Managing the Long-term Preservation of Electronic Archives or Preserving the Medium and the Message[1]

JACQUES GRIMARD

RÉSUMÉ L'auteur invite les lecteurs à une réflexion sur l'utilisation des archives électroniques. Par ce terme il entend toutes les archives produites et accessibles seulement par le truchement d'instruments électroniques. Il montre que le maintien de l'information doit se faire dans une démarche globalisante et qu'il faut préserver à la fois le médium et le message. Il insiste sur l'opacité de l'information électronique qui n'offre aucune structure naturelle quoique régie par un éventail de codes et de conventions, sur la multiplicité des formats et sur la mobilité et la maléabilité de cette information électronique. Il propose trois solutions pour la préservation du contenu : le transfert de support, la normalisation des formats et la conversion de l'information. En troisième partie, l'auteur se penche sur la fragilité des supports et sur la durée de vie des technologies de soutien. En guise de solutions à ce problème des contenants, l'auteur insiste sur les conditions d'entreposage, la conversion de l'information, la recherche et la normalisation. En conclusion, l'auteur nous rappelle l'importance de la conservation de la mémoire documentaire. Pour ce faire, il faut non seulement préserver le message et le médium mais il faut également intervenir tôt en prenant les décisions au bon moment.

ABSTRACT The author invites readers to reflect on the use of electronic records. He defines the term as encompassing all those records produced and accessible only by means of electronic equipment. He shows that electronic information must be maintained through a global approach that preserves both the medium and the message. He underlines the opaque nature of electronic information, which has no natural structure even though it is regulated by a range of codes and conventions; the multiplicity of formats in which it is found; and the fluidity and malleability that characterize it. He proposes three solutions to the problem of preserving the contents of electronic records: changing the medium, standardizing formats, and conversion of the information. In the third part of his paper the author examines the fragility of electronic media and the lifespan of supporting technology. As solutions to the problem of preserving the media, the author underlines the importance of storage conditions, information conversion, research, and standardization. In conclusion, he reminds readers of the importance of

1 This title was inspired by the theme of a workshop offered during the Conference of the Society of American Archivists, Washington, September 1996. The article is a revised version of a paper presented at the workshop entitled "Preserving Electronic Archives ... or Striving to Stabilize Fluidity." It was first published in the journal *Archives* 27, no. 4 (1996), pp. 21–34, under the title: "Gérer la préservation à long terme des archives électroniques ou préserver le médium et le message."

preserving recorded memory. To succeed, not only must the message and the medium be preserved, but early, appropriate, and timely intervention is needed.

Gordon B. Neavill, referring to the musings of the German Benedictine monk Johannes Trithemius on the subject of new printing technologies, cites an excerpt from the monk's ardent plea on behalf of the work of copyists:

> The word written on parchment will last a thousand years. The printed word is on paper. How long will it last? The most you can expect a book on paper to survive is two hundred years. Yet, there are many who think they can entrust their words to paper. Only time will tell.[2]

One can only smile at these words dating back nearly five hundred years and reflect that we now know better paper's properties, its resilience, its intrinsic limitations, and its characteristics as a carrier of information. To those of us who have seen the birth of a multiplicity of new information media over the last century, and have been warned numerous times about the demise of paper, Trithemius's musings are not that farfetched! The monk's remark that "only time will tell" resonates with us, who must understand the properties and the durability of the new vectors of our documentary heritage.

Just like Trithemius and his contemporaries, we ourselves face the challenge, on the eve of another Information Revolution, of the preservation of and long-term access to what our societies have deemed important enough to conserve as memory. Like them, too, it is our task to ensure that the medium and the message can withstand the test of time and preserve evidence of our era for future generations. Systematic and generalized use of automated procedures for creating, recording, processing, and disseminating information produces unique challenges in the areas of the protection of and the long-term accessibility to this so-called "electronic" information. This data is unique in both its form and its configuration.

This article offers an overview, an outline of the problem, a framework for reflection. The first section will identify the subject to be studied by defining the principal terminology. Second, once we have grasped the complexity, fluidity, and multiplicity of electronic information and presented possible solutions, we will examine the medium – the vehicle used to hold information – and its numerous preservation difficulties.

What Are We Talking About?

