# Chapter 5
# Back to Paper? An Alternative Approach to Conserving Digital Images into the Twenty-Third Century

**Graham Diprose and Mike Seaborne**

**Abstract** Many museums and other archives worldwide are digitising their collections. However, it does not follow that the digitised data files are likely to survive any longer than the artefact that has been copied. Curators have centuries of experience in the conservation of paper and pigments, but there are many unpredictable factors in the preservation of digital archives, which implies digital storage and data migration hundreds of years into the future. This chapter explores an alternative proposal to archive vital images and documents as hard copy inkjet prints. We suggest that this will increase their chances of survival into the twenty-third century. We are not advocating this method in place of digital materials, but rather as a sound form of insurance, based on existing well-known methods of the conservation of acid free paper and pigments.

## Introduction

The best archiving and curatorial practices for traditional silver halide photographs are very well established worldwide. Even before the introduction of silver gelatine prints in the 1880s, Victorian photographers were concerned to take steps to avoid their photographs fading, and one of the most successful processes developed in this

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G. Diprose (✉) • M. Seaborne
London's Found Riverscape Partnership, Heathfield Drive 13, Redhill, Surrey RH1 5HL, UK
e-mail: grahamdiprose@gmail.com; mickey_vista@yahoo.co.uk

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regard was the carbon pigment print. That the dyes used in post-world war II colour negatives and transparency films would begin to fade in as little as 30 years was probably less anticipated by photographers of their particular era [1].

The vast majority of the world's digital image files are presently stored outside professional archives, and their makers will be very lucky indeed if they can still be accessed and viewed in a mere five or ten years' time. Since the technology continues to evolve rapidly, there is no certainty that the image creation, storage and retrieval devices of the future will continue to be based on today's popular digital platforms [2]. We may therefore conclude that Victorian black and white photographs could outlive the majority of those colour dye images shot by our parents, which may themselves last longer than most of the digital images that we shoot today. From an archiving point of view, we seem perhaps to be going backwards.

The authors are researching the idea of selecting and then sending our most significant artworks, digital photographs and documents forward into the twenty-third century as smaller, high-resolution inkjet prints as an alternative to digital data. The image can be recovered from the print-out with minimal loss, using whatever capture or scanning technology may be available in the future.

We are not arguing that this method should replace archiving images as digital data, rather we propose that it could be an additional technology-proof form of insurance. While not everything can or should be archived in this way, at least with this method today's curators can select what they wish to send forward into the future and use technology most likely to ensure its survival. The alternative is to hope that our grandchildren's sons or daughters will be discerning when it comes to wiping data to free up space on whatever storage devices are used in 2099 or 2199. There is a serious risk in relying on them to decide what digital records and images from today's culture get migrated or deleted.

## The Digital Print Debate

We are all indebted to the work of Wilhelm Imaging Research, Inc. for its pioneering investigations into the causes of fading of different kinds of photographic and digital prints [3]. Over the past 25 years, using simulated aging tests, it has meticulously mapped the expected fade resistance of both silver and dye-based colour photographic prints and the more recent dye and pigment-based inkjet digital prints. A simplistic summary would be that ten years ago the life of a dye-based inkjet print was around a third of that of a photographic colour coupler print. Then, about five years ago, both technologies could claim a life expectancy of around 60–90 years, given careful storage. Now certain combinations of acid free papers and pigment-based inks can lay claim to a possible fade-free life of over 250 years. This may be longer still for a monochrome image printed exclusively with carbon-based black pigments onto acid free cotton rag paper. A process not so very different from the highly fade-resistant carbon printing method developed in the 1850s!

To this day, some participants in the fine art market for photographic prints, particularly in the US, appear to remain sceptical that inkjet prints can be longer-lasting than traditional C-type prints (where less fade resistant dyes are chemically synthesised when making the colour print). However, this argument is no longer tenable, as pigments will always be more lightfast than dyes due to their inherent chemistry and only the 'hand made' nature of these C-type prints remains as a reason for the value that they attract. The debate about fine art media has led a number of technologists to suggest that prints may be an alternative way to archive digital images into the distant future [4].

