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ABSTRACT

The Commission on Preservation and Access has published a number of reports on the preservation and access implications of scanning text and microfilm. This report focuses on what sets the digitization of visual collections apart from other scanning projects. Projects to digitize visual collections present their own unique set of questions and concerns, as well as issues that overlap with digital capture of text. The report provides basic suggestions about planning digitization projects, practical guidelines for working with images, and some final thoughts about the future systems and infrastructure needed to provide collections of images over the long-term. To use digitization as a tool to provide worthwhile, enduring access to treasured cultural and historical resources, one must become informed, establish guidelines, and proceed in rational, measured steps to assure that such reformatting of visual matter is accomplished as well and as cost-effectively as possible. The paper includes the following sections: (1) Introduction (Digital Images as a Reproduction Medium and Of Letters, Lines and Images: Reproductions in Print Publications); (2) The Original Object and Its Reproduction; (3) A Framework for Assessing Image Quality; (4) Color Matching for Image Collections (Color Management, Transformation and Image Output and Controlling Images in Distribution Environments); (5) Documentation and the Integration of Image and Text (Production and Management Documentation); (6) Building Image Collections; and (7) Image Access and User Environments (Rights To Image Collections, Electronic Publications and Use of Visual Materials, and How Will Collections of Digital Images Be Created?). (Contains 45 references.) (SWC)

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Cover Image: Edge margin of color gum-bichromate print by Drake Zabriskie.
Reproduced from approximately 15% of full digital image.

The example of the illustrated book on page 5 comes from the publication *Library of Congress Prints and Photographs: An Illustrated Guide* (Washington, DC: Library of Congress, 1995). The left-hand illustration is of a watercolor on laid paper, circa 1830, *Mill on the Brandywine, Delaware*, by John Rubens Smith. The right-hand illustration is of an albumen silver print, 1876, *Portrait of Alfred, Lord Tennyson*, by Julia Margaret Cameron.

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Digital Image Collections: Issues and Practice

Michael Ester

December 1996

About the Author

From 1985 to 1993 Dr. Michael Ester was Director of the Getty Art History Information Program (AHIP), an operating program of the J. Paul Getty Trust. In collaboration with domestic and international institutions and organizations, AHIP works at several levels of policy, standards and practice to help shape the direction of automation in the visual arts. Michael Ester was responsible for setting program direction and policy, and for managing its many projects based in the U.S. and in Europe. During his tenure at the Getty, he initiated basic research and technical development in the use of digital imaging as a reproduction medium for the visual arts.

Prior to joining the Getty Trust, Ester was Information Systems Manager then Director at URS/Berger, a firm conducting remote sensing and environmental studies for the United States Government. He was also formerly General Manager at Technical Data Processing Associates, which provides CAD/CAM systems and services for architectural and engineering applications.

Before entering the private sector, Ester was on the faculty of Rutgers University, where he taught courses in both computer applications and archaeology. He received his Bachelor's degree in mathematics and anthropology from George Washington University; he earned doctorates in the same disciplines from Brandeis University.

Dr. Ester currently is President of Luna Imaging, Inc. Formed in late 1993 with support from the J. Paul Getty Trust and Eastman Kodak Company, Luna applies new forms of electronic imaging technology for use in the arts and the humanities. Luna offers services to convert collections of reproductions into digital form and use them electronically; it publishes collections of images related by theme or artist, together with the complex information needed to document objects and visual material; and it provides software and systems that allow institutions and individuals to access, view, manage and study image collections.

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Preface

The Commission on Preservation and Access, which recently merged with the Council on Library Resources, has published a number of reports on the preservation and access implications of scanning text and microfilm. This is the first report to focus on what sets the digitization of visual collections apart from other scanning projects. Projects to digitize visual collections present their own unique set of questions and concerns, as well as issues that overlap with digital capture of text. For the report, we asked Michael Ester to draw upon his previous studies and writings for the museum and art history communities. Through his experiences at both the Getty Art History Information Program and Luna Imaging Inc., the author provides library and archives administrators and others who oversee digitization projects with ways of thinking about this activity for the long-term benefit of preservation and scholarship.

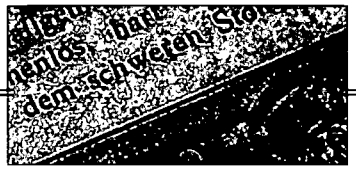
At one level, this paper can be considered another in a series on scanning projects — the tutorial on scanning of text (Kenney and Chapman 1995) and the reports from Columbia University on scanning of papyrus (Bagnall 1995) and large-scale maps (Gertz 1995). But as it evolved, the report took on a wider context, including things technical, organizational, intellectual, legal, and financial. The report provides basic suggestions about planning digitization projects, practical guidelines for working with images, and some final thoughts about the future systems and infrastructure needed to provide collections of images over the long-term.

The paper assumes a broad definition of "visual collections" and resources. The concepts being discussed can be applied, with some small shifts in terminology, to historical photograph collections, art historical material, maps, text and image publications, architectural drawings, and so forth. Much of the understanding of "visual" as compared to "text" finds parallels in studies of perception and meaning in scholarship and research. An article in the July 19, 1996, *Chronicle of Higher Education* (Vol.XLII,#45) titled "Visual Images Replace Text as Focal Points for Many Scholars" notes:

> *The term "visual culture" increasingly is being used as a meeting point for scholars who study seeing and the seen. Typically, the rubric comprises researchers in art history, film and media studies, anthropology, cultural history, and literary studies as well as philosophers and intellectual historians interested in the epistemology of perception. ... As digital technologies become dominant at millennium's end ... how and what the eye sees is a matter of concern, if not consternation.*

One of the most telling conclusions of the report is that it is difficult to accomplish a large scale digitization project with the same level of speed, quality, and enthusiasm as initial tests. If we are to use digitization as a tool to provide worthwhile, enduring access to some of our most treasured cultural and historical resources, then we necessarily must take time at the outset to become informed, to establish guidelines, and to proceed in rational, measured steps to assure that such reformatting of visual matter is accomplished as well and as cost-effectively as possible. Just as with other reformatting technologies, including preservation microfilming, doing the job once properly will prove more economical and valuable in the long run.

We hope that this report will stimulate thinking and discussion, and that it will serve as a departure point for future research and investigative projects. As with all reports, we welcome comments from readers.



I. Introduction

Not so very long ago, applying automation to research and education meant working exclusively with text. Not any more. This report is about one prominent media type that is taking hold: still images in digital form. Whether it is the near stampede to show pictures on the Internet, the burgeoning creation of multimedia publications, or the growing efforts to manage and use visual collections within institutions, nearly every archives, museum, and university library is engaged in a digitizing project of some kind. Converting the visual record of our cultural heritage into digital form already has begun, and only will accelerate in the coming years.

Not everyone has greeted the surge of digital images with unqualified enthusiasm. For many decision-makers, managers of visual collections, and those who must plan work, there is a prevalent unease about plunging ahead into large-scale initiatives. It is for this audience that the present report is written. How to begin thinking about these projects? What are the important things to worry about? What will affect the long-term value and usefulness of these resources? Some of the concerns reflect proprietary interests in visual collections and questions of control and access. Equally, technology is changing so rapidly that it is reasonable to wonder whether commitments made today will become outmoded in the near future.

For those who have participated in text automation projects in the humanities over the last 10 to 15 years, the prospects are no more reassuring. There is a wealth of experience with ill-conceived technologies: undoing and repeating large amounts of work, grappling with short-sighted decisions, and losing opportunities to automate institutional collections that may not come again soon. The language of technological potential is also unsettlingly familiar. In presentations of powerful systems and ambitious designs for bringing together vast content, there remains a frequent casualty of tense: forecasts of what *could* happen in the future with just enough time and money all too readily become what is available or possible today (Schmitt 1991).

When the Commission on Preservation and Access asked that I pull together previous papers on digital images into a report, it was with the intent of providing an overview of the field. There are any number of articles that tackle one or another aspect of digital images, from the many technical considerations to the thorny problem of rights and reproductions. Much less in evidence is the wider landscape of issues, the conceptual and practical landmarks that can help guide thinking and practice for visual collections in digital form. It is hard to gauge, for example, a particular method or image standard without knowing where images come from or the purpose of the end resource. Building digital image collections also turns out to be a highly cumulative process: getting one part right may be of little consequence without accounting for the steps that precede and follow it along the way.

The scope of the report is shaped by four general considerations. First, the report looks at images from the perspective of cultural heritage materials, the works of art, artifacts, and photographic resources represented in museums, archives, and libraries. Plainly, there are highly relevant parallels in natural history, the sciences, and applied sciences such as medicine. Second, it is about *collections* of images. Collections of images raise special problems of management, production, and access that go beyond the characteristics of any one image. There also are implied issues of preservation, stewardship, and scale that more short-lived uses of images, such as pre-press, can happily ignore. Third, the focus is on images as two dimensional

surrogates that are intended as reproductions of a prior generation original. This is in contrast to synthetic images that are created directly on a computer, the many ways analytic information can be rendered into image form, and the three-dimensional modeling of objects that is becoming ever more commonplace on the desktop. Fourth, there is a strong emphasis on images and applications that serve higher education and research. The special interests of scholarship and teaching, and the organizations that support these activities, represent the central reference point of image use, whatever other audiences images are adapted to reach.

There is a fair amount of practical advice in this report on the many dimensions and tasks of imaging projects. Surely, there are more lessons to learn and more problems to discover. But the rationale is that every trouble-spot surfaced for the reader need not be confronted anew in projects. At the same time, this report is not meant as a by-the-numbers instruction manual for imaging projects. It provides an overview perspective and the reference points for assessing imaging projects and, in most cases, it advances a point of view about how issues should be understood and addressed. From this standpoint, it is hoped that the ideas and recommendations will remain reasonably durable as changing technology rewrites specific hardware and software solutions. This approach also lends itself to a more plain language presentation, making the report accessible to as wide a readership as possible. Although little of the report ventures into technical deep water, those wanting an introduction to the digital image field might turn to Mitchell's (1992) inviting book or one of several primers such as Besser and Trant (1995).

Before leaving this introduction, there are two more topics to cover. The first briefly outlines some of the advantages of digital images as a reproduction medium. Of interest to the library community — an important constituency of the Commission — the second topic looks at reproductions in print publications, and how digital imaging relates to methods developed for microfilming text.

The remainder of the report follows visual content through a downstream progression, leading from an original object (e.g., painting, sculpture, architecture or historical photographs) to a reproduction surrogate; to conversion of a reproduction into digital form; to the integration of digital images and documentation; to the many possible derivatives of a digital image; and finally to the access and use of digital images.

Digital Images as a Reproduction Medium

Since much of this report is cautionary and is spent describing potential problems, it is worth stating that digital images really do represent an extraordinary opportunity as a reproduction medium. Surprisingly, amid the general attraction to this technology, it is difficult to find explicit statements of what digital images have to offer. So, to make it perhaps a little more appealing to wade through the issues to come, below are some of the ways digital images offer distinct advantages and future possibilities for visual resources, with some caveats.

- Photographic collections are deteriorating, and in many cases, much faster than monographs and periodicals (Reilly, *et al.* 1991, see also Wilhelm 1993). Some of the corrosive forces, such as acid-based paper, are the same as for print. Other factors, such as the half-life of color film and the acceptable tolerance range of film storage, are specific to photography (Reilly 1996). Digital image capture provides reproductions in a format that will not deteriorate physically or chemically over time. More crucial to security than the expected life of new optical media, digital representation allows transfer of image data to multiple storage locations with complete visual integrity.

- A photograph loses information each time it is reproduced. Digital images permit identical reproduction quality from copy to copy and from generation to generation.

- A photograph or publication illustration normally entails as much time in the darkroom as time behind the camera. Digital images and available software allow "darkroom" malleability and control entirely in electronic form. Modifications are more easily and rapidly made; edits may be temporary or permanent. Electronic image editing incurs none of the chemical processing, environment issues, facility and supply costs, or complexities of conventional photography. The ease and sophistication of image editing does have its ominous side from the standpoint of documentary evidence, but this is a different issue from the unqualified production benefits of this technology.

- Although users become accustomed to thinking of digital images as something visual, to a computer an image is just another data file of numbers. Any form of numerical analysis or transformation can be applied to a digital image. Such techniques — valuable for enhanced viewing, scientific investigation, modeling and simulation, and comparison — have numerous applications in research and conservation.

