths and weaknesses from the point of view of institutional collections does not exist. Some vulnerabilities not found in photographic materials or older text output systems are already being observed in the newer media (for example, a susceptibility to abrasion in pigment-based IJ prints). Given the very rapid evolution of digital print media, there are likely to be a number of others.

Every institution is concerned with providing physical storage for its collections and is compelled to provide access to collection objects for individual study and public display. It is already known that housing and display materials play a critical role in protecting these objects from external forces. It is also known that the chemical and physical properties of housing and display materials can be either protective or damaging, depending on the materials' design and make-up. Additionally, it is known that not every object requires the same type of enclosure, and that some enclosure materials are safe for some objects but not others. Preliminary work at IPI has already shown that various digital print types can be harmed when stored or displayed using enclosure and framing materials of unknown quality.

In addition to the enclosures work, there is a need to investigate the potential for damage to prints due to handling. The primary types of damage are surface abrasions and image layer cracking. IPI has received reports from conservators in the field indicating that some digital print materials are more sensitive to abrasion and cracking than traditional photographic materials. One conservator reported that a digital print was seriously abraded when a common interleaving material was used with the print during shipping. The assumption that what is good for a traditional photo must be good for a digital print needs to be challenged and addressed.

Preliminary testing at IPI has also shown that, like traditional photographic print paper emulsion, digital print paper emulsion can crack at low humidity. However, unlike traditional photographic prints, some digital prints crack severely on a microscopic level even at moderate humidity. A professional at a regional conservation center reported that she could clearly hear the sound of cracking when she flexed a print. So far this seems limited to a single IJ technology, but unfortunately most manufacturers are switching to this type because the papers dry instantly after printing.

Finally, there needs to be a survey of the sensitivity of digital prints to flood damage. In 2004 IPI performed an experiment to determine the ability of some digital prints to withstand flood. The research was sponsored by a manufacturer and focused on their particular product, so the results can not be generalized to broader collection sets. The primary effects found were colorant bleed (especially for dye-based prints), emulsion delamination, and mold growth. The test samples of some print types were so thoroughly destroyed that they are considered completely unrecoverable if exposed to flood. This information needs to be communicated to collection care personnel to insure the thoughtful inclusion of these materials in their institutional disaster plans.

2. NATIONAL IMPACT AND INTENDED RESULTS

No institution in the United States will be without digitally printed materials of value in its holdings, even if they are only vital institutional records. Some institutions already have these materials *en masse,* and the rate of incorporation into collections will continue to accelerate. Maintaining these collections with great care is in the interest of individual institutions, and it may one day be an issue of national cultural importance. As information management and use continues to move to electronic formats, the risk of loss of vital cultural records increases as long as the guarantee of electronic retrieval is in serious question. It will likely come to pass that some records thought secure in digital form will be lost due to neglect, obsolescence, cyber-crime, mechanical failure, media deterioration, or mismanagement. While the conversion of all digital files into printed hardcopy is an untenable solution, items that have been digitally printed and well cared for may be the only surviving copies of some priceless items.

The final result of the project will be a set of recommendations for the housing and display of digital prints, cautions regarding print handling, and an assessment of the risk of damage to digital prints in the event of flood. This information will be published on *The DP3 Project: Digital Print Preservation Portal* website, and it will be available free of charge.

3. PROJECT DESIGN AND EVALUATION PLAN

Definition of Digital Print

For the purposes of the project, *digital print* will be defined as any print (photograph or document) that was created by an electronic printing device where the information regarding ink or toner placement on the paper originates from a digital file. A printed reproduction of an original work (such as a painting) that was converted to electronic data either by a scanner or camera and then printed on an electronic printing device using the data from the scanner or camera file is still considered a digital print. An electronic file that has been imaged on another medium such as a photographic negative or printing plate and is printed on photographic paper or through ink transfer from the plate will not be considered a digital print. A large variety of objects are created by digital printing: photos, artists' books, posters, newsletters, correspondence, postcards, tickets, receipts, pamphlets, booklets, and short-run journals, magazines, and books.

The Primary Digital Printing Processes

Three major technologies are used for digital color printing. A summary of each is given below.