Unfortunately, up until now this has looked like a massive and prohibitively expensive task and has thus received limited support. The dilemma is that digital preservation, requiring the need for long term secure data storage and regular migration as technology changes, looks equally risky and possibly even more expensive in the longer term. Andrew Green, former CEO of the National Library of Wales explained the problem:

> Will it be possible to use emulation software to mimic the software available to us now, but obsolete within ten years, let alone thirty? Or will we have to migrate our collections from one format to another over and over again, in order to keep them alive for each succeeding generation? What is certain is that national libraries will need to invest far more than they have till now, especially in staff and expertise, to even start to get to grips with the challenge of digital preservation. [5]

## Digitising Images to 'Save' Them

Many of us are aware of, and have bid for, funding to 'digitise' existing photographs and artworks to 'save' them for posterity. While this usually achieves the goal of wider public access for visitors or online, it actually does nothing for the long-term survival of the original images. The National Lottery funding of English Heritage's *'Viewfinder'* project and website is one example from many thousands world-wide, that enables massive collections to be explored using our PCs tablets and smart phones [6].

## So What Can Possibly Go Wrong?

The issues of digital preservation are the subject of well established debate, and there are now accepted ways to solve the main issues [7]. However, in our experience the approved processes are still likely to be too resource and process intensive for many smaller archives to afford. It would be wrong to say that best efforts are not being made to preserve these virtual, digital data files. Yet however advanced our technology, our world is subject to uncontrollable natural events such as extreme weather, earthquake, floods and solar flares. Political cyber attacks are serious threat.

Those of us who have suffered from a hard drive failure will already be well aware of the ultimate fragility of digital data. The natural degradation of data (sometimes referred to as bit rot) [8] and data corruption during migration are less familiar issues. Even if we store our valuable files across many RAID disks and servers in different corners of this planet, there is no guarantee that evolving technology, such as the storage of bits on strings of DNA [9], for example, will not be so radical that today's files are totally unreadable by the computers in use in 50 or even 25 years' time.

The challenges are huge, from simultaneously migrating and translating digital data on numerous websites worldwide, to writing data to archival gold DVD-R optical discs (with no guarantee there will be any devices able read them in 50 years time). Tape drives provide long-term storage of massive amounts of data, but require regular re-winding to maintain their readability. Once the durability of the tapes has surpassed the support life-time for the tape readers, the tapes are rendered unreadable unless migrated to new types of tapes or other media.

Any lack of standardisation from one present or future digital format to another will lead to considerable difficulties in consolidating or migrating collections. Thus, rather like the game of 'Chinese Whispers', during the course of repeated migrations necessitated by updates in software or hardware changes to the image data may well occur. Many smaller image archives are already finding that they are storing a mixture of TIFF, JPEG and RAW files, collected from different sources. How long will these formats survive before, like JPEG2000 before them, they fail due to lack of industry-wide support? Our conclusion is that vast swathes of our contemporary history and culture are at risk either of being randomly consigned to the twenty-first or twenty-second century digital recycle bin or of becoming inaccessible as the last hardware readers of long-outdated formats cease to function.

## Other Non Digital Solutions

Many believe that 'The Cloud' is the answer to all digital preservation, but issues have already arisen concerning security and intellectual property rights. These include hacked passwords, data interception and the fact that in the US, any cloud storage company could be served with a subpoena requiring them to open their clients' data for government examination. Apple Inc. co-founder Steve Wozniak recently said "I really worry about everything going to the cloud, I think it's going to be horrendous. I think there are going to be a lot of horrible problems in the next 5 years." [10] In 2012 an accident while backing-up Royal Bank of Scotland software wiped many thousands of clients accounts to zero. It was caused by human error during a 'routine' software upgrade outsourced to India and serves as a warning to any organisation that one day, if it can go wrong, it probably will go wrong [11].

These and similar concerns have led others to research hard copy techniques for the long-term storage of digital data documents. These include the use of microfilm, where binary data is encoded in printable form [12] and the NanoRosetta process, where either analogue or digital information (PDF, TIFF or DDP files) is laser etched onto a glass wafer from which usable derivatives on nickel plates are created [13].

While microfilm offers the advantage of dense data storage, it is at the expense of wholly accurate data recovery due to the small physical size of the microfilm formats employed (typically 16 mm). However, in contrast to other storage media, such as hard discs, flash memory or SSDs, tapes, CDs or DVDs, the technology to read microfilm is simple and generic unlike the sophisticated technologies required to recover data from any of the complex storage systems in use today.