- Anyone who has tried to match descriptive lists to microfilm or has had to locate prints by the label on their back appreciates the challenge of marrying visual collections and related text. Researchers identify the difficulty of connecting image and text as one of their primary problems. Moving reproductions into the digital arena permits full integration of visual and text documentation. Images may be incorporated within a catalog record; they may be logically connected to other images; and they may be linked to annotations by many people over time. In simplest terms, the image is just one more descriptive dimension, where visual information augments verbal abstraction.

- Moving text and image into digital form can change profoundly the management of and access to large-scale visual collections. Collections of photographic reproductions are perhaps *the* most unwieldy resources of scholarship. Apart from the expense of creating them, they carry an enormous overhead of specialized facilities, maintenance, control and staff expertise. Access relies on physical orderings that can reflect only a few logical categories (for example, subject, artist, dates). Even when accompanied by a text database for identifying material, selection/removal allows only one user of an image at a time and demands vigilant image replacement after use. The scale of collections rapidly compounds these considerations, as slides, prints and transparencies run into the millions of images. With digital format reproductions, original materials can be housed in safer, controlled storage conditions, and avoid the wear and tear of user handling. Image access becomes a direct and immediate consequence of database retrieval; there is no longer contention for a single reproduction among multiple users; and the exacting practice of replacement becomes moot.

- Access to and interchange of traditional visual resources from dispersed, multiple collections are extremely rare. Visual collections are characteristically idiosyncratic in their materials, formats, organization and methods of documentation; they usually demand local assistance for effective use. Electronic images contribute three characteristics that foster broader access to and exchange of visual resources: international standards for digital images will have a homogenizing effect on the format in which images are available; electronic reproduction, storage and communications costs promise to become relatively low, reducing a significant barrier to sharing material; and image quality can be scaled downward to meet the needs and technical capabilities of collection users, serving individuals or institutions with tailored versions of the same image.

- New publishing outlets through electronic media promise to improve dramatically the economics of distributing visual collections. The costs of illustrated art publications have increased by three- to five-fold over the past five years. Virtually every illustrated book entails economic trade-off about the quantity, size, and quality of reproductions. With electronic media, the same uniform, high quality can be used for all images.

Publishing expenses are more nearly a linear function of initial production; distribution and sales prices for thousands of images per publication are realistic. Savings for purchasers carry over to ongoing space and maintenance requirements.

- More important than financial considerations, however, is the question of *what* will be published: it is unlikely that the holdings of most archives collections will see daylight unless they appear in electronic form. Similarly, without new opportunities for distribution, specialized materials for a limited professional audience will require greater subsidization and/or higher pricing.

Other possible advantages of digital images are less well understood, but are potentially of great significance. For instance:

- Images are effectively "multilingual" in content. A constant issue with text is wrestling with how to make information available to a mixed-language readership. Accurate translation is problematic and expensive. Images do not obviate the need for text documentation, but they do represent an important class of information that can be exchanged and understood easily, irrespective of language background.

- Compared to catalog descriptions, image information is extremely efficient data to collect. Digital images present many technical considerations and issues of quality control. Acquisition of images does not, however, pose the most demanding, time consuming and costly requirement of cataloging: high-level subject expertise, vocabulary consistency, and intellectual evaluation and decision-making. The digital image contributes a major documentation component in a process that calls more on skill than knowledge.

- Electronic availability of images may reduce the amount of text needed for documentation. Only experience will tell how the availability of an image will affect cataloging. Current practice is similar to having books without illustrations or pictures, requiring words to describe what might be obvious from an image. Certain dimensions of visual content, such as iconography, need elaboration beyond what is literally apparent. Yet even allowing for these situations, images should offer some reduction of descriptive text. Presumed availability of the image, and the ability to move through large quantities of images at a sitting, may also permit a coarser sieve of database documentation and retrieval.

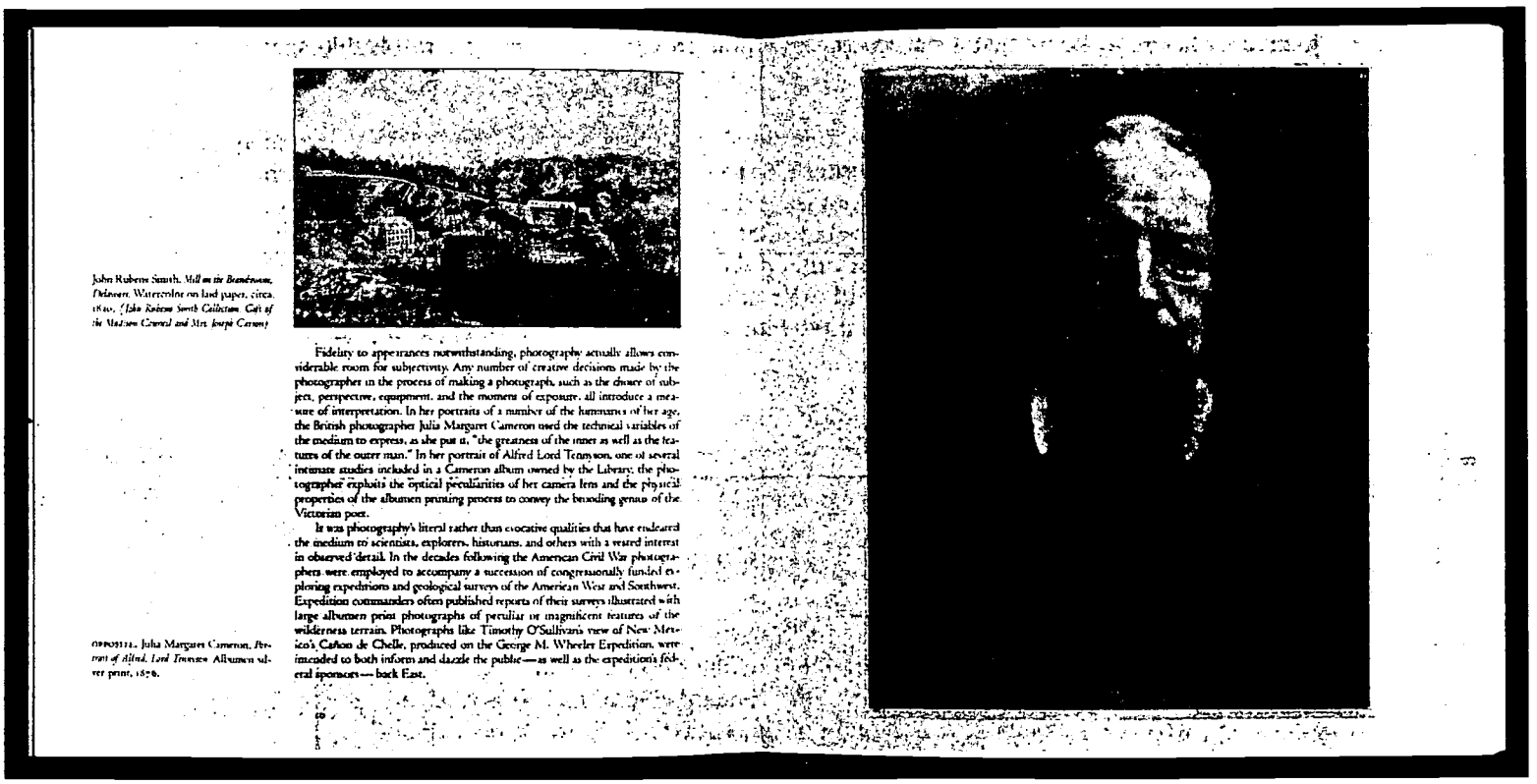
Of Letters, Lines, and Images: Reproductions in Print Publications

The literature on library practice has long been a rich source of advice on automation. When demos and pronouncements of an electronic future characterized other fields, the practical realities of taking on large-scale projects could already be found in the library world. Shared standards and collective cataloging over such services as OCLC and RLIN still have lessons to teach us even as the technology and models for on line distribution continue to change. Certainly, in contemplating the requirements for building sizable image collections there are few better references than the major microfilm campaigns that began in the 1980's. Manuals (e.g., Fox 1996, Gwinn 1987) on these joint efforts — a remarkable success story of assembling collective resources — provide a rich source of information on planning, procedures and resource projections.

One of the foundations of successful microfilming was the development of photographic standards. Given the resolving power of film and the type size of a print publication, simple calculations could be used for proper photographic settings, such as camera focal length. Direct evaluation criteria for microfilm photography were widely shared and adopted. More recently, as interest has moved to digital capture, experience with microfilm has been extended to this new reproduction medium, and comparable formulas have been advanced for the digital resolution needed to scan printed materials adequately (Kenney and Chapman 1995).

Accordingly, if the size of the content on a page is known, then the number of dots per inch (dpi) for scanning can be calculated directly.

The prospect of a simple calculation for establishing image specifications is very appealing and would be greatly reassuring for anyone embarking on a major digitizing project. At the same time, experience with collections of photographic reproductions has yielded much less tidy approaches for evaluating capture requirements. Is image content in books different from images in other media? As described below, the quantitative solutions that have evolved from scanning text do not have a logical or practical fit with capturing images even while they might prove serviceable in practice. Here is why.



John Roberts Smith, *Mill on the Brandywine, Delaware*. Watercolor on laid paper, circa. 1840. *(John Roberts Smith Collection. Gift of the Madison Council and Mrs. Joseph Carson)*

Fidelity to appearances notwithstanding, photographs actually allows considerable room for subjectivity. Any number of creative decisions made by the photographer in the process of making a photograph, such as the choice of subject, perspective, equipment, and the moment of exposure, all introduce a measure of interpretation. In her portraits of a number of the luminaries of her age, the British photographer Julia Margaret Cameron used the technical variables of the medium to express, as she put it, "the greatness of the inner as well as the features of the outer man." In her portrait of Alfred Lord Tennyson, one of several intimate studies included in a Cameron album owned by the Library, the photographer exploits the optical peculiarities of her camera lens and the physical properties of the albumen printing process to convey the brooding genius of the Victorian poet.

It was photography's literal rather than evocative qualities that have endeared the medium to scientists, explorers, historians, and others with a vested interest in observed detail. In the decades following the American Civil War photographers were employed to accompany a succession of congressionally funded exploring expeditions and geological surveys of the American West and Southwest. Expedition commanders often published reports of their surveys illustrated with large albumen print photographs of peculiar or magnificent features of the wilderness terrain. Photographs like Timothy O'Sullivan's view of New Mexico's Cañon de Chelle, produced on the George M. Wheeler Expedition, were intended to both inform and dazzle the public—as well as the expedition's federal sponsors—back East.

OPPOSITE: Julia Margaret Cameron, *Portrait of Alfred, Lord Tennyson*. Albumen silver print, 1870.

The figure here shows facing pages from an illustrated book. Look at the text and images separately. For the text, we can say that there is a fixed metric for semantic content: if we know the size of the characters and scan at a resolution sufficient to recognize them, we can be sure of getting all of the meaningful information on the page. Clearly there can be different sized typefaces, so that what we really want to ensure is that we scan at a resolution that will capture the smallest font. But regardless of what size we finally choose, the relationship is the same: if we can distinguish the letters we get the meaning.

What about capturing meaning in an image? There is no common unit, like character size, that can ensure semantic fidelity. We can see this in the variety of shapes at different scales in the image. We also probably need to know the iconographic or historical significance of the image to determine what special features are important. Further, there is meaning assigned by the text — what the image is supposed to illustrate in the context of discussion.

Similarly, no one expects that the size or visible detail of different images is directly related to the objects they represent. Turning the pages of an illustrated book is a chronicle of editorial choice: which images to print large and which to print small; which images to print in

color, which to print in gray-scale, and which to print as line art. It is difficult to decide how much loss in visual information can be afforded without undermining editorial intent (Commission on Preservation and Access. Joint Task Force on Text and Image, 1992).

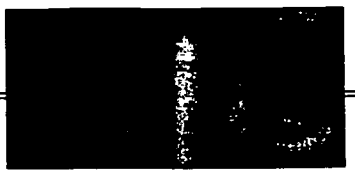
Text and image also are fundamentally different in the way they are laid down on a page. Both are printed, but while text characters carry their information in form, images (apart from line art) communicate through both form and printing tonal range (e.g., half-tone, four-color). Satisfactory capture of images will depend on how this additional dimension is handled; that is, how the screening of dot patterns to form the printed illustration is converted into electronic information.

Are there any situations where knowing only the resolution of an image might suffice? There are special cases where this may prove true. For maps of a known scale, it may be judged sufficient to know that a particular resolution provides accuracy to a resolvable spatial unit. The same may apply to other graphics such as architectural drawings.