Inkjet Prints (IJ). This technology is used by many desktop computer printers. It has wide appeal, since images can be produced in a home or office environment. Small droplets of ink in an aqueous solution are rapidly jetted onto the printing paper. IJ is used for both documents and images. Several variations of the technology exist, and each produces prints with unique properties. (Note: there are some solvent-based IJ systems; however these are almost exclusively used in industry for large-scale outdoor signage. IPI will not evaluate these materials)

Dye Diffusion Thermal Transfer Prints (D2T2). In these systems, the image-forming colorants are transferred to the print paper from colored donor ribbon. The printer modulates heat energy to the donor ribbons to control the amounts of yellow, magenta, and cyan inks that are transferred. This technology is most often used in snapshot-size photo printers and in commercial photo kiosks. Like IJ, it has the advantage of producing images very rapidly compared to traditional photographic processing. This process is used only to created pictorial images. It is never used to create documents.

Electrophotographic Prints (EP). This process (also referred to as xerography) is used to produce photocopies or prints from laser printers. In color EP systems, color toners are deposited on the printing paper by an electrical charge (modulated by a laser, by LED array, or by light reflected from the original) and "fixed" by heat or pressure. The toners are usually pigments with the black toner being very stable carbon black. Although black-and-white prints using preservation-quality paper are quite stable, color prints may be sensitive to their environments and deteriorate.

In addition to the above technologies, several smaller technologies, which are often proprietary, are also being used. Examples are risography, thermal autochrome, and encapsulated pigment. Their scale of use is not insignificant but is far smaller than that of the three described above. IPI will not attempt to address every technology in this project, as it would not be financially feasible.

Methods for Evaluating Potentially Harmful Chemical Effects of Storage Enclosures and Framing Materials

The possibility of harmful chemical interactions between traditional photographic prints and enclosure/display materials has been recognized for many years. This is an important institutional consideration, since image degradation can occur not only because of the inherent instability of the image itself, but because of chemical interactions between the image and materials with which it is in contact. For traditional photographic images, the photographic activity test (PAT) was developed at IPI and subsequently was standardized by the International Organization for Standardization (ISO) as ISO 18916 *Imaging materials—Processed imaging materials—Photographic activity test for enclosure materials*. This test involves the incubation of a colloidal silver layer on polyester base against the enclosure material being studied. The colloidal silver is a very sensitive indicator of chemical changes of traditional silver images. The incubation conditions which proved to be most effective are 15 days at 70°C and 86% RH. A second indicator that has been used is a photographic paper processed to minimum density; this has been a good predictor of stain growth.

The PAT is a helpful starting point to assess interactions between traditional prints and digital prints or between enclosure materials and digital prints, but a modification of the procedure may be required. Testing will be done with the colloidal silver detector and the minimum-density traditional photographic print in contact with IJ prints made with both dye-based and pigment-based inks, thermal dye diffusion transfer prints, and EP prints to determine if storing traditional and digital prints together is safe. Changes in the incubation conditions may be necessary, but the apparatus used in the standardized test is applicable.

In addition to the testing done with the two detectors used in ISO 18916, incubation testing will also be performed on the digital prints under study together with common storage and display enclosures. These will include a variety of materials with which digital prints may be in contact under practical use conditions, such as paper having a high lignin content, cotton paper, conservation mat board, purified wood-pulp paper that has been buffered, polyester film, and PVC (polyvinyl chloride) plastic sheeting.

Methods for Evaluating Potentially Harmful Physical Effects of Storage Enclosures and Framing Materials

As important as the chemical effects between enclosures and digital prints are potentially harmful physical effects. The physical effects of concern are ferrotyping, sticking (blocking), and/or transference of the image to the adjacent contacting layer. A test for blocking has already been standardized by the ISO for photographic films. This method is described in ISO 18901 *Imaging materials—Processed silver-gelatin type black-and-white films—Specifications for stability* and involves incubation of the film for 15 hours at 40℃, 62% RH. After incubation, the film is examined for adherence between films in a stack or on a roll. Preliminary work at IPI with digital images indicates that different incubation conditions may be required for these materials.

All of the print types under study will be incubated in contact with polyester, polypropylene, polyvinyl chloride, framing glass, and polycarbonate glazing. Glass and polycarbonate are being studied to determine whether there are any adverse effects when digital prints are framed for display. PVC sheeting is a thin plastic film used to manufacture print and negative sleeves as well as pocket pages for prints or large format negatives. PVC is particularly susceptible to sticking and image transfer. In addition to tests with these five materials, tests will be required involving both the digital prints stacked face to face and the image surface of digital prints stacked against the back side of adjacent prints.

Methods for Evaluating the Abrasion Resistance of Digital Prints

For this test, IPI will use the UGRA Rub Tester. IPI successfully uses this test to rate the abrasiveness of enclosure materials in contact with traditional photos. For this project, the abrading material will remain constant as the imaging material is varied, so that the relative sensitivities of the various digital print materials can be ranked. Abrasion test results have typically been measured by a qualifying scale; however, IPI has done preliminary work with ImageXpert Inc. to develop a quantifiable method to measure abrasion.

