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The Wild West No More: Preserving 40 Years of Electronic Records at the University of Wyoming American Heritage Center

Cover Page Footnote

Special thanks to Mark Greene and Irlanda Jacinto, and to Tim Walsh, without whom this project could not have been completed.

THE WILD WEST NO MORE: PRESERVING FORTY YEARS OF ELECTRONIC RECORDS AT THE UNIVERSITY OF WYOMING AMERICAN HERITAGE CENTER

Introduction.

The American Heritage Center (AHC) at the University of Wyoming is a large manuscripts repository, rare books library, and university archives. The archives holds over 75,000 linear feet of records and employs ten faculty archivists and eleven archival and support staff. Founded in 1945, the AHC has evolved into a nationally recognized repository, winning the Society of American Archivists' Distinguished Service Award in 2010 and maintaining collections of local, national, and international significance. The AHC's mission statement is to "preserve a clearly defined set of primary sources and rare books . . . and to make those sources available to all."¹ The AHC serves a large number of patrons each year, with many collections made available to researchers within one half hour of their request. This is due in large part to the AHC's policy of providing access to any unrestricted collection material irrespective of its state of arrangement or description.

These accomplishments are thanks to the dedicated staff and faculty of the AHC, as well as its director emeritus Mark Greene. However, the AHC has only slowly embraced the need for digital archival practice. Before 2009, the university archivist was in charge of digitization and born-digital records. In 2009, the AHC hired its first dedicated digital archivist, who developed procedures for born-digital ingest and preservation—but the archivist left the AHC in 2012. A fourteen-month gap followed before I was hired as the AHC's second full-time digital archivist.

In 2013 when I was hired as the AHC's digital archivist and manager of digital programs, I was not fully aware of the state of the center's born-digital records. Over the course of a year, I set about reviewing the procedures in place for born-digital ingest and preservation, and I discovered that there were several gaps that needed to be addressed. The most pressing of these was the lack of documentation regarding the extent of the AHC's records on physical computer media. Subsequently, I decided that the AHC needed to fully assess the extent of these records, namely where they were, what types of media were present, and what files they contained. The result of that effort directly led to the creation of this project to ingest all born-digital records onto the AHC's secure born-digital archive, a redundant networked space managed by the University Information Technology Department, with a separate offline copy on a network attached storage drive.

This project was conceived to preserve and, most importantly, make accessible the AHC's significant backlog of uningested born-digital collection material. This was to be done in comportment with the AHC's mission of making electronic resources "available to all." The project would ultimately succeed in this goal, ingesting the majority of electronic records for preservation and access.

Planning the born-digital backlog ingest project.

¹ American Heritage Center, University of Wyoming, "Mission and Vision Statement."

It took almost a full year, from late July 2013 to June 2014, to thoroughly assess the known quantities of uningested born-digital material on analog media. The term “ingest,” for the purposes of this article, expands on the definition in the Society of American Archivists’ *Glossary of Archival and Records Terminology*. It means not simply the prepared storage of disks in a collection but rather the storage of the disks’ digitally created content in a managed, networked, secure, and redundant digital storage environment.²

A previous digital archivist at the AHC has described the “disk-in-a-box problem.”³ In essence, the AHC had never taken the step of conducting an inventory of any of the digital content on computer media within collections, sometimes never even listing the descriptions on disk labels. This problem had not improved in the intervening years since that article’s publication in 2011. In point of fact, many disks were not listed at all on content lists. Thus, in the summer of 2014, I undertook a project to eliminate the backlog of born-digital records on physical media that had accumulated at the AHC over the past forty-plus years.

I began my search for the uningested born-digital records with documentation left by my predecessor. This list included entries from a previous collections management database stored in Microsoft Access, colloquially referred to as GRACE. This list contained, at least as of 2011, the “known knowns,” to quote Donald Rumsfeld.⁴ With approximately one hundred entries, it included information on some collections where the born-digital material had, in fact, been ingested.