It is useful, before confronting the issues and developing responses, to consider our terminology and revisit the key words used in the title of the present

2 Gordon B. Neavill, "Preservation of a Computer-Based and Computer-Generated Record," in Kathryn Luther Henderson and William Henderson, eds., *Conserving and Preserving Materials in Nonbook Formats* (Urbana, IL, 1991), p. 45.

article: managing the *long-term preservation of electronic records* or preserving the *medium* and the *message*.

Electronic Records

Let us first examine the term *electronic records*. The International Council of Archives' *Dictionary of Archival Terminology* defines "machine-readable records" as: "... usually in code, readable only by machine ... recorded on a medium such as a magnetic disk, magnetic tape or punched card, whose contents are accessible only by machine."[3]

Although the definition should be updated (it does not include optical and magnetic optical technologies), one can conclude that the principal characteristic of *electronic records* is that they are produced and accessible only through electronic means. Further, they are recorded using codes – numeric or otherwise – on media that can be read only indirectly, and exclusively through the use of appropriate technology. We are familiar with the various tapes, cassettes, disks, and floppy or hard diskettes on which ever-growing quantities of information are recorded. Electronic information encompasses texts and graphics generated by office automation systems used by large or small organizations; gigantic and numerous databases and databanks supplied and administered by one or more parties; all manners of spreadsheets; engineering or architectural plans; geographical maps of all kinds; industrial drawings; and an increasing number of works of art. Let us not forget that although not usually included in the category of *electronic records*, the majority of contemporary audio-visual documents are also produced electronically, recorded the same way, and readable only through the use of electronic equipment.[4] Lastly, important technological convergences are occurring through recent progress in multi-media, which will be developed far beyond the initial advances already undertaken on the information highway.

Long-term Preservation

Preservation is another important term, especially its *long-term* dimension. Drawing on earlier definitions that appeared in past editions, the latest version of the *Dictionary of Archival Terminology*, still under preparation, offers the following definition of preservation: "The totality of processes and operations involved in the physical protection of records against damage or deterioration and in the restoration/repair of damaged or deteriorated documents."[5]

3 International Council on Archives, *Dictionary of Archival Terminology / Dictionnaire de terminologie archivistique* (New York, London, Paris, 1984), p. 103.

4 In fact, it is revealing to note that radio and television are often known generically as "electronic media."

5 International Council of Archives, *Dictionary of Archival Terminology*, p. 103.

The authors add that "Preservation may also include the transfer of information to another medium, such as microfilm." They define "conservation" as: "The component of preservation which deals with the physical or chemical treatment of documents."[6] And when we refer to the management of electronic records, we mean all professional and technical measures necessary for the maintenance of electronic information in both its physical and intellectual dimensions, its protection against all possible damage to its integrity, and to the restoration of the documents themselves. We are not referring here to occasional interventions but to an integrated approach, one that involves prioritized and organized measures aimed at stabilizing electronic information, protecting its essential stability from harm, and if necessary, restoring its stability. The term "management" best sums up this approach, for it suggests a global, visionary, strategic approach as opposed to piecemeal actions, focussed on individual items, centred only on the immediate task. The long-term preservation of electronic records is, by its very nature, no small feat. It holds particular significance because electronic records have a very short life span given our current state of knowledge. Preservation, in the words of Gordon B. Neavill, is concerned with the transmission of information through time.[7] The particular fragility of electronic records means that archivists must be concerned about their preservation; they are after all the memory of future generations. The preservation of electronic records also involves the creators, users, and managers of this volatile information, none of whom are guaranteed that this information will survive even for the period of what Theodore Schellenberg called its primary value. To preserve records for the long term must necessarily mean they first survive past the short and medium terms!

The Medium and the Message

Finally, a word about the *medium* and the *message*. Both these terms come from communications theory and, according to Marshall McLuhan, they are interchangeable: in the expression known worldwide, "the medium is the message." Consequently, if the *medium* is the *message*, we must remember that for our purposes, the contemporary notion of information finds its origins in (among other things) "the thinking that attempts to distinguish between form and meaning."[8] In this case the *message* is the content, the meaning of the

6 I would like to thank Bjorn Lindh of the Swedish National Archives, who graciously allowed access to this information.

7 "Many of the information technologies that emerged in the nineteenth and twentieth centuries, such as telegraph, telephone, radio, and television, are concerned primarily or solely with transmission through space ... Preservation is concerned with transmission of information through time rather than space." Neavill, "Preservation of a Computer-Based and Computer-Generated Record," p. 47.

