This version of the document does **not** contain any listing of contents or extracted files from any of the disks in the collection. It is solely a report on activities performed and a discussion of the tools Warhol may have had at his disposal.

Summary

This report presents details of the work completed by members of the Carnegie Mellon Computer Club working in cooperation with Cory Archangel at the Andy Warhol Museum in Pittsburgh, PA in March-April and August 2013, with further support from the Frank-Ratchye STUDIO for Creative Inquiry at CMU. Archival disk images of the roughly 40 Amiga floppy disks found in the collections were made and then studied for valuable historical content such as original artwork or glimpses into the workflow of early computer art. In the process, 10 disks were found to contain a total of at least 13 graphics files apparently created or modified by Warhol, as well as several copies of pre-release or unreleased software that may also be of great historical interest. For the most part, the disks were in excellent condition allowing easy data retrieval, however several were found to be corrupted, allowing access to only partial versions of some files. Raw low-level disk images and physical low-level copies of the disks found to be corrupted were made and may provide a starting point for future study if warranted.

Historical Context

In 1985, Commodore International (makers of the once-famous Commodore 64 home computer) released the first model of the Amiga—the Amiga 1000—as a move into more serious business and productivity computing. To show off the multimedia capabilities of the machine, Commodore hired Andy Warhol to appear at the launch and produce several artworks using the Amiga. Warhol's presence was intended to convey the message that this was a highly sophisticated yet accessible machine that acted as a tool for creativity. He was provided with various pieces of pre-release hardware and software, eventually exploring digital photography, video capturing, animation editing, and audio composition. All of this had been done to limited extents earlier, but Warhol was an incredibly early adopter in this arena and may be the first major artist to explore many of these mediums of computer art. He almost certainly was the earliest (if not the only, given several pre-release statuses) possessor of some of this hardware and software and, given their steep later sale prices, possibly the only person to have such a collection. According to the contract with Commodore located by the museum in March 2012, Warhol was to own the rights to all such work created and any hardware provided, so these works and the machines themselves have, except for sporadic "rediscoveries" of small components, remained hidden and unpublished within Warhol archives.

Related Efforts

Several rediscoveries of Warhol-created works on Amiga floppy disks in individual or museum archives are known.

The first such instance is a short multimedia opera entitled “you are the one” consisting of 20 images of Marilyn Monroe that could be assembled into an animation accompanied by a soundtrack. These were discovered on several floppy disks in 2001 by parties unknown and “restored” in 2006 by the Detroit Museum of New Art. The opera received a single day screening before its seizure by the estate.
Reference: http://www.artdaily.com/section/news/index.asp?int_sec=2&int_new=18091 (press-release version of article on MONA website: http://www.detroitmona.com/Jef_Bourgeau/still_famous.htm)

The second known instance was the rediscovery by Don Greenbaum, the CFO of Commodore who worked directly with Warhol at the 1985 launch, of several disks in his possession around 2011. According to the referenced article, nine works (“campbells,” “banana2,” “andy7,” “cycle2,” “flowers,” “andys,” “bigflower,” “money,” and “cycle1”) were produced and hand-delivered by Don himself for the launch event. This discovery and referenced article is of particular relevance as it mentions pre-release Kickstart ROMs and Graphicraft software also used in this effort, which has unearthed versions of some but apparently not all of these files. Pending his ongoing determination as to the ownership of the works (now known to be Warhol), Don has not published any of these files.
Reference: http://www.academia.edu/1467355/Nine_Warhols_Waiting_

Narrative

In December 2011, Cory Arcangel approached the Warhol Museum regarding Amiga hardware in the museum’s possession with the idea of restoring it for exhibition and cataloging any files on associated disks. In April 2012, Golan Levin, director of the STUDIO for Creative Inquiry at CMU, connected Cory with the CMU Computer Club, which had gained some renown for its retrocomputing expertise.

An initial planning meeting at the museum was held in October of that year to introduce the parties, demonstrate the disk archiving hardware to be used, and see Warhol’s Amiga collection for the first time. Here it was seen that the museum’s collection included two Amiga 1000 computers in pristine condition (one apparently never used), incomplete portions of a video capturing hardware setup, an early drawing tablet, and a large collection of floppy diskettes comprised of mostly commercial software accompanied by original boxes. It was immediately clear that this was an exciting window into history given that several pieces of Amiga hardware had shipping labels directly from Commodore, others had internal Commodore labels warning that the components were not yet for sale lacking FCC approval, and that the drawing tablet appeared hand-made. Great initial disappointment set in when all but a single unlabeled floppy disk appeared to be

commercially produced software. Given that computers lacked hard disks in this era, it was common to use many data and backup floppy disks, leaving the unfortunate impression that actual data disks were lost or in un-cataloged collections.