I then searched several other locations for information on how to identify the large quantity of uningested born-digital records. The first search conducted was through the AHC’s current internal collections management database, running in Cuadra Star Knowledge Center for Archives (SKCA). SKCA includes fields for media type as well as a text search function. The database was migrated from the in-house Microsoft Access database GRACE in 2012, therefore SKCA contained legacy data in fields that were not specifically designed to be sorted. It also contained redundant data from my predecessor’s list. In contrast to GRACE, the fields in SKCA were searchable. Armed with a list of terms, I proceeded to search successive fields in SKCA with these terms, which included CD, born-digital, DVD, ROM, RAM, disc, disk, floppy, drive, HDD, digital, computer, and media (fig. 1). My searches were successful and returned 147 results.

Next, I searched the AHC’s online finding aids using the same terms. The AHC stores machine-readable cataloging (MARC) records in the Online Computer Library Center (OCLC) and the university’s online public-access catalog. Its encoded archival description (EAD) finding aids are stored in the Rocky Mountain Online Archive’s online catalog.⁵ These two locations returned twenty-seven results. Once the results were compiled and duplicates from the same collections were consolidated, the complete list of collections with uningested physical media included 195 entries. For point of reference, the AHC has a total of 3,383 collections with catalog records and EAD finding aids.

² Pearce-Moses, *A Glossary of Archival and Records Terminology*, 207.

³ Goldman, “Bridging The Gap.”

⁴ Rumsfeld, *Known and Unknown*, xii.

⁵ University of New Mexico, “Rocky Mountain Online Archive.”

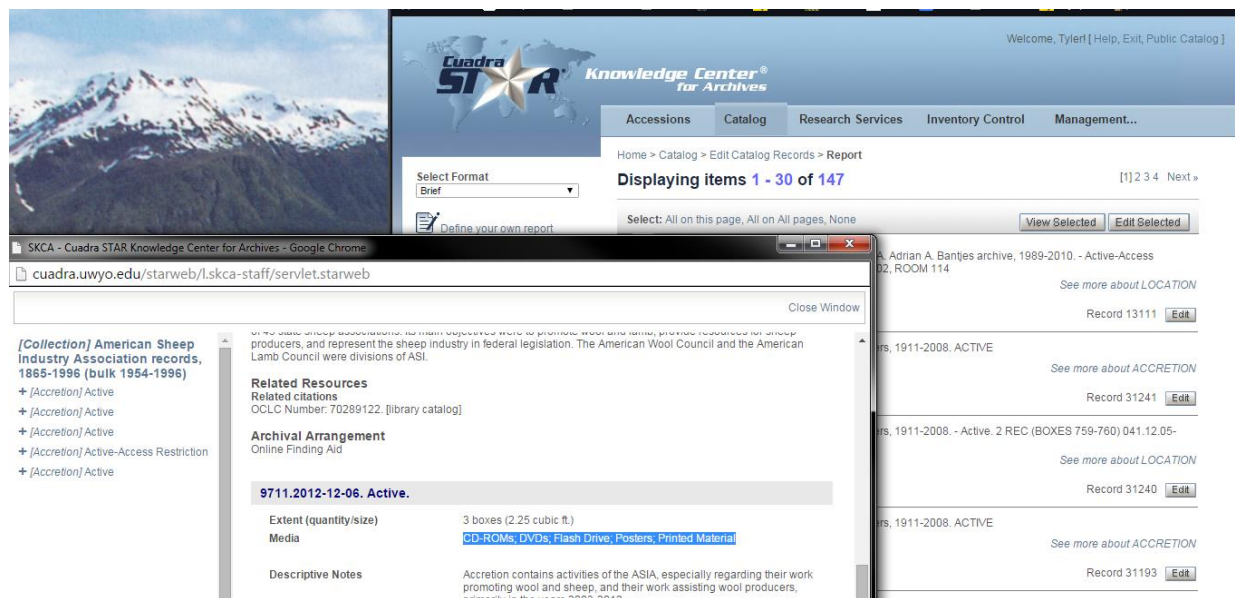


Figure 1. Example of a record in SKCA with nonuniform terms for digital media listed in a note field.

This list of 195 entries contained both the “known knows” as well as a significant amount of “known unknowns,” that is, the list indicated whether the content type was recorded as computer media, disk, or CD-ROM, but no other information was specified (fig. 2).