8 Philippe Breton, *Histoire de l'informatique* (Paris, 1987), p. 37.

information. In our archival terminology, the *medium* is normally associated with the physical medium, its formal dimension alone: the paper, the magnetic tape, the photographic or film negative, etc. Accordingly, in information theory the *medium* is the form of the *message*; the *message* is further broken down to the *symbol* – the representation of the information – and the *signal* – the unit of communication of that information. For the purposes of our discussion, when using the term *medium* we must take into account three dimensions of the *form* of the information: the *medium*, the *symbol*, and the *signal*.

Preserving the Content

When looking at the question of preserving the content of electronic records, we soon discover that the terms used to describe the medium and the message are not easily separated from each another.

Opaqueness of Electronic Information

Unlike its paper counterpart, the electronic document "does not possess any natural structure: it consists of a perfectly linear file, a continuous series of characters in succession."[9] Humans can neither discern the architecture nor directly grasp the arrangement of electronic documents. This does not mean, however, that electronic information is disorganized or chaotic; the information may be "opaque," but it is controlled by a range of codes and conventions that give electronic information its form and meaning. This is what Jeff Rothenberg, Senior Information Scientist in the Social Policy Department at the RAND Corporation, demonstrated in a recent article in *Scientific American* on the longevity of digital documents. Projecting the reader into the year 2045, Rothenberg presents a scenario where his future grandchildren wish to read a compact disk created in 1995 that contains information on their grandfather's fortune! Rothenberg reminds readers that the children will not only need to find the characters on the CD, they will need to understand what the characters represent and what links them together. The children will also need to see how the characters are organized and structured in order to get their hands on this fortune! Finally, in order to decode the information, they will need access to instruments – both equipment and software – that can reactivate the information and capture the original programming.[10] In other words, as Rothenberg explains, electronic information is characterized by its opaqueness.

9 Yves Marcoux, "Les formats de documents électroniques en archivistique. La solution au problème des archives électroniques passe-t-elle obligatoirement par les formats normalisés de documents structurés?," *Archives* 26, nos. 1–2 (Fall 1994), p. 88.

10 Jeff Rothenberg, "Ensuring the Longevity of Digital Documents," *Scientific American* (January 1995), pp. 42–47.

The Variety of Formats

The variety of formats for electronic records only increases their opaqueness and the difficulty of coming to terms with them. In an article on archival electronic document formats, Yves Marcoux of the École de la bibliothéconomie et des Sciences de l'information at the Université de Montréal explains that "information accessible through the Internet is available in more than 300 different formats." He further explains that since a format is only a set of conventions, software developers or manufacturers can readily develop new formats which are in turn easily duplicated and made obsolete. This offers undeniable financial and commercial advantages to businesses in this field. The fact that an infinite variety of information management needs exists in the marketplace entails the development of an endless variety of software formats to meet these unique and wide-ranging functional requirements.[11] This limitless variety of formats can hardly help to reduce the opaqueness of electronic information. Indeed, these different formats only serve to obscure further the electronic record, to add to its opaqueness, to make it barely perceptible.

The Fluidity and Malleability of Electronic Information

To the opaqueness of electronic records, and their multiple configurations, can be added another characteristic: their fluidity and, as a corollary, malleability. Both qualities determine and shape directly the content of the information. In an article entitled (in translation) "The Management of Electronic Archives: A Few Key Questions to Consider," Pierrette Bergeron, also of the École de la bibliothéconomie et des Sciences de l'information at the Université de Montréal, explains: "An electronic archival document is neither a finite nor a static element ... it can be seen as a set of relations or pieces of information capable of residing in multiple files or databases stored on different media dispersed throughout the organization ... It is possible to create 'composite' records which integrate not only text, but also sound, images, graphics, numerical data, etc., making electronic records more complex than ever."[12]

"Neither a finite nor a static element," "set of relations or pieces of information," and "composite archives" – all these phrases speak to the fluidity and complexity of electronic information. They remind us that the documents that shape our knowledge are no longer uni-dimensional; rather, they are composites which integrate image, sound, text, and graphic elements. These terms also indicate that these electronic documents are extraordinarily dynamic,

11 Marcoux, "Les formats de documents électroniques en archivistique," p. 91.

12 Pierrette Bergeron, "La gestion des archives électroniques. Quelques questions-clés à considérer," *Archives* 23, no. 3 (Winter 1992), p. 53.

adaptable to the particular needs of the user, and using the same body of data, assume different configurations. The fluidity of electronic records, however, also means they are never static, never materially fixed, and have the added quality of escaping, in a manner of speaking, the anguish of fixity.

