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# *DCC / Digital Curation Reference Manual*

## *Instalment on*

### *“The role of microfilm in digital preservation”*

<http://www.dcc.ac.uk/resources/curation-reference-manual/microfilm/>

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## ***About the DCC***

The JISC-funded Digital Curation Centre (DCC) provides a focus on research into digital curation expertise and best practice for the storage, management and preservation of digital information to enable its use and re-use over time. The project represents a collaboration between the University of Edinburgh, the University of Glasgow through HATII, UKOLN at the University of Bath, and the Council of the Central Laboratory of the Research Councils (CCLRC). The DCC relies heavily on active participation and feedback from all stakeholder communities. For more information, please visit [www.dcc.ac.uk](http://www.dcc.ac.uk). The DCC is not itself a data repository, nor does it attempt to impose policies and practices of one branch of scholarship upon another. Rather, based on insight from a vibrant research programme that addresses wider issues of data curation and long-term preservation, it will develop and offer programmes of outreach and practical services to assist those who face digital curation challenges. It also seeks to complement and contribute towards the efforts of related organisations, rather than duplicate services.

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## ***Preface***

The Digital Curation Centre (DCC) develops and shares expertise in digital curation and makes accessible best practices in the creation, management, and preservation of digital information to enable its use and reuse over time. Among its key objectives is the development and maintenance of a world-class digital curation manual. The *DCC Digital Curation Reference Manual* (formerly the Digital Curation Manual) is a community-driven resource—from the selection of topics for inclusion through to peer review. The Manual is accessible from the DCC web site (<http://www.dcc.ac.uk/resources/curation-reference-manual>).

*Digital Curation Reference Manual* instalments provide detailed and practical information aimed at digital curation practitioners. They are designed to assist data creators, curators and reusers to better understand and address the challenges they face and to fulfil the roles they play in creating, managing, and preserving digital information over time. Each instalment will place the topic on which it is focused in the context of digital curation by providing an introduction to the subject, case studies, and guidelines for best practice(s). To ensure that this manual reflects new developments, discoveries, and emerging practices authors will have a chance to update their contributions annually.

To ensure that the manual is of the highest quality, the DCC has assembled a peer review panel including a wide range of international experts in the field of digital curation to review each of its instalments and to identify newer areas that should be covered. The list of current and previous members of the peer review board is provided at the beginning of this document.

The DCC actively seeks suggestions for new topics and suggestions or feedback on completed instalments. Both may be sent to the editors of the *DCC Digital Curation Reference Manual* at [info@dcc.ac.uk](mailto:info@dcc.ac.uk).

Joy Davidson and Kevin Ashley  
Digital Curation Centre  
18 April 2011

## **Biographies**

**John Baker** is currently non-exec Editor of *IDMi* (Information & Document Management International,) the international circulation magazine with a remit to cover all aspects of IM. His experience of microfilm extends back to 1975 when he worked with Aberdeen University in Scotland. As a specialist technician he covered general and specialist photography (copying of originals), and microfilm. His photography experience goes back even further to the late '50's, and a stint as a professional photographer introduced him to the vagaries of colour negative (C22/C41) and reversal processing (E4/E6).

Other working experience includes managing a high-security data, media and document storage facility, and also at various times, microfilm and scanning bureau management. He adds EDMS project and account management to round off his portfolio.

Since 1995, his consultancy company has been involved with the oil & gas, nuclear, manufacturing industries, as well as local and regional government on a wide variety of archive, preservation and new-technology projects. With considerable experience in project and account management, he has travelled throughout Europe and the USA on assignments.

He is currently completing the content for an e-Book on scanning, microfilm and document management, which is based on a series of articles for *IDMi*. He is also set to complete visits to all major manufacturers of colour microfilm writing equipment by the end of June 2009, and mono microfilm writing and scanning manufacturers by the start of 2010.

**Heather Brown** is a preservation manager with a long standing experience in preservation microfilming. In 2003 she was commissioned by IFLA-PAC and the National Library of Australia to write the international training materials *Training in Preservation Microfilming* <http://www.nla.gov.au/preserve/trainmat.html> [10 modules]. She is a member of the Editorial Committee of the journal *Microform and Imaging Review*, founder of the international listserv *Microlink-1* and has delivered a range of conference papers and training workshops on the role of microfilm in 'traditional' and digital preservation in Australia, New Zealand, Singapore, Thailand, the Philippines and India. Heather is currently an Assistant Director of Paper and Books at Artlab Australia [www.artlabaustralia.com.au](http://www.artlabaustralia.com.au) and also the State Library of South Australia's Project Officer [www.slsa.sa.gov.au](http://www.slsa.sa.gov.au) for the Business Information program at the University of South Australia where she lectures in the courses *Preservation Principles* and *Digital Preservation*. <http://www.unisa.edu.au/>

**Walter Cybulski** is a preservation manager with experience in preservation microfilming as part of the New York State Newspaper Project / U.S. Newspaper Program, and in microfilm quality assurance at the National Library of Medicine (NLM) in the U.S. He is the author of "You Say You Want a Resolution? Technical Inspection and the Evaluation of Quality in Preservation Microfilming" (*Microform & Imaging Review*, 28, no. 2 (1999): 56-67). Walter taught library and archive preservation courses at the University of Maryland, College Park, for several years and teaches a library preservation course at Catholic University in Washington, D.C. Walter manages NLM's microfilm duplication and offsite storage projects and coordinates the Library's environmental monitoring program. He manages NLM's Preservation and Collection Management Section print and microfilm digitization projects, chairs the NLM Digital Projects Technical Group, and currently serves as the Library's disaster response coordinator. Walter is a member of the AIIM C10 Committee and the Still Image Working Group of the (U.S.) National Digital Standards Advisory Board.

**Andy Fenton** is the Managing Director of New Zealand Micrographic Services (NZMS), and a leading authority in New Zealand on the digitisation and preservation microfilming of heritage materials. NZMS was established in 1990 and has filmed over 11 million pages of historical and current newspapers for public libraries and the National Library of New Zealand. Andy co-founded a commercial digitisation company Desktop Imaging Ltd in 1997 and the two companies jointly run one of the largest facilities in Australasia for digitising microfilm, microfiche and aperture cards. This includes large volumes of property records for Local Government bodies and microfilmed early newspapers.

Andy has a strong commitment to the preservation of New Zealand's literary and archival history and the Heritage Materials Imaging Facility (HMIF), currently based in the National Library building, was a collaborative project between NZMS and Victoria University of Wellington's Electronic Text Centre to bring the best scanning equipment to New Zealand for large format, fragile and rare material. Refer [www.hmif.co.nz](http://www.hmif.co.nz)

Andy has been actively involved nationally and internationally in the development of imaging standards. He was invited to represent the interests of the New Zealand micrographics industry on the Australia/New Zealand Joint Standards Committee (MS/4) for Information and Image Management in 1996, served on Archives New Zealand's Digitisation Standard Advisory Group in 2006, and is currently a member of the IT-021-11 Sub-Committee on the Integration of Digitisation. Andy is also an elected member of the Board of the National Digital Forum, a coalition of New Zealand organisations, including museums, archives, art galleries, libraries and government departments, with an interest in digital resources.