Nevertheless, while microfilm may offer a viable and cost-effective archival method of storing text files, its data recovery limitations pretty much preclude its use for true photographic quality images. On the other hand, our process of printing full tonal range photographic images on 100 % rag paper with pigment inks provides both a high degree of data recovery and the same level of archival permanence for all images, both monochrome and full colour. It may not offer the same high storage density as microfilm but – and this is especially true of photographic images – it does provide a much more acceptable level of image quality. As with microfilm, the actual storage medium is completely de-coupled from the IT systems needed to read it, and so a future-proof archiving system is guaranteed.

Anne Kenney, a digital preservation pioneer from Cornell University Library who has extensively researched microfilm and other alternative hard copy solutions makes the same point "I've always thought that it's not how much you can capture, it's how little you can capture and get away with doing the things that you need to do. It's always been how you make managerial decisions where there are trade-offs." [14]

## Archiving Projects as Inkjet Prints Example: "London's Changing Riverscape"

In 1997, London's Found Riverscape Partnership (LFRP) was formed by Mike Seaborne, Charles Craig and Graham Diprose to make a continuous photographic panorama of both banks of the River Thames from London Bridge to Greenwich, 5 miles downstream [15].

This was to be a remake of a panorama first photographed in black and white in 1937 for the Port of London Authority (PLA). In 1997, LFRP shot the new panorama on 6×17 cm Fujichrome colour film, as at the time this was considered to be one of the most archival dye-based films available. In 2008, LFRP was invited by the PLA to make a new digital version of the panorama to celebrate its centenary in March 2009. Shooting digitally, LFRP was faced with the dilemma of how to archive its new digital files alongside the existing silver gelatine prints from 1937 and the colour transparencies from 1997. Despite some slight discolouration


**Fig. 5.1** Panoramas of Wapping, London: silver gelatine from 1937 (Courtesy of Port of London Authority) and from digital files, 2008 (Courtesy of London's Found Riverscape Partnership)

in places, the silver gelatine prints still seemed very likely to outlast the newly created TIFF files.

The black and white prints comprising the 1937 panorama (each approximately 12 in. × 10 in.) are mounted on strips of linen made up into fourteen sections for the north riverbank and thirteen for the south side, with each section being about 2.5 m long or 35 m long in total, if laid end to end. LFRP convinced the PLA that the safest way to ensure that that the new digital panorama would survive for their bi-centenary in 2109 was to have a physical version of the new panorama, to match that from 1937, with the same lengths of sections and locations. Prints were made using the Hewlett Packard HP Z3100 printer on Hahnemühle 188gsm Photo Rag paper. The joined 1937 panorama of jointed prints was replicated by cutting and mounting the digital prints using archival dry mounting linen. This allowed any location on the panorama to be viewed simultaneously in both versions placed side-by-side (Fig. 5.1).

Once completed, the new 2008 panorama was placed in blue leather folders similar to those made to house the 1937 panorama. It was then presented as a complete package to the Museum of London in 2009, as one of the PLA's centenary events. LFRP handed over the TIFF files as well, but we are much more confident that the printed version will survive to be part of the PLA's future centenary celebrations.

## Project Methodology 1: Archiving Images

No doubt many curators may conclude that, while they can see the advantage of making full-size high quality archival inkjet prints, this is unlikely to be economically viable for their archives, and requires more storage space.

We therefore explored the idea of reducing the size of the printed images to about a half or a quarter of the original, so that several could be fitted onto a single sheet of paper. This would considerably reduce both production costs and storage requirements. The constraint is that the images should be capable of being scanned or photographed using whatever equipment and file format is available in the future without an unacceptable loss of image information. While they will not be 100 % perfect replicas of the original image, if the digital files have been lost or become corrupted then at least the prints will provide useable and reproducible images (Fig. 5.2).