Methods for Evaluating the Brittleness of Digital Prints

IPI will use the wedge brittleness test described in ISO 18907 *Imaging materials – Processed films and papers – Wedge test for brittleness* to determine the radius of bend before macro- and micro-cracking occurs. The effects of RH on macro-cracking will be studied to determine if there is a different recommended lower RH limit for digital prints than for traditional images. The potential for micro-cracking, even at moderate RH, will also be studied determine if certain digital prints require rigid support to prevent damage.

Methods for Evaluating the Flood Resistance of Digital Prints

IPI developed a test method for this in previous work for a manufacturer. The data was based on only a few materials, as it was primarily intended to test that manufacturer's products and not digital prints in general. That method was found to be effective, and will be used in this project. It is not a standardized test and is measured qualitatively, but IPI believes the results will be very accurate in communicating the relative sensitivities of these materials to help institutions review their disaster plans with digitally printed objects in mind.

Test Prints

The systems to be tested will include all three of the previously described technologies: IJ, D2T2, and EP. For all three systems, both desktop and high-volume printers/copiers will be tested. The EP digital presses will be also tested. For EP systems, both liquid and dry toners will be examined. D2T2 contains only dye, but both dye and pigment inks will be included for IJ. A variety of uncoated, coated, and photo-coated papers will be used to make the test targets so that the project's total sample set will be a good representation of the types of objects that are in or will be entering collections.

Note that this project will examine only original equipment manufacturer (OEM) inks. IPI will use OEM paper for the IJ and D2T2 photo-coated prints; however, for EP systems most papers will be third-party manufacturers, as this is often the norm in actual use. Also, IPI does not to wish to perform quality ratings of specific products on the market, determining which products are "good" or which are "bad". Such an approach would not be useful for two reasons. First, it would require a print identification system clear enough for institutional staff to identify their objects down to the level of specific manufacturers of the printers, the inks, and the paper supports, and such an identification system is not likely possible. Second, digital printing products have a high turnover in the market. A rating for a particular product now could become irrelevant in as little as six months when the manufacturer introduces a "new" version. IPI will discuss all results in terms of material classes and technologies rather than specific equipment or products.

Controls

It is important that the results of this project are presented from within the context of the already familiar traditional print technologies in order to determine to what extent adjustments in object care policies will be needed. The controls will be traditional (dye-gelatin) photographic prints, black-and-white EP prints/documents (preservation copy systems), and offset lithographic prints/documents. It should be noted however, that offset prints are not easily custom-made in small quantities, so test targets and subsequent results for this material may not be as complete as for the other processes.

Equipment

Ultra-low Humidity Chamber. This unit is critical for performing both the chemical and physical enclosure interaction portions of the plan of work. Current IPI incubation chambers have worked well for the Arrhenius-type studies used to evaluate the thermal stability of traditional photographic materials; however, they cannot be taken to RH values below 40%.

Image Analysis System. This system will allow for the quantification of the abrasion test. Abrasion has typically been a qualified measurement with great potential for error due to human judgment. In addition, many materials develop significantly different abrasion patterns, which make direct comparisons between the digital technologies almost impossible.

WORK PLAN

Project Phases

Year One

- Install, calibrate, and test humidity cabinet
- Print the chemical interaction, abrasion, and flood damage test samples
- Perform traditional colloidal silver PAT with digital papers and inks
- Perform digital paper PAT in contact with paper having high lignin content, cotton paper, conservation mat board, purified wood-pulp paper that has been buffered, polyester film, and PVC plastic sheeting to represent good- and poor-quality enclosures

- Perform abrasion tests in contact with a standard abrader, archival envelope paper, polyester film, and an interleaving tissue
- Perform flood-sensitivity tests on both individual prints and stacks of prints

Year Two

- Print the physical interaction test samples
- Perform digital print blocking and colorant transfer test (unprinted paper and paper printed to 1.0 density patch neutral) in contact with polyester film, polypropylene film, PVC film, polycarbonate glazing, soda-lime glazing, and print reverse side to represent stacked papers, and print front side to represent stacking of papers printed on both side or bound in volumes
- Perform print brittleness tests to determine radius of curl to cracking
- Analyze data, draw conclusions, and write final research findings report, including recommendations for selecting storage and display materials, handling of prints, and risks for flood damage
- Write final project report and final financial report to IMLS
- Publish the research results on the DP3 Project website
- Cross-promote the results published on the DP3 Project website through web links on other frequently accessed preservation-related websites, such as Collections On Line (CoOL) and Heritage Preservation, and user groups, such as the Conservation Dist List
- Present research findings at professional conferences of interest to all institutional personnel at the local, state, and national levels.