**John Glover** is a Consultant in the Information Technology Industry with extensive expertise in image conversion and preservation. He currently serves on AIIM's (Association for Information and Image Management) Micrographics (C-10) Standards Committee. He also served on AIIM's MIT/LIT Accreditation Committee for six years and the FbIA (Film base Imaging Association) Board for four years. With the Association of Records Managers and Administrators (ARMA) he served as the Group Leader for ARMA's Industry Specific Microfilm Services Group from 2000 to 2003 and established a generic microfilm information web site: [www.fyiglover.com](http://www.fyiglover.com)

**Paul Negus** is Managing Director of The Microfilm Shop, a UK based company that has been involved in the microfilm industry since 1974. The Microfilm Shop is an international company at the heart of the very latest technologies using microfilm as a digital preservation medium. Paul has been involved in many digital preservation projects from the Census, Library, Archive, Government, Energy and Commercial areas. Paul has written many articles and presentations on microfilm use and more recently made a presentation entitled "The Future of Microfilm" for the Second Life for Collections Conference at the National Preservation Office, British Library <http://www.bl.uk/npo/publicationsconf.html>

Paul has been very much involved in the recent 500 year Life Expectancy announcements for Ilford colour microfilm and the new colour pattern developments for writing digital files to microfilm. Until very recently Paul was also owner and Managing Director of OITUK, a Document and Records Management software company. This commercial experience of the digital software world has allowed him to build on his digital/microfilm integration knowledge.

**Jonas Palm** Since 2002 Mr Jonas Palm has been Director and Head of Division of Preservation at the National Archives in Stockholm, Sweden. His present areas of responsibility are paper, photographic materials and modern media. He was Head of Conservation at Uppsala University Library, Sweden from 1983 to 1994; and Head of Preservation at the Royal Library, Copenhagen, Denmark from 1994 to 2002. His qualifications include a Masters degree in graphic conservation from School of Conservation in Denmark. Mr Palm was a Member of IADA (Internationale

Arbeitsgemeinschaft der Archiv - Bibliothek - und Graphik restauratoren) board from 1987 to 1999. Since 1995 he has been a Member of the UNESCO Memory of the World Program Subcommittee on Technology, and its chair since 2007. Jonas Palm is a Consultant for both Swedish and Danish government aid agencies SIDA and DANIDA respectively on preservation programs in archives and libraries in developing countries.

Jonas Palm has been in charge of microfilm preservation at Riksarkivet (RA), the Swedish National Archives, and involved in the strategic planning of both analog and digital records. He is author of the article "The Digital Black Hole (2005)" published on the ECPA web site. RA is now in the process of starting production after two years of evaluation of different COM technologies.

## 1. Introduction and Summary

Drawing on a risk management perspective, this instalment introduces the complementary role that microfilm, and particularly computer output microfilm (COM), can play within the broad spectrum of the digital preservation domain. It provides some international examples of current and best practice and highlights some technical issues relating to standards.

Silver gelatin microfilm on polyethylene terephthalate (PET) base has been available as a stable, reliable and relatively inexpensive preservation medium since the 1980s. When properly produced and stored according to international standards and recommended practice, PET-based camera master films secure a life extension of 500 years for the captured content without need of replenishment, upgrading or hardware replacement<sup>1</sup> (BS ISO 18901:2010).

Microfilm serves as a well-established bridge technology in digitisation efforts, proving in many cases to be a critical resource in the repurposing of scholarly content. Some reels contain the only record of historic material for which missing, lost or discarded originals are no longer available for scanning. Microfilmed surrogates of brittle materials, including acidic wood pulp newspapers, enable cultural repositories to scan and provide access to originals that cannot be handled without loss of significant content. Digitisation of microform surrogates facilitates electronic access to rare and unique materials without subjecting originals to potentially damaging handling.

Software and equipment developments in the past several years suggest a more fully integrated role for microfilm within digital asset life cycle strategies for both surrogates made from print originals and especially non-dynamic 'born digital' content. To maximise their potential, both existing stored microforms and newer microfilm produced with digital access and storage in mind should be given serious consideration for appropriate inclusion within the range of digital preservation strategies that can be applied to non-dynamic materials. Preservation quality microfilm potentially provides long term storage, data integrity and content re-purposing options from the point of creation throughout the life cycle of the digital asset.

## 2. Background and Developments

A standard definition of digital preservation is:

*'The series of managed activities necessary to ensure continued access to digital materials for as long as necessary. Digital preservation... refers to all of the actions required to maintain access to digital media beyond the limits of media failure or technological change'* (DPC Handbook 2002).

Within this overarching framework, international strategies for the management of digital preservation are embedded within a risk management approach. In essence, the management of digital preservation is about managing the risks of loss of digital information over time. The aim is to ensure the survival of digital information in a form that is accessible and where integrity is assured.

### **Benefits and limitations of preservation microfilm**

Microfilm's key advantage lies in its longevity and sustainability. Properly produced and stored silver-gelatin PET films are proven, secure and reliable information carriers capable of storing large amounts of uncorrupted text, image and numerical data for hundreds of years, according to

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<sup>1</sup> BS ISO 18901:2010 *Imaging materials - Processed silver-gelatin type black-and-white films - Specifications for stability*. BSI, London /ISO, Geneva. See Section 8.2 **Accelerated ageing test**. Extrapolation of high-temperature data down to a room temperature of 23 °C indicated that the time for a 0.1 density change in conservative conditions at 60 % relative humidity exceeded 500 years.



accelerated ageing tests (BS ISO 18901:2010 Section 8.2). They merit a place in digital risk management and should be considered for use alongside a developing suite of digital preservation strategies.

More specifically, as a long term storage medium, microfilm potentially reduces the frequency of interventions that may be required where a strategy such as migration is used. In this context, it is noteworthy that a number of authors such as Rusbridge (2006) and Rosenthal (2010) argue that what we are seeing now in practice is a much longer life time for digital formats, especially open source, and hence much less pressure for preservation strategies to adopt short cycle migrations. Within this environment, the advantage of microfilm lies in the scale of its life expectancy; it offers a long term ‘holding position’ that extends to several hundred years (BS ISO 18901:2010 Section 8.2).

From a risk management perspective it makes sense to use a combination of digital preservation strategies within and between organisations. Given the sheer scale and variety of digital forms: *‘It may well be that there will never be a single definitive strategy and a range of strategies appropriate to different categories of digital materials may need to be employed’* (DPC Handbook 2002).

An interrelated feature is microfilm’s contribution to the assurance of integrity of data. Integrity is defined by the UNESCO Guidelines as *‘the state of being whole, uncorrupted and free of unauthorised and undocumented changes’* (UNESCO 2003 p.158). The Guidelines add that integrity is an important component of storage, owing to the potential for changes or losses that can be caused by strategies such as migrating data from one system or carrier to another (UNESCO 2003 p.13).

In this context, microfilm’s contribution stems from the fact that it is produced to well-established rigorous international standards and quality assurance systems that are embedded within a risk management framework (ANSI/AIIM MS23, 2004). Microfilm is a prudent risk management option that retains the integrity of its contents independently of changes in software and hardware. Additional information on standards is provided under **Standards** below.

Furthermore, microfilm is extremely difficult to alter without detection. Guidance for the expungement of data from microfilm records describes the physical removal of image-bearing emulsion from the film surface, an action which leaves behind tangible evidence. Removal of an entire segment of film would require the use of easily detectable splices or the return of the film to the reel in pieces. In most preservation microfilming programs, the existence of a second ‘print master’ copy in a separate storage location further assures that if one reel is tampered with or stolen, a complete copy remains available. These safeguards highlight microfilm’s capability of ensuring and allowing validation of the integrity of stored data within a repository environment, a key factor in quality assurance of ‘trusted digital repositories’ (OCLC 2007<sup>2</sup>) The case study of **Datawitness** below is an example of an application of microfilm in significantly contributing to the integrity of data copies in a digital repository.