Accession	Accretion	Collection	Format
1656	1656.2010-07-21	Rogers, William C.	Computer Media; Manuscript Material/Papers/Records; Photographic Material; Printed Material
2373	2373.2001.03.13	Gurney, Gene	CD
3211	3211.2010-03-11	Wynn, Robert H.	Computer Media; Manuscript Material/Papers/Records; Photographic Material; Printed Material; Video Tape
3211	3211.2010-07-28	Wynn, Robert H.	Fine Art; Computer Media; Manuscript Material/Papers/Records; Printed Material; Video Tape
3586	3586.2012-05-29	Sullivan, Eugene J., 1872-1956	Computer Media; Manuscript Material/Papers/Records
3711	00-05-25	Clinton, Larry	CD-rom

Figure 2. Selection of the compiled spreadsheet listing the collections and accretions with digital media.

During the search stage, I had no idea whether an entry on the list contained one CD-ROM, five CD-ROMs, or fifty floppy disks. As it would come to pass, the latter turned out to be more true than not. Naturally, what this list did not contain were the “unknown unknowns,” media in the collections with no hint of documentation whatsoever. At the time of this writing, three

collections containing roughly a dozen disks and CDs have been found through normal collection use.

With the thoroughly checked but almost certainly incomplete list of uningested born-digital material compiled, I began developing a course of action for the backlog ingest project. The majority of the ingest legwork would be accomplished by an intern, Timothy Walsh, who was then a graduate student in library and information science at Simmons College, Boston. Tim would use the survey list I had compiled to physically pull the collection boxes and assess whether the AHC's databases had correctly listed the presence and quantity of physical media. If there was media in the locations noted, the intern would assess the condition of the media and determine if it was readable using modern computers. If the media was readable, Tim would ingest it according to procedures and then separate the media into new folders. I would then pass the new folders to the AHC's accessioning department along with the paperwork, in order to list the ingested born-digital files on the network as the primary record location. The actual physical media would then be stored in a separate location from the rest of any physical media purely as a last-stage backup—not to be accessed during routine retrieval of collections for patrons.

Once I had described this project to the AHC director, he provided funds for a stipend to support the travel and housing for Tim during his twelve-week stay in Laramie, Wyoming. The project required Tim to be trained in the AHC's collection management policies and in retrieving collections in the SKCA system, including physically pulling boxes from the stacks. This proceeded quickly. Next I brought Tim up to speed on the AHC's digital collections management procedures, including how and where the multiple copies of born-digital collections were stored on the university's servers, how to document ingest and preservation activities, and what further metadata would need to be created. Fortunately, Tim proved not only to be well versed in handling physical collections but also in Linux and Windows operating systems. He was a quick study and efficient in accessioning digital materials.

The OAIS (Open Archival Information System) reference model is an accepted archival standard for electronic records. The model describes the submission information package (SIP) as content and descriptive information sent by an information producer (i.e., a donor) to an OAIS (i.e., an archive).⁶ The model calls for a submission agreement between the donor and the archive, specifying what content information, file types, packaging information, and preservation descriptive information are to be received in the SIP.⁷ As of 2014, the American Heritage Center had not implemented this model for the acquisition of collections with born-digital content, beyond the customary appraisal and deeds of gift used for physical records.⁸ This meant, in practical terms, that hundreds of collections had born-digital content with no metadata whatsoever. The AHC neither has plans to adopt the full OAIS reference model nor has plans to become a Trustworthy Digital Repository through the audit and certification process.⁹ However, the ingest project highlighted gaps in the appraisal and acquisitions process. I address the lessons learned from this at the conclusion of this paper.

⁶ Consultative Committee for Space Data Systems, *Reference Model for an Open Archival Information System*, 33.

⁷ *Ibid.*, 36.

⁸ American Heritage Center, University of Wyoming, "Collections Management Policy."

⁹ *Trustworthy Repositories Audit*.