The choice of digital printer for this work was straightforward as the Hewlett Packard Z3100 provides the most fade-resistant prints of any pigment inkjet printer currently available (March 2013). Wilhelm Imaging Research, Inc. still rates this printer and its slightly modified successor the Z3200 as yielding longer-lasting prints on a range of archival papers than any other printer. We used these inks

**Fig. 5.2** PLA collection images ink-jet printed 16 up on A2 paper

**Fig. 5.3** English Heritage Henry Taunt and "…in the footsteps of Henry Taunt" Digitised Silver gelatine and contemporary digital images printed side by side 16-up on A2 paper

throughout the project as they were continuously reported to be the most permanent available from any company [16] (Fig. 5.3).

The choice of paper was much less straightforward and hence a number of different types were tested. We correctly suspected that if the paper had a texture this might interfere with the quality of the image created through scanning or copying. We also thought that the sharpness of the dot was likely to be an important factor, particularly if we intended to print images at a much reduced size. To assess how the nature of the paper surface affected dot sharpness we tested several fibre-based and resin coated papers to determine the differences, if any, in dot bleed.

We printed a range of monochrome and toned images from the Museum of London's Port of London Authority collection onto A2 sheets so that they were reproduced at approximately A4, A5 and A6 (see Technical Details below).

English Heritage's National Monuments Record allowed us to experiment with a collection of digital files made from 1860s silver gelatine prints by Henry Taunt, and we interspersed these with the modern digital colour images. This enabled us to see whether or not a full colour image would reproduce more or less successfully than a toned or pure black and white one.

However, from these tests, using only a high magnification loupe to assess the dot structure by eye, we found it impossible to accurately determine which paper gave the sharpest dot or the best quality image for re-copying and enlargement back to A4 from the reduced A5 and A6 prints. We needed a more accurate, objective and repeatable method of assessment.

## Project Methodology 2: Type

We were also interested in exploring this method to archive vital business documents, using inkjet technology as an alternative to microfilm. We made TIFF files of 64, 96 and 128 A4 pages from the Microsoft Word files of a photographic textbook. The files were loaded into Photoshop™, using Contact Sheet II, and printed out. Even at a scale of 128 A4 pages per A2 sheet the text was still readable with a magnifying glass. We then used optical character recognition (OCR) software (see Technical Details below) as an objective assessment of readability. Once a single tiny page was scanned and read into OCR Software, we could count the number of errors as a measure of ink dot sharpness. OCR works by recognising the 'shape' of words that are in its dictionary. All that it can read correctly are printed out as black, editable text. Those it cannot recognise are flagged in green by the software. The sharper the ink jet dot, the fewer green flagged errors occur on the page. We counted errors for different varieties of paper, but generally we could tell at a glance if a paper surface was likely to be suitable for follow-up experiments. (Obviously there would always be some proper nouns or technical words not in the OCR dictionary that we would need to factor out (Fig. 5.4).)

In our own continuing tests on a range of gloss, rag and matt coated papers from manufacturers Harman, Hahnemühle, and Felix Schoeller we concluded that all matt papers tend to cause the dot to bleed into the paper fibres, and on most gloss or lustre papers the ink tends to form tiny bubbles on the paper surface that gave a less accurate, dot shape. Ortiz and Mikkilineni (Purdue University) reported on Inkjet Forensics in 2007, and reached the same conclusion: that smooth Rag papers produced the sharpest dot [17]. We were keen also to avoid choosing papers containing artificial brighteners (baryte) as these have been considered by a number of researchers to risk reducing archival life [18]. If a paper has a very slight warm tone base that does not change over a long period of time, this seems advantageous over a paper where changes in brightness are likely.

**Fig. 5.4** Experiments with type to measure dot accuracy. Harman Baryta gloss fibre-based A2 with pages of type in Arial 64-up and then selecting two single pages to OCR from 64-up and 96-up, showing measurable errors. There are fewer from the 64-up page (*left*) than from the 96-up page (*right*)

The Canson paper company were among the paper suppliers with whom we discussed our research. Their Infinity Rag Photographique paper, while not containing any optical brighteners, did have a special barrier layer that prevented the ink from sinking into the paper base; it fully met the archival standards specified in ISO 9706 [19]. This paper gave us by far the best result of all the papers tested. The 96-up showed about 30 very minor errors as green words in the OCR file, but the 64-up was almost faultless. Additionally, this paper is internally buffered to resist gas fading, and is totally acid free to avoid any long term paper degradation.