Microfilm requires only a light source and magnification to be read. In a worst case disaster scenario, microfilm does not depend on electricity and can be readily accessed without the mediation of sophisticated retrieval systems and other peripheral equipment.

Microfilm is also very flexible. It can integrate the storage of digital and analogue material. As a high-density storage medium, it can be integrated into digital workflows because it has the capacity

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<sup>2</sup> See TRAC Checklist requirement A3.8 *‘The repository must develop or adapt appropriate measures for ensuring the integrity of its holdings’* (OCLC 2007 p. 15).

to be readily reused and transferred as it is digitised or ‘turned digital’. In the other direction ‘born digital’ data can be similarly converted to COM (Computer Output Microfilm).

Microfilm’s flexibility to ingest and store both analogue and digital data is exemplified by the case study of the **Kreiskrankenhaus Rendsburg Hospital** (Germany). The hospital creates many types of documents such as patient records, diagnoses and medical reports in both digital and paper records - the equivalent of over one metre of ‘hard copy’ records per hospital bed. The digital records together with paper records are combined on microfilm for longer term storage (Kreiskrankenhaus Rendsburg Hospital 2010).

Microfilm also has the capacity to incorporate relevant bibliographic and preservation metadata. With ‘born digital’ material, metadata can be readily assigned and inserted into relevant microfilm frames using archive writers, in accordance with quality assurance processes (Fenton 2006).

Other benefits are discussed in section 3 below in the context of the DCC Curation Lifecycle and OAIS models.

At the same time, microfilm has clear technical limitations. Microfilm is a physical medium and the most significant limitation is its lack of ability to capture the digital functionality of dynamic web materials. Furthermore, levels of complexity and interactivity of born digital objects are likely to increase in the future, with user-generated comment and mixing and mashing of data to create new knowledge<sup>3</sup>. Additionally, from an access perspective, microfilm’s strict linear nature can make it tedious to use.

In terms of colour and tonal range, high contrast black and white microfilm has been largely limited in tonal range and was mainly suited for the capture of the intellectual content of text-based materials. Furthermore, until a short time ago, the life expectancy of colour microfilm has been somewhat short of preservation goals (IPI 1992 Section 7<sup>4</sup>), while the ‘digital to colour’ option has been limited by a lack of colour microfilm writers and scanners. Colour dye stability in chromogenic microforms, as in many analogue colour photographic applications, is considered to be problematic. New technical developments with continuous tone and colour films that ameliorate a number of these earlier limitations are described below under **Summary of current developments**.

In all, bearing in mind its limitations, microfilm remains a versatile recording medium highly suitable for the capture and long term storage of non-dynamic scholarly digital and print content that currently comprises a significant proportion of the world’s intellectual heritage, while at the same time acknowledging the exponential growth in dynamic interactive content.

#### **Summary of current developments**

A number of new technological innovations have enhanced the capacity of microfilm to play a key role as a digital preservation strategy for non-dynamic materials.

The COM (Computer Output Microfilm) option is one of the most significant developments. It involves the capture of digital images onto film through ‘archive writers’ (Microfilm Services Group: Archive Writers 2010). Archive writers have fundamentally changed the way in which preservation microfilm is created. Instead of using reflected light from an object to produce an image, this technology reads the binary data from a digitised image and records the location of each

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<sup>3</sup> See for example born digital growth statistics provided by the IDC (International Data Corporation).

<sup>4</sup> Section 7 Results Summary ‘Predictions for the future physical properties of Cibachrome film gelatin emulsions were notably shorter than for chromogenic film emulsions. However Cibachrome emulsions can be expected to remain in usable condition for at least 100 years at room temperature and moderate RH conditions.’

pixel on the film using RGB lasers (direct to film) or similar devices. As a variation in technique, there are now archive writers that can also copy directly from the monitor – a technique made possible through advances in computer graphics cards and the manufacture of specific monitors with a very high screen resolution. Today's COM machines can accept the majority of 'common-use' text and graphic file formats, and a number of new machines have made it easier to improve the final output when dealing with a wide variation of 'original' or input images.

See **Appendix 1** for a table of common archive writers. This table clearly illustrates that there is an active industry of archive writer manufacturers to support the use of microfilm in digital preservation.

A further advantage of the archive writer application lies in its scalability; with these systems, the velocity of transfer to the medium of microfilm is high and the output is a high-density 'mass' product.

Exciting new innovations with COM enhance microfilm's potential. They showcase how purely 'digital code' for a range of digital formats can be written to microfilm ('bits on film'), with the film becoming the long term coded optical archive medium from which it is readily possible to retrieve data for future use (Gubler 2008, Negus 2008, Fluck 2008, Hofmann & Giel 2008, IDMi 2010). As part of this process, so-called 'binary microfilm' must include unambiguous decoding instructions (such as human-readable text) alongside machine-readable code. Using the human readable 'metadata', technicians in the future will be able to configure devices to read the film and retrieve the data. Error correction codes have been written that compensate for any scratches and dust that may be present on the film (Voges, Märgner & Fingscheidt 2008). Meanwhile, in Switzerland, research into digital archive systems based on microfilm has led to the development of **PEVIAR**, a system that stores digital data as a two dimensional bar code on microfilm and is independent from proprietary hardware and software technologies (Amir 2008).

While these advances are significant, further research and development is required in this technical area, especially on the extent to which the 'bits on film' can satisfy the requirements of 'preservation actions' as described in section 3 below.

Other more established hybrid options include the 'film first scan later' alternative, or the choice of combining filming and digitising in the same process, using a dual film/digital image capture system, although the latter is slow in a production scenario. They provide alternative approaches that can be flexibly integrated into digital workflows. With the former option, a number of guidelines have been recently developed to support the optimising of microfilm for use in digital applications. These are discussed further below in section 5 under **Standards**.

Aligned with these hybrid developments are innovations relating to the film itself. While the application of continuous tone has been common in forensics and institutional photography departments for many decades, the microfilm industry has only comparatively recently exploited the possibilities. Recent developments with continuous tone films and film processing techniques have made it possible to produce micrographic images that render the grayscale properties of source materials with greater fidelity - especially photographs and other types of illustrations in books and newspapers (Cybulski 2006, NEDCC 2007).

Similarly, research and development in the field of colour microfilm has led to a new generation of silver-dye bleach colour microfilm that has the capability to provide colour stability for images and hence the potential to create colour digital images from these films. Unlike earlier colour microfilms that generated their dye image during processing, this new film has colour layers built directly into its emulsion. Testing at the **Image Permanence Institute** suggests that the life

expectancy of the relevant dyes and film base may be as much as several hundred years<sup>5</sup> when the film is not exposed to light (NEDCC 2007). However further independent testing and research are needed in this area. Colour films also have the advantage of providing increased storage capacity because of their ability to record three separate channels of information, and they offer excellent image structure for high resolution (LaBarca 2008).

Complementary to the developments with long lasting colour film are advances in digital to colour archive writer technologies. **Pro Archive** from Switzerland and **Fraunhofer IPM** from Germany are two examples of organisations that have developed their own RGB laser writing devices which allow for full colour images to be written to colour microfilm using red, green and blue lasers. They provide for very high quality colour images. Moreover, both can be used to produce grayscale as well as conventional black and white microfilm images. Recent examples of developments combining both archive writers and grayscale comes from manufacturers that produce high speed 35mm/16mm archive writers that are capable of recording multi-format digital grayscale, and bi-tonal images directly onto a grayscale microfilm (Micrographics Data 2010). In turn, these developments will potentially expand the types of digital source materials that microfilm can effectively capture and preserve.