The born-digital ingest project used free and open source tools to ensure authentic copies from physical media were ingested. The first and foremost program used was the Duke Data Accessioner (version 0.3.1 at the time of the project). The Data Accessioner was utilized to migrate data from physical media to the server, ensuring authenticity while also creating technical and preservation metadata.¹⁰ FTK Imager, the free component of Forensic Toolkit, was used to create disk images for preservation, utilizing the .eo1 Encase Expert Witness forensic disk image format.¹¹ An MD5 file hash generating and checking tool, MD5 Checker, was also used to independently create checksums for sets of files.¹² Two other tools were used for problematic media: HFS Explorer and the FC5025 hardware/software suite. HFS Explorer, a free utility, was used to access Macintosh-formatted hierarchical file system (HFS) disks. However, as I explain below, utilizing this method proved problematic.¹³ The FC5025 floppy disk controller and its software were used to access some 5.25” disks.¹⁴ This process followed the guidelines laid out by Ricky Erway and Julianna Barrera-Gomez in the “Demystifying Born-Digital” series of articles by OCLC.¹⁵

For the backlog ingest, a computer running Windows 7 SP1 with the latest security updates and Microsoft Forefront antivirus was utilized. A Tableau UltraBlock USB write blocker was purchased, for write-protecting hard disk drives and USB flash drives.¹⁶ For floppy disks the write-protect tables were enabled. The PC had a CD/DVD reader but no disk-burning functionality, ensuring that optical disks could not be accidentally overwritten. A USB Zip 100 drive was not compatible with the Tableau write blocker but had native file system support in Windows 7 with pass-through support in BitCurator. Over two dozen Zip disks would be encountered throughout the project in a variety of collections.

The survey of uningested media found that roughly fifty collections had CD, disk, or CD-R media identified by type. Roughly twenty had 5.25” or 3.5” floppy disks identified by type, while the rest were listed either as “computer media” or nothing. Beginning the project by collection number, Tim encountered two CD-Rs and one collection of commercial CDs containing no born-digital content. I made the decision that any commercial or widely published material stored on digital media would not be accessioned as part of the backlog project. Tim went on to separate several further occurrences of commercial and published digital media, using visual identification of signifiers such as barcodes. Tim also searched OCLC to see if other

¹⁰ David M. Rubenstein Library, Duke University, “Data Accessioner.”

¹¹ Access Data, “FTK Imager Version 3.4.2.”

¹² “MD5 Checker.” MD5, or message digest format, is a type of code generated via algorithm that produces, for lack of a better description, a file’s “signature.” This signature is referred to as a checksum. The MD5 algorithm creates a string of thirty-two characters, which when checked against an archival copy of a file, is a quick way to assess if any information in that file has been modified. While this is not a 100-percent secure method of validating a file, it is a simple way for archivists to check files for authenticity at a glance.

¹³ Catacombae, “HFS Explorer.” HFS Explorer is advertised as capable of reading HFS, HFS+, and HFSX file systems, though in practice it seems incapable of reading HFS formatted disks created between 1985 and 1998.

¹⁴ Device Side Data, “FC5025 USB 5.25” Floppy Controller.” The FC5025 is a small controller board that plugs into a modern computer using USB. It then connects via a floppy disk controller ribbon to a 5.25” disk drive, allowing 5.25” disks to be accessed by a proprietary program developed by Device Side Data. This program only allows a certain list of file systems to be read, however, and the file system must be selected before the program will generate a disk image.

¹⁵ Barrera-Gomez and Erway, *Walk This Way*.

¹⁶ Digital Intelligence, “Ultrablock USB Write Blocker.”

heritage institutions held copies. The occurrence of commercial digital media identified and encoded as “computer media” or born-digital records was prevalent throughout the project, so much so that it resulted in a restructuring of how physical computer storage media is appraised by the accessioning department.

When the backlog project began, the clean PC had the hardware to read CD, DVD, 3.5” floppy disk, 5.25” floppy disk, Zip 100 disk, and USB devices. We quickly ran into a few interesting challenges. The first and most consistently problematic media type was the 5.25” floppy disk. Using a FC5025 floppy disk controller, the intern was able to read a predetermined number of disk file systems, which included Apple DOS, ProDOS, MS-DOS, and Amiga (fig. 3).¹⁷