Nevertheless, a proposal was formed to archive the contents of the floppy disks, whatever their contents, as a guard against future degradation. This roughly outlined the plan to read the disks at a low-level using a commercial device called the KryoFlux, which is able to record magnetic flux transitions and can therefore generate an archival dump as close as possible to the original. So-called disk images (an interpretation of these magnetic variations typically handled by the Amiga operating system) are necessary for file-level analysis, and these can be generated by the KryoFlux for formats it understands (in this case, standard AmigaDOS filesystems typical of system or data disks). These could then either be studied by loading the images into Amiga emulator software or by writing them back to new floppy disks. To address disks that might be in non-standard formats (common for copy-protection purposes in commercial software), it was decided that any such disks would be copied separately onto new disks using a low-level disk copier program. These physical copies could then be studied directly on the club's own Amiga hardware.

Possible risks during the process were anticipated as best as possible. The primary concern was damage to the disks during the reading process. While impossible to eliminate without using extremely expensive equipment well beyond the reach of involved parties, it was believed this risk could be minimized by using a recently cleaned and tested floppy drive for copying, setting the write-inhibit switch on the KryoFlux that physically disconnects the write pin on the floppy drive, having exclusively a member of the museum staff handle the disks, and by carefully monitoring the printed output of the copying software for any indications of problems. In contrast to the modern magnetic storage medium of hard disks, floppy disks use relatively low-density recording allowing for much more magnetic degradation before data cannot be retrieved and a physically more robust design given that recording heads are intended to touch the disk platter itself rather than fly above it as is now common, in hard disks. This resilience and the safeguards taken provided confidence that the process could be completed safely.

On March 1st 2013, Cory and two members of the Computer Club met with staff at the museum to perform the archiving. Equipment brought included the KryoFlux, several floppy drives, an Amiga 500 and a Amiga 1200 owned by the club, an unrelated prototype video conversion system allowing the convenient use of the Amiga with a modern LCD monitor, several boxes of floppy disks, and various tools in case on-site repairs to any of this equipment was needed. As hoped, the process went quite uneventfully, indeed almost boringly so. Nearly all the disks were dumped smoothly using the KryoFlux. Four disks reported bad sectors (one of which had all sectors read correctly on a second pass) and were copied using the X-Copy nibble copier on the Amiga 500 onto blank disks. As everything was being packed up, several overlooked disks were discovered and quickly dumped. After the fact, based upon museum inventory and disk contents, it was discovered that two additional disks were neglected.

The following evening, Cory and videographers from the Carnegie Museums joined club members to get a first look at the contents of the disks. One by one, disk images were loaded in the UAE emulator for initial study. Several disks labeled Workbench (the operating system) were first attempted, as their contents would be most recognizable. It was quickly observed both that these were very early versions lacking convenient features of later ones and that there was a strong association between the Kickstart (boot disk) version used and whether a given Workbench version would function. As expected, this carried over to bootable program disks as well, many of which contain a minimal version of Workbench. After gaining initial familiarity, the disk image corresponding to the single unlabeled floppy disk thought to have the greatest hope of containing interesting data was studied. Alas, this too turned out to be merely a copy of a Workbench disk, solidly dashing the hopes of everyone present. Though it was already late in the evening, it was decided to press forward with several more disks. The next disk was one labeled "GRAPHICRAFT," the software mentioned in the article about Don Greenbaum's earlier find. To everyone's shock and delight, it contained several files with very promising names such as "campbells.pic," "flower.pic," and "marilyn1.pic." Though these were not recognized by modern utilities as any recognized file type, with great anticipation the Graphicraft program was started in an attempt to view these files within the emulator. After some difficult familiarization with this very primitive software, horrifyingly, the files refused to open! Initially thinking that perhaps these were saved with a different version of the software, several other versions of Graphicraft found on the Internet were attempted, also to no avail—these later versions refused to recognize the files as a known format. As consolation, two other files on the same disk labeled "tut" and "venus" *were* recognized as ILBM image file types and were viewable in modern software. The prior appeared to be a frame capture of using Digi-View, and the second appeared to be a clip-art rendering of Botticelli's Venus but with a third eye added, unmistakably in Warhol's playful style. It was now clear that these disks did contain files created by him, but further investigation into the Graphicraft format was necessary.