Furthermore, the emergence of production model colour microfilm scanners means that there is now the capacity to digitise from colour microfilm. This technology effectively completes the cycle in both directions, as it is now possible to convert from digital to colour microfilm, and then back again (Negus 2008).

### ***3. Application to the DCC Curation Lifecycle model and OAIS framework***

Microfilm has the potential to play a role in the key stages or components of the DCC Curation Lifecycle and OAIS models.

The DCC Curation Lifecycle model provides an overview of all the key stages required for the successful curation and preservation of data right from the point of creation (DCC 2008).

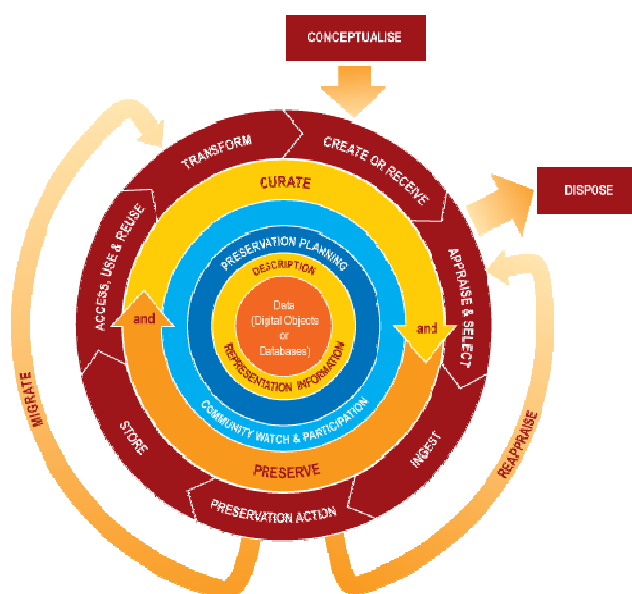
The model defines ‘preservation actions’ as ‘actions to ensure the long-term preservation and retention of the authoritative nature of data. Preservation actions should ensure that data remains authentic, reliable and usable while maintaining its integrity. Actions include data cleaning, validation, assigning preservation metadata, assigning representation information and ensuring acceptance data structures or file formats.’

Within this organic and flexible model, microfilm can be readily considered in the risk assessment process for key stages including: *conceptualise, create or receive, appraise and select, store and transform*.

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<sup>5</sup> Subject to recommended storage, processing and usage. See also the comments about the need for further testing and research in this area.

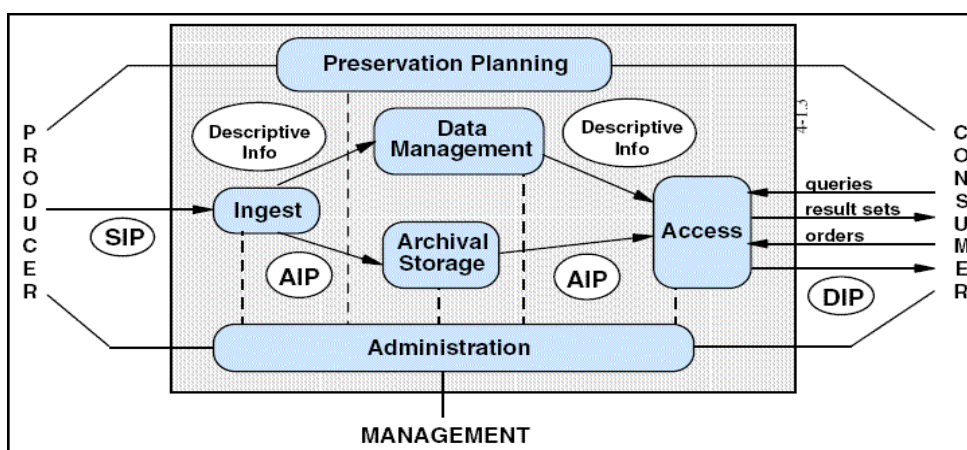
**Diagram: DCC Curation Lifecycle**



Complementary to the DCC model is the OAIS (Open Archive Information System) reference model (CCSDS 2009).

Similarly embedded within a risk management framework, this high level model has the flexibility and capacity to traverse both digital and non digital worlds with a foundation *‘that may be expanded... to cover long-term preservation of information that is not in digital form,’* although the modelling for this is not addressed in detail (CCSDS 2009 1-1). It follows that microfilm can be readily incorporated as a strategy within this framework – in particular, within the OAIS Functional Model components of **archival storage** and **preservation planning**. A focus on these two stages, that are critical to both the DCC and OAIS models, illustrates how microfilm can potentially contribute to OAIS conforming strategies.

**Diagram: OAIS functional model**



## Archival Storage

As highlighted in the earlier section on **Benefits**, microfilm can potentially contribute a number of useful attributes to the storage component that is critical to both the DCC Lifecycle and OAIS models. In the latter the *archival storage* component broadly manages the long term storage and maintenance of digital materials within the archive (CCSDS 2009 section 4.1.1.3). This includes ensuring appropriate types of storage media, as well as undertaking strategies such as media refreshment or migration. The archive storage function also implements safeguard procedures to ensure the integrity of data, as well as disaster recovery functions.

The scale of microfilm's life expectancy provides a long term 'holding position' that extends to an estimated 500 years (BS ISO 18901:2010 Section 8.2). Microfilm's own storage requirements are well documented (ANSI/NAPM IT9:11 1993) with clear-cut systems for ongoing maintenance. As above, a longer holding position potentially means a reduction in the need for interventions, which in turn also potentially lowers the risk of associated data loss over time.

Microfilm's quality assurance standards and the difficulty of alteration without detection contribute to the safeguarding of the integrity of stored data in a repository environment. Other useful qualities relate to microfilm's capacity to perform as a flexible, high volume and high density carrier, suitable for both born digital and turned digital materials and able to be integrated into digital workflows while incorporating preservation metadata. It can seamlessly transfer data in black and white, grayscale and colour from digital to film and 'back to digital' as part of archival storage functions.

As microfilm provides a discrete analogue copy, this has particular relevance to *disaster recovery* functions of storage; moreover the existence of microfilm copies can potentially help inform the risk assessment process and shape decisions about priority salvage categories.

A standard application of microfilm in the Lifecycle model stage of *transforming* lies with the various international newspaper digitisation programs where the microfilm copies of older newspapers (out of copyright) have been digitised, while access to and user interaction with the information has been enhanced through OCR and Web 2.0 functionalities. (See for example ICON, British Library, ANPLAN, Gatenby 2009). An area requiring further research is the potential use of microfilm as a long term storage carrier for versions of modern digital newspaper files, bearing in mind again the limitations in capturing dynamic and user generated content. See the *Irish Independent Newspaper* below under **Case Studies of Microfilm in the Digital Life Cycle**.

## Preservation Planning

In both models preservation planning is a high level function, occurring throughout the digital life cycle.

In the OAIS model, the *preservation planning* component monitors the external environment for changes that could impact on preservation (such as technological innovations), develops preservation strategies and standards and assists in the implementation of these strategies within the system (CCSDS 2009 section 4.1.1.6). In the Lifecycle model, preservation planning includes plans for management and administration of all Lifecycle actions.

