This document describes the procedures and workflow used in a project to digitally capture several Arabic and Persian manuscripts at the Medical Historical Library at Yale University. Some of the manuscripts have several hundred pages, and we have devised the following procedures for safely and efficiently making high-quality images of the complete manuscripts, one page per image, for on-line access by scholars. Its aim is both to provide a record of procedures for the library documentation of the project and also to provide guidance to others seeking to replicate the work, especially operators not trained in photography of this type.

Digital capture by scanners requires pressing the page against glass and opening the binding past what might be the breaking point and does not provide even illumination where a page curves away from the glass into the spine of the book, so we chose to photograph individual pages with a digital camera. Scanners can capture same-size images at higher resolution than cameras can, but today’s better cameras provide more than adequate resolution and have the advantage when handling rare and valuable manuscripts safely and lighting them optimally are important considerations. Additional reasons for this approach will become apparent as specific procedures are described.

**Equipment and Setup**

**Firenze series 800 motorized camera stand.** We added a larger work surface made of MDF (medium density fiberboard). The motor control provides two speeds for raising and lowering the camera. The faster speed allows initial positioning, and the slow speed allows minor adjustments required to keep the magnification the same as pages in a thick book are captured in sequence. (Focus is kept constant; the camera is moved to maintain focus and image size as the position of the imaged page changes.) The subject matter is laid horizontally on the work surface (leveled if necessary with foam blocks or wedges made of mat board or wood, depending on the thickness needed.) The camera faces down, vertically.

**Canon 5DmkII digital camera.** This 21 megapixel full-frame sensor camera captures approximately 280 30MB camera raw images, each yielding a 60.2MB TIFF file, on an 8GB compact flash card. The full frame uncropped image dimensions are 3744 x 5616 pixels, enough to print an image 12.48 x 18.72 inches at 300 pixels per inch.

**Canon 100mm f2.8 Series L macro lens.** This lens offers resolution equal to the theoretical maximum resolution of the camera. The focal length is twice that of a normal lens on this format, putting the camera high enough so that it is out of the way of the person handling the book and also offering a more flattening perspective on pages that do not lie flat and on text that may curve into the spine. The Canon 100mm f2.8 non series L and Sigma 70mm f2.8 macro lens were used during the testing phase of the project and also offer adequate resolution. All of these lenses also
can produce close-up images down to 1:1 (the image on the sensor is the same size as the subject), though this project does not exploit that capability.

**Norman electronic flash.** The Norman 404 power pack provides finely adjustable power to two Norman LH500 flash heads with 10-inch reflectors and barn doors to direct the light and control light spill beyond the work area. The heads are mounted on robust (Lowell) collapsible light stands 5 feet from each side of the copy stand’s work surface, set at a height that aims the light at a 45° angle to the work surface. The distance and angle ensure even illumination over the work surface and the direction of any reflections of the lights away from the camera. Since some of the manuscript pages are encapsulated in Mylar®, reflections from the shiny plastic might otherwise be directed up toward the lens. The 45° angle sends any reflections from the horizontal subject toward the opposite light.

**Kinex fiber optic illuminator.** This light source provides a bright, cool light that is used for focusing and framing the image. The lamp housing sits on the rear part of the work surface, and the six-foot flexible fiber optic cable directs the light down through the camera’s reflex viewing system. The rubber eyepiece of the 5DMkII is detachable, and one was modified to accept the end of the fiber optic cable. A block of hardwood (or cabinet grade birch plywood) 1.125 x .75 x .3125 inch was glued to the plastic part of the eyecup with epoxy to cover the eye opening. A .25 inch hole in the block accepts the end of the fiber optic cable and holds it in place. The fit is tight enough that the cable won’t slip out as the camera travels up and down but loose enough to insert and remove the cable easily.

The camera’s standard focusing screen has been replaced with the **Eg-D grid screen**, which has horizontal and vertical lines molded into its surface. Normally used for alignment when viewing through the camera, the grid lines are projected onto the subject by the camera’s lens. The edges of the frame are also projected down, and when the grid lines are in focus on the subject, the subject is also in focus on the screen (and therefore on the sensor), and the image is framed as seen in the projected image. This setup eliminates the need to view by eye through the camera, a step that would be awkward at best, requiring a step stool or ladder, and hazardous to the operator or subject at worst. Framing and focusing using light projected through the camera’s viewing system works best if the ambient room light is not very bright.

**Other items.** A small **level** is used to align the camera when it is mounted on the stand. (The levelness of the work surface was established when the stand was put in place.) A **flash meter** (Minolta Auto Meter IVF) is used at the start of each shooting session to measure exposure and confirm that the light is even over the entire work surface. An electric **cable release** with a 30 foot extension is used to trigger the camera shutter. The extension allows the cord to be routed down the back of the camera stand so the trigger switch can sit on the front edge of the work surface, next to the control that adjusts the height of the camera. Routed in this way with the extension, the cord does not interfere with the person manipulating the book as the standard cable would.