4. PROJECT RESOURCES: BUDGET, PERSONNEL, AND MANAGEMENT

IPI staff understands that although this project requires a substantial effort to reach its objectives, the long-term benefits to the humanities will be considerable. The individuals listed below, all veterans of previous significant projects, have the technical, organizational, administrative, and design skills to complete the plan of work outlined above. They are thoroughly committed to this project and to IPI's ongoing activities in preservation research.

Daniel Burge, Senior Research Scientist, Principal Investigator, will have overall responsibility for the project. He has been a researcher at IPI since 1990. He managed IPI's enclosure testing services from 1991 to 2004, overseeing $80,000 to $100,000 annually of corporate-sponsored research. In 2004, he took over responsibility for all of IPI's corporate-sponsored research projects (including the testing of digital print materials) bringing his most recent annual total of successfully completed projects to $250,000. He was project planner and manager for all of the preliminary testing for this project. Mr. Burge will be the lead writer of the final report on the project. He will spend 25% of his time on this project over the next two years.

James Reilly, IPI Director, Co-PI, will act as technical advisor. Mr. Reilly has been the director of IPI since its inception in 1986. He has extensive experience as the principal investigator on major research grants. His knowledge of photography and experimental work make him one of the leading contributors to the science of photographic preservation. He will devote 5% of his time over the next two years to this project.

Jannette Hanna, Research Scientist, will be responsible for implementing the chemical interaction and flood portions of the work for this project. Ms. Hanna will spend 40% of her time on the project.

Andrea Venosa, Research Scientist, will be responsible for implementing the physical interaction, abrasion, and brittleness portions of the work for this project. Ms. Venosa will spend 25% of her time on the project.

Douglas Nishimura, Research Scientist, will act as a technical advisor to the project and assist in the analysis of the experimental data. He will devote 10% of his time to this project.

Peter Adelstein, Senior Research Assistant, will act as a technical advisor to the project and assist in the analysis of the experimental data. He is a 57-year veteran of research in photography; 20 years of that research has been in photograph preservation. He will devote 10% of his time over the next two years to this project.

Web Designer, TBD, will be responsible for inclusion of all IMLS digital print project results into the DP3 Project website. This individual will spend 25% of his or her time on this project.

TBD, Business Manager, will be responsible for the financial administration of the project. This individual will spend 5% of his or her time handling the grant accounting for this project. He or she will also be responsible for coordinating IPI's interface with RIT administration, purchasing supplies, checking on legal issues, and ensuring that all financial reports to IMLS and RIT are completed on time.

Gene Salesin (Consultant) will aid in performing the abrasion and brittleness tests at IPI. He joined IPI in 2004 on a part-time contract basis and has worked on a variety of projects including the preliminary testing for this project. He retired from the Eastman Kodak Company in 1997 after 36 years in the research laboratories and several manufacturing divisions at Kodak Park.

5. DISSEMINATION

The primary form of dissemination will be the DP3 Project website. IPI will also publish links to the full research findings and final IMLS report on this project on all of the IPI websites. As the new results are published on the DP3 Project website, they will be cross-promoted through web links on other frequently accessed preservation-related websites, such as Collections On Line (CoOL) and Heritage Preservation, and user groups, such as the Conservation Dist List.

Finally, IPI will also offer information to the library and archive communities through public presentations at conferences and events of interest to the general public, local and state institutions, and national archives and library associations. IPI is committed to wide-spread dissemination of its research findings to all interested parties.

6. SUSTAINABILITY

IPI is experienced in the development and long-term maintenance of websites that provide free, high-quality information to the entire field. Examples can be found at the following:

- www.imagepermanenceinstitute.org
- www.ArchivalAdvisor.org
- www.digitalsamplebook.com

The experimental results of this project will also be presented to the ISO TC-42 WG-5 committee responsible for developing standards for the preservation of imaging materials. These standards include terminologies, test methods, and specifications for storage, handling, and housing materials. The inclusion of the results from this project will result in better ISO guidelines for libraries, archives, and museums around the world.

Finally, the results will be entered into the internal educational programs that IPI offers to library, archive, and museum personnel: the IPI summer seminar and the Andrew W. Mellon Advanced Residency Program in Photographic Conservation.