With the range of inherent advantages discussed earlier, microfilm can potentially play a role in the preservation planning process. It is one option that can be considered alongside a range of strategies (such as migration, emulation and replication) to preserve non-dynamic digital information. In turn, this enables the information to be accessed, re-purposed and/or value-added with new information as part of the ongoing life cycle. All options to extend the useful life of collection material should be taken into consideration in the preservation planning process. As

below, this is relevant to the application of microfilm within the framework of digital preservation planning tools.

### **Potential application throughout DCC Lifecycle**

Optimum preservation planning takes into consideration the full range of options that potentially contribute to a successful preservation outcome, and, from the earliest point in the Curation Lifecycle, there is potential for preservation microfilm to be considered and planned for as an option for the long term storage of and access to non-dynamic digital data. **Appendix 2** provides a basic summary of the stages in the DCC Curation Lifecycle, from *conceptualising* to *transforming*, where microfilm could potentially be considered and adopted for both born and turned digital data. Again further exploration of this area is required, particularly into identifying the types of digital materials (such as textual materials) which might be most suitable for the application of microfilm.

The time is ripe to further explore the potential for identification of relevant digital materials, as well as the application and integration of microfilm into relevant parts of the digital realm, for example within the framework of such tools as PLATO (PLANETS 2010), and to consider the potential for prudent, measured and relevant application within models such as the DCC Curation Lifecycle.

## **4. Cost benefits**

The ongoing management costs of digital preservation are complex and difficult to quantify. The Blue Ribbon Task Force report highlights that '*sustainable economics for digital preservation is not just about finding more funds. It is about building an economic activity firmly rooted in a compelling value proposition, clear incentives to act, and well defined preservation roles and responsibilities*' (BRTF 2010 p.7). While considerable progress has been made in costing the digital preservation life cycle with projects such as the LIFE model, digital preservation costing still remains at the early stages and current tools provide indicative costings only (Wheatley 2008, Lavoie 2008). Rusbridge has also argued persuasively that digital storage is much cheaper than physical storage of originals (2006).

Theoretically, preservation microfilm provides a long term holding option with a potential to reduce the frequency of interventions that may be required where strategies such as migration, emulation or other options are used<sup>6</sup>. In short, any likelihood of reducing the need for intervention strategies can potentially reduce costs.

The case study of the National Archives in Sweden (*Riksarkivet*) supports such a premise. Following several years of testing, the *Riksarkivet* has recently introduced COM to store images as an integral part of its preservation strategy. The cost for storage of microfilm at the repository (12 °C and 20% RH) is estimated to be around 4-7% of digital storage. This is based on a single image per film frame. Laser plotting can scale down to 2, 4 or 8 images per frame and then costs will shrink<sup>7</sup> (Palm 2009).

Data provided by commercial organisations corroborates this premise. For example, Daniel Fluck from **Pro Archive** showcases how the hybrid storage option, utilising colour microfilm and scanners, can potentially result in a significantly lower total cost of ownership (TCO) than digital

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<sup>6</sup> As above, in the context of the view that there now may be less pressure for preservation strategies to adopt short cycle migrations (Rusbridge (2006) and Rosenthal (2010)), the advantage of microfilm lies in the scale of its life expectancy.

<sup>7</sup> These costs exclude the production of the film and apply to 35mm colour microfilm. Each film frame with laser is estimated to cost about €1- to €1.6,- .

storage. Fluck also provides examples of TCO costs for a range of organisations and analogue and digital media (Fluck 2008).

However, while these examples are interesting they are inconclusive. There is a need for further research to develop the ability to compare and contrast analogue and digital life cycle costs. This includes storage<sup>8</sup>, access, retrieval and reuse costs, and at what point in the life cycle key costs are incurred, as '*few preservation managers are able to separate the cost of preserving materials from the costs of making them accessible*' (BRTF 2010 p.46). There are a significant number of collecting organisations that have already rigorously evaluated their microfilm costs, for storage, access and retrieval and together with the data from commercial organisations; it would be useful to link this work with that being undertaken by key projects such as the LIFE model.

Such collaborative data sharing would assist in more accurately determining the relative cost benefits of digital and film media. In turn this will mean that cost data can better inform the whole risk management approach to digital preservation.

## 5. Standards

The potential usefulness of microfilm as a preservation medium relates to its quality and management. A basic quality principle is that all information visible in the 'original' must be visible in subsequent copies, whether digital or analogue (National Library of the Netherlands 2007 & 2010). To achieve this it is necessary to ensure a verifiable relationship between the copy and the original based on objectively measurable quality criteria, and it follows that such criteria are the foundation of internationally accepted standards. (See lists of standards in the following: NPO 2000, National Library of the Netherlands 2007 & 2010, National Library of Australia 2003.)

Many of the valid criticisms of microfilm relate to older, poor quality films, including acetate-based films, produced without recourse to such standards (Gatenby 2007). However as it turns out, many of these earlier acetate films will probably fulfil the purpose they were originally intended to accomplish: to 'buy time' and ensure the survival of the contents of deteriorated print originals for up to 100 years (Cybulski 2006)<sup>9</sup>. Similarly, deficiencies in collection management and storage practices have resulted in inadequate documentation of the location of microfilm masters and have also reduced their potential life expectancy.

Building on the foundation of international standards, a number of guidelines and recommended practices have been developed and have been widely adopted internationally to optimise microfilm for use in digitisation applications.

These include:

- *The RLG Guidelines for Microfilming to Support Digitization* (2003)
- *Metamorfoze Preservation Microfilming Guidelines* (2006)
- *Microfilming for Digitisation and Optical Character Recognition* (IFLA) (2002).

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<sup>8</sup> Long term storage costs for microfilm masters include the cost of maintaining appropriate environmental storage conditions and risk management systems.

<sup>9</sup> A significant number of repositories continue to duplicate acetate film perceived to have reached a critical deterioration point (measurable with acetate detection strips) onto polyester stock. As a regional example, in New Zealand and Australia, some inadequately produced (and stored) microforms are deteriorating after about 40 years – typically material produced between the 1960s and 1980s.



Further research is being undertaken in the relationship between the technical quality of microfilm, scanners and the final OCR (optical character recognition) accuracy with the aim of optimising OCR accuracy (van Dormolen 2008). For example, it has often been found that a better scan is available from a duplicate copy because it is of higher contrast and yields a higher accuracy in OCR. Another factor is the quality of the algorithm(s) in use by the software.

Such research is of particular interest to newspaper digitisation projects.

However, it is not surprising to find that in the newer area of 'digital to microfilm' output from archive writers, the standards and guidelines are still nascent. While there are standards for document scanners there are not, as yet, standards for the scanning process itself and the many formats and resolutions available as well as for standards that specify the quality level of the output from the COM device. **PRIA** (Property Records Industry Association) has produced a well-written document in this regard (PRIA 2007, Glover 2009). This field is complex, as the quality of the film is dependent on all components of the system including the resolution output of the monitor (Baker 2009b). As in the case of costings above, this emerging area requires further research.

## 6. Skills, Education and Training

Effective digital preservation management and stewardship require a whole new awareness and skill sets that are supported through education and training.

The PADI website<sup>10</sup> highlights the need for digital preservation managers to be well informed about the range of appropriate digital preservation issues and strategies, and to have an awareness of the interconnections with broader frameworks:

*'Management decisions need to be based on an informed viewpoint, including an awareness of the technological implications and the legal and political framework within which digital preservation initiatives may operate. Those managers with a well-developed understanding of problems and issues confronting digital preservation practitioners will be best placed to deliver innovative and appropriate solutions'* (PADI 2010).

