Electronic Records Management Guidelines
Digital Media

Summary

On-going and rapid advances in technology require you to store electronic records on media that enable you to meet long-term operational and legal requirements. Your records must be trustworthy, complete, accessible, legally admissible in court, and durable for as long as you need them. Because every digital storage option will eventually become obsolete, consider digital storage options that will allow you to maintain records by migrating and/or converting them during their required retention period.

Digital Data Storage

Electronic records are digital data that are stored on digital media. Digital data exist, at their most basic level, as just zeros and ones, or on and off. For example, black and white photographs in the newspaper are printed as a series of either black or white dots (0 or 1, on or off). The complex organization of a large number of dots allows the human eye to complete the image. The digital data in an electronic record use the same principle to organize digital data into the record to make the record readable. A bit (short for binary digit) is the smallest unit of data in a computer. A bit has a single binary value, either 0 or 1. Digital data are stored on digital media. Digital media are divided into three main types:

- *Magnetic*. On magnetic media, the digital data are encoded as microscopic magnetized needles on the surface of the medium (e.g., disk or tape).
- *Optical*. On optical media, the digital data are encoded by creating microscopic holes in the surface of the medium (e.g., CD or DVD).
- *Solid State*. Containing no moving parts, solid-state media encode digital data by applying small voltages that temporarily induce a group of transistors either on or off (e.g., flash memory media, USB removable memory).
- *Cloud Storage.* Cloud storage is a computing model in which data is stored on multiple remote servers and accessed via the internet, or "cloud". It is maintained, operated, and managed by a cloud service provider.

Sequential Versus Random Access

Access to digital information on digital media is divided into two types:

- *Sequential*. Sequential access requires the user to access specific information by accessing the preceding information on the

medium. For example, if you want to view a specific portion of a videotape, you must first fast-forward through the preceding portion of the videotape.
- *Random*. Some digital media allow users to access the stored information from any physical place on the media. For example, when you put a disk into your personal computer's disk drive, you can access any single file stored on the disk without having to first access all the files that precede it.

Storage Measurement

The storage capacity of digital media is measured in bytes, the basic unit of measurement:
- 1,024 bytes make a kilobyte (KB)
- 1,024 KBs make a megabyte (MB) or 1,024,000 bytes
- 1,024 MBs make a gigabyte (GB) or 1,024,000,000 bytes
- 1,024 GBs make a terabyte or 1,024,000,000,000 bytes

For example, a one-page, text-only letter might be 20 KB, a graphics file might be 200 KB, and a fifty-page, desktop-published document with graphics might be 2 MB.

Storage Options

As part of a records management plan for electronic records, you will need to determine where and how these records will be stored. This decision will be based on the likelihood of access to those resources versus the overall cost in maintaining them. Your options for storage include the following:

Online. Properly designed storage in your computer system may provide full access to appropriate users. Online access means that the record is accessible immediately through your network (e.g., on your network server or on your personal computer's hard drive). This option maintains the greatest functionality but requires more expensive network storage.

Nearline. Nearline storage includes storage in a system that is not a direct part of your network, but that can be accessed through your network (e.g., optical media jukebox). This option maintains a moderate amount of functionality. While the storage space is cheaper than online storage, nearline storage requires that the user take time to manipulate both the files and media of choice to access the records.

Offline. Offline storage refers to storage that is not accessible through your network (e.g., removable media such as external hard drives). This option trades functionality for stability but maintains records in an electronic format.

Magnetic Media

Magnetic media include:
- *Magnetic disk*. Magnetic disks include the hard disk found inside your computer that stores the programs and files you work with daily. Magnetic disks provide random access. Also included are:
  - *External Hard Drive*. External hard drives are encased in a plastic housing and connected via cable to a computer port. In this way, a single processor can have access to the data on multiple hard drives.
  - *Network Environment.* Multiple hard drives are connected to each other in a way that shares resources and information, creating a network.
- *Magnetic tape*. Magnetic tapes come in reel-to-reel as well as cartridge format (encased in a housing for ease of use). The main advantages of magnetic tapes are their relatively low cost, their security (if they are not mounted in a drive, they cannot be read)

and their storage capacities (up to several terabytes. Magnetic tapes provide sequential access to stored information which is slower than the random access of magnetic disks. Magnetic tapes are a common choice for both long-term storage and the transport of large volumes of information.

