

Options and preferences for collection digitisation

**Report to the Technical Subgroup
of the Pictorial Digitisation Review Group, 18 November 1999
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This document describes various technologies, techniques and standards used in image digitisation.

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1. Introduction

Our main task is to provide access to and to a lesser degree, preserve the National Library's Pictorial collections. Digitisation is an excellent tool to deliver the first aim and to a certain degree help with the latter. However, what makes it complicated is, that there are no universal standards. Patricia Battin in her talk¹ remarked that "...a major obstacle to successful cooperation is a pervasive mistrust of other people standards." I tend to agree with that statement.

Nevertheless, digital imaging technology is a fact and we no longer have a choice - we have to deal with it.

According to the Library of Congress the main characteristics of standards for digital imagery are:

- Nature of digital technology implies continuing volatility.
- Precipitous standard setting can inhibit creativity and continuing development; delayed standard setting results in chaos.
- Standards are now a complex issue involving the medium, the hardware, the software, and the technical capacity for reproductive fidelity and clarity. Why worry about a standard for the longevity of the recording medium when the software and hardware will be obsolete long before the medium deteriorates?
- So--in my opinion the prognosis for reliable archival standards as defined by librarians in the analog world in the foreseeable future is poor.²

It seems that at the moment we cannot rely on any digitisation standards with certainty that they will be adequate (and accessible) in the near future. However, for practical reasons we have to try and undertake the task of setting standards for digitisation of the Library's collections.

¹ Library of Congress, Talk presented at the Workshop on Electronic Texts, June 9-10, 1992

² Ibid., Library of Congress.

2. Charge Coupled Device (CCD)

Charge Coupled Devices are used in most scanners and digital cameras. They capture the image by converting light levels into electric current. An Analogue to Digital Converter (ADC) is used then to convert this analogue data to digital data. CCDs are solid state devices, composed of thousands of very small elements called photo sites or pixel wells. Photo sites are grouped either in a row (linear array) or a rectangular block (matrix or area array). CCDs are almost perfect sensors. They have very linear response to light intensity over a large dynamic range and they are geometrically precise and dimensionally stable. Also, they are sensitive to a broad range of wavelengths.

CCDs are monochromatic devices – ie. they do not capture colour. To be able to obtain colour images several techniques have been developed. Scanning arrays use three parallel CCDs separately coated with RGB (Red, Green, Blue) filters. Matrix CCDs employ RGB filters on a rotating filter wheel to take three consecutive readings, or use an RGB overlay of filter mosaic to capture full RGB information instantaneously (additional, less popular techniques also were used). After the capture, software combines three separate images (red, green, and blue) into a full-colour image. By using a filter overlay (mask) in matrix CCDs, the full spatial resolution of the chip is reduced and colour Moiré patterns may appear in the image.

Resolution

Resolution of a CCD depends on the number of elements that are physically present. In high-end scanners or scanning backs there are thousands of pixel sites; in area array CCDs there are millions of them.

Noise

Photons converted to electrons in a CCD carry statistical variation fluctuations in the photon arrival rate at a given point. “This phenomenon is known as Photon noise and follows Poisson statistics. Additionally, inherent CCD noise sources create electrons that are indistinguishable from the photoelectrons.”³

We can distinguish three major sources of noise:

“Photon noise refers to the inherent natural variation of the incident photon flux.

Photoelectrons collected by a CCD exhibit a Poisson distribution and have a square root relationship between signal and noise.

Read noise refers to the uncertainty introduced during the process of quantifying the electronic signal on the CCD. The major component of readout noise arises from the on-chip preamplifier.

Dark noise arises from the statistical variation of thermally generated electrons within the silicon layers comprising the CCD. Dark current describes the rate of generation of thermal electrons at a given CCD temperature. Dark noise, which also follows a Poisson relationship, is the square root of the number of thermal electrons generated within a given exposure. Cooling the CCD from room temperature to -25°C will reduce dark current by more than 100 times. In addition, many scientific-grade CCDs employ multi-pinned-phase (MPP) technology to even further reduce dark current.”⁴

Dynamic Range

“Dynamic range refers to intrascene performance; that is, the ability to quantitatively detect very dim and very bright parts of a single image.”⁵ In other words, it is the range of greytone a device is able to capture, from black to white. CCD

³ Photometrics Reference Library, <http://www.photomet.com/ref/refdr.html>

⁴ Ibid., Photometrics Reference Library.

⁵ Ibid., Photometrics Reference Library

manufacturers have adopted a definition for specifying dynamic range that is a dimensionless number:

$$\text{dynamic range} = \text{linear full well (electrons)} / \text{read noise (electrons)}$$

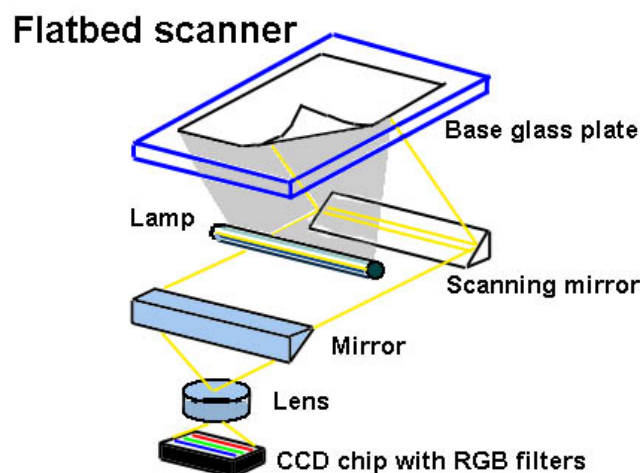
“The linear full well (full well capacity defines the amount an individual pixel can hold before saturating) is a specific measure of pixel well. With a high-performance, cooled camera, the read noise (the noise associated with a single readout event) is therefore minimized to yield the largest dynamic range possible.”⁶ To eliminate thermally generated noise, some cameras and scanners implement active cooling of the CCD.

⁶ Ibid., Photometrics Reference Library

3. Scanning

Scanning is currently the most popular way of digitising 2-dimensional objects. Scanners are often cheaper than other digital devices and require less professional training to achieve good results.