Education and training can take the form of formal qualifications, workshops, short courses, conferences and self-learning, and all have their place in the continuous learning spectrum.

Internationally, a growing number of formal courses are available in the field of digital preservation, exemplified by the information management and preservation courses run by HATII at the University of Glasgow (HATII 2010). Similarly, a new U.S. preservation curriculum covering both digital and non-digital preservation has been developed by the North East Document Conservation Center and Simmons Graduate School of Library and Information Science (NEDCC 2008). Harvey (2010) has also recently commented on the similarities between analogue and digital preservation and the implications for new curricula in curatorial streams. Within such integrated curricula and courses, there are opportunities to educate future digital preservation managers and curators about the potential role that preservation microfilm can play in bridging the analogue and digital worlds, and in the context of its benefits, its limitations and its new developments. In turn this will encourage them to consider the holistic application of a range of appropriate strategies in their future digital curation and stewardship.

On another level, to complement the formal courses, a range of flexible and online training courses is available. These range from Cornell University's *Digital Preservation Management* Tutorial to LYRASIS courses on digital stewardship (Cornell 2010, LYRASIS 2010).

While recognising that these are overview courses, there is an opportunity to briefly include the role of preservation microfilm to maximise awareness of the full range of preservation strategies.

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<sup>10</sup>The PADI website is no longer maintained by the National Library of Australia from July 2010.

At the vocational training or 'how to' level, formal training is far more specialised. Australia's competency-based *Certificate IV in Preservation Microfilming* course, delivered by TAFE SA, is an example that includes digitising and COM requirements, and provides students with the requisite skills framework to enable them to work flexibly across digital and film media at different points in the life cycle (Certificate IV NTIS 2010, Brown 2007). While this course is now being taken up throughout the Asian-Pacific region, nonetheless there is an ongoing need for similar courses to develop internationally, to nurture the specialised technical skills required in this area and hence ensure the quality and effectiveness of microfilm's role as a digital preservation strategy.

Finally, all digital curatorial stakeholders from ICT staff to archivists, records managers and librarians need to be re-educated about the role that microfilm can play in digital preservation and how to maximise its potential (Baker 2009-10).

## ***7. Case studies of microfilm in the digital life cycle***

The following case studies showcase different ways that preservation microfilm can flexibly and effectively support the preservation of born digital and digitised materials, including an example of a current research project.

### **7.1 The National Archives of Singapore**

**Key factors:** flexibility, long term storage, data integrity, government records

#### **Introduction and Background**

The National Archives of Singapore (NAS) houses the collective memory of Singapore. As the official custodian of the corporate memory of the government, NAS manages public records and provides advice to government agencies on records management. Its holdings comprise mainly government files, historical maps, photographs, audiovisual records and also oral history interviews and private papers.

#### **Practical Application of Preservation and Access through Microfilm and Digital Capture**

The National Archives of Singapore receives documentary material in both paper and electronic form. With respect to electronic files their policy is to maintain the digital version of the files for short to medium term access, typically on CD/DVD-ROM, as well as in databases and records management systems for material which is accessed more frequently. However government text-based records are converted to COM (computer output microfilm) as the preferred long term storage option and some documentary materials are scanned and then output to microfilm where a mix of access and preservation is required. This approach ensures the integrity of the material with a significantly long term 'holding option' that reduces the need for interventions over time.

This policy was developed as far back as 2001 when they purchased the first pair of COM machines available in the market. For 35mm work a Polycom (from Microbox) was used to output building plans from a public office. Back then it took about 8 hours (3 hours for preview and 5 hours to write!) to produce a 35mm roll microfilm. Nowadays they expect 1-2 hours per 100ft film and the current model employed for 35mm work is the Zeutschel OP 500 (purchased in late 2006). For 16mm work; smaller format records up to A3 in size, and the vast majority of the born digital material, they can use the Zeutschel but a faster alternative is the Kodak 4800 (purchased in 2001) or the newer i9610 (purchased in 2008). The latter COM machines can produce ~2300 x A4 images

onto a 100ft 16mm reel in black and white format in less than half an hour. Typically they produce 8-9 reels per shift per 16mm COM machine.

With respect to quality, Mrs. Kim Gek Kwek-Chew, Deputy Director Records Management, noted: *'Our Image Preservation Lab (IPL) measures the quality of the scanned images using target sheets provided by the manufacturer of the equipment. Though IPL adheres to the ISO and Singapore Standards pertaining to quality checks on microfilms, the lab sets the standard one notch higher.'* It is essential to adopt this practice as ISO and Singapore Standards set the minimal requirements. In NAS's context, most records are destroyed after writing to microfilm. The best attainable standard is therefore required to ensure that the second generation of microfilm produced meets the legibility, density and associated quality requirements of relevant standards (Singapore Standard 2006).

Of interest to NAS is that while the cost to produce microfilm direct from paper records is less than the price to scan and then output to COM, the relative quality control costs of the project are essentially the same, and thus a smaller percentage of the project costs. You gain the greater flexibility of dual formats for preservation and access as well the option to spread the workload across a range of operators with different skill sets.

Post-capture in the IPL the respective CD/DVD-ROMs and microfilms are stored in fully climate controlled vaults and monitored rigorously over time. There may be a need to migrate the CD/DVD-ROMS on a case by case basis in the future and NAS is vigilantly monitoring technological changes. NAS undertook extensive studies of optical media from the early 1990s to establish their potential longevity and have incorporated this knowledge into their policies.

For the future they intend to maintain a long-term approach to digital data preservation by outputting the electronic files to secure preservation-standard microfilm and retaining the files needed for more frequent access in electronic form. NAS will continue to monitor the cost benefit and best use of each technology with data preservation in perpetuity being the ultimate goal.

## **7.2 The Republic of South Africa, Department of Land Affairs (Deeds Office)**

**Key factors:** flexibility, long term storage, data integrity, government records

This South African Office keeps records of all private land in the Republic of South Africa. At their Head office in Pretoria they have long been users of 16mm microfilm dating back to the 1970s. Recently they decided to replace their ageing 16mm microfilm cameras with a number of high-speed paper scanners. Land records are now scanned and held in an electronic document management system. However the Deeds Office recognised the need to be able to retain these land records indefinitely and no digital storage media could deliver the archival qualities they needed. After exhaustive investigation they opted for a 16mm archive writer that allowed their scanned images to be stored on 16mm microfilm with a life expectancy of up to 500 years. Following a trial period the Deeds Office have since purchased more archive writers that are deployed in each of the regional capitals within the country (South Africa, Department of Land Affairs - Deeds Office 2010).

### 7.3 The MILLENIUM Research Project (Germany)

**Key factors:** long term storage, data integrity, current research

In 2006 the MILLENIUM project was started to provide a technological solution for the workflow of digital data storage on microfilm. The MILLENIUM project is funded by the German Federal Ministry of Economics and Technology (BMWt), comprising two research institutions Fraunhofer Institute for Physical Measurement Techniques (IPM) and Technische Universitat Braunschweig, Institute for Communications Technology (IfN)) and several small businesses.

The specific aim of this project is to develop a data storage solution based on microfilm and laser exposure technology. The laser exposure technology is developed at the IPM and research on signal and information processing is conducted at IfN.

The foundations of the project are based on the key benefits of microfilm:

*'As a real WORM (write once read many) medium, microfilm guarantees a high level of data security. Furthermore, this innovative storage medium offers the possibility for hybrid storage of digital and analogue data on the same medium... Microfilm data storage features zero handling costs by eliminating the need for data migration and could be used as a long-term storage solution for all digital archives...'* (Giel 2009).