Nothing in this discussion is meant to imply that capturing printed illustrations is particularly difficult. The point is only that deterministic formulas that fit text specifications have no logical relevance for complex images. To raise a little optimism before getting to later sections on image quality, experience has shown that printed illustrations can be captured effectively with modest effort and technology. Most printed illustrations simply are not of very high quality relative to other media (e.g., film), and offer little challenge to modern scanning technology. Those wishing to look a bit further into the relationship of digital and print quality may want to pursue the short digression below.

Digital and Print Quality

It always has been an article of faith that printed illustrations are an extremely demanding, high quality reproduction medium. Underscoring this impression, the standard rule of thumb is to double the resolution of a digital image to get a satisfactory final printed image of the same size. However, sometimes anomalous situations throw tacit assumptions into relief. When Luna Imaging produced its own electronic publication on Frank Lloyd Wright using 4x5 inch transparencies as the scanning source (Ester 1995), the goal was to rival the visual information of a single page plate in a high quality art book. As we compared displayed and printed images, we found we were achieving this objective comfortably with a digital image of much lower resolution than expected. This was very surprising. How could one see everything and more in a digital image that was much smaller in size than should be necessary for a comparable page-sized illustration? The answer is that print is a horribly inefficient reproduction medium. It is not that print presents such high quality, but rather so much more quality has to be poured into a print image to achieve a given result — in short the print medium is a "quality sink." Although this conclusion now seems obvious, the relationship between how much visual information can be viewed on screen and how much can be viewed on the printed page is not generally appreciated.



II. The Original Object and Its Reproduction

It is useful to consider briefly the original object and its relationship to photographic and electronic surrogates discussed in the rest of this report. The original object in this context might be a work of art, historical artifact or scene, or a page from a manuscript. Even though it is a reproduction medium, a photograph also can be an original object in many situations. The most obvious statement that can be made is that an original object and a reproduction are not one and the same thing, and the relationship between them is neither simple nor inevitable. When asked, scholars state unambiguously that no reproduction ever replaces confrontation with the original object or the use of primary source material (Bakewell, *et. al.* 1988). A visual reproduction entails decisions about what set of characteristics should be abstracted and what choices — e.g., levels of detail, lighting, perspective — follow from these decisions.

Photographic Originals

Original photographs create a situation where concepts and terminology can become a bit confusing. The enormous collections of historic photographs, photographs as works of art, and documentary photography are common examples where photographs are not in any sense copies, but are fully original works in their own right. A photographic original may be represented by film or print depending on the medium that expresses the photographer's creative intent. The anomalous characteristic of such photographs is that digital capture ideally will begin with the *original* and not with a second generation duplicate. Second generation duplicates—a copy photograph or reference copy, as they are sometimes called—constitute a significant loss of quality and are an inferior scanning source compared to the original photograph. A second generation surrogate may even merit different (reduced) scanning requirements. Sometimes, scanning from the original photograph will be termed "direct digital capture." Although direct digital capture may conjure up the use of digital cameras required for other kinds of cultural material, for original photographs it simply may imply standard film or print scanning technology.

There is no single right way of creating a reproduction from an original object, nor is there an absolute yardstick for measuring the importance of a reproduction. A photograph may, for instance, show facets of an object that have been altered or that may no longer exist. The "best" reproduction in this instance may have nothing to do with exemplary photography, but may evoke especially well qualities of interest for specific current research. None of these comments is intended to detract from the contribution of professional skill and high-quality equipment and materials to the quality of a reproduction. They merely underscore that any reproduction surrogate is only an approximation of the original object and that considerations beyond simple fidelity determine an image's value.

Reproductions carry their own identity in other ways. Rights to a reproduction may not follow from ownership of the original object, but may be retained by a photographer or reproduction owner. Reproductions are appropriate objects of study in themselves, not only because they may be the sole vestige of a lost or destroyed source object, but also because they reflect and influence cultural norms. Styles of photographing objects have evolved dramatically over time; there have even been changes in what is considered worth photographing in archives and other repositories (Roberts 1992).

Direct scanning of text and line graphics — black or white, bit-mapped surfaces — have been actively explored by several organizations (e.g., Kenney and Personius 1992 and The Mellon Foundation 1996). More closely related to the interests of this paper is direct electronic capture of gray-scale and color images using digital cameras. There is an abiding expectation that sometime in the future, digital photography of cultural artifacts will be a commonplace reproduction method. Even today, a persuasive case can be made for digital cameras rivaling and in some cases surpassing 35mm photography. Yet for general reproduction purposes, as opposed to special analytic purposes, digital photography still plays a very modest role compared to the vast majority of scanning from film and print sources. Some of the reasons why photographic media will probably predominate over the near future are:

- Film remains the transaction medium of professional use for institutions, printers and publishers. Publishers rarely want digital images as a visual source, even though the first thing they may do is scan incoming film. At the moment it is more effective to send off large format film than to wrestle with correspondingly large electronic files and import them correctly.

- Film is a well understood and familiar medium. Currently, several granting institutions *require* a film intermediary, considered a "stable" technology, for digital imaging projects. Although this may seem an overly cautious position, funding guidelines are intended to serve the conservative objectives of preserving intellectual access to cultural materials.

- Film is an extraordinarily efficient and sensitive medium for recording light and, despite the aura of conventionality, combined improvements in cameras and film keep photography a vital and evolving technology.

- Perhaps most persuasively, there exists a huge base of photographic collections that constitutes a very real and central concern in the humanities. Comprising an assortment of slides, transparencies, prints and publications in museums and universities, these holdings number into the many millions of images. Beyond serving a variety of research, educational, and management needs, visual collections represent major capital investments and operating commitments.

It follows, then, that for much of what we do, the digital image will only be as good as its photographic source; if visual detail or subtlety is not in the photographic medium, neither will it appear in the digital image.

Where institutions are preparing original photography, what are the important considerations in anticipation of digital conversion? Several points simply appeal to good studio practice; others are more closely tied to the digital environment.

Lighting. Very even, medium contrast lighting works best. High contrast lighting, frequently used for dramatic effect, can produce characteristics that become more evident in digital form: for example, bright colors can flare or reflect from light backgrounds, UV and strobe color casts are more likely and more pronounced. High contrast photography also leaves little latitude for error: there may be a trade-off between achieving accurate color control and losing already marginal highlight or shadow detail.

Alignment. It is remarkable how many objects are photographed slightly askew. Even in obvious examples, it seems that our eyes are quite forgiving and we mentally ignore or adjust for misalignments. Scanning can be performed exactly square to the photographic medium, and a crooked photograph is more noticeable, particularly when multiple images are displayed at once. Etched grid lenses, levels, placement markings, and simply greater attention to this factor are some of the ways to manage alignment easily.

Color control bars. Though less practical for outdoor photography, color control bars should be considered essential for studio work. As discussed more fully below, systematic inclusion of color bars with an object can reap major rewards moving into the digital environment. Improvements in fidelity, efficiency and cost are possible if these standard devices are used. These advantages can be projected across entire collections if properly applied. Optimally, color bars should be placed in the identical position for every frame, allowing automatic processing of images in electronic form. Standard color bars are readily available; reasonable care should be taken that color bars have not faded over time and are otherwise in good repair.

Gray-scale control bars. Often color bars are included but gray-scale controls are left out. When one asks why, the answer is usually that the gray-scale bars were considered superfluous with the use of color film. This is not so. Correcting a digital image involves control in three continuous areas: shadows, mid-tones and highlights. The gray-scale gradient is crucial to this process.

Maximizing useful image real estate. In most studio photography it is common to see considerable extraneous content toward the outside edges of a photograph. This may include stands, backdrops or the ambient surroundings. But of course, these parts of the picture can be cropped out later before use. Although the situation is similar in the digital medium, the allocation of available pixels to represent a picture draws attention to the premium on area. Ideally, every pixel of an image would record something important. When an image contains considerable extraneous content, pixels are assigned (or cropped out) that could have contributed to the photographic subject. Giving up a few pixels is hardly worth attention. However, the border effect can be deceptive in how much area is actually wasted. For example it is only necessary to give up a quarter inch in either dimension of a 4 x 5 transparency to loose 5% of the area; similarly reducing the outside area a quarter inch on all four sides reduces the useful area by 25%. Ironically, we have seen the unconsidered placement of color bars — an effort to maintain image quality — take away a third or more of the useful image area. In framing a subject, selecting an orientation, and picking the size and placement of color bars, it is worth considering how such photographic decisions will affect useful image area.

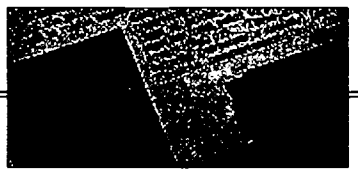
Film processing. Film processing may produce artifacts such as chemical streaking or mechanical roller marks. These may be less noticeable in the photographic original than in the digital image, depending on how much detail is available to a user. Processed film should be closely examined periodically; some defects can be left behind or corrected if they are identified before digital capture.

Avoiding darkroom magic. We encountered this issue the hard way. In correcting a group of images based on color bars, we found that we were making certain parts of the image look wrong. Repeating and checking the previous work yielded the same results. After considerable investigation, we determined the cause: in the darkroom the photographer had selectively altered sections of the image, and thereby rendered useless the relationship between the control bars taken in the photograph and the film that we scanned. It should be recognized that darkroom modifications of this sort, although desirable for print objectives, undermine the ability for global corrections to images after scanning.

Avoiding duplicate film. We have come to presume very little or no loss in converting film media into digital form. Beginning a project based on second generation film as a source was a vivid reminder of the significant quality degradation resulting from photographic duplication. This difference will, of course, be reflected in digital capture. Especially for long-term archival use, second generation film should be avoided whenever possible. At the least, it is important to know the status of the source; in some cases institutions are unaware that there are duplicate reproductions in their film collections.

Film stock. What would be the characteristics of a film if its major purpose was as a source for digital capture? Although there is some ongoing research in the film industry, simply pursuing this question with commercially available film has proven valuable. Slower, fine-grained film is greatly preferable for studio work, although this is true whether or not the intended purpose is digital. Perhaps the greatest improvement we have witnessed is the use of negative film. Normally, negative film, especially for color photography, would be an unlikely choice because it is not immediately human-readable. This limitation falls away in conversion to digital form. The notable advantage is a smoother curve in the dynamic range of negative film, yielding additional highlight and shadow detail. Our experience is still too limited to know whether equally successful results will hold for different mixes of image content, film formats and scanning. Moreover, this approach is only viable for standardized photography set-ups where the photographer does not have to check film regularly to evaluate the shot.

To be sure, some of the above problems can be partially corrected through image processing. Slight adjustments in alignment, for example, can be done quite expediently. Other problems, such as proper color controls, have no easy remedy. Even where certain types of corrections are feasible, in general, there can be no assurance of satisfactory improvement for a particular image without introducing artificial information.



III. A Framework for Assessing Image Quality

What determines the potential of a digital image to approach the quality of a photographic source? It cannot be emphasized enough that calling an image "high-quality" is not the same as saying an image "looks good." There are many ways to enhance the appeal of an image. Assessment of image quality is a statement about the image's fidelity to the source from which it is derived. One clear measure is the amount of information captured from a photograph, which is determined by image resolution (how many observations or points are collected over a spatial area) and dynamic range (how many color or gray-scale values each point can assume). Unquestionably, moving digital images toward the quality of available film formats requires scanning resolution and dynamic range well into the tens of megabytes of information. However, study has shown that although resolution and dynamic range are important factors, they are insufficient by themselves to account for image quality.

The *process* used for scanning also has a major impact on the resulting image. The term "process" as used here is an umbrella term for several distinct steps, including the specifics of the sensing technology, the processing that occurs throughout the analog-to-digital conversion, and the way numerical data are fashioned into an image format.

Two further implications of the capture process are worth citing. First, when a digital image is reduced in resolution or dynamic range (typically, for different user applications) the difference in quality of a better capture process will be retained as the image is degraded. The notion that if a lower-resolution image is desired a poorer scanning method will do is true only with the caveat that the image will look much worse than necessary. Second, differences in the capture process are particularly sensitive to challenging visual content. Examples of difficult content are shading and the background support of architectural drawings; perception of depth and surface texture in sculpture; color transitions and edge retention in paintings; and color translucency and overlay in photography and watercolor.

We know, then, that approaching the level of photographic reproductions in digital form will require large amounts of information, but also that chasing the latest scanning resolutions and image capacities on the desktop is an unpromising basis for building image collections. The quality of the capture process will also be critical. How much investment in image size and refinement of scanning technique is appropriate? How much pictorial information is contained in the original? What is the intended purpose of the digital image? How much time and cost is it worth? In pondering how good the digital image should be, consider also that the entire motivation for creating digital images is the ability to use them practically. Images intended for working applications must conform to prevailing technical and functional constraints, including the intended audience, the economics of distribution and access, and the capabilities of technologies.