## Project Methodology 3: Back to Images Again

We next tested the Canson Rag Photographique paper with our photographic images. We printed a set of the PLA's monochrome pictures once again as 8-up and 16-up on A2 size paper (for sizes see Technical Details below), and did the same with a set of digital colour pictures from our project, '…in the footsteps of Henry Taunt'. Once printed, we scanned one A5 and one A6 image from each reduced format set, enlarged the files to A4, and printed them together with the original A4 files for direct visual comparison.

Figure 5.5 shows a ship entering Surrey Docks by crossing Rotherhithe Street, London (1928) by A.G. Linney. The A4 print from the A5 reduced image was excellent and the A4 from the A6 was still usable for most purposes, including small-scale reproduction in books and journals. There are many hundreds of beautiful historical images in the Port of London collection in The Museum of London, and in our opinion it would be much better to have them preserved as slightly lower resolution ink jet prints than to try to send huge digital files forward in time and risk losing many of them. It may also benefit future scholars to be able to view many small images, for context or comparison.

For a colour image, we selected a photograph of Moulsford Ferry (2004), on the River Thames in Oxfordshire (Fig. 5.7). The A4 print from an A5 original was again good enough for many reproduction purposes, and although there was some loss on the A4 print from an A6 original, it was still acceptable and looked similar to a


**Fig. 5.5** Comparison of original A4 (*left*) and images re-copied and enlarged from A5 (*middle*) and A6 (*right*) in monochrome

**Fig. 5.6** *Left*: a small close-up taken from the original A4 print (*top left*). *Centre*: same section from archived half size at A5 and then copied and enlarged to match the A4 original. *Right*: same section printed at A6 and then copied and enlarged to match the A4 original

**Fig. 5.7** Moulsford Ferry: comparison of original A4 and images re copied and enlarged from A5 and A6 in colour from digital original "…in the footsteps of Henry Taunt"

JPEG that had been re-saved a few too many times. We are continuing to research the use of image enhancement software to improve the quality of the reproduction from images archived as smaller A6 prints (Figs. 5.6 and 5.7).

## Project Methodology 4

Our paper at the EVA London Conference 2011 [20] was met with a mixture of polite applause and scepticism, from delegates who relied on the preservation of digital data from their research, and others who had possibly spent a fortune on high-end RAID systems, or were employed to develop data storage. However, after seeing our results first-hand, the audience at least began to appreciate our right to question the data migration approach. This did lead us to seek out other expert opinion, as described below, 'New Developments'.

One of us (Mike Seaborne) had worked on a project at the Museum of London called 'Snapshop London', using digital photography to document the landmarks,


**Fig. 5.8** This original image by Mike Seaborne of Whitechapel High Street from 'Snapshot London' is a high quality 73Mb TIFF file and will be archived by the Museum of London as digital data, plus printouts retrieved from 8up, 16up and 32up on A2

culture and people of each borough in London, which had resulted in more than 4,000 digital images. The MoL allowed us access to these files to develop our research and to calculate some costings, important to assessing if our project was financially viable.

This, and the massive number of digital images in other similar projects and archives, led us to question whether all images needed to be archivally printed at the same size. Up until now it had seemed reasonable to follow the path of standardisation in file-size and formats, because altering some data files but not others during any data storage or migration would be time-consuming and expensive. But surely many images now, let alone in the future, will only ever be viewed on tablets, websites or e-books, rather than large high resolution uncompressed TIFF files needed for exhibition prints or high quality book reproductions? If we try to archive all our digital images as high-resolution TIFFs we risk adding to the problems of future generations.

This thought prompted research in two related directions: first, to examine the quality of images printed at a much smaller size, 32-up on A2, and second, how this could reduce the costs of archiving larger numbers of less significant images, but still with enough quality to be a useful reference.

The image above, copied back from an A5 print (8-up on A2 sheet) produces a reasonable quality A3 print and is easily good enough for any normal book or screen output. The same image recovered from an A6 print (16-up on A2) is still good enough for any smaller book or column width reproduction, as well as any screen-based output. The A4 copy of the A7 print (32-up on A2) does however clearly reproduce the pattern of ink dots, particularly in areas of light even tone such as the forearm of the man with the mobile phone (Fig. 5.8). Even that would probably be useable on a web page and it certainly retains enough of its historical context for reference use by future scholars.