Flatbed scanner – how it works



3.1 Spatial sampling frequency (linear resolution)

There is an ongoing discussion on what linear resolution is sufficient to preserve the original's quality. However, by scrutinising various projects a certain pattern seems to emerge. The majority agrees on standards that are outlined in the table below (table 2.1).⁷

Medium	Type of scanning	Resolution
Published text/line art	Bitonal	600dpi
Colour illustrations	Colour 24-bit	300dpi
Black and White photos	Greyscale 8-bit	300dpi minimum
Colour photos	Colour 24-bit	300 dpi
B/W Halftones	Bitonal	600 dpi
Colour halftones	Colour 24-bit	300 dpi
Typewritten/laser printed	Bitonal	300dpi minimum
Ball point pen text	Bitonal	300dpi minimum
Pencil/quill/felt tip text	Greyscale 8-bit	300dpi minimum
Damaged/stained documents	Greyscale 8-bit or colour 24-bit	300dpi
Papyri	24-bit	600dpi

Table 2.1

The above-described standards will be sufficient in most situations. However, we need to be flexible as some originals may require special treatment. For example, documents or maps with very fine detail may require 600 and more dpi scanning resolution. Also, the table does not include parameters for scanning from film. This is a separate issue, as film resolution requires much higher sampling frequency to

⁷ Kenney, A.R. and Chapman, S. "Digital Imaging for Libraries and Archives", *Workshop conducted by the Cornell University Library*.

preserve all the information. Typically, film emulsions would have resolution equivalent of 1200dpi for fast films and up to 5000dpi and more for slow, fine-grain, black and white films. Library of Congress quotes 1800dpi for ISO 200-500 films and 3000dpi for ISO 25-64 films⁸. Scanning from film at such resolution requires expensive, high-end scanners. It is preferable to scan an original, when possible. National Museum of Natural History (Smithsonian Institution, USA) which favors scanning the original, argues that in a single conversion process there is less information loss and quality control is much simpler.

3.2 Colour depth (bit-depth, pixel depth)

Modern scanners and digital cameras capture from 8 bits per channel (for low-end digital devices) to 16 and sometimes more bits per channel. Such enormous colour depth (at 16 bits per channel – i.e. 48 bits per pixel offers 2^{48} colours = $2.8 * 10^{14}$ – roughly 280 trillions of colours⁹) is sometimes very useful for capturing difficult and tonally rich originals. However, for practical reasons, that colour depth is usually translated into the de facto standard of 24 bits per pixel for the final image.

Nevertheless, to avoid the loss of detail, the input devices should be able to work at larger than 8-bits depth. This allows for accommodation of originals with different dynamic ranges and the translation into 24 bit colour can be done skilfully, resulting in the superior image.

It seems that 24 bit images (over 16.7 million colours) are reasonably sufficient to represent all colours found in originals. The human eye is not generally able to perceive any finer distinction in change of colour. The vast majority of imaging professionals work with 24 bit colour to obtain full colour images. Of course, it is possible to stipulate that in the future, with advances in data storage technology and increased processing power of computers, we will be capturing images at a higher colour depth to preserve a greater degree of detail of the original. This assumption influences decisions in choosing the right graphics file storage format, as some only allow maximum 24-bit colour to be stored.

Such colour depth is not required for images that have limited usage (reference images, etc.) and images created from originals with limited number of colours. For the sake of convenience (storage space, processing power) using 8-bit greyscale with 1-bit colour depth, where appropriate, seems to be the best policy (Table 2.1).

3.3 Dynamic range

Good quality scanners and digital cameras have dynamic range in excess of 12-bits. Such dynamic range requires equally high bit depth to preserve all captured grey levels. As stated before (2.3), it is beneficial to scan at a higher bit-depth. It means, that a scanner (or digital camera) should have sufficient dynamic range – in order to capture the required bit-depth.

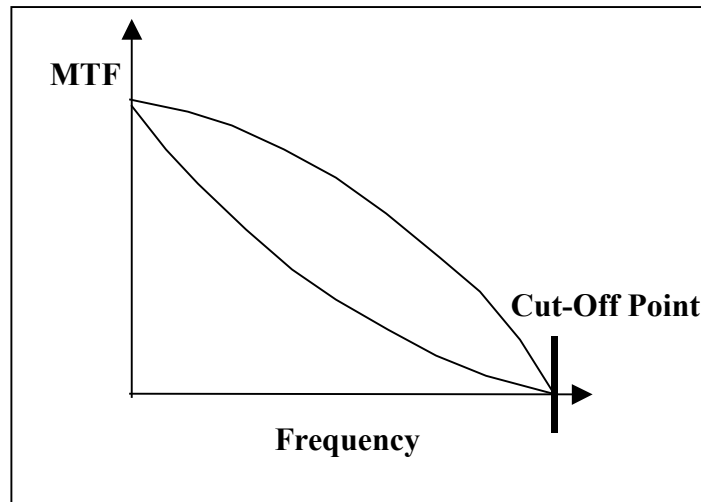
⁸ Reilly, J.M., Frey, F.S. "Recommendations for the Evaluation of Digital Images Produced from Photographic, Microphotographic, and Various Paper Formats", *Report to the Library of Congress, NDLP, Contract #96CLCSP7582*, May 1996

⁹ Using American notation.

3.4 Sharpness (Modulation Transfer Function – MTF)

In simple terms, MTF refers to how well the lens of a device can reproduce a pattern of alternating black and white lines. The MTF is a graphical representation of image quality. Therefore, it gives us an indication of the quality of the equipment used, and eliminates the need for decision-making by the observer.

Fig. 2.4



To test the detail and edge reproduction of an imaging system, an edge or a sine-wave target should be scanned. Results can be plotted onto a graph that represents the image contrast relative to the object contrast on the vertical axis over the range of spatial frequencies on the horizontal axis. The high frequency in the test target corresponds to small detail in an object (Fig. 2.4)

$$\text{MTF} = \frac{\text{OUTPUT MODULATION}}{\text{INPUT MODULATION}}$$

The Cut-Off Point in Fig. 2.4 represents the highest frequency (the finest detail) that the scanner can resolve. MTF targets can be used for quality control.

3.5. Noise

See Noise in Charge Coupled Device – (2.)

3.6 Preservation issues

Light Levels

Most of modern scanners use a cold-cathode type of light source (fluoro lamps). Also, today's CCDs have sensitivities between 0.1 to 0.001 lux¹⁰. This means that the amount of light needed for scanning is quite low. Table 2.5 shows typical light intensities for various scanners¹¹.

¹⁰ Breitenbach, A. "Inside the Charged Coupled Device", *Digital Camera*, Vol.1 July 1998, pp.54-55

¹¹ Vitale, T. "Light Levels Used in Modern Flatbed Scanners", *RLG DigiNews*, Vol.2, No.5 October 1998

Table 2.5

Model	Max Lux	Exposure time (sec)	lux-hours
Umax Astra 1220S	1368	167	15.8
Umax Powerlook III	1574	124	14.4
Umax Mirage II	2500*	114	23.8
Microtek ScanMaker 4	2270	15	2.8
Linotype Saphir Ultra 2	1393	230	14.0
Heidelberg Quickstep	1302	56	4.5
Heidelberg Topaz iX	1632	218	38.6

* Maximum lux for this measurement is uncertain due to the A-D converter saturating. This was not noticed at the time of the scan. The actual reading could not be more than 4000 lux.

For comparison: day on a museum wall is 600 lux-hours¹². Most researchers agree that light levels during scanning present negligible risk to light-sensitive documents.

3.7 Other important issues

- Flatbed scanners allow the user to scan documents up to A3 size. They can scan transparent as well as reflective originals. They may not be suitable for fragile material or bound documents as usually they include a cover that has to be placed over the original.
- Sheet-feed scanners allow the user to load a sheaf of paper to be bulk scanned. They are not suitable for most collection material.
- Film scanners are used for scanning from transparencies and negatives. They work very well but some high-end flatbed scanners can do the job as well.
- Drum scanners require the user to tape the object to a rotating glass cylinder. They produce images of extremely high quality but are slow, expensive and not suitable for collection material.