5.25” floppy disks

- Recommended practice for 5.25” floppy disks at the moment is to create an accurate disk image that can be saved on the shared network drive. Do not worry about extracting files from the disk. This can be done later using emulators or original hardware so long as we have an accurate disk image.
- The FC5025 and its bundled software will allow you to create a disk image so long as a disk is one of the following types:
 - Apple DOS 3.2 (13-sector)
 - Apple DOS 3.3 (16-sector)
 - Apple ProDOS
 - Atari 810
 - Calcomp Vistagraphics 4500
 - Commodore 1541
 - Kaypro 2 CP/M 2.2
 - Kaypro 4 CP/M 2.2
 - MS-DOS
 - Motorola VersaDOS
 - North Star MDS-A-D
 - PMC MicroMate
 - Tandy Color Computer Disk BASIC
 - TI-99/4A
- If you are unsure which type a 5.25” disk is, you can try using the file system browse capability to test. Be aware that this capability only exists for ProDOS, MS-DOS, Kaypro, PMC MicroMate, Disk BASIC, and VersaDOS disks.
- If the disk is not one of the types the FC5025 is able to image, or the disk type is unknown, the Kryoflux can be used to create a bitstream disk image.

Figure 3. Guide to ingesting 5.25” floppy disks.

This file system selection is driven by a pull-down menu and requires an archivist to know beforehand (or guess) as to which file system the disk was formatted with. A wrong guess would return an error message; a correct guess returned a disk image file. After the fourth or fifth time of exhausting the list of pull-down options, the intern and I determined that a number of 5.25” floppies were formatted with an older or more obscure file system, and would have to be imaged using a Kryoflux disk controller, which would arrive after the project was finished.

¹⁷ “Requirements,” in Device Side Data, “FC5025 USB 5.25” Floppy Controller.”

The second most problematic occurrence during this project was the prevalence of Apple- or Macintosh-formatted media. The AHC exclusively uses Microsoft Windows computers, with the exception of one 2009 Mac Pro. This Macintosh tower is used to interface with an out-of-production negative and transparency scanner but proved useful in the backlog project as a tool of last resort. For the first few Macintosh-formatted pieces of media encountered, Tim was able to read the several floppy disks and hard disk drives successfully. However, problems arose in two cases. In the first case, 3.5” floppy disks that were formatted in Apple ProDos or Macintosh File System format could not be read by a conventional USB floppy drive. The older, low-density floppy disks use a variable rotational speed that both modern Macs and PCs cannot read.¹⁸ These disks could only be imaged after the conclusion of the project, using the KryoFlux. In the second case, high-density Macintosh floppy disks formatted in HFS, which was in use from 1985 to 1998, could not be properly read with HFS Explorer for Windows. The solution was to attach the external USB floppy drive to the 2009 Mac Pro tower, running MacOS 10.5. From that computer we succeeded in creating disk images, and transferred them to networked storage for subsequent metadata creation and ingest into the dark archive.

Generally speaking, audio CDs proved to be a problematic format, at least initially. Although the scope of the project did not include ingesting commercial audio disks, one composer’s collection included a significant number of recording session master CDs. Similar to the problem encountered with Macintosh-formatted media, audio CDs are not natively supported in the Windows file system.¹⁹ Apple computers have been able to natively display tracks on audio CDs within the file system since the release of MacOS 10.0 in early 2001. In contrast, Windows computers, rather than displaying a list of AIFF or WAV files for copying, must instead rely on third-party software to obtain digital audio tracks in a desktop-friendly file format.

Findings.

The project ended after twelve weeks having successfully ingested 346 pieces of media from 75 collections. It should be noted here that the disparity between the total number of disks and other media ingested with respect to the original survey result of 195 possible entries is significant. Not only were over thirty entries on the original list not computer media (rather, they were commercial CDs, DVDs, and other published material), but many entries listing only one or two disks had a dozen or more disks in the collection. This disparity in quantity of digital media can be attributed to the procedures in place by survey and acquisitions archivists whereby quantities of any individual medium were not listed discretely or in total. The varied formats of computer media were simply not taken into consideration at the time of accessioning. Accessioning staff and assistants compounded this problem as well, though only through a lack of knowledge of computer media and by no fault of their own. While these errors in listed quantities of computer media resulted in the backlog project finding a surprisingly large amount of previously unidentified born-digital collection material, they also resulted in better policies moving forward. In years previous, the AHC reorganized how collection materials were accessioned into active storage. The head of the Accessioning Department employed several students in a work-study program, who after thoroughly reviewing the accessioning handbook—a manual of policies and procedures—listed the contents of each box and re-boxed material as needed. For digital media,

¹⁸ Hertzfeld, “Quick, Hide in This Closet!”