The next day, while exploring the relationship between Kickstart and Workbench versions, one of the club's members discovered that Graphicraft would successfully run and open the ".pic" files on its disk if the Kickstart ROM from one of the other disks—labeled Kickstart 26.1—was used to boot the emulator. On discovering this, Cory was quickly invited back over, and the 3 aforementioned image files were confirmed to indeed be *signed* original works: a soup can, a red poppy flower, and a Marilyn portrait. Another disk also labeled "GRAPHICRAFT" contained several more ".pic" files, which included more signed works including a self-portrait, portraits of several individuals, and more flowers. Screenshots of the emulator viewing each image were made, and though this is technically sufficient to fully capture the content of each image, further study of the image format was warranted.

Since then, the contents of each disk have been exhaustively studied, with filesystem recovery applied to the few disks known to have corruption and lost file salvaging applied to all disks to extract any deleted (or otherwise lost without strictly causing filesystem corruption) files of possible interest. Another of the club's members who specializes in and is world-renowned for hacking and reverse engineering was brought in to study the

Graphicraft format. He quickly discovered that the format is nearly identical to the most basic form of an archaic format called PLBM with merely some minor file header changes and quickly produced a conversion program. Using this and existing software for ILBM conversion, all discovered image files were converted to the modern PNG format. Along the way, a demo disk showing off various Electronic Arts software titles was found to contain images of yet another unknown format. Though it was almost entirely certain that these files were part of a slideshow for this demo, these were derived to be in full-blown PLBM format as well, for which a rough converter was written out of completeness and as a programming challenge. Indeed, the images were uninteresting as expected.

While crosschecking disk identifiers against a catalog inventory report, it was realized that two additional disks were overlooked during the initial archiving. Members of the Computer Club returned to the museum on August 13th, 2013 to capture these as well. As predicted by the disk titles, they did not contain data of particular interest and, in fact, were duplicates of previously archived disks.

In the process of studying disk contents, two facts helpful to this and any other historic data recovery effort were noted. The first is that much of the software of the era defaulted to (and in some cases *only* supported) saving files on the same disk as the software itself. As many of these programs were relatively small even compared to the already small size of the floppy disks, this presented little problem. It was simply assumed either that copies of the disk would be made for separate uses or that the files would be manually moved to other disks as needed. The second observation was that all the image formats were merely slight variations of the raw format used by the Amiga hardware itself used to display graphics. At the time, this made the most sense as memory scratch space and processing time necessary to perform any conversions could be avoided. ILBM is the most famous such format of the era for Amigas and is well documented thanks to its widespread use and is very roughly comprised of a series of black-and-white images each corresponding to a color channel that are then stacked (interleaved by row). The early Graphicraft format is a small variation of this, and in fact, the files themselves literally contain a rendering of the title bar with the program's name and version number.

All image files of potential interest were separated, collected, and converted to modern PNG format. For each, a scaled version correcting the aspect ratio (as pixels on TV-resolution monitors of the era were not square as today) was also produced, without which images appear horizontally stretched.

Technical Details

This section contains additional technical details on elements of the process and the tools used, roughly ordered by sequence in which they were applied.

The **KryoFlux** is a USB-attached floppy drive controller that interfaces a modern PC to a variety of types of floppy drives. It is produced by SPS, the Software Preservation Society, a European group dedicated the mission of preserving the contents of floppy

disks, particularly every commercial game ever produced. It is able to read and write standard-format floppy disks via disk image files, but its primary strength is its ability to capture a very low-level picture of disks: the raw timing between magnetic flux transitions rather than the mere presence of these at expected locations forming an interpreted a bit-stream provided by usual floppy controllers. This allows it to better handle and successfully dump damaged floppy disks and those with non-standard encodings or copy-protection schemes. In this effort, the KryoFlux was used to produce raw dumps ("streams") of all the floppy disks and filesystem-level disk images (ADF files) of all disks in standard AmigaDOS format. In the end, all disks encountered were of this format, so disk images were produced for all disks.