A **flash synchronization cable** plugs in to the camera’s left side next to the trigger cable and follows a similar route down the back of the stand to the 404 power pack, which sits on the back edge of the work surface next to the power supply for the camera height adjustment motor.
To ensure accurate color, a custom white balance for the camera is set using a Gretagmacbeth White Balance Card. For confirmation, a reference image is made before starting with Kodak color bars and gray scale. A piece of black mat board with a hole in it is attached to the lens by its shade to prevent reflections of the camera itself when the subject pages are encapsulated in reflective Mylar®.

Image Capture Workflow

Several parameters are checked or reset at the beginning of each session. Before the camera is mounted on the stand, an 8GB compact flash memory card is inserted in the camera. The camera is turned on and its battery power level checked. The memory card is formatted. The camera is attached to the stand and leveled to match the work surface. The position of the light stands, which is marked on the floor, is checked, along with the angle of the lights. The intensity and evenness of the light is checked with the flash meter. The fiber optic cable is attached to the camera viewfinder and its light source switched on. The flash and trigger cables are plugged in.

If encapsulated pages are to be photographed, a black card is attached to the lens so that the lens protrudes through a hole in the card. It is held on by the lens shade, which is larger than the hole in the card. The card prevents reflections in the shiny material over the subject of bright parts of the camera or upper stand, which can appear in the darker parts of the image. This would also be standard procedure for subject material held flat under glass, but the fragility of the manuscript surface precludes the use of glass touching the surface in this case.

The camera’s exposure mode dial is set to manual control. The ISO sensitivity is set to 100. The shutter speed is set to 1/125 second. The speed of the flash really controls the exposure time, so the exact speed set is not critical; 1/125 is fast enough to remove any effect on the exposure from ambient light and below the camera’s maximum sync speed. The aperture is set to f11. This is slightly smaller than the lens’s sharpest aperture but gives enough depth of field to sharply render any text that is on a portion of a page curving away into the spine of the book, yet is not so small as to introduce sharpness degradation from diffraction at very small apertures. The intensity of the flash is adjusted so that the flash meter gives f11 as the correct exposure. Without the adjustability of the Norman 404 electronic flash in small increments, the light would have to be adjusted to this optimum by changing the distance to the flash heads by moving the stands back and forth.

As the camera sits on the stand, the long dimension of the image frame is oriented right to left, and the short dimension front to back in relation to the work surface upon which the subject is placed. A typical book, which is taller than it is wide, is placed on the work surface so that the binding of the book aligns with the long dimension of the image. This is also necessary so that the lights on each side shine into the gutter where the pages meet rather than across it, casting a shadow and also creating reflective highlights from a shiny page surface where the page curves away from the camera and down toward the spine. Lights should always be aligned with the spine. In the case of a book wider than it is tall, the camera should be rotated 90° by means of a tripod head or other device attached to the camera stand rather than turning the book.
Before photography of a book begins, a reference image is made of the front cover with gray scale and color bars and a tag that identifies the volume. While this image may ultimately be deleted, it is delivered along with the final image sequence as a color reference and identifier. The camera is then set for the first page to be photographed. The page edges are included, as well as a bit of the opposite page. The image of the grid screen is focused on the page as described above.

This project involves photographing the entire book, including the cover and blank end leaves as well as pages containing text. To minimize handling of the bound manuscript, all recto pages are photographed, going from one end of the book to the other, and then the book is turned once and the process is repeated for the verso pages. There are different possible starting points for the process that will yield the same final results. The shooting order determines the post-production procedure for combining both image sets into a continuous sequence. Of the various possibilities, we chose the one described here because page 1 is the first imaged page with content.

We have found it practical for one person to be the book handler and the other to make photographic adjustments and release the shutter. Because the Arabic and Persian books read back-to-front in relation to western books, we begin with the inner cover of the beginning of the book, what would be the inside back cover of a western book. The book handler starts with the book open to the inside cover, which is a recto page. That page lies flat, with support from below if the spine lifts the inner edge a bit. The spine faces the handler, who at this point holds the bulk of the pages and the other cover nearly vertically, so that the page being photographed will lie as flat as possible with the minimum tendency to curve in to the spine. The handler turns pages away from him or her to lie in the horizontal position under the camera. The sequence is: inside cover, blank leaves, page 1, page 3, etc., ending with blank leaves and the outside of the back cover. At the end of the recto sequence, the book is turned around so that the spine is again facing the handler and the front cover is up. The top and bottom of the book have changed places relative to the camera frame; one sequence will have to be rotated 180º later to put them in the same orientation, and then the whole set 90º to put the images in vertical or portrait mode (see post-imaging workflow, below).

For the second, or verso, sequence, beginning with the front cover, the handler still has the spine facing him or her, and pages are now turned by lifting from the bulk of the book to a vertical position, ending up holding the bulk of the book, the reverse of the previous sequence. The verso page sequence is: front cover, blank leaves, page 2, page 4, etc., blank leaves, ending with the inside of the back cover.