¹² Ibid., Vitale; D'Amato, D.P., Klopfenstein, R. C. "Requirements and Options for the Digitization of the Illustration Collections of the National Museum of Natural History", March 1996

4. Digital Photography

4.1 Camera types

- **Scanning CCD linear array (photo sites grouped in a row)**

Linear array types are currently the highest resolution digital cameras available. Usually, they are available as scanning backs that can be attached to an existing camera. They work by moving in steps three linear CCDs, each with its own colour filter (Red, Green or Blue), across the image plane area recording successive lines of information. Scanning array cameras deliver the highest resolution images.

However, they require a high level of lighting (flash is not suitable) and can not capture moving objects as exposure times are very long.

- **CCD area array (photo sites grouped in a rectangular block)**

CCD area capture cameras use a CCD chip to capture the full image. Some cameras require three consecutive exposures (through three different colour filters – Red, Green, Blue) to assemble a full colour image. Others employ a CCD that is coated alternately with RGB filters.

Area capture cameras are more difficult to manufacture, hence their resolution is lower than scanning array's, and prices are higher. However, exposure times are short (it is possible to use flashlights) and light levels can be very low.

Most popular professional digital cameras are listed in the table 4.1.

Table 4.1

Camera	Manufacturer	Type	Resolution	Max file size (24bit RGB)	Dynamic Range / ADC	Platform	URL
STUDIO CAMERAS AND BACKS FOR 4"x 5"							
Better Light 4000	Better Light	SA, 1-S	3,750x5,000	53 Mb	9+ f-stops/ 12-bit	Mac	http://www.kjp.de/cds-europe/better.html
Better Light 6000	Better Light	SA, 1-S	6,000x8,000	137 Mb	9+/12-bit	Mac	http://www.kjp.de/cds-europe/better.html
Better Light 8000	Better Light	SA, 1-S	8,000x10,640	244 Mb	9+/12-bit	Mac	http://www.kjp.de/cds-europe/better.html
FieldPro	Dicomed*	SA, 1-S	6,000x7,520	129 Mb	8+/12-bit	Mac, PC	http://www.dicomed.com/
PowerPhase FX	Phase One	SA, 1-S	10,500x12,600	380 Mb	12+/14-bit	Mac, PC	http://www.phaseone.com/
PowerPhase	Phase One	SA, 1-S	6,000x8,400	144 Mb	8+/12-bit	Mac, PC	http://www.phaseone.com/
PhotoPhase vII	Phase One	SA, 1-S	8,400x12,200?	103 Mb	8+/12-bit	Mac, PC	http://www.phaseone.com/
Eyelike	Jenoptik	SA, 1-S, APT	6,144x6,144**	108 Mb	8+/12-bit	Mac, PC	http://academicimaging.com/tech/diginput/cameras/jenoptik/eyelike.html
S1 Pro	Leica	SA, 1-S	5,140x5,140	76 Mb	11+/14-bit	Mac, PC	http://www.leica-camera.com/digi_img/di_cam_e.htm
Leaf Cantare	Scitex	AC, 1-S COOL	2,048x3,072	18 Mb	12+/14-bit	Mac	http://www.sinarbron.com/leafmain.htm
Leaf Volare	Scitex	AC, 3-S, COOL	2,048x3,072	18 Mb	12+/14-bit	Mac	http://www.sinarbron.com/leafmain.htm
SinarCam	Scitex/Sinar (back/camera)	AC, 3-s, COOL	2,048x2,048	12 Mb	11+/14-bit	Mac	http://www.sinarbron.com/leafmain.htm
OTHER CAMERAS AND BACKS FOR MEDIUM FORMAT							
DCS 465	Kodak	AC, 1-S	2036 x 3060	18 Mb	8+/12-bit	Mac	http://www.kodak.com

Note: Dynamic range as listed by the manufacturer

* Declared bankruptcy

** CCD physical resolution is 2048x2048 pixels

SA – Scanning Array

AC – Area Capture

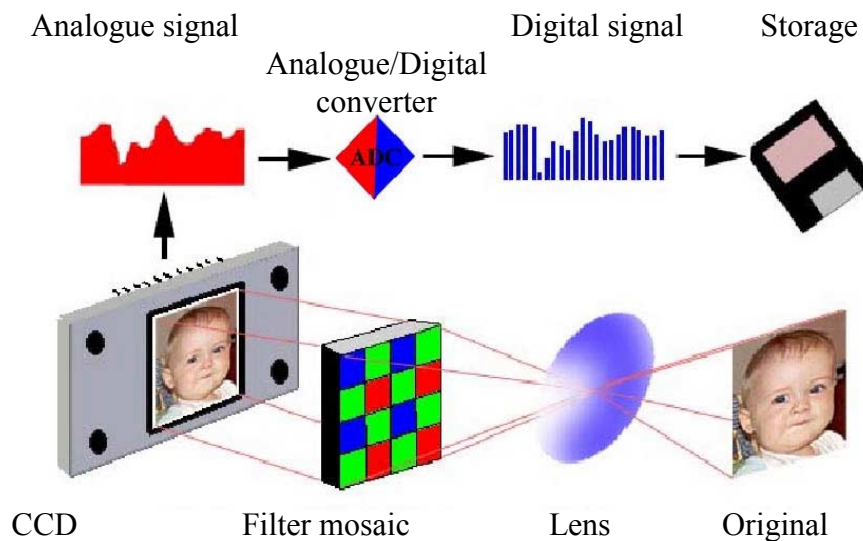
APT – Advanced Piezo technology

1-S – one-shot (filter mosaic or filter wheel)

3-S – three-shot (separate shots R+G+B)

COOL – CCD actively cooled.

Area array capture camera – how it works



4.2 Digital camera workflow

4.2.1. Preparation

The creative process for both digital and conventional photography starts in much the same way, with input from the creative photographer. Setup and lighting also proceed similarly.

4.2.2. Calibration

The digital shot has the quick added step of calibration, where a neutral target is photographed to precisely balance the color response of the digital camera to the lights. This has to be done only once – at the beginning of the session.

4.2.3. Capture

Sometimes it is advisable to capture an “empty” picture for every shot that requires different camera or lights settings. This flat-field is useful for the correction of vignetting and illumination.

4.2.4. Archiving

When the job is done, the question of how to store the images arises. In conventional photography, generally we have one or more originals, which can be archived. Since it is impossible to produce a perfect photographic dupe, NLA's policy is to produce four transparencies and two black and white negatives. Even under the best conditions, chemical images will deteriorate over time. Archiving digital photos is a much simpler matter. We are saving first generation images, so later reuse isn't a problem. And since they're digital, they can be duplicated exactly, with no loss in quality.

4.3 Lighting

As mentioned earlier, different digital cameras require different approaches. CCD area capture cameras work very well with flash packs or low level tungsten lights. CCD scanning arrays require a more sophisticated (and expensive) approach – light levels need to be high and very constant. So, for high-end, high resolution cameras we either need very powerful tungsten lights, or so called “cool lights” which are specially designed, continuous-spectrum fluorescent lights. The latter are used when it is important to reduce the amount of heat radiated by the lights.