For disks in nonstandard formats for which the KryoFlux could not produce a disk image (though none were found in this effort) and for disks reporting bad sectors (implying that the disk image produced would contain errors), a low-level disk copier program (also known as a "nibble copier") called **X-Copy** was also applied. This program makes use of the fact that most disk interpretation in Amigas is done in software and, rather than interpreting disks as usual, attempts to derive and duplicate nonstandard parameters of a source disk. As all disks were found to be in the standard format, only the 4 disks reporting errors were copied onto blank disks for further study.

Disk images were loaded for study in a well-known Amiga emulator called **UAE**. This software fully emulate Amigas of various vintages allowing selection of Kickstart ROMs, virtual floppy disks via disk images, and transfer between the emulated Amiga and the host PC. The use of this greatly sped up study of disk contents and understanding of software operation. It was also used initially to load and view image files found on disks using the original accompanying software prior to understanding or reverse engineering the file formats.

Kickstart is the boot code used on Amigas to perform initial hardware tests, load the actual OS from a floppy or hard disk, and provide a small library of hardware abstraction functions that may be called by the OS or programs. It is most analogous to the BIOS in PCs, except used a bit more heavily. Typically, it is stored on one or two ROM chips in Amigas, however at the time of the release of the Amiga 1000, the software was not yet ready, and it was decided that an extra 256KB of RAM would instead be included (at immense expense) to be loaded from a floppy disk containing the Kickstart boot code. Among the Warhol floppy disks, several versions of Kickstart were found, including a hitherto unseen pre-release version 26.7, along with known released versions v1.1 (31.34), and v1.2 (33.189).

The four disks indicating bad sectors required filesystem **repair** to prevent error messages when accessing certain files or creating new ones. More importantly and generally, repair is the process by which the filesystem is made "consistent" in that all internal data structures such as those indicating how large files are or whether a portion of free space is properly marked as such are in agreement. Along the way, files missing components or incorrectly marked as sharing pieces with other files are re-assembled as best as possible. This process is performed using the Amiga "disksalv" utility in repair mode and is

analogous to fsck or scandisk on PCs. An additional step performed on all disk images, including ones not reporting any errors, was to **salvage** any "lost" files that could be readily located. Such files may arise if something was deleted but the space it occupied was not yet reused or if a file was being written to disk at the moment the machine crashed or lost power. The salvaging operation was performed by invoking the same Amiga "disksalv" utility in salvage mode and is analogous to "undelete" utilities on PCs. Strictly speaking, the repair operation is an in-place operation, while the salvage operation effective performs a repair on a temporary copy and then performs undeletion. Both processes may, depending on what data is available, be unable to restore the entirety of a file or lose certain information about it such as its original name.

Possibly the most interesting topic from a historical restoration and preservation perspective is that of image formats. Several early and more common Amiga image formats were observed across the disks, which as previously noted are for convenience and simplicity small variants of the raw format used by the display hardware itself. Most image files on Amigas have been traditionally stored in the so-called Interchange File Format (**IFF**), a container format somewhat analogous to TIFF in that it is comprised of chunks of pre-defined types providing file content identification and that allowing extensions and additional data fields to be added without compromising other and existing software's ability to interpret components known to them. Conceivably useful to store essentially any type of data, it was primarily used for images, sound, and animations. Probably the most common IFF image file type was **ILBM** (InterLeaved BitMap), which, very roughly, defines a color palette and then contains a series of row-interleaved bitmaps each providing a bit of an index into the color palette. Though odd by modern conventions, this coincided well with the raw format used by the graphics hardware in Amigas, minimizing software processing requirements and permitting easy image scrolling. Due to its ubiquity and detailed documentation, this format is reasonably supported even today, and the "ilbmtoppm" program from the "netpbm" utilities package was used to convert any ILBM files found. DeluxePaint, Digi-View, and later versions of Graphicraft appear to have all produced ILBM files, though with additional chunks specific to each program that are largely unnecessary for image interpretation but may be needed for handling animations. An older format, also an IFF instance, which was considered deprecated by the early 1990s was called **PLBM** (PLanar BitMap). This is similar to ILBM but stores each bitplane's bitmap contiguously rather than interleaved by row. This format is much more poorly documented, but sufficient information was available online to write a primitive PLBM decoder program. One disk containing an EA slideshow contained PLBM files. It also appears that the pre-release version of Graphicraft Warhol used, as well as the A-squared framegrabber software, both produced what herein will be called "**Graphicraft format**" that was essentially the contents of an uncompressed PLBM file but without the IFF header. All the files found in this format contained palettes of at most 32 colors. To interpret these files, another simple conversion program was written.