The distinction that points the way to resolving this quandary is the difference between what can be termed *archival* digital images on the one hand and *derivative* digital images on the other. An archival image has a very straightforward purpose: safeguarding the long-term value of images and the investment in acquiring them. The production phase of capturing large numbers of images will be the most expensive and time-consuming aspect of an image database project. But significantly, the largest expense will not be the actual scanning. Instead, the greatest costs are for the subject expertise of documentation, followed closely by a succession of labor-intensive manual procedures: locating, reviewing and assembling source material; preparing and tracking it; and controlling its quality (McClung 1986). No less real are disruptions to personnel, facilities, and circulation of materials over the life span of these projects. Given these demands, it is extremely unlikely that an organization will repeat this process more than once in a generation.

An archival image safeguards long-term value and investment.

To ensure the image's longevity, the standard for archival digital images should be the functional range of an institution's reproduction source: that is, it should be possible to use the archival digital image in any of the contexts in which photographs, whether historical photographs or reproductions, would be used — direct viewing, prints, posters, publications, and so on — as well as to open new electronic opportunities and outlets. Note particularly that institutions have made qualitative and economic decisions concerning the format of photographic reproduction collections (i.e., 8" x 10" prints, 4" x 5" transparencies, 35mm slides, and so forth). In these cases, the electronic image should be consistent with these decisions.

A benefit of using the photographic reproduction as the archival standard is that it puts judgments concerning quality back in the hands of professionals rather than depending on the incomplete measure of technical specifications. When working from photo reproductions, a good method for testing is to go "film-to-film": to begin with the photographic reproduction, capture it digitally, then use the digital image to regenerate the initial photographic format. In this case, comparing the photographic source and the digital reproduction provides an effective means of evaluation. Using this archival digital image to produce other commonly used print and film derivatives expands the basis for evaluation. The observed differences in digital output indicate the risk or trade-off of using the electronic medium. These sample tests, which should include actual examples from an institution's collections, are well worth the investment

considering the commitments required by full-scale production. If a round-trip assessment from source to digital to source again is a useful practice, in some circumstances it may prove impractical: original photographs, for example, may include such formats as glass plates, lantern slides, daguerreotypes; it is hardly advisable to recreate some of these historic media as a testing process.

A derivative image satisfies the requirements of user applications.

In contrast to the long-term objectives of archival digital images, the quality of *derivative* images depends entirely on satisfying the pragmatic requirements of specific imaging applications. Who is the audience? What are the existing technological and cost constraints? Derivative quality is also situation-dependent: an image level considered acceptable for browsing large numbers of objects may be objectionable for other study purposes. Derivative-quality images are judged according to highly pragmatic criteria: a good image is one that conveys a maximum perception of desired visual information for the amount of data stored.

As the name implies, derivative quality images are a natural byproduct of archival-quality images. It is always possible to degrade higher-quality images and even support multiple quality levels of a single image at the same time. The reverse, however, is impossible to achieve: images captured at lower quality cannot be elevated to higher-quality images.

Different operating contexts make derivative images and archival-quality images complementary in practice as well as in principle. Derivative-quality images are presumed to operate in real time, or near real time. Archival-quality images need not conform to this constraint, or even be on line at all. Archival-quality images remain the electronic reservoir of quality that can be revisited as larger amounts of information can be used effectively. We can count on continuing technological change and improvement. Archival-quality images assure a depth of content that can accommodate such changes.

IV. Color Matching for Image Collections

Scanning reproductions and working with images in electronic form have been widely available in the pre-press world since the early 1980's. Highly trained technicians typically hand-tune each scan individually, color-correcting the image by eye to meet specific publication objectives. Many of these systems and practices, though now often scaled down to desktop technology, have been adopted for use in creating image databases. This section discusses how the construction of image archives as *collections* requires very different thinking from a pre-press mentality. Certain conventional approaches can undermine profoundly the prospect of attaining long-term visual resources. At the same time there are essential steps that must be taken if the digital conversion efforts of institutions are expected to endure for the museum, library and archives communities.

The crucial difference between pre-press and creating digital archives turns on two points. First is the issue of longevity. In the commercial print world the purpose of the image is immediate: it is a production step on the way to a publication. Images may be retained, and there is a good deal of talk about "re-purposing" digital material, but the image is a byproduct of the original print objective. Moreover, "color-correction" has more to do with the intended visual impact, paper stock, and printing process of a publication than it has anything to do

with a concept of image fidelity to a source. By contrast, the implied value of a digital image archive is directly related to its ability to last. In the context of a technological environment, this also mean that images must be transferable from system to system — including systems that do not yet exist — and must look the same across many display and output devices (Waters and Garrett, 1996).

The second point is the issue of contending with many images at once; image collections must behave as a coherent resource. It should also be assumed that image collections will accumulate in segments or phases within institutions, and that there will be a premium on accessing and combining multiple collections.

On both these counts — having image collections behave in unison and sustaining them over the long haul of technological change — the practice of arbitrarily adjusting individual images is highly undesirable. Visually hand-correcting images to the content of a photograph makes each one unique; even a trained operator cannot resolve color, brightness and contrast combinations for the contents of a photograph in exactly the same way over series of images. Organizations that are storing away their pre-press images from different publication projects are not accruing the long-term asset they imagine.

How can photographic collections be brought into the digital environment consistently? Two basic rationales for matching a digital image to a reproduction source are: "matching to film" and "matching to the scene." There are additional factors that determine how successful and complete the match will be.

Matching to film. Under this logic the goal is to make the digital image look the same as the photographic reproduction. In favorable circumstances, with color control bars in the photograph, one can take densitometer readings from the film and, knowing their digital counterparts, use these values as references for the scanned image. This process can be applied very consistently to achieve a record of the film. Where color bars are not present there are less precise ways to pursue the same objective by working with the bright and dark points of the film. Without color controls some operator judgment is involved, but the problem is narrowed to matching film values rather than visually correcting for the original objects in the photograph.

Matching to the scene. The logic of this process says that if we have a color bar in a photograph and the digital values of the target are known, then as the color bars in a scanned image are adjusted to their correct values the rest of the image is matched to these controls as well. We call this matching the "scene," because it represents the photographic scene at the moment the photograph was taken. In this case, the correspondence is to the actual objects in the photograph, where one constant object — the color bar — provides the reference. This can be taken a step further if a gray-scale bar is included, so that corresponding highlight, mid-tone, and shadow variation also can be corrected.

Bringing this summary down to familiar ground, the practice and relationship between these two methods emerged from our work in scanning more than 5,000 4 x 5 transparencies of drawings from the Frank Lloyd Wright Archives. We began the project from the perspective of matching to the film. Bringing in this mass of photographic material as a consistent and accurate digital version of the Archives' film seemed a remarkable goal at the time.

However, we then began to think that it might be possible to go beyond the film, and if we could match the Archives' color bars in the image, potentially we could represent what the camera lens saw rather than what the processed film recorded. Luna created film output from the resulting digital images and sent it to the Frank Lloyd Wright Archives. The response received from them was that the digital images produced were closer to the actual drawings than the Archives' photography. Only through comparison of the images did some of the problems become evident. We see the same characteristics in nearly every project: the Archives'

film ranged over twelve years, there were film processing differences, and there were marked differences in film batches.

It should be mentioned that not every image could be processed fully to match the scene. Several fine line drawings had been photographed with slightly overexposed areas. To have corrected to the color bars would have washed out detail, and manual adjustment away from ideal values was necessary in these instances.

It is also interesting to consider the status of images from the two methods. In the course of the Wright project, we concluded that the images matched to the film should always be produced and kept as the archival referent. The thinking was that since the film was the physical source from which digital images were derived, there ought to be a digital version of the drawings that represented this literal association. Although the reasoning is defensible and seemed a conservative touchstone for an initial project, we no longer subscribe to this position. As we looked at the practical implications in project after project, images matched to film only enshrined the intervening photographic problems between object and image.

Color Management, Transformation and Image Output

If such production steps as color matching present a certain level of complexity in themselves, the prospect of obtaining a consistent collection of images is greatly compounded in difficulty by the many potential junctures for losing control of how images look. Any time an image is captured, changed or transferred to another system, medium or device, the outcome may vary from the intended result. The industry is presently at the stage where no transition can be taken for granted. Even the seemingly benign act of moving an image file in the same format from one computer platform to another may trigger selective color shifts. This section outlines some of the key areas to watch and proposes some of the measures for coping with the still unsteady world of digital images.

In our work at Luna Imaging there are several sources of image input. We use different scanners for 35mm and 4 x 5 film; we use several other units for reflective media (such as prints) and for large and odd sized reproduction materials. We also receive image files from clients as the basis for additional processing. One decided source of variation, then, is the capture device that produces the digital image.

Discussed earlier was how image quality is determined by a mix of resolution, dynamic range, and the process of capture. For the moment, consider but one dimension of image quality, the impact of scanning systems on consistency. Although the battles waged in promotional literature are typically confined to the numbers game of resolution and density, scanning systems can also be judged on a suite of other characteristics: precision, accuracy, linearity, flare, and optical properties. What is important here is that images will vary among scanning systems, and moreover, how they vary also will be conditioned by specific image characteristics.

Scanning systems are not the only source of variation. Translating into and out of a color space is the other big factor. Commonplace color spaces include RGB, CMYK, Photo CD, and CIELAB. Although it would be tempting to control this variation by committing to one of these color models, even this tactic will not suffice. Move an image from one system to another or from one software program to another, and you are very likely to have gone through an inadvertent conversion as one vendor's representation and processing of a color space varies from the next. And the thorny part of this problem is that color transformations are by no means simple mechanics. As an added twist, there are both computer platforms and software products that optimize performance by constraining color values.

Occasionally, the difficulty of color transformation erupts into spectacular failure, where particular areas of the color gamut go to some anomalous value. These glaring events also reveal another point: the effects of variation are cumulative. Multiple passes into and out of

image environments can dramatically amplify small deviations. Blatant examples are hard to miss; the real interest is in how to cope with color control in the more subtle and commonplace situations we do not readily see. This is an area of practical concern in migration from system to system, where long-term retention of visual archives is the goal.

Someday, moving images around reliably in production will be a transparent activity. But in the meantime, the linchpins to managing images are the abilities to detect and measure variation and to map images into a uniform color space that serves as the clearinghouse for processing image collections. As a sample regimen, the steps that we follow and that work well in our situation, can be described briefly as follows:

- We move images into and out of the CIE color space. Common image representations are UVL or CIELAB formats.

- Input sources are characterized in terms of CIE by capturing standard targets in different film media. Software measures the deviation of the target from the known digital values and develops a corresponding transformation. Images from the input source can be translated into CIE on this basis.

- During production the input source must remain in calibration, which can be determined by independent testing of the associated input device or by reconfirming the characterization process above.

- As a safeguard, a standard target image is associated with every production batch; a batch may represent the number of images stored on a particular medium such as CD-ROM, or it may be an arbitrarily fixed number of images that are processed as a unit. Not only is this a standing check on input calibration, but the standard target image can be used to reference any subsequent change to the group of images, whether this is a processing step or transfer to a new computer platform.

Color Space

Color space is one of the terms often encountered in discussions about digital images, and it is a helpful, orienting concept in thinking about how images are represented and managed. As with anything digital, what we call an image or an image file, is actually a stream of binary data that is assigned meaning. Most readers probably know that image data are divided up into pixels (picture elements) that are observations for each point in an image. But how does the number assigned to each pixel correspond to a color or gray-scale value in a picture? In 1931, the Centre Internationale d'Eclairage (CIE) defined a mathematical model for representing color. The model uses the luminance, or lightness of a point plus two additional values to define color. Because there are these three different dimensions or coordinates to determine a color, it is called a "space" in the same way that axes of length, width, and height can define a volume area. The CIE color space, as it is often called, was refined in 1976, and is the accepted international standard for color measurement.

The CIE color space is the most inclusive model with the widest gamut or range of visible colors. All other color models and the gamut of color devices — scanners, monitors, printers — fit within the CIE color space. This includes the common RGB (red, green, and blue) and CMYK (cyan, magenta, yellow, and black) color spaces that mix intensities of color primaries to produce specific color values. RGB is based on the emission of light, such as monitor displays, while CMYK is based on subtracting primaries from printing inks. In principle, all color models and all devices can be mapped into the CIE color space and back out to any other color model or device. The main idea is that a device, a printer perhaps, may not have the full gamut of one of the above color models, but that portion of the image that it can do will be matched in the CIE color space. Controlling the transformation of visual information across different models, devices and actual software is at the heart of color management and color management systems.