4.4 Important issues

4.4.1. Camera resolution

Highest resolution scanning backs produce images in excess of 12,000 x 10,000 pixels. This is a very high resolution and digital camera manufacturers like to compare it to the resolution of 8"x 10" transparency film. However, if we assume transparency film to have from 1800 to about 3000 dpi resolution it gives us resolution closer to 4"x 5" sheet of film.¹³

4.4.2. Pixel depth

As with scanning, bit depth of a digital camera is an important factor. The greater bit depth – the better the final image. (Ref. point 2.2)

4.4.3. Shooting times

With scanning backs exposure times vary from a few minutes to over 30 minutes. The camera has to be completely still and lights need to be very stable.

4.4.4. Light levels

Light and heat levels produced by light sources required for high-end digital photography may worry conservators. Sometimes it is advisable to use "cool", fluorescent lights that produce very little heat. Such lights are still very bright and with exposure times up to 30 minutes it has to be taken into consideration.

4.4.5. White balance

4.4.6. Noise

See Noise in Charge Coupled Device –(2.)

4.4.7. Lenses

Lenses intended for film cameras are only satisfactory for the lower resolution CCDs. For high-end digital cameras special, high-resolution lenses are required.

¹³ Ibid., Reilly, J.M., Frey, F.S.

5. Manipulation of images and special requirements

5.1. Manipulation

Basically, it is not advisable to manipulate master images in any way. Any manipulation introduces the danger of losing or changing important elements of the image, such as dynamic range, colour, and image geometry. For derivatives however, some image manipulation is required. Due to the digital capture technology images are always slightly out of focus. Images must be sharpened up before delivery to a customer. Also, dynamic range adjustment, dust spots removal, colour replacement and other techniques may be required to improve the image.

5.2. ICC colour profiles

One of the most difficult problems facing the digital imaging industry is that all computer platforms and digital devices have their own ways of dealing with colours. It means that an image viewed on one computer will have different colours to the same image viewed on another computer. To rectify this problem a set of standards has been developed to enable devices to “translate” colour between different devices.

The International Color Consortium (ICC) was established in 1993 by eight industry vendors for the purpose of creating, promoting and encouraging the standardisation and evolution of an open, vendor-neutral, cross-platform colour management system architecture and components.

The ICC developed a standard which attempts to serve as a cross-platform device profile format to be used to characterise colour devices. A profile is simply an evaluation report. There are several kinds of profiles: input, monitor, and output. Each is a colour performance evaluation of a unique machine. A profile assesses the capabilities of a single machine so that colour pictures sent to that machine, consider those capabilities, and render colour images as accurately as possible.

ICC colour profiles are widely used by all major digital imagery players. Windows and Macintosh include ICC profiles in their operating systems and Adobe uses them in all software. Most high-end devices employ them as well. ICC profiles are extremely useful and should be embedded in every colour graphics file.

5.3. Compression

While saving images to a particular file format it is possible to employ compression algorithms. JPEG files, so popular on the Net, always use compression. For detailed description of various compression techniques see point 8.4.

6. Storage

6.1. Magnetic storage

Magnetic storage can be divided into two major groups: linear access, and non-linear access. The first group includes tape based magnetic storage. The second relies on magnetic disk technology and consists of floppy disks, hard disks, JAZ and ZIP drives, and many more old and emerging devices. With linear-access devices it is not possible to quickly access any part of data. It is like a tape audio player – you need to rewind the tape to be able to listen to a particular song. The non-linear devices have no such limitation but they are more expensive.

Magnetic storage is widely used due to its availability and speed. It is not archival as it can be corrupted by magnetic fields, temperature and physical errors. Also, magnetic storage (with the exception of tape) is more expensive than optical.

6.2. Optical storage

Currently there are a number of optical discs (we use letter “c” in the word “disc” when we are talking about optical discs, and letter “k” when we are referring to magnetic disks) used for data storage purposes. Most popular are CD-R (Compact Disc - Recordable) and DVD (Digital Versatile Disc). Both types contain a dye layer (or layers) that can be altered by light (ie. coherent, laser light).

CD-R discs are currently the most popular storage medium. They can hold up to around 650 Mb of data. They are cheap and safer than magnetic storage media, and have better archival properties. Manufacturers claim that new phthalocyanine dye based discs have over 200 years archival longevity. Many conservators challenge that sort of statements. More important however is a fact that CD-Rs will eventually be replaced by other media in the near future.

CD-RW (Compact disc re-writable) uses compact discs to store and re-write information on them. There is no substantial research proving them to be archival.

DVDs are newer, emerging technology that seems to be replacing CD-Rs. The technological concept of a DVD is the same as CD-Rs. DVD's however, can store up to 4.7 Gb of information and, additionally, can be two-sided and include two layers of media on each side, to achieve a total of 17 Gb storage capacity. It is also faster than CD-ROM. At the moment I have no information on archival properties of DVD's but it seems that they may be prone to certain problems.

6.2.1. Magneto-optical storage (MO)

Magneto-optical disks use magnetic media to store information. A laser is being used to control very precise positioning of the read/write heads. They suffer from the same sort of problems as other magnetic storage media.

Table below illustrates comparison of costs (US\$) per Mb for various storage media (media's average selling price per data capacity).¹⁴

CD-R	CD-RW	ZIP	MO (640MB)	MO (230Mb)	JAZ
0.002	0.021	0.107	0.016	0.019	0.089

¹⁴ Ricoh's media comparison, http://www.ricoh.co.jp/cd-r/e/-e_asia/hikaku/index.html

7. File naming and directory hierarchy

7.1. Kodak PhotoCD file naming convention

Kodak PhotoCD discs have a particular directory and file structure. Images reside in a directory PHOTO_CD\IMAGES. File names are seven characters long (plus extension), and observe a naming convention in which file name starts with three characters "IMG", followed by consecutive numbers "0001", "0002", etc. On PC platform files have an extension ".PCD". An **example** will be "IMG0023.PCD".

7.2. ISO 9660 file naming convention

ISO 9660 is an international standard for file systems. The use of this file system enables many different platforms to access files recorded in conformation with this file system. It is widely used in creation of CD-ROM discs and it is the only system to allow such widespread conformity.

ISO 9669 is a hierarchical file system that defines directories, subdirectories and paths. The depth of the directory hierarchy is not to exceed 8. For file and directory identifiers (names) capital letter from "A" to "Z", digits from "0" to "9", and the underscore "_" are to be used. The length of the name may be 8, the length of the file extension may be 3 letters.

Examples

IMG01.TIF

IMG_0001.TIF

IMG001

HURLEY_1.JPG

8. Graphic File Formats

I will discuss 2-dimensional, raster based file formats only, as they are the formats used to store photographic quality images.

8.1 Introduction

Currently, there are a large number of graphics file formats in use. However, only a few are being widely used. Such institutions as the Library of Congress, British Library, Stanford University and National Museum of Australia use almost exclusively TIFF, JFIF JPEG, GIF, and Kodak PhotoCD formats to digitise their collections.