All image files found were first converted from their respective format to PPM, a simple raw format. These were then converted to modern PNG to form original, unmodified "unscaled" versions. An additional "scaled" version was created from this to produce an

image better corresponding to what Warhol himself would have seen. The reason for this is that monitors of the era were essentially interlaced NTSC televisions with a 4:3 aspect ratio displaying effectively non-square pixels, while the image files are 320x200 or 640x200 (8:5 or 16:5). As NTSC has no formally defined horizontal resolution, the image data available was simply drawn across the available width and with the same image repeated on both interlaced fields to fill the approximately 480 vertical scan lines. As such, the scaled version of each file attempts to correct the aspect ratio by applying a 20% horizontal stretch and overall appearance by doubling pixels in both dimensions to emulate display on an interlaced screen. An additional step (commonly performed for such a transformation) of applying an unsharp filter with a 0.5pixel-wide kernel is added to avoid softening edges through the interpolation step.

For print or exhibition purposes, 20-inch wide 1200dpi (24000x18000) “pixel-perfect” scaled versions without any interpolation or filtering performed were also generated. These were produced by simply applying a large scaling factor along each dimension using nearest-neighbor color selection. At extremely large scaling factors, any relative dimensional rescaling may be approximated to arbitrary precision because rounding pixel dimensions for e.g. a 20% horizontal stretch to integers has negligible effect.

Several Aegis Animator scripts, encoding visual animations, were also discovered. One was located on a disk containing data corruption and could not be played, and the others appeared to be demonstration animations. Video captures of playback of these animations in an emulator were generated.

The disk archive contains a large number of files but within a logical hierarchy now described. Primarily, a directory is present for each disk, named according to catalog number. In each of these directories, the file **streams.zip** contains raw KryoFlux archive data. An interpreted disk image is named **adf**. For reference, a non-archival-quality picture intended merely for identification is present as **photo.jpg**. The file **identification.txt** contains a brief written description of the contents and any issues encountered during its analysis. For most, the directory **contents** contains an extracted copy of all files on the disk. Several contain instead a directory named **repaired_content** indicating that this is an extracted copy following the execution of a filesystem repair step. Each directory also contains a directory named **salvaged_content** containing any files recovered by a filesystem salvage step to seek deleted or lost files. Several further contain a **repair_salvaged** directory if some additional files could be salvaged prior to running the repair step. Various **.log** files report the output of any salvaging operation, **listing.txt** files are for convenience and merely enumerate contents of directories, **file_info.txt** files report the output of running the utility called “file” that identifies common file types, **content.lha** files are Amiga LHA archives of the contents used to transfer the file contents from within the emulator used to perform all the repair and salvage steps, and **sha256/md5sums** files contain checksums of extracted files for rapid comparison for uniqueness. If any image files were found on the disk, a directory called **images** is present. Within this, the **noscale** directory contains the raw file extracted without any modification. In some cases, additional directories named **noscale,damaged** and **noscale,padded** are present containing respectively extracted files that were damaged and a version padded with empty content to

generate a valid image file. The directory **scale** contains versions of the images with the size and aspect ratio correction step previously described applied. A **scale,padded** version also exists for each where the source had to be padded. Analogous **1200dpi** and **1200dpi,padded** directories contain respective versions suitable for print. At the top level, an additional directory **extracted_images** containing only image files that appear to have been added by Warhol is present to simplify the process of reviewing the images that were discovered.

Warhol's Hardware Collection

This section contains very preliminary research into the Amiga-related equipment Warhol had at his disposal that was performed in the process of identifying the software on each diskette. It may not be completely accurate as it is based on an incomplete understanding of Amiga history and assumptions such as that hardware for which a driver disk is present was in his possession. Only some of this equipment was immediately apparent in the museum's collection.