- *Digital Audio Tape (DAT)*. DATs are in a cartridge format a little larger than a credit card. The industry standard for DAT cartridge format is a digital data storage (DDS) cartridge. DDS cartridges provide sequential access. Without proper care, DAT is prone to significant data degradation over time.
- *Digital Linear Tape (DLT)*. DLT is a high-speed magnetic tape and drive system in cartridge format that can hold up to 70 Gigabytes of data. *Super DLT* can hold up to 100 GB on a single cartridge. DLT offers significant speed and storage advantages over DAT.
- *Linear Tape-Open (LTO)*. Linear Tape Open is an open standard magnetic tape system. Similar to DLT in capacity and speed, LTO's standardized format allows interoperability between tapes and tape drives made by different manufacturers.
- *Videotape*. Videotape provides sequential access to video footage (e.g., feature films). Of the options available for magnetic storage, overall life expectancy is greater with DLT and LTO tape.

With proper care and handling, the life expectancy of DLT and LTO should be greater than ten years. Currently magnetic tape is a great method for security backups, especially when needed for long-term retention.

Optical Media

Optical media options include:

- *Compact Disk (CD)*. Compact disks come in a variety of formats. These formats include CD-ROMs that are read-only, CD-Rs that you can write to once and are then read-only, and CD-RWs that you can write to in multiple sessions. CD-RW disks have less life expectancy than non-rewritable ones. CD is relatively stable and with proper error checking suitable for data storage of five years before refreshing.
- *Write-Once, Read-Many (WORM)* disk. WORM disks require a specific WORM disk drive to enable the user to write or read the disk. WORM disks function the same as CD-R disks.
- *Digital versatile disk (DVD)*. These disks are also called digital video disks, but do not necessarily include video. DVD disks are types of optical disks with more storage capacity than CD-ROMs. Various types of DVD are often incompatible. Because of the rapid improvements in DVD technology and incompatibility issues, DVD is not an ideal storage medium for your records. Common types of DVDs include:
  - *DVD-ROM*. These DVDs are read-only disks that also have enough storage capacity for a full-length feature film. They are accessed using a special DVD drive attached to a personal computer. Most of these drives are backward compatible with CD-ROMs and can play DVD video disks.
  - *DVD-RAM*. DVD-RAM are rewritable disks with exceptional storage capacity. They come in one- or two-sided formats.

Rewritable disks have less life expectancy than non-rewritable ones.

- *DVD+RW and DVD-RW*. These are a direct competitor to DVD-RAM that offer similar functionality, are rewritable and have slightly greater storage capacity.
- *DVD-R and DVD+R.* DVD-Rs and DVD+Rs can be written to once and are then read-only.
- *DVD+R DL also called DVD+R9* (DL stands for Dual Layer). Employs two recordable dye layers, each capable of storing nearly the 4.7 GB capacity of a single-layer disc, almost doubling the total disc capacity to 8.55 GB.
- *DVD+RW DL* is a rewritable optical disc with storage capacity of 8.5 GB. DVD+RW DL discs employ two rewritable dye layers.

Solid State Media

Solid state media include various removable devices utilizing flash memory. Smart phones, digital cameras, computer games, video recorders, etc. rely on solid state media. Small cards and "memory sticks" offer ever-increasing storage capacities. Due to its popularity, solid state media always evolving. As such, the long-term (10+ years) storage capability of solid-state technology is not possible. If vital records are created or saved on flash memory devices, your agency should develop a plan to migrate the records to another type of media either every ten years, or sooner, if access to the records is jeopardized. Please see the *Digital Media Storage: Facilities and Procedures* guideline for more information.

Cloud Storage

Cloud storage is a cloud computing model in which data is stored on one or more remote servers. The data is accessed via the Internet, or "cloud". Data is maintained, operated, and managed by a cloud service provider on storage servers that are built based on virtualization techniques. The cost of cloud storage is calculated based on the amount of data being stored. This method of storage is becoming increasingly popular because cloud storage transfers the responsibility for long-term storage issues to the cloud service provider. **Please note: if your government office chooses to employ a cloud service provider, the ownership and ultimate responsibility for your public records remains with your office.** Both the remote server and the access point must have an Internet connection to operate. Data stored on the cloud is not accessible without an Internet connection. Please see the *Digital Media Storage: Facilities and Procedures* guideline for more information.