*'In today's digital archives the problem of continuous migration is ubiquitous. Due to the limited lifetime of storage media and the availability of reading devices, the digital data has to be copied ... As each migration process requires financial and personal resources, a real long-term storage medium would be appreciated...'* (Voges 2008).

The MILLENIUM project has resulted in a number of research products including a high-resolution laser recording system for capturing digital data to film. This system has the capacity to correct errors due to dust and scratching as well as a significantly increased mass storage capacity (Giel 2009, Voges 2008 & 2009). The research has been presented at conferences sponsored by the Society for Imaging Science and Technology (SIST 2010), and includes technical information relating to laser recording, signal processing and data organisation and synchronisation.

The MILLENIUM project's ongoing research and development will result in a standardised technology that will ultimately enable very small digital data structures to be written onto 35mm microfilm.

## 7.4 Merrimack County (US) Register of Deeds in New Hampshire

**Key factors:** long term storage, data integrity, government records

Merrimack County uses a combination of scanners to scan deeds for new property sales and archive writers to transfer the scanned images on to microfilm. This now means the original documents can be returned to property owners in one day rather than the previous two weeks. This is because the Title deeds are scanned immediately on entering the office. The electronic version of the document is then used for all the necessary administration and distribution. Then on completion the electronic document is written onto 16mm microfilm for the requirement to keep title deeds for the long term<sup>11</sup> (Merrimack Country Register of Deeds 2010).

## 7.5 Datawitness Online Ltd (Canada)

**Key factors:** long term storage, data integrity

This started as an online service for lawyers so that they could exchange legal documents with each other but have a detailed audit trail and log of who had received and opened documents. It then developed into a digital repository of documents where all the digital copies are archived on to microfilm behind the scenes but the clients access everything via a web portal. The microfilm copy is the long term storage option that provides data integrity (Datawitness Online 2010).

## 7.6 The Swiss Post Office

**Key factors:** long term storage, data integrity

The Swiss Post Office has recently established an online 'post box' for customer files. Should a customer require an archiving option, the uploaded file is written to microfilm for long term storage (Swiss Post Office 2010).

## 7.7 The National Archives of Sweden (*Riksarkivet*)

**Key factors:** flexible long term storage, government records

The National Archives of Sweden in Stockholm currently has a preservation strategy that is divided into three lanes. The first one is to store digital records and digitised audio and video (of which the amount is small) in an HSM tape robot, the second lane is storage on duplicate LTO4 tapes and the third is storage of images on COM.

The COM solution has been on its way for several years following testing, checking the market, evaluating and discussions with manufacturers. The Archives has also bought a custom made film scanner to be able to scan high resolution COM (like 'Swiss Eternity film').

The National Archives of Sweden will use the COM solution primarily for preservation of information on documents that are in such a poor state that they cannot be used by researchers and are falling to pieces mainly due to old fire and water damages, or acidity. Since the 1950s the *Riksarkivet* has microfilmed documents in such physical condition to secure the information. It will continue this but with digital cameras and scanners.

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<sup>11</sup> Acknowledgement to Kodak for this case study.

This will make the information available digitally as well as transferring the image files on to COM for long term storage, which (if undertaken properly) probably will outlast the heavily deteriorated paper documents. The storage of digital information on film as a bit-image (2 dimensional bar code) is in the next phase of this strategy, which is yet to be tested (Palm 2009).

### 7.8 The Irish Newspaper Archive Project

**Key factors:** long term storage, newspaper format – digitised and born digital

The **Irish Newspaper Archive Project** is a joint collaboration between a host of newspaper proprietors in Ireland and the document management bureau **National MicroMedia**, based in Dublin (INAP 2010).

#### **Digitising from microfilm**

A key purpose of this project was the opportunity to generate revenue from each newspaper's dormant archival microfilm resource. A number of requests were received for extracts, pages or issues of the newspaper (rather than a full microfilm reel) from around the world with the advent of increased genealogical research via the internet. Microfilm archives were considered essential in this process as they allowed for a far higher degree of automation and greater cost effectiveness than the alternative of scanning from hard copy archives. The Irish newspaper proprietors understood that it was their microfilm archive that made the digitisation of their entire archives a viable business proposal.

The advantages of digitising from microfilm (as opposed to hardcopy newspaper scanning) included:

- greater cost effectiveness - estimated to be least one fifth of the cost of scanning from hardcopy
- speed - high quality equipment was capable of digitising 6000 pages/images per working day, whilst scanning from hardcopy using an A2 scanner yielded approximately 2500 images per day and required a much higher degree of user intervention
- quality - in the majority of instances the microfilm was in good condition having been produced up to 40 years ago, while the hardcopy archives had deteriorated considerably in this time, if they still existed at all.

#### **Born digital newspapers**

The Irish Newspaper Archive Project has continued to grow as newspaper proprietors have generated ongoing revenue long after the capital investment has been realised. In all instances partners continue to microfilm their titles as they have determined that there are significant cost savings and a sustainable long term strategy in investing a hybrid approach. This hybrid approach now extends to born digital titles such as *The Irish Independent*. These are created digitally and used to print the paper on a daily basis and then converted to PDF files which are also hosted online<sup>12</sup>. The same PDF files are sent to an archive writer that converts all the PDF files to 35mm microfilm for long term secure storage.

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<sup>12</sup> These files do not constitute dynamically changing content such as those found in newspapers with user generated content schemes.

## 8. Conclusion

In combination, microfilm's key benefits of longevity, sustainability and flexibility, together with its contribution to the assurance of data integrity, merit its place in digital risk management alongside other digital preservation strategies. Microfilm's versatility enables it to be readily incorporated into digital life cycle management right from the point of creation and thereafter.

Microfilm's limitations have also been noted. It is a physical medium and not suitable for capturing dynamic, interactive digital materials. These types of materials pose complex preservation problems that are beyond the capability of microfilm.

Recent developments have expanded microfilm's potential in bridging the digital and analogue worlds, allowing it to be more fully integrated into the digital life cycle of non-dynamic scholarly digital and print content that currently comprise a significant proportion of the world's intellectual heritage. The latest innovations with archive writers and scanning equipment mean that it is possible to seamlessly convert from digital to microfilm and back again. Likewise, new developments with continuous tone and colour microfilm have increased the types of digital materials that microfilm can effectively capture and preserve.

To maximise the potential of microfilm's role further research is needed in areas such as:

- a) exploring and identifying the types of digital materials which might be most suitable for the application of microfilm
- b) exploring the potential to which microfilm can be incorporated as a 'preservation action' within frameworks such as OAIS and the DCC Curation Lifecycle model
- c) exploring the potential application of preservation microfilm within the framework of preservation planning tools.
- d) testing the life expectancy of colour film
- e) developing standards for 'digital to microfilm' conversion
- f) developing a more generic understanding of costs associated with the storage, retrieval and access of digital and microfilm formats over time.

Microfilm's success as a preservation medium is evident in the aggregate of collections stored and re-purposed digitally on an ongoing basis in libraries and archives throughout the world. While it is a mature technology supported by a substantial body of theory, standards and recommended practice, microfilm is hardly an obsolete format (as developments noted in this document demonstrate).