One disk in the collection has a handwritten label and corresponding contents indicating it is the driver disk for a framegrabber used to capture stills from an attached camera that was produced by a company called **A-squared**. Though not apparently present in the hardware collection at the museum, it was reported that this was the device used by Warhol at the 1985 launch event to produce a portrait of Debbie Harry. Interestingly, the first such product produced by the company, called *Live!*, was only released in 1987. An article (referenced below) indicates that the product suffered from development delay due to internal politics. This fact, the handwritten label, and the "version 0.0" reported by the software that has never been seen online suggest that Warhol possessed a pre-release version of the device years before anyone else. Though color-camera versions existed later, it is likely that its operation was similar to Digi-View.

Another disk appears to contain the software corresponding to a similar video capture product called **Digi-View**. This appears to have been a more common product, likely due to being less expensive than the *Live!* framegrabber because it attached to the Amiga's parallel port and thus required far fewer components. In typical operation, a monochrome TV camera was used, and the subject had to remain still while 3 captures were taken using different color filters (red, green, and blue) placed in succession in front of the camera. Filter rotation was a manual procedure and only automated later with a motor. Components of the Digi-View system were found among the hardware in the museum's collection. Here too, Warhol likely possessed pre-release versions since the product was first released in 1986 and all available versions of the driver disk are later revisions than the one found here.

Yet another form of graphics input—a drawing tablet called **Easyl**—does appear to have all its components present in the collection. This is an early drawing tablet quite similar to modern ones except that it was strictly pressure-sensitive (albeit apparently in a binary sense) and therefore neither required nor supported multifunction pens. According to text

on the demo disk found in the collection, its surface was 8.5x13in, and it had a resolution of 1024x1024 pixels. This further states that its driver can be used as a standalone program or attached to either Aegis Images or Deluxe Paint. A disk providing an instance of the latter was found in the collection. It was initially suspected that the tablet in Warhol's possession was a pre-release unit solely given the fact that its exterior is wooden rather then melamine as later versions, however pictures of the Amiga 1000 release model linked below suggest a wood base as well. The driver disk also appears identical to disks for sale on eBay. Thus, it may be the case that he simply had the first commercial version.

A final and particularly fascinating piece of hardware Warhol may have possessed on the basis of the presence of a driver disk is the **Polaroid Digital Palette** film recorder that attached to an Amiga using an interface known as the **Imprint**, produced by Liquid Light. The Digital Palette was for many years intended to solve a fundamental problem now very foreign—that computers were merely a step in the process of digital creation and that a physical print was still required for volume printing or photographic enlargement for exhibition. Only recently have printers become suitable for this purpose, and prior to that, literal screenshots were typically used, canonically by photographing the computer's monitor in a dark room. Natural problems arose such as color mismatching, incorrect color saturation, and distortion due to screen curvature. Basic ways to solve this usually involved taking polaroid photos of calibration screens, iterating through manual adjustments. The Digital Palette, intended to be a professional solution to this, is a box containing a color-calibrated mini-CRT, lensing for distortion correction, and a 35mm camera back, forming a self-contained system for doing exactly the same much more precisely. A particularly important but unobvious strength is that by using an interface that receives raw digital video data from the computer internally, analog degradation is greatly improved over TV-signal quality video available for monitors and delayed until the final stage of display on the internal CRT. Available until relatively recently—with Windows 95 drivers last produced—similar interfaces for the Apple II and original IBM PC were marketed prior to one for the Amiga.

Avenues for Further Exploration

- As it is believed that Warhol may have also produced visual animations such as that allegedly recovered by Detroit Museum of New Art, verification that the Aegis Animator scripts discovered here were not in fact created by him may be worthwhile. At least one script was corrupted and might be at least partially recoverable with sufficient forensic effort.
- A full historical study of the features of (and a comparison between) the art-relevant hardware and software at the time would be fascinating. The process of capturing images (e.g. via Digi-View) and printing them (e.g. via Imprint) is nothing like today.
- A live exploration and demonstration of the software Warhol had at his disposal—perhaps as a video, an exhibition of the original hardware, or an interactive exhibit running in modern emulators—would be a great way to educate the art community and the public at large in the origins and history of modern media.

- Acquisition of copies of the media held by Don Greenbaum containing several works not discovered here would permit data comparison and proper exhibition of the entire set of works known to have been created by Warhol on the Amiga.

