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Managing Editors

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AMERICAN INSTITUTE FOR CONSERVATION OF HISTORIC AND ARTISTIC WORKS

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ABSRACT

Born-digital time-based media art is an emerging and rapidly growing art form that poses significant technology challenges to art museums and other collecting institutions across the globe. Within the Smithsonian Institution, the Office of the Chief Information Officer and the National Portrait Gallery are working together to address the unique challenges inherent in preserving works of this kind. Born-digital works are generated in real time using digital information stored in the form of binary data. As such, they are vulnerable to the same integrity or data corruption and obsolescence concerns as any digital file format or software. The preservation of born-digital works requires both IT-based infrastructure to safely store and organize this data, as well as an organizational method to document, describe, and categorize information related to the artist’s intent and the work’s provenance. To meet these needs, the Office of the Chief Information Officer has developed the Digital Asset Management System and the National Portrait Gallery has created the Time Based Media Archival Package. The Digital Asset Management System is an enterprise-level system used to store, manage, preserve, and share the Smithsonian’s rapidly growing collection of digital assets and related information. An enterprise digital asset management system is essential to meeting the Smithsonian’s objectives for the following: preservation and stewardship of objects and specimens; organizing, classifying, and locating digital assets; delivery of digital assets in multiple
formats; public outreach and education and electronic commerce; and participation in external cultural heritage, library, and science initiatives.

The Time Based Media Archival Package is a method used to organize time-based media assets including the digital essence of the work, as well as related curatorial, exhibition, and collections management related documents. This presentation will include discussions of the Digital Asset Management System architecture (including hardware, database, application software, storage, staffing resources, and operational procedures); its functional aspects (such as user roles, asset security policies, ingest methods, metadata models, and transcoding); and the structure and various components of the Time Based Media Archival Package.

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FUTURE, OR HOW TO SURVIVE FOREVER

ANNET DEKKER

ABSTRACT
This extended abstract is part of an ongoing study of the documentation of net art. The research project focuses on conservation strategies and comparing methods that are developed in museums to document artists’ practices. For this presentation at the 2013 Annual Meeting of the American Institute for the Conservation of Historic and Artistic Works, I concentrated on a case study of Naked on Pluto (2010), a Facebook game that was created by Dave Griffiths, Aymeric Mansoux, and Marloes de Valk. I will explore whether a project that is dependent on a commercial platform can be documented, and if so, how to approach documentation.

INTRODUCTION
Net artist Igor Štromajer started to delete all of his net artworks in 2010. Over a period of 37 days, he deleted one of his artworks each day, based on the conviction that “if one can create art, one can also delete it. Memory is there to deceive” (Dekker 2013). Other artists like Constant Dullaart and Robert Sakrowski are currently giving people guidelines on how best to document their, or other people’s, net artworks. Their approach of subjective documenting, and straightforward collecting of meta data is aimed at the participation and exchange of the collected documentation by all parties interested in preservation of Internet based artworks. At the same time more and more net artists are translating their online artwork into
objects, sculptures, and installations, and experimenting with ways to present and document their work for future generations.

The way artists make, use, and present their documentation, from the work in progress to the final presentation, can give a lot of information about the work. This is of vital importance for the preservation or re-creation of a work. Analyzing artists’ documentation methods and comparing these to the information that is asked for in museum documentation models showed that specific and inherent qualities of the artworks have previously not been taken into account. For example, closer analysis of the English performance group Blast Theory’s creative processes indicated that integral information might get lost when using standard questionnaires or applying emulation methods that transfer the game-play to new platforms (Dekker 2012). For this presentation I analysed the multiplayer game Naked on Pluto (2010), a work that is based on process and relies on the commercial and restricted online platform Facebook, and identified and mapped out the implications of its conservation.

Although there is still little analytical reflection on artworks that proliferate on commercial social media platforms, or interest in the presentation or acquisition of these works by museums, through this—rather extreme—case study, I will show that this practice is gaining attention with artists and thus can be regarded as paradigmatic for contemporary artworks.

NAKED ON PLUTO

Naked on Pluto (2010) is a multiplayer text adventure on Facebook, conceptualized and developed by Dave Griffiths, Aymeric Mansoux, and Marloes de Valk. Naked on Pluto was launched in 2010 and is still active at the time of writing: http://naked-on-pluto.net/. When entering the game, the player finds him or herself on planet Pluto, in a city under the rule of Elastic Versailles revision 14 (EvR14), an artificial intelligence functioning as an entertainment colony. It is the Las Vegas of the solar system, a true paradise for consumers and corporations alike. The game starts with a prolific textual exchange between the player and the computer, during which bots mix and muddle up data, faces, and profiles to generate a framework of strangely familiar relationships. The complexity of the exchange increases as the game progresses. Players can only free themselves from harassment by the bots by resisting and waiting until their resources run out, or the logic of the plot loses all sense. Naked on Pluto explores the limits and nature of social networks from within, slowly pushing the boundaries of what is tolerated by the companies that own them, while carefully documenting this process as it unfolds. Story and play are combined with an investigation into the degree to which people are exposed on social networks, and how their data is being used.