These qualities entail vulnerability, as Gordon B. Neavill affirms in speaking of the malleability of electronic information:

> The ease with which data in magnetic digital records can be deleted, modified, updated, and rearranged in new configurations gives computer-based systems a tremendous advantage over print-based systems for the provision of current information. However, it raises serious questions about the survival of information ... The malleability of information that is one major advantage of computer-based electronic systems has as its corollary the potential transience of information ...[13]

There is no need to elaborate on the subject in order to understand that the fluidity and malleability of electronic information present dangers for the archivist entrusted with keeping track of evidence of human activities and actions. By way of an example, think of the updates and corresponding deletions in population or environmental databases that could deprive demographers or other scientists of analytical data necessary to examine the duration of observed phenomena. Fortunately, such losses are avoided by the timely capture of "snapshots" of this evolving and ephemeral information through periodic transfers of data to preservation databases.

Possible Solutions

At first glance, dealing with the problems inherent in the opaqueness of electronic records seems relatively easy. The long-term preservation of the keys to readability themselves (the initial programs used to create the information, and their accompanying documentation) seems to be the correct solution. However, for archivists such a solution seems impracticable within a context of a multiplicity of software formats.

The Transfer of Recording Medium

In some instances, the transfer of electronically-generated information to microfiche, particularly data in simple, infrequently-used databases, can be a viable option. For example, this solution was proposed by a special committee representing several universities in Québec for the long-term preservation of computer files relating to student populations and the services provided to

13 Neavill, "Preservation of a Computer-Based and Computer-Generated Record," pp. 48–49.

them.[14] It is hoped that if the need arises, the information will be readable and reusable using future technologies, thereby avoiding the constraints of original hardware and software.

Format Standardization

Elsewhere, others are counting on the standardization of formats for structured documents such as Standard Generalized Mark-up Language (SGML, ISO 8870) or Office Document Architecture (ODA, ISO 8613) and their respective extensions used in hypertext documents (such as HyTime / Time-based Document Structuring Language, ISO 10744 and Hyper ODA). These standardized formats for structuring documents employ a logical method of parsing documents and offer a structural representation of their components (parts, chapters, sections, etc.). In fact, these are "meta-formats, actual languages ... by means of which we can … represent, using the same format, documents as varied as memos, hypertext reports, employee files, encyclopaedias, etc."[15] This tool seems particularly promising for the reactivation and use of multi-form and multi-type information generated by increasingly versatile office systems; its value lies in its independence from original hardware and programming.

Information Conservation

Large national archival institutions all seem to agree that "... conversion rather than preservation is the critical issue for future usability of electronic records in the long-term ... that conversion from obsolescent software and hardware to media readable by standard contemporary systems would become the chief requirement for long-term retention.[16]

Thus, in its twenty-fifth report, the US Committee on Government Operations stated that:

> The Archivist of the United States reports that 8,000 data files have been accessioned and that none of the files is hardware dependent. Only 2 percent of the files required special processing to deal with unusual or obsolete formats. The files were processed using current high level software, and there was no need to rely on the original operating system or database management software used to create the records.[17]

14 Conférence des recteurs et des principaux des universités du Québec, *La gestion des archives informatiques.* Collection Gestion de l'information (St-Foy, 1994), p. 63 and passim.

15 Marcoux, "Les formats de documents électroniques en archivistique," p. 96.

16 T.K. Bikson and E.J. Frinking, *Preserving the Present: Toward Viable Electronic Records* (The Hague, 1993), p. 55.

17 Committee on Government Operations, *Taking a Byte out of History. The Archival Preservation of Federal Computer Records*. Twenty-fifth Report to the 191st Congress (Washington, 1990), p. 18.