By the Numbers

40 Disks archived
4 (of which **2** affected used space) Disks with bad sectors (severe corruption)
9 (of which **5** affected data files) Disks with any form of observable filesystem damage
10 Disks with Warhol-added files
16 Disks of which copies do not seem to exist online
11 (plus **1** partially recovered) Signed works (incl. any comprised of just a signature)
2 Unsigned works clearly in Warhol's style
1 Works possibly by Warhol but not clearly attributable
12 Apparently-unmodified video frame captures (including possibly basic colorizing)
3 Modified video frame captures (including possibly substantial recolorizing)
2 Animation files possibly by Warhol but not clearly attributable

Interesting Resources

Possible later product referred to by A^2 Color Framegrabber disk:
http://amiga.resource.cx/exp/search.pl?product=&company=A-Squared&amiga=1000
http://www.atarimagazines.com/compute/issue90/Amiga_View.php
http://www.bigbookofamigahardware.com/bboah/product.aspx?id=280 (later version)
Digi-View:
https://56programs.wordpress.com/2010/05/12/1986-1989-how-the-set-up-worked/
http://amiga.resource.cx/exp/search.pl?product=DigiView&company=
http://www.bigbookofamigahardware.com/bboah/product.aspx?id=307
Easyl:
http://amiga.resource.cx/exp/search.pl?product=easyl&company=
http://www.bigbookofamigahardware.com/bboah/product.aspx?id=717 (later version)
http://www.pcmuseum.ca/galleryview.asp?id=28
LiquidLight Imprint / Polaroid Digital Palette:
http://www.philpem.me.uk/code/filmrec/
http://www.bombjack.org/commodore/amiga/magazines/amiga_world/pdf/Amiga_World_Special_Issue_1987_Reference_Guide.pdf (p. 48 – pdf, 46 – document; part of an article on how to save screenshots to paper)
Graphicraft history:
http://books.google.com/books?id=My8EAAAAMBAJ&lpg=PA14&ots=-RvhIfDPTQ&pg=PA14#v=onepage
http://www.randelshofer.ch/animations/anims/commodore/AmigaSys.ilbm.html

Glossary of Selected Terms

ADF Amiga Disk (or AmigaDos) Format. This is the disk image format typically used to store floppy disks in the standard AmigaDos format, and it usually cannot store disks using custom encodings more common in later copy-protected software. Directly loads in emulators such as UAE or extractable using the readdisk utility accompanying UAE.
Amiga 1000 The first Amiga, only assigned the model number retroactively, released in 1985 and the model used by Warhol. It was highly impressive at the time of its release, having better sound (4-channel stereo PCM) and graphics (up to 640x200 and 4,096 colors in the highest mode) capabilities than competing PCs and Macintoshes (with PCs having beepers and up to 16 colors, while Macs had limited 22.5kHz mono audio and monochrome displays).
DeluxePaint (Often abbreviated DPaint) Developed by Electronic Arts, the most popular bitmap graphics editor on the Amiga, though also available for other platforms. It was the source of EA's introduction of the ILBM format.
Disk image A file containing a representation of the contents of a floppy disk.
DMS The traditional disk image format for non-DOS disk images (but also works directly as an alternative to ADF), extractable with software called xDMS
Easyl An early drawing tablet, used by Warhol. It is 8.5x13in and is 1024x1024 resolution (~120x79dpi) and was released in 1986 for $499 (according to text on the Easyl demo diskette; other sources suggest a resolution of 640x400 and release year of 1987). Accompanying drivers and software were also simply called “Easyl.”
Graphicraft A very early bitmap drawing program in Warhol's possession, originally developed by Island Graphics and marketed by Commodore, but later sold to Aegis Software in late 1985 to be integrated into its Aegis Images program after Island had difficulty completing the software. Commodore, having rights to work up to that point, then released its own stripped down version.
IFF The “Interchange File Format” commonly used to store multimedia file formats on Amigas. Described further in the Technical Details section.
ILBM The “InterLeaved BitMap” image format commonly used to store bitmap graphics on Amigas. Described further in the Technical Details section.
Imprint Software and hardware produced by LiquidLight Inc. for interfacing Amigas to the Polaroid Digital Palette, available by 1987 for $495.95.
KryoFlux A USB-attached floppy drive controller produced by the Software Preservation Society that enables low-level disk dumping. Described further in the Technical Details section.
PLBM “Planar BitMap” format, an early image format for Amigas. Described further in the Technical Details section.
PNG So-called “Portable Network Graphics” format. Designed to be an un-proprietary and patent-unencumbered format in which image files could be stored and transmitted with maximal compatibility. Though relatively modern, its very widespread adoption and impeccably documented format will likely assure great longevity and appropriateness as an archival bitmap format.
Polaroid Digital Palette Film Recorder Device attaching to a PC that contains a color-calibrated mini-CRT and a film camera that allows easy creation of screenshots onto film.