8.2 General description of selected formats (see table 8.2)

JFIF (Jpeg File Interchange Format) JPEG (Joint Photographic Expert Group)
JPEG as such is not a format – it is a standard. However, JFIF file format is the most popular way of implementing it. Files written to this format have an extension ‘.jpg’ on a PC platform. JPEG is being used mostly on the Internet and when storage space is of importance because it compresses data to a large degree. The compression ratio can be controlled. As compression is lossy, the more you compress the file the more data you lose resulting in image quality loss. Sometimes, it is visible in the image in form of various artefacts or image ‘outline’. Migration to other formats is possible with limitations introduced by compression.

GIF (Graphics Interchange Format)
GIF has been created by CompuServe for storing and exchanging colour raster images. Files written to this format have an extension ‘.gif’ on a PC platform. It supports transparency and multiple images. Maximum colour depth is 8 bits per pixel which translates into maximum 256 colours. This limitation allows files to be relatively small – another ideal format for the Internet. Limited migration to other formats possible.

TIFF (Tag Image File Format)
One of the most flexible and popular formats. Files written to this format have an extension ‘.tif’ on a PC platform. Migration to other formats possible.

PNG (Portable Network Graphics Format)
PNG is a format created as a replacement for the GIF. It is full-featured compressed format intended for widespread use without legal restraints. Files written to this format have an extension ‘.png’ on a PC platform. Migration to other formats is possible within the colour space limitations.

Kodak FlashPix
This format was developed through the combined efforts of Kodak, Microsoft, Hewlett-Packard and Live Picture Inc. FlashPix is based on compound object storage, which allows storage of various kinds of data. A FlashPix file may consist of several pages where each page has storage for a source image, non-image data in the form of comments, transform data, and a stamp or thumbnail. Files written to this format have an extension ‘.fpx’ on a PC platform. Migration to other formats possible.

Kodak PhotoCD (image packs)

This is a common format for images scanned from 35mm film. An image file can contain one or more physical resolutions, with fixed dimensions. Maximum size of the image stored in this format is 2049 x 3072 pixels from PhotoCD and 4096 x 6144 pixels for Pro PhotoCD. Files written to this format have an extension '.pcd' on a PC platform. Migration to other formats possible.

MrSID (Multiresolution Seamless Image Database)

MrSID, utilizes a patented wavelet-based compression technology for compressing and viewing digital raster imagery. It is suitable for very large images (no size limit). As it creates many resolutions of the same image, it allows one to zoom into an image without (or little) quality loss. MrSID uses '.sdw' extension on a PC platform.

Raw Format

This is the most straightforward way of storing bitmaps. It is simply a list of bitmap information, byte after byte, row by row. It preserves all information but results in very large files. Files written to this format have an extension '.raw' on a PC platform. Migration to other formats possible.

8.3 Characteristics of selected file formats

JPEG

Platforms: Mac, DOS-Windows, Unix

Owner:

Max colour depth: 24 bits per pixel (16,8 million colours)

Colour spaces: YCbCr

Maximum size: ?

Compression: Lossy, JPEG

Limitations: Not suitable for archival storage – it is a lossy format. Limited colour spaces supported.

Metadata: Can be stored with the image

Comments: An excellent format for the Internet and for reference images. Unsuitable for high-quality images for archival and publishing purposes as compression introduces various artefacts. All Web browsers directly support JPEG.

GIF

Platforms: Mac, DOS-Windows, Unix

Owner: CompuServe

Max colour depth: 8 bits per pixel (256 colours)

Colour spaces: Indexed colour

Maximum size: ?

Compression: Lossless, 12-bit LZW

Limitations: Very limited maximum number of colours – not suitable for quality photographs and artworks.

Metadata: Limited support

Comments: Good format for images with limited number of colours. Good for small images for the Internet. All Web browsers directly support GIF.

TIFF

Platforms: Mac, DOS-Windows, Unix

Owner: Aldus (Adobe) / Microsoft

Max colour depth: 48 bits per pixel

Colour spaces: RGB, CIELab, YcbCr, Indexed, CMYK

Maximum size: 4 Gb of raster data

Compression: (Optional): Lossless - LZW, ITU-T Group 3 and Group 4 (suitable for bitonal images only), Lossy - Jpeg (not well implemented yet in ver. 6.0)

Limitations: No provision for text annotations.

Metadata: Capable

Comments: It is almost always supported by major applications that provide bitmap manipulation. It is platform independent. Has a very rich space of information elements for colorimetry calibration, gamut tables, etc. Has ability to decompose an image by tiles rather than scanlines. This permits much more efficient access to very large imagery, which has been compressed.

PNG

Platforms: Mac, DOS-Windows, Unix

Owner: None, patent free

Max colour depth: 48 bits per pixel

Colour spaces: Indexed, RGB

Maximum size: ?

Compression: Lossless: LZHUF (similar to LZW)

Limitations: Not supported by all Web browsers. Limited colour spaces support.

Metadata: Can store any metadata

Comments: Very good format for screen display. May in the future replace GIF and to a certain degree JPEG on the Internet.

FlashPix

Platforms: Mac, DOS-Windows, Unix

Owner: Digital Imaging Group

Max colour depth: 24 bits per pixel

Colour spaces: YCC, RGB

Maximum size: ?

Compression: (Optional): Lossy - JPEG

Limitations: See comments.

Metadata:

Comments: FlashPix format technology is based on a new philosophy of what digital imaging should be. FlashPix format recognises that most users don't need most of image data most of the time. It retrieves information needed for a particular use only. It stores image data in tiles – this feature allows applications to choose the appropriate resolution a user needs for a selected procedure and to access directly the specific areas of an image needed for the operation being performed.

FlashPix has been created for an average user to simplify digital imaging technology. There are limitations that keep it from becoming a professional standard in its present form. It has limited colour spaces support, needs greater bit depth, and further support of ICC colour management. Also, it has been reported that Storm Technology Inc. has filed for a patent for the EasyPhoto AFF format, which is very similar to—and may cover—Flashpix. That may restrict FlashPix format usage in the future.

PhotoCD

Platforms: Mac, Windows, Unix

Owner: Kodak

Max colour depth: 24 bits per pixel

Colour spaces: Photo YCC

Maximum size: 6144 x 4096 pixels*

Compression: Visually lossless: Chroma subsampling + Huffman

Limitations: Limited maximum image size. Proprietary format. See comments.

Metadata: Capable

Comments: Popular format, used especially for scans from 35 mm film. Limited maximum image size makes it unavailable for very high spatial resolution images. YCC colour space used enforces RGB to YCC translation, as all input devices are RGB. YCC has a very large gamut but this translation probably might introduce some colour shifts. PhotoCD was primarily designed as a format for image display on a TV or computer monitor – chroma subsampling algorithm used throws away almost 60% of the colour information, which is great for file sizes and does not affect human eye perception but nevertheless loses information. Pro PhotoCDs can be created on a dedicated PhotoCD Imaging Workstation (PIW) only. PIW requires considerable investment. Currently, Pro PhotoCD can be written to special Kodak CD-ROMs .