¹⁹ While CD ripping is a component of Windows Media Player, this is optional software.

as I describe above, these were listed in our collections database haphazardly. The backlog project has allowed us to put into place new procedures for students working part-time as content listers, which include not only identifying the media types but also utilizing a non-networked computer to create directory snapshots (fig. 4).

Partition	Filename	Extension	Filesize	File format	Change time	Access time
1	_WRD1841.tmp	tmp	21504	Composite Docu	None	2002-07-04T04:0
1	_WRD1720.tmp	tmp	22528	Composite Docu	None	2002-01-31T05:0
1	Spanish Chicken.	doc	22528	Composite Docu	None	2002-01-31T05:0
1	Salad chicken.do	doc	19456	Composite Docu	None	2002-01-31T05:0

Figure 4. Directory snapshot generated by FTK Imager.

From the original list of 195 entries, 12 collections appeared to contain no digital media whatsoever. Two of these collections had an extent of over one hundred linear feet, and therefore searching all collection material at the time of the project was unfeasible. Sixteen collections contained a total of fifty-eight 3.5” and 5.25” floppy disks that were unreadable using the clean computer with a USB 3.5” or FC5025 5.25” drive.

The number of disks that were unreadable using existing technology was not surprising. The over forty years of uningested digital media stretched the backward compatibility of modern operating systems and forensic software. Using USB 3.5” floppy drives, the FC5025 5.25” floppy drive, and HFS Explorer was largely effective at reading older computer media. However, the addition of the KryoFlux disk imaging hardware and software has expanded the capacity for ingest of the fifty-eight formerly unreadable disks. It also provides options for reading future acquisitions on media over fourteen years old, as well as for maintaining more obscure disk file systems.²⁰

The percentage of individual files that could be copied off of physical media varied depending on the age and structure of the media. Using Windows Explorer and the Duke Data Accessioner yielded fewer results than using FTK Imager to image and subsequently mount disks. As a consequence, this resulted in a new policy of using FTK Imager as a first-line ingest tool to create forensic images for ingest and extraction. The image file, along with machine-readable files on the disk, were ingested together, with metadata and checksums created for both. In addition, the BitCurator Tools (version 1.5.1 at the time of writing) were used to extract reports on file types and data, and to generate PDF reports of the same.²¹

Utilizing BitCurator during the project evolved from a small need into a larger part of born-digital ingest procedures. For Zip 100 disks, the software write-blocking in BitCurator prevented

²⁰ Software Preservation Society, “KryoFlux Supported Formats.”

²¹ BitCurator, “Generating DFXML Output.”

any unintentional modification of files on the disk during imaging.²² The BitCurator software suite, built in Ubuntu Linux and containing a myriad of free and open-source tools, proved to be an essential component of born-digital ingest and preservation. In addition to software write-blocking, BitCurator contained HFS Explorer; Guymager, a forensic disk imaging utility; ClamAV, an antivirus program; and the BitCurator reporting tools. The reporting tools suite included FiWalk, which allowed us to generate data visualization of the content of disk images (fig. 5). This provided us with useful metadata that can be passed along to patrons during their research.