Apparently first available in 1984, it was considered for many years to be the best way to produce high-quality screenshots.

Pro Paint Intended to be the name of the "pro" version of Graphicraft, and it was this name that was visible on the screen during the Debbie Harry launch event. No software by this name was ever actually released.

TOSEC "The OldSchool Emulation Center," an effort to collect all known software disks for classic machines. This is the archive against which disks in Warhol's catalog were primarily compared.

UAE The most popular Amiga emulator, allowing emulation of both old and new models as well as the import of ADF images. Several forks of this software exist with slightly differing feature sets. For this work, the version called e-UAE was used.

X-Copy A so-called nibble copier program for the Amiga, allowing relatively low-level and often-successful copies of damaged disks or ones with non-standard formats. Described further in the Technical Details section.

Revision History

Revision	Date	Remarks
1	30-April-2013	Initial incomplete draft
2	5-May-2013	Expanded draft
3	6-May-2013	Completed draft
4	11-May-2013	Improved formatting, initial delivery
5	14-May-2013	Correction of minor typographical errors
6	16-May-2013	Expanded biographies
7	26-Sep-2013	Additional biography expansion
8	2-March-2014	Update for two additional disks, minor corrections, biographical updates
9	3-March-2014	Final biographical tweak and section reordering
10	9-March-2014	Additional information on discovery of animations

People

The **CMU Computer Club** is a student organization at Carnegie Mellon University that is locally best known for its many customized computing services for power users in the campus community. Recently, it has gained some renown for its retrocomputing expertise through its possession of one of possibly the largest actively-used retrocomputing collections in the country, various restoration projects, new hardware development, prize-winning multimedia demonstration ("demo") authoring, and an annual demo exhibition on modern and historic hardware attracting visitors and online live viewers from around the world. Highlights of projects include the authorship of three demos that have earned first place in competitions in nearby Ohio and the world's largest demo party in Finland, the design and manufacture of a featureful sound card for the obscure Apple Lisa, and custom hardware interfaces to extract raw digital video in HDMI form from a large number of classic computers. Club members that have most heavily contributed to this effort include Keith Bare, an alumnus who holds an MS in Computer Science and now works at NetApp, Inc., and Michael Dille, a PhD candidate in Robotics at the time of this effort who is now a Sr. Computer Scientist at SGT/NASA Ames Research Center. Tyler Nighswander, a world-renowned hacker who recently completed a double BS in Computer Science and Physics and is now pursuing a PhD in Quantum Computation, reverse engineered the Graphicraft image format. Other project contributors include alumni Derek Kozel and Lincoln Roop.

Efforts by the Computer Club were supported in part by classic Amiga hardware whose funding was provided by the Carnegie Mellon University Frank-Ratchye Fund For Art @ the Frontier maintained by the **STUDIO for Creative Inquiry**, a center in the College of Fine Arts at Carnegie Mellon University which supports atypical, interdisciplinary, and inter-institutional research and outreach projects at the intersections of the arts, technology and culture. The Computer Club gratefully acknowledges the support of **Golan Levin**, its director and Associate Professor in the School of Art, for this funding and encouragement.

Cory Arcangel is a Brooklyn-based artist and self-proclaimed Warhol acolyte who has produced works for a number of different media that explore the relationship between technology and culture. He is most famous for hacks to modify videogames to emphasize certain elements, such as an altered version of Nintendo's Super Mario Brothers in which all of the game's graphics have been removed except for a blue background with scrolling clouds. His work has been exhibited internationally in numerous group and solo shows at many institutions including the Migros Museum in Zurich, the Museum of Contemporary Art in Chicago, and the Lisson Gallery in London. In 2011, he became the youngest artist to be honored with a solo show at the Whitney Museum of American Art in New York. His work has been profiled in The New Yorker, The Guardian, and The New York Times.