Predictably, the phrase "in principle" anticipates the bad news. Although the basic equations for color conversions are well documented, they are non linear systems, and the ability to generate real-world transformations successfully remains the stuff of proprietary experience and color science. Also, it is possible to make decisions that are theoretically unassailable but debilitating in practice if taken to an extreme. In matching to film, is it always better to ignore photographic flaws such as over- or under-exposure and pass them on in digital form?

In shaking out a work flow process it is also useful to perform a round-trip check: starting with photographic media; capturing to digital media and processing the image; and outputting back to film or print stock for review. Again, a standard photographic target is useful for this purpose. Similarly, in assessing transfer of digital images across multiple systems, measurement of digital values at each juncture can identify and isolate problem areas. It is even worth running test images through hardware and software transfers multiple times: subtle errors may become additive or self-amplifying over several iterations.

In principle, mapping image output — for monitor displays, hard copy devices, and other storage formats — involves the same process of characterization and calibration. Exporting to other color spaces and systems is very much the same, although monitors and printers are harder to control for metric fidelity. In the context of our production, it is worth the investment in labor and equipment to maintain exacting standards of image quality and consistency for the institutions we work with and for the contents of publications. Yet even so, we consider it no small task to ensure that images remain the same as they go out to the variety of computers around our organization. But it can be said of imaging technology today that if there is sufficient incentive to control color and retain fidelity, it can be done.

Controlling Images in Distribution Environments

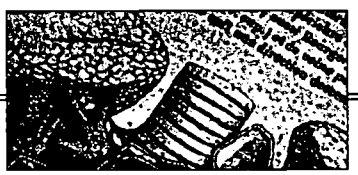
Within the context of production facilities and archival systems that support institutional applications, it is realistic to maintain electronic images that are consistent visually and in terms of their pixel values. It is important to distinguish *how* this is achieved. In pre-press, if each device and system along the chain from capture to display to film output have been tightly bound and matched to each other by the manufacturer, images may well flow gracefully through this environment. However, it is extremely common for this system to offer utterly no control within the broader diversity of computer platforms and software systems. Again, as discussed above, the solution is to create images benched against a general color (and gray-scale) model and then use characterization and calibration to bring them in line with different input and output devices. An extremely crucial point is that unless this level of control is achieved *from the beginning* for entire collections of digital images, there is little prospect of achieving image resources that will survive technological change. But very much along the lines of the distinction between archival and derivative digital images made earlier, the image standards that underwrite the long-term value of an institution's collections are unlikely, for the time being, to find their way into everyday distribution and user applications.

As CDs are inserted into home and office systems or as images are spun out to Web sites, strict control of digital content and viewing conditions is rarely a sufficient priority to prompt the extra trouble of proper transformation and calibration. Most users are content if the reds look moderately red and greens look rather green. In our electronic publication, *Frank Lloyd Wright: Presentation and Conceptual Drawings,* we included a standard target image on the disc. Probably few users have used this target even for visual inspection, let alone employed it for calibration. The only controls that are apt to see widespread use are those that are built into applications and underlying software.

Images can be stored in many file formats. Examples you are likely to see include TIFF, BMP and PICT, as well as more specialized files such as JPEG compressed files or the GIF format commonly used on the Web. In conversion utilities that transform one image format to another, it is not uncommon to encounter a selection of twenty or more alternatives from which to choose. Sometimes the choices and limitations are fairly obvious, for example BMP is largely a Windows format while PICT is a common Apple format. RGB TIFF (red, green, blue) or CMYK TIFF (cyan, magenta, yellow, black) refer to complementary color representations of an image, the former based on a video display model and the latter more typical of print applications. TIFF has the virtues of established use and wide support as an international standard. Even though there are a few sources of incompatibility, by and large a TIFF image will behave the same way on every system.

If TIFF has this degree of universality, perhaps it should be used as the archival format for digital images. In fact, it has been the format of choice in many situations. But what has been missed in this decision is that TIFF and the above formats are just the packaging, and do not account for the information that *goes into the image*. Hence, each representation, processing, or transformation of an image may be completely idiosyncratic and proprietary, even though the *form* is the same. The mixed blessing is that two images from different sources in TIFF will be equally readable on a given system, but with the decided drawback that they will not look the same.

For an intuitive sense of this issue, consider the older problem of word processing where systems were considered open, based on support of ASCII files. Although compatibility was literally true, the frustration was that none of the formatting was preserved or the same between different software products. Color management is similar to text formatting in that it is a second, very important dimension that makes the underlying common standard (ASCII for text, TIFF for images) really useful. If interchange of text documents with proper formatting can still prove troublesome after all of these years, color management is a far less mature area of development. The Photo CD format, by contrast, combines a color model with a cross-platform, color management system (CMS), making it one of the few practical ways to control image content as well as format. Specifications developed by the International Color Consortium (ICC), an organization formed by major corporations such as Adobe, Apple, Kodak, and Microsoft, is expected to yield additional approaches to consistent color management.



V. Documentation and the Integration of Image and Text

The introduction of digital images presents familiar documentation issues as well as some entirely new management requirements. Images only can be regarded as an additional dimension of humanities databases that have accrued over the past twenty years. Images cannot stand by themselves: where cultural meaning is paramount, image and text are inseparable. As suggested below, availability of the image may provide certain strategic efficiencies in cataloging or in finding material. But documentation and the long-standing issues associated with it will continue to be a fundamental task as image resources are developed and used.

The idea of many thousands of images floating in the electronic environment without text access may seem such an untenable prospect as to need little further elaboration. However, some observations are still worth making. First, some of the most important characteristics of what is represented in an image — for example, creator, dates, medium, dimensions and institutional location — are not contained in the image itself. The other common feature used to find material is the actual visual content of the image. Some promising directions are emerging for the use of pattern recognition to find images that match or approximate a target input image. But much of the visual content of interest to the humanities is based on iconographic and stylistic meaning, in contrast to what is represented literally in an image. For art historians, for example, who is the classical figure with a lion skin and jawbone? How do we identify countless biblical scenes? For historians and sociologists, what are the markers of place, time and event in historical photographs, e.g., the infrastructure of a Western town, the way the U.S.

Capitol looked when it had a wooden dome? These and countless other examples show that images may be of little value or wholly unintelligible without interpretive context.

Although the conventional problems associated with cataloging collections are well beyond the scope of this paper, the motivation for advocating documentation standards is easy enough to state. Standards apply to what information is recorded, how it is acquired, and the language in which it is expressed. Only by developing and applying standards is it possible to provide consistent and reliable access to information. The long-term value of an information asset will be determined by the choice of standards and how they are applied during data collection. Consistency is crucial within collections at the local level; they are the only way to conduct credible searches across multiple databases or to conceive of sharing information.

A special problem is developing standards that accommodate realistic levels of variability across more arts and humanities collections. There really are good reasons that objects of different types (architecture, contemporary art, manuscripts, photographs), different disciplines, and different interest groups (collections managers and scholars, for example) may require information recorded in disparate ways. Similarly, for standardized vocabularies there may be numerous legitimate variations in descriptive terms and proper names. (See Baca and Harpring 1996 for related articles in the arts.)

National and international consortia are addressing documentation standards. These efforts have yet to work completely in unison; still it is possible to identify the key attributes of successful approaches:

- Participation in and review by a broad cross-section of constituencies.
- Flexibility to select levels of cataloging by means of appropriate subsets of standard fields.
- Hierarchical and cross-referenced standard vocabularies that accommodate alternate terms and varying subject expertise.
- Generalized communications formats that allow systems to import and interpret data records from multiple sources and collections that may reflect a wide latitude of choices within standard approaches.

This last point is a very important ingredient of the standards mix. Most humanities databases today remain tightly coupled to parochial data designs and even to specific system and hardware constraints. But electronic information must assume a predictable and public structure if it is to move from system to system and survive technological change. The library world has long offered its community the MARC format as the solution: MARC has been variously adapted to serve specialized needs for archival and object cataloging. More recently, Standard Generalized Markup Language (SGML) has emerged as a more inclusive formatting vehicle for the humanities, offering a highly robust means of defining and encapsulating information, building in controlled variability, and supporting multiple media types (McClung 1995, Pitti 1995, Bearman and Perkins 1993).

Production and Management Documentation

Digital images are beginning to stack up like cordwood as museums and archives plunge into more and more electronic applications. Yet from a management standpoint, it is not at all clear that collections of digital image files are any easier to manage than collections of film and prints. At least with photographic materials, institutions have had decades to develop filing and recording methods. This is not the question of how to describe the contents of an image, which is an entirely separate discussion. Rather, production and management data answer the questions of: what is the source of this image; how was it created; what are its characteristics;

where can it be found; and what is it called. As an instance of such management information, for a typical project at Luna Imaging, we generate and export files containing the following record types for each image:

- the source of the master or archival digital image;
- the master digital image created from the reproduction;
- the derivative digital images generated from the master digital image;
- the media on which digital images are stored.

Pointers within each record maintain the interconnections among versions of images and where they reside. There is no one time or place where all of this information is acquired: reproduction data are entered when film is received; image capture variables are recorded during scanning; image characteristics and linking references are added in a subsequent production step. Not incidentally, working with visual materials raises a very problematic association: How do we know that we have connected the right image with the right text record? To address this quandary, we create a small reference image that tags the text record and can be used for review.

It is hard to communicate in words the magnitude of information that is generated. A project that involves only ten thousand images may well generate forty to fifty thousand data records, depending on the number of image versions. The information represents the basic management documentation on an image collection, and also is used to build tables needed for control and access within computer applications.

It seems extraordinary there is so little talk about such documentation as an essential part of production. Projects often add extra data fields in databases to record image file names, but these pointers seem a modest step toward what is needed. To state the obvious, unless certain production information is recorded at the time work is done, the opportunity to record the process is lost.

VI. Building Image Collections

If the preceding sections frame the major issues about digital images, this section tries to anticipate situations an institution will face in carrying out an imaging project. The stakes can be quite steep. If in the past modest demonstration projects might have been prompted by technical specialists or early adopters, increasingly it is senior managers with broad responsibility for institution-wide holdings who are asking how to create digital image collections. Some of the suggestions below come from the particulars of image applications; others are drawn from well-worn general experience with automation projects in the humanities.

Especially for initial forays into technology, creating a team around a prospective project will be an extremely valuable first step. Representation from administration, collections management, subject specialists, reproduction services, technical support, and the intended user

community will bring diverse interests and expertise to the mix. Of course the smaller the organization, the more these roles are apt to reside in the same people. With the prerogative to move forward, it will be tempting to circumvent the inefficiencies of group involvement. And indeed bringing together people around automation projects does throw into sharp relief the very different backgrounds and points of view that otherwise remain dormant in day-to-day operations. Cultivating enough mutual understanding to move toward practical solutions as a group will demand substantial effort and more than a little inefficiency. However, to plunge ahead without securing broad consensus misses two opportunities. One is the chance to create robust approaches that are responsive to a spectrum of institutional practice — appreciating that there will be compromise and not everyone's agenda will be satisfied the first time out. The other missed opportunity is the long-term benefit of building collective knowledge and experience into the organization. So frequently what is learned from early projects is concentrated in too few hands, with valuable understanding lost to staff turnover.

Many tasks of building image collections can be handed off to outside services. Yet, there are certain important domains where an institution must retain active control. Assessing how digital images and related technology will serve the institution's mission, setting the reproduction standards for the institution, evaluating the quality of images and associated documentation, and identifying target audiences and shaping the way images can be used are good examples. Taking responsibility in these key areas may seem self-evident, but the sometimes jarring discord between an institution's traditional design and style and their new electronic presence suggests the point is still worth making.

Another place to start — which also has the virtue of modest cost — is to conduct an audit of an organization's visual collections. The intent is to assess the character and scope of the material and to identify reasonably coherent subgroups. A remarkable number of projects are started without much overall sense of an institution's reproduction holdings. Projects that "begin at the beginning and end at the end" have rarely proved a recipe for success. They usually deliver too few usable results over too protracted a time line. Picking individual examples of an institution's "best" or "most important" material can have its merits. However, this approach has the great disadvantage of creating highly disjointed coverage that adds little in the way of coherence or depth to digital resources. Skimming "greatest hits" of a collection also consumes institutional commitment. Everyone can acknowledge the comparative value and richer context of having full collections in digital form, but will an organization truly have the resolve to take on secondary material in follow-on projects, once the best known objects are covered?