* 6144 x 4096 pixels for Pro PhotoCD
3072 x 2048 pixels for standard PhotoCD

MrSID

Platforms: Mac, Windows, Unix.

Owner: LizardTech.

Max colour depth: 24 bits per pixel.

Colour spaces: RGB.

Maximum size: unlimited.

Compression: Lossy. Wavelet.

Limitations: Proprietary format. Requires special viewers and plug-ins. Lossy compression.

Metadata: Capable.

Comments: It uses a selective decompression technique that gives the ability to decompress only a part of the compressed image that you want to view. This makes it very quick even with very large images. The wavelet compression algorithm makes it much better quality than JPEG. MrSID is very useful for making very large images available on the net. It is not really suitable for archival masters, as the compression is lossy. Also, it is possible that similar formats will emerge (ER Mapper is an existing competitor) making MrSID obsolete.

Raw

Platforms: Any

Owner: None

Max colour depth: Any

Colour spaces: Any

Maximum size: Any

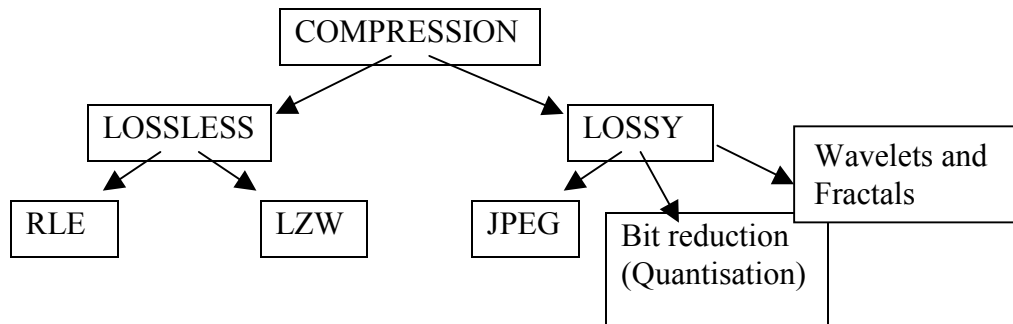
Compression: None

Limitations: Very large file sizes.

Metadata: No provision for standard metadata implementation.

8.4 Compression techniques

There are two broad categories of compressed file format, those which are lossless (retain the bitmaps perfectly) and those which are lossy. The main hierarchy of compression techniques is presented in the diagram below.



Lossy compression

One lossy technique is called bit reduction or quantisation. It works by reducing the colour information. It is regarded as a very crude way of reducing file sizes.

The most common of lossy techniques is JPEG. It offers huge compression ratios in comparison to the lossless formats. JPEG converts the image to YCbCr form to allow compression on the different channels. Due to human sensitivity to luminance this feature is usually compressed the least. For each channel, the image is decomposed into 8 by 8 pixel blocks. By using Discrete Cosine Transform (DCT), Huffman and Variable Length Code (VLC) algorithms it is possible to achieve great compression rates but it results in a loss of data. JPEG Baseline Sequential compression should be used.

Another quantisation technique uses wavelets. Wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale. It seems that wavelets compression results in less quality loss than JPEG. Also, there are some wavelets based applications (Ricoh's CREW¹⁵) where the same codestream can be used for both, lossless or lossy applications due to embedded quantisation. However, most wavelet compression applications are still in the early stages of development and are not widely implemented. There is heavy mathematics involved here and I would be lying if I said that I fully understand how they work.

Lossless compression

The simplest lossless compression technique is called Run Length Encoding (RLE). The idea is to reduce the amount of data by saving the number of same colours in every row of pixels in the image. The implementation is more complicated but this is the basic principle.

Another lossless technique that achieves higher compression rates is Lempel-Ziv Welch (LZW). LZW compression creates a table of strings commonly occurring in the data being compressed, and replaces the actual data with references into the table. It is a very good and widely used compression algorithm.

¹⁵ CREW can obtain around 50% compression without losing any data.

Table 8.2. Most popular graphic file formats

	MrSID	JFIF JPEG	GIF	TIFF	PNG	Kodak FlashPix	Kodak PhotoCD	Raw
Main characteristics		Very popular format for the Internet. Recognised by all Web browsers. Uses lossy compression that doesn't work well on lettering or line drawings but is very efficient in terms of file sizes	Very popular format for the Internet. Recognised by all Web browsers.	One of the most popular and flexible formats.	Replacement for GIF format.	FlashPix is based on compound object storage, which allows storage of various kinds of data.	This is a common format for images scanned from 35mm film. An image file can contain one or more physical resolutions, with fixed dimensions.	This is the most straightforward way of storing bitmaps. It is simply a list of bitmap information, byte after byte, row by row.
Colour depth /colour spaces	24 bit / RGB	24 bit / YCbCr	8 bit /Indexed	48 bit / Indexed, RGB, CIE Lab, YcbCr, CMYK	48 bit / Indexed, Indexed, RGB	24 bits / YCC, RGB	24 bit /YCC	
Max size	unlimited	?	?	4 Gb	?	?	6144 x 4096 pixels*	unlimited
Limitations	Lossy format. Requires proprietary writers and readers.	Not suitable for archival storage – lossy format.	Very limited maximum number of colours – not suitable for quality photographs and artworks	No provision for text annotation.	Limited colour spaces support. Limited bit depth. No support for ICC colour management.	Limited colour spaces support. Limited bit depth. No support for ICC colour management.	Limited max image size. Pro PhotoCD requires dedicated workstation.	Huge file sizes. No standards for additional features.
Compression	Lossy, Wavelet	Lossy:JPEG	Lossless: LZW	Optional: LZW, G3, G4, Jpeg	Lossless: LZHUF	Optional lossy: Jpeg	Visually lossless: Chroma subsampling, Huffman	None
Metadata	Capable	Capable	Capable	Capable	Very capable	Very capable	Capable	No standard

Platform	Mac, DOS-Win, Unix	Mac, DOS-Win, Unix.	Mac, DOS-Win, Unix.	Mac, DOS-Win, Unix.	Mac, DOS-Win, Unix.	Mac, DOS-Win, Unix.	Mac, DOS-Win, Unix.	Any
Copyright	LizardTech		CompuServe	Aldus (Adobe)/Micro soft	None, patent free	Digital Imaging Group	Kodak	None
Other	Great format for making very large images available on the net.	An excellent format for the Internet and for reference images.	Supports multiple images. max 256 colours – not suitable for most colour photographs and artwork	The most popular and flexible format. Rich space of information elements for colorimetry calibration, gamut tables, etc.	Not many Web browsers support it yet. Doesn't support multiple images. Variable transparency, gamma correction (cross-platform), 2-D interlacing.	FlashPix has been created for an average consumer. There are limitations that keep it from becoming a professional standard in its present form.	Popular format, especially for 35 mm film scans.	Uses too much storage space.