PATHS TO EXPLORE

In talks I’ve had with the artists, a few points came up and, looking back, I think are interesting to explore in a wider context.

First, Naked on Pluto is a complex network of distributed parts in which individual parts function separately in different domains. For example, the game-engine is freely distributed and built upon by various users. Besides the present technical difficulty of conservation, this dispersion makes it even more difficult for a conservator to decide what is important to preserve. However, when acknowledging that multiple versions—or even parts of a work—exist and are scattered around different platforms, re-installation may become less of an obstacle. Within certain restrictions, freedom to choose will be possible, and will likely lead to interesting results. Such a process already exists in the practice of curating, where variability is especially visible in the presentation of installations (Ippolito 2008; Noël de Tilly 2009). Although curators recognize this more and more, conservators may be more hesitant in choosing the method of reinterpretation. A shift in thinking will be necessary for this change to come about.
Second, besides challenging general concepts and strategies in presentation and conservation, these artworks also show that conventional roles are shifting. Artists are not necessarily the main actors anymore. For example, the public can take over parts of the work; the work itself is distributed in various versions, forms, and platforms, so that a broad range of knowledge and a variety of perspectives are needed to present and conserve the work. Vivian van Saaze (2009) concluded that due to the nature of such works—her example is the project No Ghost Just a Shell (1999–2002), an extended exhibition process based on a computer file, by Phillip Parreno and Pierre Huyghe—there are multiple actors who are involved and co-determine the process. Thinking about conservation, Van Saaze argues that “knowledge and existing practices in different areas (vocabularies, the work itself, the artist’s intent, professional roles, economic models) needed to be revised” (2013, 179). She continues by stating that “the notion of ownership as defined as freezing the art object in a singular state is in need of a revision; one that acknowledges a more tactile, practice-based, and interventive kind of engagement of the museum professional” (2013, 179).

My analysis supports this conclusion. Furthermore, I would like to suggest that this engagement should focus on bringing several types of professionals together, likely including people from outside of the museum. In other words, the goal should be, to use a phrase by Jill Sterrett, “advancing collaboration in museums”. Or, as Pip Laurenson suggested in the opening talk she gave at the AIC Annual Meeting in 2013, adopting the notion of “interactional expertise and acknowledging and using contributory expertise” (2013). To add to this, it would be relatively easy to say that net artworks, or as outlined by Laurenson, performance artworks when acquired by the museum, will change the museum structure. Although this may come true, it is perhaps more fruitful to see how such a new modus operandi will affect other more traditional works of art. I believe that a change could generate interesting new knowledge within traditional approaches and methods.

This brings me to the third point I’d like to make. With documentation being part of the artwork, replacing the artwork, or even being regarded as the artwork, what does this shift mean for documentation? In other words, what happens when the context, for example a distributed network, is also the work? Can something immaterial, such as a process, or a virtual network, be documented? If not, what does that say about a work, or a document? Lev Manovich argues that software culture is moving beyond the 20th century terminology of document, work, message, or recording, and “instead of fixed documents whose contents and meaning could be determined by examining their structure and content...we now interact with dynamic ‘software performances’” (2013, 33).

Manovich uses the term performance, because what we are experiencing is built by software in real time. Whether we are surfing on a website, using email, playing a video game, or using a GPS phone to friends or a particular spot in the surrounding area, we are always working on dynamic and real time interactions and no longer with static documents. He continues:

Computer programs can use a variety of components to create these performances: design templates, files stored on a local machine, media from the databases on the network server, the real-time input from a mouse, touch screen, joystick, our moving bodies, or another interface, etc. Therefore, although some static documents may be involved, the final media experience constructed by software usually does not correspond to any single static document stored in some media. In other words, in contrast to paintings, literary works, music scores, films, industrial designs, or buildings, a critic can’t simply consult a single “file” containing all of work’s content. (2013, 34)
Could it be possible for a conservator to work with algorithmic processes, or other software performances, instead of objects and documents? Some, including Deena Engel and Glen Wharton (2013) point to the importance of reading code. I also believe that such methods of analysis are crucial to acquiring a good understanding of the work, because they give a lot of information about how and why decisions were made. Others have taken this point onward, comparing the execution of code with music notation, but while musicians play notes from paper, software is based on interactions. So while the idea of notation or scores is promising, it is dealing with just one function of software-driven media and neglects another important dimension, namely, interactivity. Also, reading code is possible in a closed project, but will be much more difficult when it comes to real-time interaction that involves networked processes and other external dependencies. When dealing with web applications or a dynamic website, where multiple software architectures are used and individual software modules work together (e.g., a web client, application server, and a database), it is impossible to read all the code. For example, in the case of large-scale commercial dynamic websites, such as Facebook or Amazon, user experience in a single web page involves different interactions that can amount to sixty separate software processes (Manovich 2012). Even if a software program is relatively small and a reader understands exactly what the program should do by examining the code, then the concept of the structure still says little about the actual user experience. The content of a document (the code) is obviously a part of this experience, but it is also formed by the interface and the various software tools. In this respect, it is important to distinguish between code and software. Moreover, it demonstrates the relationship with performance art, as well as the importance of collaborative and networked strategies that are developed in gaming, theatre, and contemporary dance where also a number of actions (in most cases intentionally) lead to ambiguous experiences.