To eliminate such dependence, the US National Archives and Records Administration (NARA) established precise requirements for the transfer of information from originating organizations. This practice was well suited for files generated by mainframe computers whose contents and functions were generally less complex than documents produced on contemporary microcomputer networks.[18] The US Committee on Government Operations emphasized that the information revolution of the 1990s, coupled with the wide distribution of personal computers as tools for daily work, would most likely require approaches that both limit technology/media independence while becoming more responsive to new contexts of automated information in organizations.[19] The archival community is well aware of this, recognizing that:

> Future efforts to handle other material (e.g. relational databases or formatted documents) are expected to be more complex and costly. Nonetheless, these efforts are judged to be far less difficult and expensive than attempting to keep electronic records in their original state, maintaining the necessary software, hardware and expertise to use them.[20]

Further, it is important to keep in mind, from an archival point of view, that the context in which information is created is as important as its structure. The long-term preservation of that context is a daunting challenge. This is clear when one looks at some of the projects already taking place in archival repositories. These efforts are aimed at maintaining the links between a given body of electronic information and other essential sources of information necessary for understanding its meaning and use.

The Preservation of Recording Media

Another set of problems is adding to the difficulties encountered in the long-term management of the configuration of electronic information. These problems relate to the information support technologies: the support/media/carriers and the retrieval equipment/readers/operating systems. Much has been written in information management professional circles about these technologies. However, much remains to be done on the subject in order for archivists to reach adequate comfort levels.

The Fragility of Recording Media

One of the most frequently expressed concerns among information professionals is the fragility of the recording media. Magnetic or optical storage

18 Bergeron, "La gestion des archives électroniques," p. 54.
19 Committee on Government Operations, *Taking a Byte out of History*, pp. 19–27.
20 Bikson and Frinking, *Preserving the Present*, p. 55.

media used to "carry" information are comprised of heterogeneous composite chemical products that allow characters to be encoded.

A magnetic tape is no more than a thin magnetic coat of pigments held together by a polymer-binding agent; the polymer itself is sometimes reinforced by an underlying layer.[21] For example, the CD-ROM (one of many optical recording media) is a polycarbonate disk in which minuscule cavities are moulded and covered with a thin layer of metal; the metal layer is sealed with a plastic finish.[22] These and other similar recording media are vulnerable in their make-up. John van Bogart, a lead researcher in the Media Stability Studies Division of the National Media Laboratory, indicates that the first element to deteriorate in magnetic tape is the binding agent, where the polymer and the lubricant are integrated. He also mentions the instability of magnetic particles and the distortion of the underlying coating on the base, leading to possible disruption of the reading heads.[23] Jonas Palm of the Upsala University Library summarizes the problem well:

> What physically may happen with magnetic tapes and disks is a distorsion [sic] of some kind, either through handling or through environmental influences. In both cases the magnetic layer is distorted or looses [sic] from the plastic support. The polyurethane binder between magnetic layer and support deteriorates when exposed to moisture.[24]

The newness of optical disk technology means that little is known about its behaviour and durability over time. We do know, however, that it must be handled with great care; any scratch can compromise its legibility. There is general agreement that its chemical components are no less vulnerable and unpredictable than those of magnetic media.

The Life Expectancy of Support Technologies

Compounding the inherent fragility of new electronic and optical recording media themselves is the undoubtedly short life span of the equipment upon which these media run.

21 John W.C. van Bogart, *Magnetic Tape Storage and Handling. A Guide for Libraries and Archives* (Washington, 1995), pp. 2–3.

22 Mark Arps, "CD-ROM: Archival Considerations," in Janice Mohlhenrich, ed., *Preservation of Electronic Formats and Electronic Formats for Preservation* (Fort Atkinson, WI, 1993), p. 96.

23 van Bogart, *Magentic Tape Storage and Handling*, pp. 3–10.

24 Jonas Palm, "Preservation and Conservation of Non-book Materials in Libraries and Archives," in Jean-Marie Arnoult, Virginie Kremp, and Musila Musembi, eds., *Proceedings of the Pan-African Conference on the Preservation and Conservation of Library and Archival Materials. Nairobi, Kenya, 21–25 June 1993* (The Hague, 1995), p. 93.

During a recent study of the long-term preservation of audio-visual media, three Canadian practitioners associated with the Task Force on the Preservation and Enhanced Use of Canada's Audio-Visual Heritage developed a summary table of information available on the life expectancy of magnetic, optical, and optical-magnetic media presently in use. What is most striking is the degree of uncertainty in establishing the life expectancy of these various media. For example, the projected life expectancy of magnetic media is five to forty years for the RDAT and D8 and roughly ten to fifteen years for the DD2, provided they are stored in favourable environmental conditions (at 18C and ca 40% relative humidity). The projected life expectancy of CDs is five to 100 years. As for WORMS (Write Once Read Many), some types may last a decade, others a century depending on the alloy used.[25] Taken at face value, the numbers can help us measure our margin of manoeuvrability in the search for viable solutions to at least save the information itself.