It is desirable to keep the image size the same for all pages. Refocusing as captures progress from one end of the book to the other will result in larger images for pages that are closer to the camera than for those that are at the far end of the book. The solution is to move the camera up or down to keep the camera-to-subject distance the same for all images. Fortunately, the motorized camera stand allows fine incremental adjustments to the height of the camera with a tap on the switch. In our testing we achieved good results by moving the camera every few pages and monitoring the focus of the grid screen on the subject. A more precise method is to measure the thickness of the book and determine how many taps on the switch will move the camera that distance. Dividing the number of leaves in the manuscript by the number of taps will give the
number of pages that can be imaged before a switch tap moves the camera to the proper position for the next group of pages.

**Post-Capture Image Processing Workflow**

All of the image processing is done with Adobe Photoshop CS4 and Adobe Bridge. Bridge is a separate file viewing application, which allows a number of useful batch operations on files, including rotation and renaming.

The above process results in a sequence of images consisting of all the recto pages, ending with the back cover, followed by all the verso pages, beginning with the front cover. The fact that the two covers occur together at the middle of the complete sequence makes it easy to identify the transition from one set to the next. At this stage the pages are sideways in the images, all in one set with the top at one side, and all in the other set the opposite way because the book was turned 180° for optimal handling. At this point each set is identified, selected, and rotated to the correct orientation.

For this project, a two-step renaming process quickly rearranges the recto and verso image sets into one continuous ordered sequence representing the entire book from beginning to end. The verso set, the second half of the capture, begins with the front cover and that image will become the first in the final sequence. The entire verso sequence is selected in Bridge and renamed 1a, 2a, 3a, etc. Then the recto sequence is selected and named 1b, 2b, 3b, etc. A simple sort by file name, which sorts by alphanumeric order, puts all the images in the correct order (1a, 1b, 2a, 2b, etc.).

It is critical that for this interdigitation of the two sets to work properly, there must not be any duplicate or missed pages. Duplicates should be detectable, but a mismatch of pages at the end after combining both sets may be the only indication that a page or two was missed. Another clue is the number of images in each set, which should be equal. The range of camera heights used for a particular book should be recorded to obtain the same magnification in any images that were missed and must be added.

If such a problem is discovered after the two sets are renamed, sorting “by creation date” will restore the original image order. (The camera records image capture time to the second in metadata. Even two images taken during the same minute will be ordered properly.) Any missed images can be inserted in the proper position in the sequence manually, and then the renaming of the two sets can be redone, resulting in a complete set of pages in the proper sequence.

The final file naming conventions are covered in another document (Yale University Library, Yale-SOAS Islamic Manuscript Gallery: File Naming Conventions). Suffice it to say here that a letter at the end of the sequence is not allowed by the ingest script that puts the files into their repository, and that the final file names will have the form xxxxxxxx_r0001, xxxxxxxx_v0001. It may prove easier to apply this naming convention while the recto and verso sets are still separate. As of this draft, some questions remain. In any case, we have a versatile mechanism to rename the files to the desired final specifications.
Once the camera raw images are sequenced in Adobe Bridge, they are opened in Adobe Photoshop’s Camera Raw Plugin. A moderate sharpening level of 50 is applied at this stage, and color and exposure are checked, with minor adjustments made if necessary. Also at this stage the images may be rotated slightly to straighten them and some unnecessary background cropped out, though the entire page and some surrounding background is kept. The images can be batch-saved directly from the raw plugin as TIFF files, or opened for close examination and then saved as TIFF files from Photoshop proper.

If the page was not level when it was photographed, it will appear trapezoidal rather than rectangular, but that can be adjusted at this stage in Photoshop. The effort to make the page level when it is photographed avoids the need for this correction. No additional sharpening or other adjustments are made.

In particular, despeckling, sometimes used to clean up scans of printed text, is not used because some of the Arabic and Persian text characters contain small marks that might be removed. These images are photographs of the page, and despeckling is not a tool normally used on photographic images.

The TIFF files are saved in the Adobe RGB 1998 color space at their full resolution at 300 pixels per inch. The optimal resolution for inkjet printers is 240 ppi, while halftone separation (for offset printing) and libraries usually specify 300 ppi. The same image can be saved either way and will contain the same information. As resolution goes up, the image size goes down, but the total pixel count stays the same... as long as resampling is turned off in Photoshop. The convention for this project is 300 ppi.

The process of initiating the save, specifying a file type, color space, and location for the file has been automated in a Photoshop action and can be invoked with a single press on a function key to save files that have been opened. Opening and then saving files this way is more time-consuming than batch-saving from the raw plugin, but it gives a final opportunity to visually check each image. The automated action expedites the repetitive parts of the process.

Because of the potential for confusion and human error in photographing and working with pages in a language unfamiliar to the operators and in a sequence the reverse of what we are familiar with, a backup of the original images and also of the current state of each volume’s work is kept on a separate hard drive. This would be good computer housekeeping practice in any case. In addition, an off-site file server is available for temporary backup.

When a volume is completed, it is copied to one of two 1 terabyte hard drives and delivered to the client. This drive is swapped for an identical one held by the client, onto which the current files are then also written. Thus there are two additional drives, one with the client and one with the imaging team, each of which has all of the completed work on the project to date.

The procedures described above are based on long-standing practices and ones devised specifically for this project by the author and Terry Dagradi, also a photographer at Yale ITS Photo+Design department.