A better approach is to survey or audit available visual collections and distinguish how selections of specific subsets of material are incremental steps to an accumulating whole of digital information. A survey of visual resources offers a useful reference for decision-making and is an informed way for gauging strategic entry points into the collection. It may be that certain sub-collections constitute tractable projects, or that they reflect priorities in terms of parallel conservation or publication initiatives. Assessment of visual holdings also can surface opportunities to assemble projects that crosscut material from different departments. There is no implication that such a survey commits the organization to prolonged enumeration of everything it owns; characterization at a group level perspective may be perfectly satisfactory. Information for describing and segmenting a collection might include subject, size, potential use and interest, necessity for service surrogates, access rights and readiness in terms of documentation and photography.

This last point — the state of readiness of a visual collection or of the original objects — cannot be over-emphasized. In the case of original objects (e.g., art and cultural artifacts), they may not be photographed, they may have partial or scattered descriptive information, or they may be represented by a reproduction medium that is inappropriate for the intended digital use. For example, not a few multimedia producers have reacted in horror to find that an institution has only 8" x 10" black and white prints as official photographs of record for artifacts.

There are perfectly good reasons why this medium has been used as a standard, but it may be far less than ideal for something like a popular consumer title. A project starting without adequate documentation or a suitable reproduction source is a project that will likely require at least again as much investment as a project for which these materials are already assembled.

One final generalization is to keep priorities straight. The first responsibility of an institution should be to become an effective *consumer* of digital images and technology in order to serve its users and patrons. Without overdrawing the distinction, an institution would seem to spend its resources better on first learning to *apply* digital images to its field rather than on necessarily making them or developing production systems. It also is hoped that earlier topics in this report arm the reader with one important asset toward being a good consumer — knowing what you want. The topics discussed earlier in this paper — problems in photography, a rationale for archival image quality, image consistency and the logic of color matching, creating associated management data, integration of descriptive information — are all highly relevant to defining and assessing project tasks.

When it actually comes to building digital image collections, some institutions will do the work themselves; others will contract for outside services. Many readers may have already witnessed the following:

> *A recently trained staff member is surrounded by a workstation full of new computer equipment. There is a scanner over to one side, a big color monitor dominating the desktop, and a tangle of cables leading to a computer on the floor. Leaning forward, she is looking intently at the screen, making corrections to a digital image just captured from a film transparency. The lights are dimmed. Rich looking pictures appear on the display, and more than a few curious visitors stop in during the day to see the most recent images. In just a few days of production, there is already a sizable body of image files listed on the disk. Available storage is beginning to dwindle, and there is already thought of moving images off-line to make room for more scans.*

This scene, or one much like it, has been replayed in countless organizations at the beginning of an imaging project. The first images are dramatic; there is visible progress; enthusiasm and interest are high. With these kinds of encouraging results, what is apt to go wrong and why shouldn't an institution do everything itself? *Beginning* an imaging project is very seductive. In-house production may be the right choice, so long as this decision is based on what it actually will take to carry out a project. This section presents realistic requirements and describes some of the potential pitfalls.

Expertise and Skills in Digital Image Production

If the implication of "computer automation" is that creating digital image collections is just a matter of purchasing the right hardware and software, then the term is surely an unfortunate misnomer. Giving someone a scanning system is tantamount to offering them a camera and film lab and expecting them to produce a photographic collection. With the right person, training and experience, the expectation is reasonable. But push-button scanning will not compensate for limitations in staff background. Note too the difference between creating text databases and capturing images. Although it is always better to do things right the first time, text databases, at least, can be iteratively improved, added to and reorganized. Images on the other hand, cannot be fixed in this same way. Once images are captured and stored there is little recourse for shortcomings, save for repeating production or living with mistakes for a very long time.

Whether a project is staffed by few or many, the required skills are considerable: technical knowledge of image production; familiarity with the special reproduction requirements of cultural materials; and knowledge of the documentation side of the project, including descrip-

tive information about what is in an image as well as data about the images. It is important too, not to get the *wrong* expertise. Someone seasoned in the pre-press industry may have a wealth of experience about image scanning, processing, and quality control, yet have little sense about how individual images transcend print and become an end resource in their own right. Likewise, sophistication in image technology is not the same as project experience. As help is needed to begin an imaging project, find someone who has actually done one.

Hardware and Software

There is enormous variety of hardware and software for capturing and processing digital images. Scanners run from desktop units under one thousand dollars to professional systems that cost several hundred thousand dollars. Generally, the differences reflect the reproduction formats that are supported, the quality and size of images that can be handled, production throughput rates, and available tools for monitoring and controlling image characteristics. Interestingly, image consistency is not so closely aligned with price. Some of the most expensive equipment is notoriously difficult to keep in calibration over large quantities of images. Less troublesome for pre-press applications, consistency is a critical factor for digital collections. Finally, no one scanner is ideal for every job: some are better suited for prints and similar media, while others give excellent quality and performance for film.

A somewhat less obvious problem is that, to this day, manufacturers of scanners and image processing systems have trouble thinking of a collection of digital images as an end result. In many subtle ways — continual reference to CMYK color, a constant attempt to create closed production loop of control to film separation, emphasis on the initial use rather than the future life of an image — manufacturers or vendors show the dominance of pre-press as the justification for creating images. And of course pre-press is still big business. For the organization that wants to build image collections, however, this means that they cannot necessarily depend on vendors to account for their needs. It will be up to the institution to assess each step — from capture to finished image — to make sure that image content will be consistent and extendible to other electronic environments.

The sheer large storage consequences of image collections that rival film place a special burden on hardware and work flow decisions. It is not uncommon to process gigabytes of image data in a single day. In a classic "weakest link in a chain" problem — a slow peripheral device, an additional transfer to another medium or server, an extra round of handling — each step can add literally minutes to each image. Purchase dollars in capture equipment need to be matched by comparable investments in storage and communications technology.

Some of the decisions, then, are whether an institution is willing to make the initial capital investment, whether the corresponding equipment will meet the quality and production demands of the source collection, and whether there is a commitment to underwrite advancing production technology as current equipment becomes obsolete.

Multiple Image Versions

Planning and cost estimates for an imaging project should account for the likelihood of producing and managing not one image per reproduction source, but several versions of the same image. Initial archival capture will give way to image resizing and transformations needed for immediate use, whether the derivative version is for mounting images on the Web or incorporating them into a multimedia application. Also likely is the creation of derivative images for general distribution within the organization. With future advances in communication, storage, and display technologies, we may think nothing of shipping around digital images that rival today's photography. Until that time, however, most systems for sizable collections of digital images will employ some form of progressive transmission. The basic idea is that multiple versions of the same image are created at different resolutions. Smaller versions of images take up less space and can be put on a faster storage medium such as hard disk. Larger images can be put on slower media and stored "near line" (CD jukeboxes, for example)

or completely off-line. Some technologies, like the multiple resolutions inherent in Photo CD or wavelet compression, make this task easier. Some institutions that have gotten far enough to realize they now have the same images in several formats and sizes think that multiple versions are a problem, something they have done wrong. Rather, the problem is how to *document and manage* what will seemingly be a natural outgrowth of building image collections. Whether for derivative use or for progressive transmission, the consequence is the same: every project should anticipate that producing an initial image from scanning will be multiplied by several versions of the image.

Management Data

Designs for most imaging projects focus on producing digital images, or at most allow for the integration of descriptive text. Provision for management data that documents the production process and links reproductions with images and their derivatives is rarely mentioned. Yet this is an essential and significant commitment, as described earlier in this report. Also, in creating databases, it is routine to document who entered information and when. Similar information is pertinent to the creation of images, along with still further useful data such as the scanner that was used, the scanner settings and the format and size of images. It is worth remarking that if such information is not collected during production, it will never be recorded.

Organization of Images

Where do all of the images go? Do master images and derivatives simply reside in one directory? What are they called? How are batches of new images added to existing digital collections? These organizational problems have solutions in file naming conventions, directory structures, and merge operations. But they are non-trivial production operations to develop and maintain, and require solutions which do not imprison resources within specific systems.

Complexity and Scale

Many of the above considerations are barely on the horizon as projects are getting started. And they all lead to the same conclusion: methods that are adequate for a few images or even a few hundred images may not scale very well unless they anticipate the complexity of processing and managing images as their numbers grow large. It is not a linear problem, but a *multiplier* effect as images have derivatives, as each of these must be stored and organized, and as data must be assembled for both the documentation and later access of digital content. To take a simple example, consider giving an image a name. This can begin as a straightforward task of giving each image file the same name or identifier as the reproduction from which it was scanned. This assumes, of course, that the name will fit in a filename. Next there are perhaps three or four smaller images created from the master image, or alternatively, versions of the image in different formats. More names are needed. The image variations will probably not be stored in the same place, so now we need to come up with names for the places we put them and what goes into these different areas so we don't mix them up. Finally we need to record all of the names somewhere so that other people and computer programs can find the images and versions of images they need. What starts out as giving one file name to an image grows to a many-sided production step, and names are only one characteristic of the image we need to track.

VII. Image Access and User Environments

Too seldom do we hear from those academic professionals and other communities that will ultimately use digital images in their work. In a recent article, Charles Rhyne (1995) examines both the promises and shortfalls in the ways digital images can affect research and teaching. His rationale is that the humanities has both a great deal to contribute in shaping image use and a great deal to lose if it chooses not to participate. The delicate balance, as he puts it,

> *. . .is to be open to the dramatic new possibilities of digital imagery without being misled by unrestrained enthusiasm for the new technology. This requires above all that we have a firm grounding in our disciplines and a long-term view of what we hope to accomplish in our research, teaching and in the broader dissemination of information and ideas (1995:22).*

Who will maintain digital images?

Rhyne is a rare voice for those who would build digital collections and systems to suit the interests of actual practice. His article is at its best when overlaying the specific textures of the academic enterprise onto the prospects for image collections. Whether it is looking at how answers rest not in the "best" photograph but in the multiple stories different images have to tell (i.e., more reproductions of the *same* object), highlighting the inadequacy of digital projection as a major gap in technology, or exploring image use and the rhythm of classroom dialog, Rhyne joins familiar experience with thoughtful insights.

Permeating virtually all of Rhyne's comments and aspirations are two fundamental givens:

- Somehow, there will be immense numbers of high quality images available.
- Scholars, teachers and students will be able to get images and use them in the ways that they want.

Rhyne explicitly defers issues of feasibility, since his main objective is to articulate what kinds of images the humanities might want and what the field might do with them. The underlying construct that brings together both Rhyne's assumptions and the question of practicality is *access* to images. To make much headway on this issue requires looking at access as it takes on at least three different meanings:

- Who will have the rights to image collections?
- Will the scope of image collections and the electronic environments for using them lend themselves to academic practice?
- Who will underwrite the creation of image collections, and who will maintain digital resources once they are available?

Each of these questions amounts to a major topic in its own right, and in the case of rights and reproduction, there is an entire literature on the subject. This section only attempts to prompt the reader's thinking by raising some of the issues and hazarding a few observations on potential directions.

Rights to Image Collections

In principle, electronic images present exactly the same issues of rights and reproductions as any other medium. However, several characteristics of the digital medium and the ground it opens up for applications create new kinds of proprietary tensions that move legal constructs and conventional thinking into unfamiliar territory:

- Rights to a high-quality digital image are tantamount to controlling the full reproduction potential of an image, since access to the digital image provides an immediate source for any other format or medium.
- A digital image is easily and rapidly modified; the possibilities for altering an image or integrating it with other images are limitless.
- A digital image is readily copied and can be reproduced without degrading quality.
- Electronic media applications foster many times more text and images than used for print publications. The expanding appetite for content multiplies the number of sources and complexity of securing rights of use.
- The fluidity with which digital material moves through production and distribution channels has eroded traditional roles and boundaries among content owners, service providers, producers, publishers, and distribution channels (Bearman 1991).

Should an owner abdicate control over how an image is used?

Interestingly, other frequently cited traits do not merit the alarm they seem to cause. In comparison to photographic media, electronic media offer a greater number of better options for protecting images, including system controls for limiting access and functions, and ways to directly encode or mark an image to identify ownership and authenticity. Misuse of reproductions is always possible and is ultimately governed by professional and legal sanctions, but images in digital form are not inherently more vulnerable than those on film.

It is important to examine the potential impact of existing copyright law and contracts and licensing on digital images. What extensions or revisions in legal mechanisms are needed? What alternative schemes in other intellectual property contexts might fit electronic visual resources? Several conference sessions over the past few years have explored these topics (see Branscomb 1995, Ginsburg 1993, Greenberger 1990, Okerson and Mogge 1993, Steiner and Neuburger 1995). A different approach is to examine the considerations that will prove most crucial for institutions, for scholarly and general access, and for the accrual of visual resources of lasting value to the community. These points entail a mix of issues about ownership, rights, approved uses, and arrangements among different interested parties.