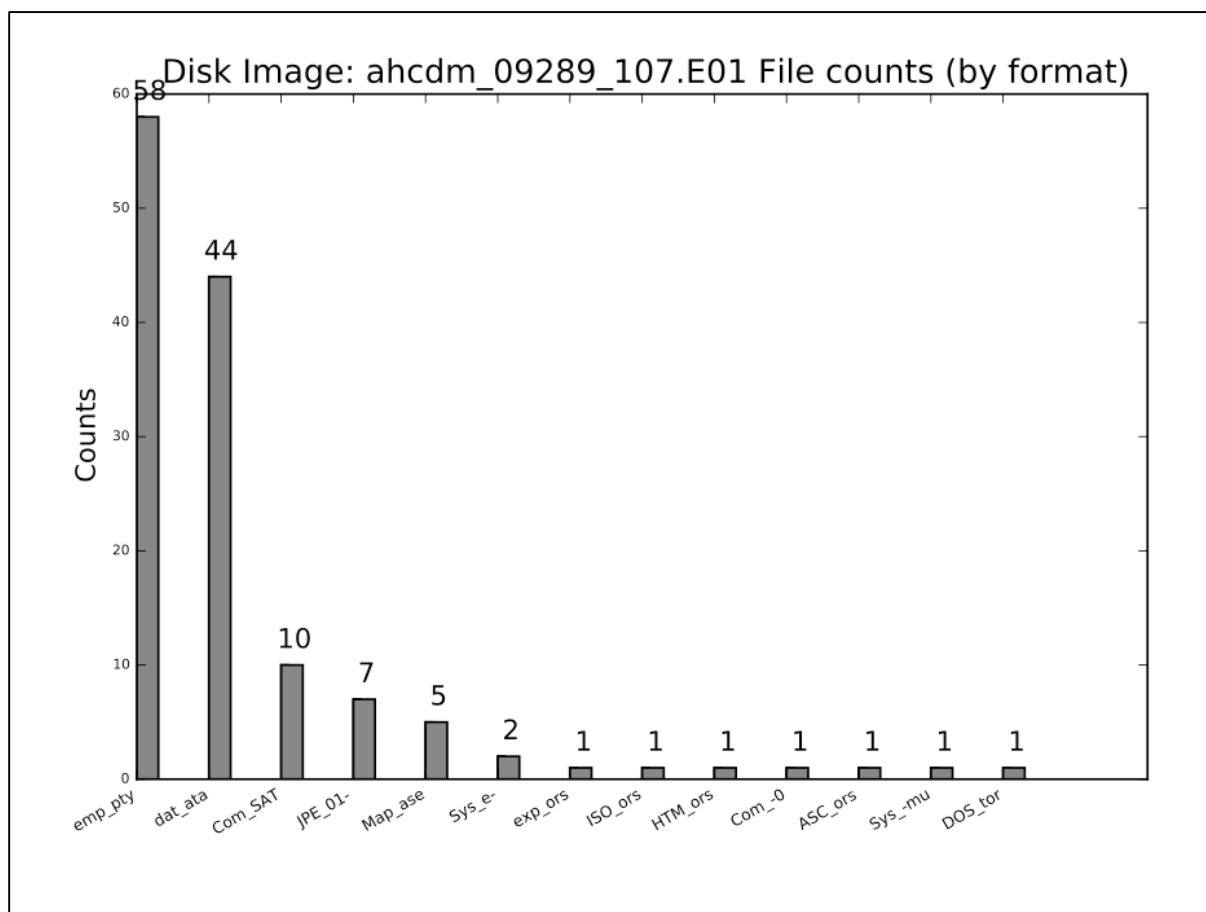


Figure 5. PDF output from the BitCurator reporting tools. (The columns list quantities of file types, both unidentified [at the left] and identified. Two formats easily recognizable include JPEG images and HTML files.)

Before the project began, the AHC had 225 gigabytes of collection material in storage, not counting redundant copies. After the project was completed, the extent of born-digital collection material exceeded 4.4 terabytes—an expansion of 2,000 percent. Since August 2014, using the methods outlined here, we have added almost 500 additional gigabytes of collection material, including redundant copies, metadata, and checksums. The number of collections blossomed from 45 in August 2013 to 120 by August 2014.

²² “Software Produced by the BitCurator Team,” in BitCurator, “Software.”

During the course of the project, the American Heritage Center’s born-digital committee discussed and implemented new procedures for accessioning. The committee was chaired by me and was composed of the university archivist and representatives from the AHC’s accessioning, processing, and reference departments. The committee was charged with working “toward a consistent and comprehensive approach to managing born-digital materials at the AHC.”²³ The committee was able to take the results of this project and solidify the procedures for ingest of born-digital material for future acquisitions (fig. 6).