* 6144 x 4096 pixels - Kodak Pro PhotoCD
3072 x 2048 pixels – Kodak PhotoCD

9. Digital images evaluation and quality control

The Library of Congress recommends the following methodology for evaluation of performance and products of scanning service providers.¹⁶

- Vendor qualification
 - ◆ Rule out so-called image defects as dirt, “half images”, skew, and so on.
 - ◆ Evaluate:
 - Noise
There is no objective test to measure digital noise. It is best done by viewing the blue channel of an RGB image.
 - Tone reproduction
The tonal value for the desirable archival images shall be as follows: For a black-and-white scene with a typical range of brightness, eg. a landscape in daylight or a conventional studio portrait. If the desirable images are produced at 12 bits-per-pixel, the histogram shall show continuity of sampling and include values ranging from black to white, and some pixel values in the range of 5-15 (black) will be present as well as some values in the range 4070-4086 (white). If the desirable images are produced at greater than 12 bits-per-pixel, the histogram shall show continuity of sampling and include values proportionally greater than those for 12 bits per pixel.

For color images with typical scene brightness that include white or black elements, if the desirable images are produced at 36 bits-per-pixel, similar values shall be provided for RGB (red, green, blue) renderings of white or black, ie. a white area shall have values of $r=4070-4086$, $b=4070-4086$, and $g=4070-4086$ and a black area shall have values of $r=0-10$, $b=0-10$, and $g=0-10$. If the desirable images are produced at greater than 36 bits-per-pixel, the histogram shall show continuity of sampling and include values proportionally greater than those for 36 bits per pixel.

For mandatory images (8-bit greyscale), the digital values should be linear to the original density. The digital values for each area on the greyscale target shall not deviate by more than 10 from a linear least squares regression line fitted between the densities of the original target and the digital output values. A white area shall have values of $r=243-250$, $g=243-250$, and $b=243-250$, and a black area shall have values of $r=5-12$, $g=5-12$, and $b=5-12$. Care should be taken that no clipping (= loss of details) in either the highlights or the shadows occurs.

For desirable images the digital values should be linear to reflectance / or transmittance. A white area shall have values of $r=4070-4086$, $g=4070-4086$, and $b=4070-4086$, and a black area shall have values of $r=5-15$, $g=5-15$, and $b=5-15$. Care should be taken that no clipping (= loss of details) in either the highlights or the shadows occurs.

¹⁶ Ibid., Reilly, J.M., Frey, F.S.

- Detail and edge reproduction (MTF)
The measured MTF shall have values, which fall within the ranges given in the following table, at the given spatial frequencies:

Frequency	MTF
1	0.90-1.0
2	0.80-1.0
3	0.70-1.0
4	0.60-1.0
5	0.50-1.0
6	0.40-1.0
8	0.30-1.0
10	0.20-1.0

Library of Congress' steps in digitisation process are:

- Images Quality Review
- Verify delivery of 100 percent of files
- Inspect 10 percent of file contents
- Ensure technical requirements have been met
- Provide feedback to contractor
- Review any re-work

Throughout the project, one person should be in charge of quality control. This entails:

- checking cataloguing records for required information
- checking the quality of the large image files, smaller image files for the WWW (eg. JPEGs), and thumbnail images (eg. GIFs).
- checking for consistency of file sizes and colour settings

Consistency is extremely important. Several mock-ups should be done throughout the course of the digitising and cataloguing in order to make sure that image files are the appropriate sizes. It is possible that you may need to adjust standards in order to provide better quality images or to reduce the size of the images if they are loading too slowly. Each type of media and each project will have different standards.

10. Summary

Digital Imaging is gaining popularity as it becomes cheaper and proves to be an excellent accessibility tool. Also, in some aspects digital imaging is superior to conventional technologies in creating archival masters. At the moment it seems that the emphasis should be placed on creating digital images for access. However, capturing archival masters at the same time will prevent unnecessary handling of originals in the long run, as digital masters can be used for printing and creating new digital derivatives for access. It is my opinion that it should be beneficial to select a number of most important collections' items for digitisation. Also, digitising new acquisitions instead of capturing them on film will speed-up the process and make it more cost effective. While it can be argued that the truly archival format is a black and white print or negative only, digital images allow for greater fidelity in terms of colour and dynamic range. Also, image duplication is quality lossless and can be repeated indefinitely.

File Formats

Major cultural and educational institutions like British Library, Library of Congress, Research Libraries Group, Columbia University recommend TIFF, PhotoCD, JPEG and GIF image formats to be used in collections digitisation. For example the Columbia large maps project used the following format specifications¹⁷.

Media Type	Archive File Format	Screen Presentation Format
Black & White Text Document	TIFF w/CCITT ¹⁸ Fax 4 Compression	GIF, 4-bit
Illustrations, Maps, Manuscripts, etc.	TIFF	Multiple JPEG, 24-bit Quality level 50
3-dimensional objects to be represented in two-dimensions	TIFF	Multiple JPEG, 24-bit Quality level 50
35mm Black&White & Color slide or negative	PhotoCD or TIFF	Multiple JPEG, 24-bit Quality level 50
Medium to	PhotoCD or	Multiple

¹⁷ Technical Recommendations for Digital Imaging Projects. Image Quality Working Group of ArchivesCom, a joint Libraries/AcIS committee. April 2, 1997

¹⁸ CCITT – currently ITU-T

Large Format photograph, slide, negative, transparency or color microfiche	TIFF	JPEG, 24-bit Quality level 50
Black & White Microfilm	TIFF w/ Fax 4	GIF, 4-bit
	TIFF	GIF, 8-bit

In my opinion TIFF as the most popular, open and expandable format is most suitable for master images. It seems that it will be widely used for many years to come and there should be plenty of software capable of retrieving TIFF images. Also, its 48 bits per pixel capability (if needed) and excellent colour support guarantee very high quality of images. The other common alternative - PhotoCD format, very good for automated 35 mm film scanning, introduces problems: Pro PhotoCDs can not be produced in-house (an expensive workstation or out-sourcing required); not all image viewers are PhotoCD capable (and almost all are TIFF capable); PhotoCD has a limit of maximum image size and a limited colour depth which is important as we might want to capture very high resolution images with exceptionally broad tonal ranges. Some institutions use JPEG for their master images¹⁹ and it seems to be an option worth considering, as at low compression rates JPEG offers good quality images visually indistinguishable from uncompressed images. However, it is probably not the best idea from the archival point of view.

Compression

The conservative approach uses no compression for creation of digital masters.²⁰ This is partially because when applying compression there is always possibility that something will go wrong. On the other hand, compression saves significant amount of storage space.

In my opinion it is better not to implement any compression techniques for digital masters. It increases risk of images becoming corrupted (unless time consuming error detection procedures are in place) and prolongs time needed to store and retrieve them. Storage costs versus processing (writing files, error checking, retrieving) costs have to be assessed. Also, if scanning from film, the granular structure of film, 'imposes a fine random noise pattern on the image that does not compress well'²¹ when using entropy-based techniques like LZW.

For derivatives and reference images JFIF (JPEG) seems to be the most suitable format, as its quality is good enough for the purpose and JPEG's excellent compression greatly reduces file sizes. Also, JPEG is an 'Internet ready' format – all Web browsers are JPEG capable. The compression ratio of JPEGs should be decided upon, prior to creating them.