The current cost (March 2013) of materials (paper and ink) to print in this way is £1,500 to print out 2,000 images at A7 size (32-up on A2 sheet) or £3,000 to print out the same number of images at A6 size (16-up on A2 sheet).

## New Developments

We are presently running a pilot project with The Sir John Cass School of Art, to print images from its East End Archive, which records the area over the past 50 years, with a wide range of file types and sizes. The archive's curators are thinking from the outset about different sizes of print according to what they consider to be the importance of the artists, the aesthetic significance of the images and their value as historical documents and sources of documentary information about East London. Archival printing at a range of sizes will help to keep overall costs down and embody within the archive a hierarchy of importance as determined by its present curators.

There is interest in our proposal from The National Archive (UK) (TNA). Whilst the TNA is confident they have the resources and expertise to manage their own massive digital archive over the long term, it recognises that our proposal has potential value in relation to smaller and less well resourced digital archives. Consequently it has offered to publish on its archive network the results of our pilot project with the East End Archive as a formal case study. Similarly, English Heritage's National Monuments Record has indicated to us that our method could provide a useful insurance for many smaller archives.

In April 2013, a feature on our work was published in the British Journal of Photography (BJP) [21]. The editor felt that many professional photographers, particularly those working in the genres of documentary and reportage, were concerned about the long-term survival of their digital images but do not have the necessary IT skills to achieve this. Making and keeping prints is something much more familiar to photographers.

## Conclusion

This project has never been intended to replace attempts at data storage and migration for archiving digital photographs, artwork or documents, but by showing how relatively small prints can capture a great deal of image information in an IT-independent and relatively incorruptible form we believe that it does offer a viable alternative, or back-up, solution for many smaller archives. Developing a policy of keeping humanly-readable analogue prints in addition to attempting to store and migrate digital data, where the potential risks may not be well understood, would significantly reduce the impact of any data losses arising from whatever circumstances.

Aside from the technical and economic aspects of this project, our methodology allows curators and archivists to have a lot more control over what gets archived. They are in a position to decide which works and images from our present culture should be printed larger, and thus be preserved to a higher quality, rather than attempting to keep huge digital files of everything. There is no reason, in fact, why a particularly important digital image could not be printed out much larger if it was felt that even more information should be captured on paper.

With a purely digital data migration strategy we run the risk of saddling future curators with all the debts and dilemmas of selecting what they can afford to continue to preserve from our era, and what they will be forced to delete as migration costs increase from one technological leap to the next. This is why we believe that it is much safer to send digital images into the future as archival inkjet prints rather than solely as easily erasable and corruptible digital data.

## Technical Details

*"London's Chaging Riverscape" Project*
Archival printing paper: Hahnemühle Photo Rag 100 % Cotton
Surface: Fine Smooth Matt Finish, Weight 188 gsm
Printer and details: Hewlett Packard – HP Z3100, 12 Pigment Ink 24" wide
Printing Resolution: 1,200 × 1,200 dpi
Printheads: Two inks in each printhead: gloss enhancer and gray, blue and green, magenta and yellow, light magenta and light cyan, photo black and light gray, and matte black and red
Ink Cartridges: Cartridges containing 130 ml of ink: gloss enhancer, gray, blue, green, magenta, yellow, light magenta, light cyan, photo black, light gray, matte black, and red

*Archiving Images*
Papers: Various tested, see text Harman, Hahnemühle, and Felix Schoeller
Canson Rag Photographique 100 % Rag
Surface: Extra Smooth Matt Surface
Weights: 310 gsm (for testing) and 210 gsm for pilot project
Printer and Details: As above
Note: While some recently launched Epson printers use a higher resolution than the HP Z3100, this appears, from their own specification sheets, to be to the detriment of archival life, which they predict at below 100 years

*Image sizes* 4, 8 and 16-up images on A2 paper (42.0 × 59.4 cm, 16.53 × 23.39 in.),
A4: 4up, 21.0cm × 29.7 cm, 8.27 × 11.69 in.
A5: 8up, 14.8cm × 21.0 cm, 5.8 × 8.30 in.
A6: 16 up, 10.5 cm × 14.8 cm, 4.1 × 5.80 in.

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