Digital Media Capacity

Table 1 summarizes the capacity of the basic digital media options. You should research the specific medium and manufacturer for exact specifications, including cost. Because of rapid technology developments in a highly competitive market, the costs for each option change frequently. The cost of the largest capacity options might exceed the resources of your state agency.

Table 1: Storage Capacity of Digital Media Options

Storage Media	**Capacity (Uncompressed)**
	Magnetic Media
External hard disk	**Up to 1 TB**
Removable disk	**Up to 2 TB**
Magnetic tape	**Up to 185 TB**
DAT	**Up to 80 GB**
DLT	**Up to 800 GB**

LTO	**Up to 12 TB**
Videotape	**Up to 8 hours of video**
	Optical Media
CD	**650-800 MB**
WORM (CD-R)	**650-800 MB**
EO	**650-800 MB**
DVD	**4.7-27 GB**
HD DVD and Blue-ray Disc	**15-50 GB**
	Solid State Media
Flash memory	**256 MB-155 GB**
Cloud Storage	**Infinite**

Note: Numbers current as of May 2020

Media Life Expectancy

All storage media have finite life spans dependent on several factors, including manufacturing quality, age and condition before recording, handling and maintenance, frequency of access, and storage conditions. Depending on storage conditions and the quality of manufacturing, the life expectancy of magnetic media ranges from 10 to 20 years, while optical media may last 30 years or longer. However, in real life situations, most media life expectancies are significantly less. For more information on the storage of digital media to preserve longevity, refer to the *Digital Media Storage: Facilities and Procedures* guideline.

Unlike paper and microfilm, no single digital medium and very few digital file formats will suffice for long term or permanent storage (10+ years) at this time. This lack of longevity is due in part to bit rot. **Bit rot,** also known as data degradation, data decay, or data rot, is the gradual, silent corruption of electronic data due to an accumulation of non-critical failures in a media storage device. Bit rot is NOT the same thing as file format, software, or hardware obsolescence. Therefore, records stored digitally will require ongoing attention and maintenance including periodic sampling of recorded media at 1-year intervals, "refreshing" or re-recording of digital records onto new media, and format migration/conversion to ensure successful preservation. CDs should be re-copied every five years or as indicated by sampling. Solid state media should be sampled each year and migrated/converted either every ten years, or sooner if access to the records is in danger. For more information on migration and conversion see the *File Formats* guideline.

In addition to media life expectancy, hardware must be available that allows you to easily read and retrieve your stored data. When selecting new storage systems, it is a good idea to stay with well-known, supported and proven technologies. Although new technology may offer certain unique benefits, it may also quickly become obsolete if the technology fails to catch on with consumers. The same is true for software. New, or updated, versions of software are released constantly. As a result, companies will stop supporting the oldest versions of software every 10-12 years. Minimizing the different number of formats being used will make it easier to update your software as needed. (e.g. do not use Microsoft Word and OSX Pages).

Remember that all records management strategies should include the use of records retention schedules. A records retention schedule lists the types of records by series, provides a brief description of each series, and determines how long they should be kept, including…

…their final disposition. Because record schedules are designed based on informational content and NOT storage media, series that are stored in multiple formats (paper, electronic, audio, etc.) can be managed under a single retention schedule.