Discussion can begin with no more crucial topic than stewardship of a digital image collection. Here it is assumed that conversion from photographic to electronic form satisfies the quality of an archival digital image discussed earlier, i.e., one that fulfills the functional range of the source reproduction. One paramount question is whether an institutional or individual owner should relinquish either ownership or practical decision-making over this new compendium. To give up general rights in this medium is essentially to abdicate virtually all future control over how the image will be used. It is important to appreciate that securing the rights

(as well as the media and system capabilities for managing derivative images) is the best insurance for retaining effective control of a digital image collection.

The notion that institutions with traditional stewardship responsibilities should retain rights and responsibilities for digital image collections is based on the premise that the healthiest future for images will occur if ownership is diffuse and if ultimate authority rests with those who have a strong professional commitment to subject content. This premise does not require unerring wisdom and virtue on the part of museums, archives, and libraries; it only reiterates the dynamic mix of interests and points of view that produce the existing stream of exhibitions and publications. Management of collections and decisions about the use of reproductions is nothing new for most institutions, and assignment of rights is routine. To add one final point it would seem that holding onto ownership of images and assigning selective rights has to be a whole lot easier than trying to recover ownership if relationships go awry. What really is the will and capacity of academic or cultural institutions to mount significant legal challenges in the interest of intellectual property?

Unlike any other visual medium, digital images are not one thing but inherently many things at once in the myriad of derivatives that can be created from archival capture. By maintaining rights and responsibilities for the highest-quality electronic version of their material, museums, libraries and archives can exercise great latitude in what reproduction rights they release, at what quality, in what form, and for what purpose. So open is the room for choice that it is especially important that institutions conserve the rights to weigh the possibilities and reconcile the variety of options. Some of the decisions likely to arise include:

- the ways in which an image can be modified or combined with other images;
- the resolution, dynamic range, and format used for an application;
- the level and quality of documentation for an image;
- the system and distribution outlets used.

Digital information provides such creative opportunities for tuning the specifics of content that, coupled with the evolving possibilities of changing technology, even individual licenses should be limited to single, approved uses that can be clearly specified.

How does this emphasis on local control of image rights correspond to the equally significant promise of ever larger pools of images drawn from multiple collections? Although existing photo archives may be enormous in size, improving imaging technology, storage capacity, and network access makes practical centralized access to far more vast compilations of visual material in the coming decade. These two ideas can be reconciled because the very technology that makes such large assemblages of collections feasible also makes literal centralization of images and authority increasingly outmoded and unnecessary.

The Internet makes this prospect quite plain. A user entering a remote digital environment to find images need not be concerned whether retrieval has occurred on a single system at one site or whether the results emanate from the polling of multiple collections at several locations. Similarly, as long as there is a common floor of image and text standards, organizations can determine for themselves what they release, the different image qualities they are willing to offer, the terms under which they will assign rights, and even the way requests and fulfillment should take place. Even if such constructs still belong to the future, ensuring that institutions can participate in such open consortia are on the community's agenda today (NDLF, 1996).

Electronic Publications and Use of Visual Materials

Continuing advances in media, networks, and user systems will have enormous influence on access to visual materials. Yet effective delivery of information requires reasonable clarity about what materials should be provided and how they might be used. With particular emphasis on the interests of higher education and the research community, this section considers related problems about image distribution and use: Will images be distributed into the academic context, and will they be of a quality that will serve a broad range of research interests? Will available electronic environments complement and support the ways professionals use visual materials in their work? It is by no means inevitable that the arts and humanities will witness image resources comparable to what they currently find today on the library shelves of universities and study centers.

To appreciate some of the issues involved, it is worth comparing images for research and teaching with the burgeoning multimedia industry, companies ranging from communications giants to garage-sized publishers, and releases from CD's to Web sites. First, the multimedia industry shows no noticeable enthusiasm for higher education or the research community; electronic publications are overwhelmingly directed at entertainment for consumer audiences. The vast majority of electronic titles are games (Ulanoff, 1995).

Second, and no doubt related to the first, there is little obvious product differentiation by market. In print, it would be remarkable to find a publication on a subject that was aimed at all audience levels. Yet this seems to be exactly the case for most multimedia, where the content and presentation — on art, history, science and so forth — is promoted for home, school, and research use. With greater maturity, perhaps electronic media will be more selectively tailored, but it is hard to find much encouragement that the intellectual center of gravity is likely to be pushed upwards.

Will images serve a broad range of research interests?

Ironically, the liberating opportunity of the medium, allowing non linear pathways and choice for exploration, has also had a leveling effect in the increasingly prevalent 'info-nugget': a totally self-contained, summary paragraph on any object or concept (Roberts 1996). What may be several hundred or thousand blocks of text can neither presume what came before them nor what might come after. As but one choice in the scripting lattice, each is by definition expendable. Authority and authorship — who says this statement is true, when did they say it was true — are rarely evident.

Third, the vast majority of what is called multimedia is really uni-media, in that it is video-based stills, motion, and audio. Compare this to current print equivalents: the collections catalog, the catalogue raisonné the compendium by artist or subject. The multimedia industry is ill-positioned to address what might be taken as the print standard for illustrations: the single-page plate in a high-quality publication. In a very real way — in terms of important quality differences we know professionals can identify and associate with research and teaching needs (Ester 1990) — significant penetration of multimedia into higher education would actually impoverish what now exists, despite some of its other interactive advantages. The electronic images distributed in the academic world should at least meet existing professional expectations for visual quality and speed, allowing that the specific quality used at a given moment in research or the classroom will vary.

Fourth, the technology of multimedia publications is innocently confusing as a body of information. In selecting books or volumes from a shelf it is possible to get a sense of magnitude for the amount of material included. However, with information residing in a computer, it is very difficult to know the amount of content. Implicitly, multimedia publications represent themselves as major assemblages of data with endless branches of access. Yet, all of these works actually do have edges and boundaries. They are in every way authored titles, not a

limitless resource. The very idea of a coherent collection is inappropriate. Take away the interactive script, and the images, clips, and sound have no collective integrity. Neither as they are captured nor as they are integrated do they represent an accruing body of material. Electronic publications — as both resource collections and as interactive scripted titles — have a place in research and educational contexts. Still, there should be a clear understanding of how they differ from print publications.

The creation of electronic publications should be considered an opportunity to add to the digital archival level of images and text. Electronic publications can be one of the ways institutions approach conversion of their collections into electronic form. Such a strategy provides for the accrual of a long-term resource (even if only incrementally) and at the same time it serves an immediate application. Similarly, an institution might also consider requiring receipt of archival digital images as one of the obligations for companies wishing to use its material for electronic products. Decisions about the initial quality of image capture will not only determine the long-term visual resources available for the future, but also will affect significantly any lower-resolution derivative images that are produced for publication and distribution.

Attempting to enumerate the ways in which the arts and humanities might use digital images is well beyond the ambitions of this paper: problems of image processing and analysis quickly become discipline- and problem-specific. At the same time, interviews with professionals who use reproductions in their work reveal many common practices in how they interact with collections. Again, reference to prevailing use of electronic images helps highlight some of the current limitations for higher education and research.

Will user systems support the way researchers use images in their work?

Of the information systems that incorporate visual materials, digital images typically exist as a passive field of a text record: find a record satisfying certain search criteria, and an associated image appears along with it. Alternatively, finding several records may produce a screenful of small images. Although the sophistication levels of interaction, access, and interface differ, this same basic format is nearly a constant. Multimedia publications simply present a variation on this idea. Despite often rich sets of navigation tools, images are typically end destinations of a branching narrative, cemented into a text record. For publications, few, if any, actions are associated with an image apart from its place in the multimedia script.

Neither of these contexts for using images is especially consistent with the way researchers actually work with images, nor do they acknowledge the common problems with conventional reproductions that electronic images are well suited to address (Ester 1994,19-20). To illustrate, consider a few examples:

- Scholars frequently use physical juxtaposition of reproductions as a way to think. Arrangements may reflect historical progressions, stylistic relationships, or the visual outline of a scholarly argument.

- Reproductions are an extremely homogenizing and isolating medium. Digital images can offer ways of associating related material and of bringing out differences in size and scale.

- Interaction with reproductions is a process with a changing balance of image needs and activities. Tradeoffs between image quality and quantity alter in priority at different stages of research. Modes of use should make it possible to move effectively through quantities of images and yet still permit concentrated work on individual and selected groups of images.

As a general observation drawn from these examples, systems that hope to function sympathetically with scholarly practice should provide an image environment more natural to an intrinsically visual medium. We think symbolically in words, but we are also good pattern recognizers. Text searches can determine which images we choose; visual associations can likewise refine our ideas and become one side of an extended dialog. There should be greater balance in the functional capabilities between image and text. This shift is not an obscure appeal to a small number of specialists, but an elementary requirement of the way professionals work.

How Will Collections of Digital Images Be Created?

Finally, there must be some discussion of how electronic visual resources will take shape. What is the likelihood Rhyne and his colleagues will have large-scale visual resources at their disposal — coherent digital collections that also are documented and represent the high quality images he describes? Who will underwrite the substantial work of producing these materials? Several conferences and reports (AHIP and ACLS 1993, AHIP, ACLS, and CNI 1994, Dougherty and Hughes 1991, Gould 1988) make plain that there are broadly shared aspirations for the electronic library of the future. The question is how will this happen?

At the micro level, we know how work has been achieved in the past and hopefully will continue in the future: there will always be ideas, bodies of material, exhibitions, and publications with the contagious force to elicit funding. And as outlined in the introduction, there are compelling practical reasons that will drive the conversion and publication of visual material into digital form. Any rationale for individual initiatives offers good opportunities to develop coherent, high quality, and internally consistent digital collections for academic use. Within the standards and practices cited in this report and developed in other projects, there is a real sense in which these separate efforts of individuals and institutions can become an accumulating, collective whole.

Who will underwrite this substantial work?

Of course the real problem is that financial investment in resources for the arts and humanities is something short of minuscule, which does not bode well for the scale of coverage over a particular topic area or visual collections that will anticipate research and teaching needs. Traditionally, support for these projects has been approached in what E.R. Beardsley (1994) has called the "Blanch Dubois" mode of funding, depending as ever "on the kindness of strangers." The field is accustomed to grant-making organizations and other sources of sponsorship, although projects are increasingly chasing shrinking funds parceled out into ever more numerous pieces. When the obliging stranger happens to be commercial media companies, perhaps the act of kindness lacks the full flavor of philanthropy. In the most fundamental ways, the image resources needed in academics are an anathema to the broad marketplace. Simplifying greatly: For research and teaching, the premium is on the collection, providing good tools with little mediation. For consumer releases that garner sizable budgets, the emphasis is just the reverse: extreme editorial preselection, blue chip examples, and digested narrative are the priorities. Indeed, a recent casualty of language is hearing modest selections from famous art institutions called image "collections" and "libraries." Although it is surely a good bet that these are not the visual resources Rhyne has in mind, it is unclear what these terms do mean in this context.

Missing too from the equation of many individual projects are solid answers to who will provide the long-term maintenance for these resources. Decades of experience with academic databases has made clear that work does not end once information is collected. Compilations are rarely static, and securing funding for ongoing updating, technical support, and access have plagued even the most highly regarded projects.

So perhaps the technology and culture of the Internet are the answers to distribution. There is a strong tradition — underscored by practice — of putting information on the Web for free access to the on line community. Although the Internet is not income-indifferent for the general populous, it increasingly does approximate universal access for institutions, with none of the usage metering that inhibits research and exploration. It offers a nearly ubiquitous, target platform of common formats, protocols, and software tools that leverage the effort of individual institutions. This is a major advance over each organization creating and maintaining its own access system. Not incidentally, academics and cultural institutions can leverage heavy corporate investment in the Internet. The Internet and World Wide Web provide technology, resources, and services that either can be used directly or adapted to academic use. Some of the powerful commercial indexing and directory Web sites are such examples.

Taken literally, the Internet is only a communications technology. But as a social phenomenon, the spectacular growth of the Internet and the Web really has become an engine for accelerated sharing of information. Yet if the Internet is a great place for information, there is no significant change in what it takes to assemble and produce sizable collections of images and text, although the Internet does change the economic rules of traditional publication.