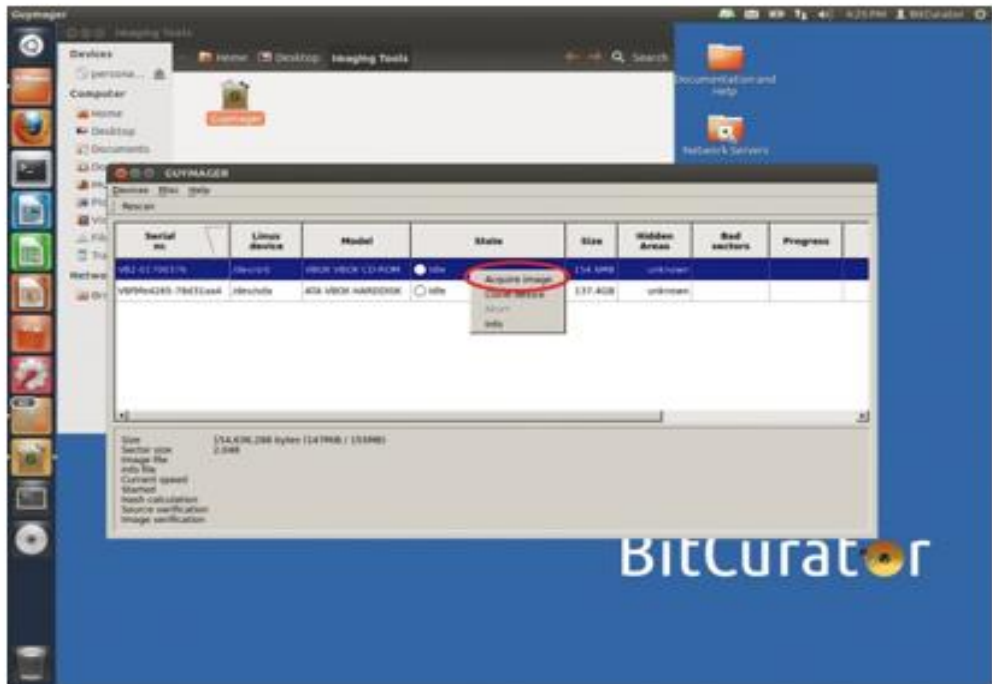
Ingesting born-digital material from physical media in Bitcurator

Bitcurator (a customized install of Ubuntu 12.04) can be installed as an OS directly on the machine or in a virtual machine. If you are using a virtual machine, as this guide assumes to be the case, be sure to allocate it at least 8GB of RAM and 20GB of hard drive space (dynamic allocation is suggested). For additional configuration requirements/suggestions, follow the most current recommended practices from the Bitcurator team (<http://www.bitcurator.net/#>).

Presently, Bitcurator is used to image and extract contents from hard drives, disks formatted with the HFS file system, DVDs that won't successfully image with FTK Imager (see below), and other special cases. In the future it may be a good idea to switch to Bitcurator entirely, especially as more features continue to be added.

- Create a shared folder that can be accessed from the desktops of both the guest and host machines.
- Use Guymager (located in the “Imaging Tools” folder on the desktop) to create a raw disk image of the media:

Guymager



Serial No	Linux Device	Model	State	Size	Hidden Areas	Bad sectors	Progress
WEL-ET-700376	/dev/sdb	WDC WD3200BB-70AEC	Write	314.5MB	unknown		
VXPWk285 78411044	/dev/sda	ATA WDC WARD2000	Write	137.4GB	unknown		

Figure 6. Page from the guide to ingest of born-digital media.

²³ Greene, “Committee Charges.”

Conclusion.

This project was successful in significantly reducing the backlog of uningested born-digital media. Seventy-five collections had their born-digital media ingested, and almost 350 new digital accretions were created. This provided redundancy, security, and ultimately availability of digital records long forgotten and ignored. The project paved the way for file format migration and ultimately access through computers at the AHC's reading room. Through the project's several stages, which included: documentation of the ingest process, tying digital records to their physical counterpart accretions, creating metadata with the Duke Data Accessioner and BitCurator, and creating MD5 checksums, the digital records that had languished in boxes for upward of forty years were made more stable and accessible. In so doing, the project fulfilled two core tenants of the American Heritage Center's mission to preserve primary source records and make them available to all.

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