Suggestions for Better Digital Media Decisions

- *Planning*. In addition to choosing a storage medium, you should establish procedures to refresh your digitally stored records periodically. Due to built-in error correction circuits, data degradation can go unnoticed at first, and periodic testing may not discover failing media until it is too late. Refreshing digital media occurs when you copy stored data from old to new digital media.
- *Speed of access*. When selecting a digital storage medium, consider how quickly you or authorized members of the public may need to access your records. You may find that some types of records require fast access, while others do not. For example, you may need fast access to key policy decisions, but not to employee records.
- *Capacity*. The volume of records that you can store on the medium will be a key consideration. Examine the volume of the records you now store and try to determine what your needs may be in the future. Consider the official definition of a record and whether that definition will affect the records volume that you need to manage. For example, you may anticipate greater use of e-mail and the expansion of your web site, which would affect future capacity.
- *Longevity*. Research how long the industry will support various media options and compare those figures with the time period prescribed by the approved records retention schedule. You may find a medium that meets all your needs but is not widely used or has a high risk of becoming obsolete, thereby limiting its usefulness.
- *Durability*. Research how easily a given medium can be damaged or will deteriorate. You may find that a medium that deteriorates after three years will still be a suitable option for records that need to be retained for only one year. Be sure to review your records retention periods.
- *Versatility*. If your records contain multiple file formats (as described in the *File Formats* guideline), research how many file formats a medium can store.
- *Cost*. Assess the costs and benefits of each medium you consider. Be sure to discuss the costs of converting and/or migrating records, as well as the basic costs of the system.
- *Compatibility*. Assess the backward and forward compatibility of the digital media you are considering. For example, DVD-ROM drives are backward-compatible for CD-ROMs, but a CD-ROM drive is not forward-compatible for DVD-ROMs. This discussion will help you to determine how often you may need to upgrade supporting computer systems, migrate records, and/or convert records.
- *Portability*. Some media, such as USB drives, are very portable, while hard disks in a computer processor are not. Consider whether you will need special devices to read the records. Consider who will be accessing your records. For example, will the public, the press, or other agencies frequently access your records?

Legal Framework

For more information on the legal framework you must consider when selecting digital storage media, refer to the *Records Management in an Electronic Environment* guideline in the Electronic Records Management Guidelines and Appendix A6 of the *Trustworthy Information Systems Handbook guideline*. Also review the requirements of the:

- South Carolina Public Records Act [PRA] (*Code of Laws of South Carolina, 1976*, Section 30-110 through 30-1-140, as amended) available at https://www.scstatehouse.gov/code/title30.php which supports government accountability by mandating the use of retention schedules to manage records of South Carolina public entities. This law governs the management of all records created by agencies or entities supported in whole or in part by public funds in South Carolina. Section 30-1-70 establishes your responsibility to protect the records you create and to make them available for easy use. The act does not discriminate between media types. Therefore, records created or formatted electronically are covered under the act.
- South Carolina Uniform Electronic Transactions Act [UETA] (*Code of Laws of South Carolina, 1976*, Section 26-6-10 through 26-6-210). Enacted in 2004, UETA facilitates electronic commerce and electronic government services by legally placing electronic records and signatures on equal footing with their paper counterparts. UETA officially repeals the 1998 South Carolina Electronic Commerce Act (*Code of Laws of South Carolina, 1976*, Section 26-5-310 through 26-5370). The purpose of UETA is to establish policy relating to the use of electronic communications and records in contractual transactions. This law does not require the use of electronic records and signatures but allows for them where agreed upon by all involved parties. While technology neutral, the law stipulates that all such records and signatures must remain trustworthy and accessible for later reference as required by law. Similarly, the federal Electronic Signatures in Global and National Commerce (E-Sign) Act [U.S. Public Law 106-229] encourages the use of electronic documents and signatures, although it goes further to provide some guidelines regarding standards and formats. For more information on UETA see Appendices A6 and A7 of the *Trustworthy Information Systems Handbook*.
- Health Insurance Portability & Accountability Act of 1996 [HIPAA] (Public Law 104-191), which establishes security and privacy standards for health information. The Act protects the confidentiality and integrity of "individually identifiable health information," past, present or future. Visit the HIPAA website at www.hhs.gov/ocr/hipaa/ for additional information.

Annotated List of Resources

Primary Resources

Byers, Fred R. *Information Technology: Care and Handling for the Preservation of CDs and DVDs — A Guide for Librarians and Archivists*. NIST Special Publication 500-252. Gaithersburg, MD: National Institute of Standards and Technology; Washington, D.C.: Council on Library and Information Resources. October 2003. www.itl.nist.gov

This guide discusses the physical characteristics of various optical media, as well as methods for their proper care and handling to ensure longest possible use in any given environment. A useful glossary is included.