What about the extraordinary variety of these media and the multiple modifications they have undergone over the last thirty years? Inspired by the work of John C. Mallinson of the Center for Magnetic Recording Research at La Jolla, California, Klaus Hendricks, Principal Researcher at the Canadian Conservation Institute, reminds us that in fewer than thirty-five years, magnetic video tapes have gone through various formats: from the two-inch "Quad" to the eight-millimetre tape. Concomitantly, the storage capacity of the media has increased considerably. For example, half-inch magnetic tapes increased their storage capacity over the last thirty years from 100 BPI/7–TRACK to 19,000 BIP/18TRACK. The IBM 350 disk used to store 100 BPI and 20 TPI in 1957; in 1987, the IBM 3380K had a storage capacity of 15,000 BPI and 2,050 TPI.[26]

Beyond the wide range of recording media of varied capacity are the software and operating systems used. Researchers agree that the life expectancies of these technologies are shorter than the recording media themselves! The three Canadian practitioners mentioned above estimate a five to ten year life expectancy for operating system technologies while their recording media can last thirty years or more! Needless to say, the obsolescence of these technologies is an important element in the stratgegies of IT equipment manufacturers. The waves of innovation in the areas of information dissemination, communication, and broadcasting become problematic when attempting to develop

25 Ed Zwaneveld, Roger Easton, and Tom Cavanagh, "The Conservation of Canada's Film and Magnetic Media Heritage," in Task Force on the Preservation and Enhanced Use of Canada's Audio-Visual Heritage, *Fading Away: Strategic Options to Ensure the Protection of and Access to our Audio-Visual Heritage* (Ottawa, 1995), Appendix E.

26 Klaus Hendriks, "Stability and Preservation of Archives Media: Paper, Photography Materials and Magnetic Recordings," *Preprints. 7th International Congress of Restorers of Graphic Art (IADA)* (Upsala, Sweden, 1991), pp. 10–11.

strategies and measures for long-term preservation beyond the simple life expectancy of the information recording media and hardware.

Possible Solutions

Recommended solutions are aimed at intervening in three areas, each with the goal of preserving electronic information so as to keep it usable for the long, even the very long, term. All three solutions, however, are premised on the recognition that the information, in electronic form, is more important than the document or particular system used to give the information its form. Not all archivists are comfortable with that notion.

Storage Conditions

First, we must take action in the matter of storage conditions. Although tests are ongoing and research needs to be done on optical recording media, all generally agree that the cold storage of recording media, coupled with low humidity levels, slows down the natural process of deterioration, reduces the danger of distortion, and encourages the stabilization and maintenance in good condition of the recording media. In his book *Magnetic Tape Storage and Handling*, John W.C. van Bogart discusses magnetic documents destined for long-term preservation using a "Temperature Set Point, significantly lower than room ambient. As low as 40F (5C)" and a "Humidity Set Point, significantly lower than room ambient. As low as 20% RH," with variations not exceeding 7F/4C for the temperature and 10% for the humidity level.[27] The installation of storage rooms that meet these criteria is very costly; consequently, archivists must make choices by ranking the importance of electronic records in their care and by reserving optimum treatment for the most valuable documentary evidence. As van Bogart states:

> ... the quality of care a magnetic tape receives should be commensurate with the perceived value of the information contained on the tape. If the information stored on the tape is of great value and must be preserved indefinitely, this could justify the cost of purchasing and maintaining the recommended archive facility.[28]

Ken Harris of the Library of Congress, citing Leslie Smith of the National Institute for Standards and Technology, also emphasizes the importance of optimum storage conditions for magnetic documents:

27 van Bogart, *Magnetic Tape Storage and Handling*, p. 18.
28 Ibid., pp. 18–19.