¹⁹ Smithsonian Institution NMNH; National Library of Czech Republic.

²⁰ Joint RLG and NPO Preservation Conference. Guidelines for Digital Imaging. Stephen Chapman, Guidelines for Image Capture.

²¹ Report to the Library of Congress National Digital Library Project, Contract # 96CLCSP7582.

All three formats, TIFF, PhotoCD and JPEG are platform independent – i.e. they work on Macintosh, PC (DOS-Windows) as well as Unix based computers.

Colour profiles

Currently, there is a growing trend towards using ICC colour profiles that are being embedded in digital image files. ICC profiles are text based so, even if it will be impossible to interpret them in the future (for lack of appropriate software or hardware) they will not corrupt the image.

It is advisable to embed ICC colour profiles in digital images, providing that the system creating them has been properly calibrated.

Capture

At the moment two most popular ways of digitising are by scanning and by capturing images using a digital camera or scanning back. Scanners are limited by the maximum size of the original that can be placed on them. On the other hand they do not require time consuming set-up as digital cameras do. Digital cameras however, can capture all sizes and kinds of originals - reflective originals, transparent originals, three-dimensional originals, etc. They are also much more effective in capturing images from bound material - books, newspapers, etc.

It seems that the most practical solution at the moment is a mix of high-quality flat bed and film scanners and digital scanning backs for collections' capture. Lower resolution digital cameras can be used for capturing Library's functions and other PR events.

If out-sourcing, vendors should be selected carefully and passing a number of specialised tests should be required.

Storage

CD-R (recordable compact disc) seems to be currently the most flexible and cost effective storage. Also, its archival properties are better known in comparison to other optical technologies and it is not as volatile as magnetic based media. It is very difficult to predict for how long CD-Rs will remain accessible. Technological changes will eventually render them obsolete. Nevertheless, it is currently a very popular format with a lot of support. I will quote Kevin Bradley's opinion on audio CDs²² that can as well be extended to the use of data CD-Rs: "...there has been a massive market penetration, millions of CD players have been purchased.

Consequently, it is likely that the effects of technical change will be gradual, and format support will be available for a time after its eventual demise."

Care should be taken in choosing adequate file formats, file naming and metadata, so future data migration can be automated as much as possible.

Discs should be written according to ISO9660 standard, as it is the most widely recognised and multi-platform model. Labels need to be created for each disc, presumably by using non-corrosive, permanent markers.

²² Kevin Bradley, Poster Session at "2nd National Preservation Office Conference: Multimedia Preservation - Capturing the Rainbow", Brisbane, 28-30 November 1995.

11. Recommendations

In-house digitisation or out-sourcing

Out-sourcing is usually cheaper than digitising in-house. However, some collection material is too fragile or valuable to be handled by untrained people. Also, by digitising collections ourselves we gain valuable knowledge in new technologies, necessary in a modern institution. It seems that the process of digitisation should be shared between an outside vendor and the Library

Selecting the vendor

- Selection process should include scanning and digital photography of a number of items.
- Vendors should indicate what equipment they are going to use in the process of digitisation. Dynamic range of the scanners and digital cameras (scanning backs) should not be less than 12 bits per channel.
- Vendor and the Library's computer monitors should be colour calibrated to CIE D65 standard and computer systems should use ICC colour profiles. Vendors should embed colour profiles in the files.
- Vendors should be asked to scan and/or shoot an MTF target and a standard greyscale and colour patches.
- One hundred per cent of images should be verified for accuracy, skew, "half images", dirt, and so on.
- Digital noise should be evaluated.
- Tonal reproduction should be evaluated.
- Detail and edge reproduction should be evaluated (MTF).

Graphic File Format

- For master images TIFF format, uncompressed is recommended.
- For derivatives JFIF JPEG is recommended with compression quality of 5 (medium) on the Adobe Photoshop scale and Progressive encoding.
- Table below describes TIFF master formats for various material.

Media type	TIFF type	TIFF bit-depth
B&W photographic prints	Greyscale	8-bit (256 shades of grey)
Colour photographic prints	RGB colour	24-bit (16.7M colours)
Daguerrotypes, etc	Greyscale	8-bit (256 shades of grey)
B&W Negatives	Greyscale	8-bit (256 shades of grey)
Colour Negatives	RGB colour	24-bit (16.7M colours)
35mm slides, colour	RGB colour	24-bit (16.7M colours)
35mm slides, b&w	Greyscale	8-bit (256 shades of grey)
Watercolours and other works on paper	RGB colour	24-bit (16.7M colours)
Objects	RGB colour	24-bit (16.7M colours)
Posters	RGB colour	24-bit (16.7M colours)
Illustrated newspapers and books	Bitonal, greyscale or colour	1-bit (2 colours) or 8-bit (256 shades of grey) or 24-bit (16.7M colours)

Resolution

Digital images should have the following resolution:

Media type	Resolution (pixels per inch of the original)
B&W photographic prints	600ppi
Colour photographic prints	600ppi
Daguerrotypes, etc	2000ppi
B&W Negatives	2000ppi
Colour Negatives	1200ppi for 4"x 5" and larger; 2000ppi for smaller
35mm slides, colour	2000ppi
35mm slides, b&w	2000ppi
Watercolours and other works on paper	300ppi
Objects	300ppi
Posters	300ppi
Illustrated newspapers and books	600ppi for bi-tonals; 300ppi for greyscale and colour

Capturing

Media type	Device
B&W photographic prints	Scanner, Digital camera
Colour photographic prints	Scanner, Digital camera
Daguerrotypes, etc	Scanner if no risk of damaging, Digital camera
B&W Negatives	Scanner if no risk of damaging, Digital camera
Colour Negatives	Scanner if no risk of damaging, Digital camera
35mm slides, colour	Scanner, Digital camera
35mm slides, b&w	Scanner, Digital camera
Watercolours and other works on paper	Digital camera
Objects	Digital camera
Posters	Scanner if no risk of damaging, Digital camera
Illustrated newspapers and books	Digital camera

- Light types and levels should be examined for use with digital cameras.
- Scanners used should be either of flat-bed or film type. Drum scanners and sheet-feed scanners are not to be used.

Manipulation

Master images should not be manipulated in any way except for the bit-depth conversion (to 24-bit colour) and colour profiles conversion. No compression should be applied to the master images. Derivative images can be sharpened up and compression should be applied to JPEG images (5 on the Adobe Photoshop scale).

Storage

- CD-Rs should be used for permanent storage.
- Two copies of the same disc should be kept – one under controlled, stable conditions.
- Discs shall be checked for errors after burning them and then, regularly, every couple of years.

Quality control

- Delivery of 100% of files should be verified
- Ten percent of digitised material should be inspected
- Overall quality (skew, dust, etc.) should be checked
- Spatial dimensions, bit-depth and colour space should be checked (can be automated)
- Metadata should be checked (can be automated to a certain extent)
- Colour patches and greyscales should be examined
- Quality Control should be performed on computer systems that have been calibrated to CIE D65 standards and use ICC colour profiles.