An opportunity exists to strategically align the microfilm research agenda listed above with relevant international digital preservation research projects. In the digital domain emphasis is placed on interconnectedness and interoperability. This argues for encouraging – rather than ruling out – investigations into the use of combinations of technologies to achieve a common goal. In the context of the broad international spectrum of complex digital preservation challenges, now is clearly the time to more fully explore, identify and maximise the potential role that microfilm can play within the digital preservation domain.

### ***Acknowledgement***

We would like to thank all our professional colleagues who have provided feedback and suggestions.



**Appendix 1: Table of archive writers<sup>13</sup>**

Features >	Model	Proprietary film	16 mm	35mm	105mm	Aperture cards	B&W	Colour	LE500 Long LE <sup>14</sup>	web site
<b>Manufacturers</b>										
Anacomp	XFP2000	Yes	X		X		X		X	<a href="http://www.anacomp.com/services/mir/dis/xfp2000.aspx">http://www.anacomp.com/services/mir/dis/xfp2000.aspx</a>
Fraunhofer IPM	ARCHE	No		X			X	X	X	<a href="http://www.ipm.fraunhofer.de/fhg/ipm_en/solutions_services/laserrecording/colormicrofilmrecorder/index.jsp">http://www.ipm.fraunhofer.de/fhg/ipm_en/solutions_services/laserrecording/colormicrofilmrecorder/index.jsp</a>
Fuji	AR-1000	Yes	X				X		X	<a href="http://ar1000.fujifilmrmd.com/Default.aspx?tab=Spec">http://ar1000.fujifilmrmd.com/Default.aspx?tab=Spec</a>
GID	6880	Yes			X		X		X	<a href="http://www.gid-it.de/53,Microfiche-Printer-6880,42,83.html">http://www.gid-it.de/53,Microfiche-Printer-6880,42,83.html</a>
Icam	Digital Writer	No		X			X		X	<a href="http://www.icamarchive.co.uk/index.htm">http://www.icamarchive.co.uk/index.htm</a>
Image Graphics	MicroPublisher 6000	No	X	X	X		X	X	X	<a href="http://www.igraph.com/EBRecords/MP%206000.htm">http://www.igraph.com/EBRecords/MP%206000.htm</a>
Kodak	Archivewriter i9610 and i9620	Yes	X				X		X	<a href="http://graphics.kodak.com/docimaging/US/en/Products/Micrographics/Microfilm_Cameras/i9600_Series_Writers/index.htm">http://graphics.kodak.com/docimaging/US/en/Products/Micrographics/Microfilm_Cameras/i9600_Series_Writers/index.htm</a>
MicroBox	Polycom	Yes		X			X		X – when wet process	ENGLISH - <a href="http://www.microfilm.com/php/display.php?ItemID=210">http://www.microfilm.com/php/display.php?ItemID=210</a> ; DEUTSCH - <a href="http://www.microbox.de/contentido/microbox/front_content.php?idart=170&amp;idcat=39&amp;lang=1">http://www.microbox.de/contentido/microbox/front_content.php?idart=170&amp;idcat=39&amp;lang=1</a>
MicroBox	Cadmic	Yes				X	X		X – when wet process	ENGLISH - <a href="http://www.microfilm.com/php/display.php?ItemID=256">http://www.microfilm.com/php/display.php?ItemID=256</a> ; DEUTSCH - <a href="http://www.microbox.de/contentido/microbox/front_content.php?idart=177&amp;idcat=41&amp;lang=1">http://www.microbox.de/contentido/microbox/front_content.php?idart=177&amp;idcat=41&amp;lang=1</a>
Micrographics Data	AW-1	No	X	X			X	X	X	<a href="http://www.md.sg/products.html">http://www.md.sg/products.html</a>
ProArchive	Eternity 105	No		X	X		X	X	X	<a href="http://www.proarchive.ch/produkte.cfm">http://www.proarchive.ch/produkte.cfm</a>

<sup>13</sup> Acknowledgement to John Glover, Paul Negus and John Baker for information from tables in the magazine *IDMI [Information and Document Management International]*,

<sup>14</sup> \*Colour microfilm has not yet received a LE (life expectancy) rating from any standards organisation.

Features >	Model	Proprietary film	16 mm	35mm	105mm	Aperture cards	B&W	Colour	LE500 Long LE*	web site
SMA	SMA16	No	X				X	X	X	<a href="http://www.sma-edocument.com/archive_writer_sma_16.html">http://www.sma-edocument.com/archive_writer_sma_16.html</a>
SMA	SMA51	No	X	X			X	X	X	<a href="http://www.sma-edocument.com/archive_writer_sma_51.html">http://www.sma-edocument.com/archive_writer_sma_51.html</a>
SMA	SMA105	No			X		X	X	X	<a href="http://www.sma-edocument.com/archive_writer_sma_105.html">http://www.sma-edocument.com/archive_writer_sma_105.html</a>
Staude	Digi-Fiche	No			X		X	X	X	<a href="http://www.e-staude.com/fc_eng/p06_digifiche.php">http://www.e-staude.com/fc_eng/p06_digifiche.php</a>
Staude	File-Convertor	No	X	X			X	X	X	<a href="http://www.e-staude.com/fc_eng/p06_fileconverter.php">http://www.e-staude.com/fc_eng/p06_fileconverter.php</a>
Wicks and Wilson	ACO-2	Yes				X	X		X	<a href="http://www.wwl.co.uk/apertureplotters.htm">http://www.wwl.co.uk/apertureplotters.htm</a>
Zeuschel	OP500	No	X	X			X	X	X	<a href="http://www.zeuschel.com/products_microfilm_plotters.html">http://www.zeuschel.com/products_microfilm_plotters.html</a>

## *Appendix 2: Potential application of microfilm for long term preservation in the DCC Curation Lifecycle Model*

The decision to utilise preservation microfilm as a long term preservation strategy will include consideration of requirements such as the following:

- levels of complexity/interactivity of digital objects (microfilm is unsuitable for dynamic, interactive materials)<sup>15</sup>
- long life expectancy / long term holding position
- contribution to the assurance of integrity of data
- utilising a combination of digital preservation strategies (risk management)
- flexibility (digital to analogue and back to digital options)
- scalability and mass production options
- space saving (c.f. analogue originals)
- ability to incorporate metadata
- potential cost benefits including storage, access and retrieval costs.

Options for born digital and digitised items are summarised in the table below.

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<sup>15</sup> Further research and development is required to explore and identify the types of digital materials which might be most suitable for the application of microfilm.

**Table: Potential application of microfilm for long term preservation for born digital and digitised items in DCC Curation Lifecycle model**

	BORN DIGITAL ITEMS					DIGITISED ITEMS					
	↓		↓			↓					
Life cycle stage	Dynamic, interactive (likely to increase in future)		Text or image based (lacking interactivity)			Text or image based (lacking interactivity)					Technology option
	↓		↓			Is there a preservation quality microfilm master held under good storage conditions					
	A1 Implement alternative digital preservation strategies	B1 Applicability of microfilm				B2 Applicability of microfilm					
		BW	Grayscale	Colour		↓	↓	BW	Grayscale	Colour	
						N	Y				
						Check location & condition of original(s)	Go to B2				
						Consider mf copy option					
Conceptualise			Y	Y	Y			Y	Y	Y	Mf to digital
Create or receive			Y	Y	Y			Y	Y	Y	Mf to digital
Appraisal and selection			Y	Y	Y			Y	Y	Y	Mf to digital
Store			Y	Y	Y			Y	Y	Y	Mf to digital
Transfer			Y	Y	Y	Digital to mf & mf to digital			Y	Y	Y

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