(Leslie Smith) observed that the tape failure occured [sic] mainly due to the polyster [sic] polyurethane binder layer, resulting in softening, embrittlement or loss of adhesion to the backing. A most significant finding of this study was that the major threat to magnetic tape is the presence of acidic atmospheric pollutants which are particularly damaging at high humidity and temperature levels. Not surprisingly, the polyester base itself was found to be highly stable under reasonable storage conditions.[29]

Information Migration

Second, we must intervene in the field of data migration, the transfer of information. Here, it is important, first, to recognize that no media will last forever and thereby ensure the information's survival in perpetuity; even if that were possible, the obsolescence of user technologies – both equipment and software – would render the surviving medium itself virtually useless. We must therefore take the measures necessary to refresh the information, that is, to transfer, copy, and migrate information to new recording media before those on which they currently reside deteriorate. This process must be repeated over and over using replacement media as they become available. We must also prolong the longevity of media by ensuring optimum storage conditions. Choosing a long-lasting recording medium and its corresponding operating technology is not an easy task. Maintaining the original quality of information – especially in the case of images – and an acceptable level of compression of the information are also problematic. All of these measures are costly and can – literally – be labour-intensive.

The literature available on the subject of conversion suggests that a wide range of solutions are currently used within the archival network. It is however surely too early to assess their viability. Yet it is clear that open-ended solutions hold the most promise. In 1992, the National Archives of Canada Working Group on Conservation Standards and Technologies recognized the utility of Digital Audio Tape (DAT) and the CD-ROM and foresaw the potential usefulness of optical tape. The Group suggested a comprehensive review of these options before making any irreversible financial commitments. Since then, new options have come to light. Rapid progress in the field of migration may permit us to adopt more efficient and less costly methods than those envisioned three years ago. Meanwhile, we continue to rely on 8mm DAT and twelve-inch WORM Optical Disk.[30]

29 Ken E. Harris, "A Review of Recent Research Findings on Preservation and Conservation of Library and Archival Materials," in Arnoult, Kremp, and Musembi, eds., *Proceedings of the Pan-African Conference on the Preservation and Conservation of Library and Archival Materials*, p. 122.

30 National Archives of Canada, *Report of the Working Group on Conservation Standards and Technologies* (1992), p. 26.

As for the management of these repeated migrations (every ten years according to the most commonly accepted practice), the development of integrated automated preservation management systems offers interesting prospects. Tom Cavanagh, of the Engineering Department at the Canadian Broadcasting Corporation, has studied Sony's "Library Management System" as part of the mandate of the Task Force on the Preservation and Enhanced Use of Canada's Audio-Visual Heritage. The intriguing concept underlying the library management system is that electronic information be monitored and inspected, and that transfer of the records be entirely automated.[31]

Research and Standardization

Lastly, we must intervene in the field of research and standardization. Current work underway in research laboratories in order to determine the durability of electronic media gives reason for hope. These efforts, however, must go beyond a formal report on research; the conclusions drawn must help to determine standards for the manufacture of durable and versatile products. Thus, the recent initiative undertaken by the Society of Moving Pictures and Television Engineers (SMPTE) in collaboration with manufacturers to establish acceptable standards of durability should be acknowledged. The results of this concerted initiative should be available shortly.

Conclusion

Societies, organizations, and individuals are at the dawn of the Information Revolution. Those responsible for managing memory cannot ignore the new means of creating, managing, storing, and communicating information, which must form an integral component of their core business activities. This is all the more critical because electronic information, which has become the favoured recording means of our time, is marked by particular characteristics: it is opaque, complex, dynamic ... fluid in its configuration; fragile, unstable, temporary ... ephemeral in its form. Electronic information requires long-term protection methods which are complicated yet transitory. In spite of their limits and imperfections, these solutions must be tried, adjusted, and modified to respond to arising needs; they must also be adaptable, reversible, and transparent so as to test the viability of solutions we have applied over time, and to offer us new avenues to explore.

Caution is necessary. Any solutions emerging from our experience and reflections or from the elaboration of integrated and global electronic document preservation strategies must take into account that:

31 Zwaneveld, Easton, and Cavanagh, "The Conservation of Canada's Film and Magnetic Heritage," pp. 28–30.

- in the field of electronic information, the preservation of the message implies the protection of the context, the content, and the structure;
- "The strategy for keeping electronic records is a migration strategy; it's not a physical conservation strategy"[32];
- In this quasi-immaterial universe of electronic information, we must intervene early and with suitable expertise to ensure appropriate, timely action.

Electronic information now forms an important part of the documentary memory of our time. We must be able to transmit through time those significant electronic traces of ourselves which form part of a coherent information heritage.

32 *The Globe and Mail*, "Preservation of Past Poses Problem: Archives Limited by Hi-Tech," (24 October 1995).