As far as images on the Internet are concerned, with the exception of a few large projects (e.g., National Digital Library Program, Library of Congress) we are probably somewhere in the "talking dog" stage at this point (it is not so much what the dog says as that it talks at all). You can show images on the Web, but image quality, size, and performance are decidedly poor for most users. Images currently illustrate — and often just decorate — Web sites, rather than constituting meaningful visual collections. Doubtless these are transitory limitations, and there are promising strategies for distributing high quality image collections across hybrid configurations of individual workstations, local servers, and the Internet itself.

How will image collections weather over time?

There is good reason to believe that technical hurdles will be gradually overcome, probably sooner rather than later. Still, the impact of adopting prevalent Internet standards remains to be seen. There simply has not been enough time to know how collections will weather over time. Many of the standards on the Internet are *de facto* solutions that have swept over the field. Filling in answers almost as soon as problems are defined is a testament to the intense momentum of the Internet and perhaps a prerequisite for its continued rate of growth. The Internet is about compatible structure and form over content, and does not really tell us *what* we will find: whether formats will be applied in the same way, at comparable levels, or mean exactly the same thing. It may prove a telling footnote that Hyper-Text Markup Language (HTML) has emerged as the dominant mark-up language, even while the semantically more robust SGML is usually the articulated choice for most academic standards organizations. Similarly the adoption of the GIF image format may beg the question of how we move beyond a standard once it begins outliving its useful life.

And what of the all-information-is-free prospect? In the arts and humanities, at least, this major operating premise has survived the growing commercialization of the Web. The challenge to this basic tenet has come, of all places, from universities themselves. As institutions take seriously a commitment to provide their faculty and students with electronic resources, many of these research and teaching assets (full texts, journals, media collections) are acquired at substantial cost and with site license restrictions. Content is available to any member of the institution within a distributed environment, but not to those outside. We can watch the communication walls go up as high value information is acquired in electronic form. Exacerbating the occasionally shrill on line response, institutions have then made the availability (but not the access) of these resources known — on the Internet.

The increasing number of multi-organization consortia constructed around electronic projects is another trend that speaks more squarely to the issues of building and distributing large-

scale digital image collections. Comprising both museums and universities these joint projects typically are centered on one or another field or subject. Widespread access and the Internet are prominent sub-themes, and although such collaboration is not new, it has become nearly a qualifying requirement for securing significant funding. The persuasive rationale, beyond the specific content produced, is that these projects are intended to develop the self-supporting policies and mechanisms for cooperative sharing of information. The idea is to create working models that are scaleable and sustainable.

These projects do foster great learning opportunities for exploring the relationships, standards, and controls that have to be in place to consolidate the production of digital material from multiple sources. However, there is an inconsistency between fulfilling academic expectations and realistic prospects for self-sufficiency. This dissonance produces a familiar, repetitive script: Through perceived needs of the same information and its wider interest in the field, colleagues from different institutions pull together a joint project. Usually the first collaborative task is to apply for a grant. In the enthusiasm of participation there is funding for the consortium from outside sponsors and member institutions. A collective resource is developed and the contents shared among the participants as the *quid pro quo* for participation. All institutions benefit by getting the cumulative return from the group effort, and certainly more than any one institution could have produced on their own. Who else gets the material? If the collaborative project has received grant funds, almost assuredly there will be a contractual rider to provide central access, increasingly on the Web. Even without contractual constraints, the pressure is to keep charges down to some projected cost-recovery rate.

The problem with this approach is that there are no funds to do the **next** project. "Cost recovery" usually means distribution costs in practice, and even if it were to include expenses for the entire project, potential income is in the future. Of course, any income at all presumes there is a rough marketing/distribution plan, which in fact is rarely the case. Moreover, in academics producers and consumers are in fact peers — the same people — and there is little premium on selling to each other. Nor is there much thought of secondary markets for content. Museums are accustomed to creating follow-on products and merchandising in conjunction with exhibitions, but there is no equivalent experience in academics. There is nothing wrong with pooling collaborative effort to develop more ambitious projects. But there are no mechanics in today's consortia leading to self-perpetuating ventures that can survive without continued patronage.

To look only at how organizations are trying to create, distribute, and sustain image collections is perhaps to lose track of the broader context of information access. There is, for example, Hawkins' (1994) still compelling assessment of an electronic age spiraling beyond academia's capacity to keep up:

> *To accept that the delightful vision of electronic libraries will be fulfilled — a vision so cherished by academics and librarians — would be a huge mistake, not withstanding the constant and confident reiteration of these predictions in the popular press. This confidence confuses what is technologically possible with what is logistically probable.. . .Such a future is not likely to be realized soon, partly because nobody is stepping back and looking at the problem, partly because a disaster which is at our doorstep is not fully recognized, and partly because of the terrible history of cooperation among institutions of higher education.*

Hawkins goes on to describe how the explosion of available information—doubling on the order of every four years—coupled with eroding purchasing power in buying books and periodicals, suggest that university libraries will be able to acquire a very small fraction of potential information by the turn of the century. No less troubling is the increasingly concentrated burden of acquisition: of more than 3,000 universities and colleges, nearly half of all library purchases are bought by less than three percent of these institutions.

If these observations are even approximately correct, a couple of conclusions seem plain. The costs of new electronic sources for images simply cannot be lumped on top of university acquisitions, but must offer effective *alternatives* to current practices. Further, so profound is the shortfall in keeping up with information growth, that nothing short of collective action will gain traction on the problem. Image collections of cultural heritage materials raise additional problems for cooperation, because their availability not only must draw on the academic community, but also bring together the overlapping, yet markedly distinct, interests of the museum world.

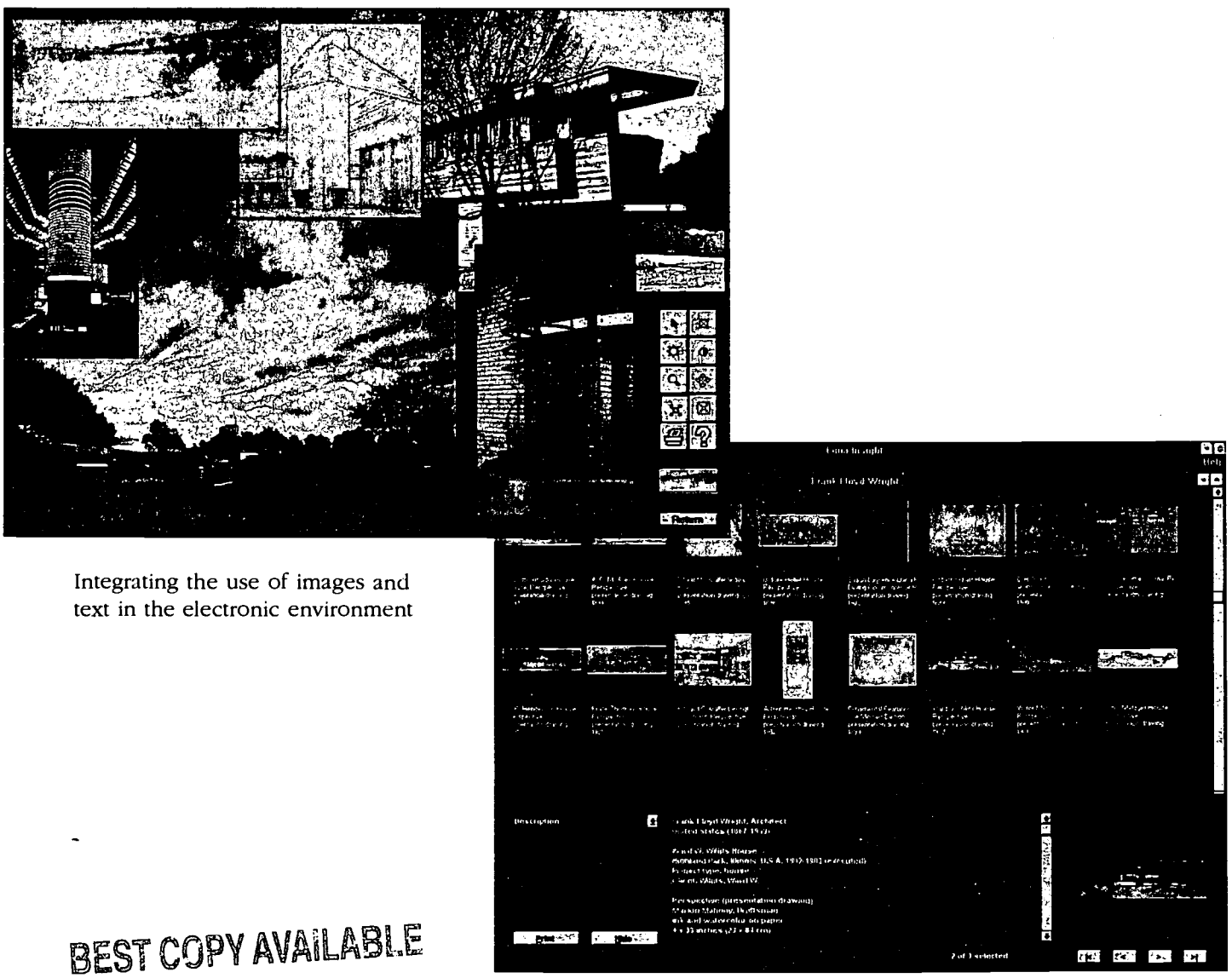
If there has been less than a stampede of institutions taking up Hawkins' challenge, this does not detract from the seriousness of his conclusions nor his strong advocacy for the formation of a collective electronic library. To do little more than prompt further thinking about this prospect, what are the characteristics and functions that are compelling and practical now, and that best can be satisfied by such an organization?

- Provide a "safe haven" for academic resources. Researchers, publishers, and institution leaders cite a recurrent mix of worries about electronic, and especially, online collections of information. An overriding concern for owners of collections and publishers is *security*. It may be a hallmark of the Internet that anything can be freely copied and used. But this simply will not wash with people who have valuable material they want to make available. Unless this problem is addressed, we will see more information teasers on the Internet, with the "real stuff" somewhere else. Rather than trying to dictate future policy, the real need is service that ensures approved access and use can be managed. A second quality is *authentication,* which plays to both information provider and user alike. Publishers and collection owners not only want to make their rights in collections evident, they also want assurance that material is presented in the way they consider acceptable. This may range from how it is documented to the quality and cropping of an image. On the user side, they, too, want to know who has assembled data, how it was done, and the source from which information was gathered. A final aspect of the "safe haven" theme is *stability and permanence.* All parties want to know that an information resource will be there tomorrow, and if the content changes, they want to know it has changed. Neither presumption can be made in today's fleeting media market. Reliable access, version control, media renewal, and updating are not nearly as exciting as launching a new project. Nor are they activities that naturally inspire funding. They are, however, the defining signatures of information with a long-term future.

- Write the academic rules of the game for collections and their use. It is safe to say that many characteristics of electronic collections and access that are sympathetic — if not crucial — to academic use are unlikely to materialize unless academia itself sets the rules. We know from experience (Bates 1994), for example, that if individuals are metered, it changes profoundly the way they interact with information resources. User or institutional subscriptions are patently more conducive to research and teaching. Similarly, in looking at research, teaching, and archival resources, questions of standards, quality, consistency, and authority take on importance beyond anything remotely similar in the consumer world. Information about collections is of little interest to the general public, but often decisive for research. For instance, large or small, good quality images or poor, the scope of a collection (what is there, what is not there) is an essential guide to correctly interpreting search results and determining what other resources should be investigated. The increasingly vast piling up and intermingling of indices and directories do not provide much solace on these counts.

- Ground electronic distribution of collections as a profitable—if not for-profit—venture. The experience of projects and collaborative initiatives suggests that the abiding cycle of funding projects and offering them up to the "circle of gifts" within academics has little promise of generating self-amplifying growth of electronic resources. Such an organization will have dynamically expanding costs in the face of technologic change

and accruing responsibilities for collections. It can count on distribution being the smallest and least considered aspect of any academic project. So certainly funds and support cannot be expected from the potential sources of collections. Could such an organization add value? There would seem to be plenty of opportunities to provide services that would be valuable to both academic and commercial partners alike, from ordering and fulfillment to market research. We know little about where the demand is, what the obstacles are, or how to assess market size and pricing. Museums are no strangers to this kind of thinking, and may have a good deal to teach us. Many have learned to balance active research and exhibition with equally successful sales and merchandising programs. Although the bad news may be that academics is a comparatively small niche market; the good news is that there remains an opportunity to define what it should be and still make good economic sense. Sponsorship will always be needed to help extend areas of research and collecting that cannot be justified on economic merit. Yet, it also seems evident that widespread accrual and access of digital image collections will depend on sounder financial objectives than recovering today's production costs and surviving on yesterday's grants.



Integrating the use of images and text in the electronic environment

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