Dollar, C. M. *Authentic Electronic Records: Strategies for Long-Term Access.* Chicago: Cohasset Associates, Inc., 2002.
This book provides a comprehensive overview of electronic records management, with chapters on key concepts, long-term access, best practices, and developing an action plan. The book also includes a comprehensive bibliography, as well as useful appendixes covering such topics as technology for records management, electronic records preservation costs, conversion standards, media life expectancies, and a preservation metadata model.

Lantz, Mark. "Why the Future of Data Storage is (Still) Magnetic Tape" in *IEEE Spectrum*, September 2018. https://spectrum.ieee.org/computing/hardware/why-the-future-of-data-storage-is-still-magnetic-tape
This article describes the advancements in magnetic tape. Despite magnetic tape having largely disappeared from consumer products, the article outlines the currents uses of magnetic tape in large-scale digital storage, usually as a back-up medium, by companies including Google and Microsoft.

The PC Technology Guide www.pctechguide.com
This site is a comprehensive resource on all aspects of the personal computer. Topics include hardware, software, computer use, and digital media.

Saffady, W. *Managing Electronic Records*. 2nd ed. Prairie Village, Kan.: ARMA International, 1998.
This book provides a thorough discussion of the basic principles of electronic records management. Chapters include concepts and issues, electronic storage media and formats, file formats, the inventory of electronic records, retention schedules, managing vital electronic records, and managing files and media. The book also includes a comprehensive glossary and bibliography.

Webopedia http://webopedia.internet.com
This comprehensive online encyclopedia for the information technology community provides an easy-to-understand, searchable database of terms.

Whatis? Techtarget
http://whatis.techtarget.com
A comprehensive online encyclopedia for the information technology community.

Additional Resources

Brown, A., 2008. Selecting storage media for long-term preservation. *TNA Digital Preservation Guidance Note 2: August 2008*. Available: https://www.nationalarchives.gov.uk/documents/selecting-storage-media.pdf
This guide defines each of the criteria that need to be considered when choosing a digital media storage option. The guide also provides a 'scorecard' for each of the most common digital media options in relation to each of the criteria discussed.

International Council on Archives. *Guide for Managing Electronic Records from an Archival Perspective*. France: International Council on Archives, 2011. www.ica.org
This handbook provides a comprehensive overview of electronic records management from an archival perspective. The handbook provides useful information on key concepts,

such as life-cycle management, legal issues, technological issues, and implementation.

COOL (Conservation OnLine): Electronic Storage Media
https://cool.culturalheritage.org/bytopic/electronic-records/electronic-storage-media/
These pages are part of the Conservation OnLine, Resources for Conservation Professionals web site at Stanford University. This web page is a collection of materials from other sources about electronic conservation, including resources on disaster recovery, electronic media, electronic formats, and storage environments.

Cornell University. *"Digital Preservation Management: Selecting Short Term Strategies For Long Term Problems"*
https://dpworkshop.org/dpm-eng/index.html
An online tutorial available from Cornell University Library. The tutorial provides basic information including terms and concepts related to digital preservation. Includes images and descriptions of obsolete media and media that is in danger of becoming obsolete in a section entitled "Chamber of Horrors."

Digital Preservation Coalition. "Legacy Media" in *Digital Preservation Handbook,* 2nd ed. 2015.
https://www.dpconline.org/handbook/organisational-activities/legacy-media
This handbook offers guidance on the preservation of digitized and born-digital materials. The "Legacy Media" section in the handbook offers guidance on the various ways to store electronic records using external media. Adequate storage of electronic records is crucial to preserve access to the records after their creation or digitization.

South Carolina Department of Archives and History, State Archives Department. *Trustworthy Information Systems Handbook*. Version 2, March 2007.
http://arm.scdah.sc.gov/erp/tishandbook.html
This handbook provides an overview for all stakeholders involved in government electronic records management. Topics center around ensuring accountability to elected officials and citizens by developing systems that create reliable and authentic information and records. The handbook outlines the characteristics that define trustworthy information, offers a methodology for ensuring trustworthiness, and provides a series of worksheets and tools for evaluating and refining system design and documentation.