ACKNOWLEDGMENTS
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NOTES
1. An initial attempt to see what this would mean and how this change could be effected was done in a workshop organised by Jill Sterrett and Layna White of the San Francisco Museum of Modern Art (SFMOMA), Chris Jones and Kelly Meanley of Hot Studio, San Francisco, and Annet Dekker at the Museums and the Web conference in April 2012. Available at www.museumsandtheweb.com/mw2012/programs/advancing_collaboration_in_museums (accessed 05/01/12). The idea for the workshop came from the concept of a “framework” that was developed by SFMOMA in collaboration with Hot Studio as a result of their successful Team Media meetings.

REFERENCES


FUTURE, OR HOW TO SURVIVE FOREVER


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A HANDS-OFF APPROACH TO CONTROLLING MEDIA-BASED ARTWORKS

BRAD DILGER AND RICHARD MCCOY

ABSTRACT

With the continued and increasing use of electronic media components in contemporary art projects, a need has arisen to efficiently and accurately control the active cycle of these components while on display. The Indianapolis Museum of Art has created a novel approach to effectively manage its contemporary art projects that have electronic media components using a hands-off approach. There are several methods controlling electronic media components in galleries, such as simple timers, manufacturer-based internal controls, the occasionally unreliable human controller, and computerized control systems. For the past seven years the museum has tested, installed, and maintained an innovative and effective approach to controlling its electronic media components in the gallery using a completely computerized control system. This solution, which was created through an inter-departmental working group composed of representatives from the Installation Department, Conservation Department, and Information Technology Department, does not require daily human interaction to maintain a gallery schedule. This relatively low-cost solution allows electronic media components to be controlled both autonomously and via web-based graphical user interface. This graphical user interface can easily function from smart phones. Autonomous control of electronic art is based on a system of linking together different software and hardware components from various manufacturers. This technology has had widespread use in commercial, educational, and residential applications to con-
trol all aspects of building functions: lighting, HVAC, security, entertainment, and irrigation are just a few systems that can be covered by computerized control systems. It is believed that the Indianapolis Museum of Art is the first museum to apply this system to electronic media components in contemporary art projects, and has been using the solution for nearly a decade with great success. This approach achieves the important goal of relieving staff from having to physically manipulate electronic media components in the gallery on a day-to-day basis, and has dramatically increased the efficiency and functionality of contemporary art projects by reducing gallery downtime caused by errors. This paper will discuss three case studies based on art installations in the museum. These case studies will demonstrate the successes and limitations of the system, as well as provide guidance for other institutions that are interested in installing this system.

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TECHNICAL DOCUMENTATION OF SOURCE CODE AT THE MUSEUM OF MODERN ART

DEENA ENGEL AND GLENN WHARTON

ABSTRACT
As part of its program to conserve software-based artworks, the Museum of Modern Art, New York, undertook a risk analysis of thirteen works that use a variety of software programs, programming languages, and libraries. Eleven artists and two programmers were interviewed as part of this project. They were asked about the software, the hardware dependencies, and their concerns for future presentation of the artworks. Risks assessed in this study include the potential impact from changes and upgrades to hardware, operating systems, programming languages and/or software applications used to create the artwork that would render the software or any associated multimedia files obsolete, thus jeopardizing future exhibition. It became evident from this analysis that acquisition and technical documentation of source code is key to preserving these works. The Museum of Modern Art partnered with the Computer Science Department at New York University’s Courant Institute of Mathematics to perform a pilot study to document the source code of four artworks. The project used standard software engineering methods to analyze the code and create textual documentation for future programmers who may need to recompile or re-write it for new operating environments. The documentation will also aid future researchers in better understanding the principles behind the work. Technical documentation of code is standard in the software and business industries, but it is new for museums. Due to artist concerns for public experience of their work, stan-
standard methods in the software industry must be adapted for museum collections. In this presentation, the authors describe their collaboration to document the source code of these artworks. The focus is on documenting how aesthetic properties such as color, movement, and sound are determined in the source code.

Aspects of this paper were published in two separate publications:


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DIGITAL VIDEO PRESERVATION IN CONTEMPORARY ART MUSEUMS AND SMALL COLLECTIONS IN 2012

PATRICIA FALCÃO

ABSTRACT

From the mid-2000s museums and other institutions caring for video collections have seen a shift in the type of material coming into their care as the production and handling of media moves from tape-based to file-based systems and workflows. This shift has had a significant impact on the procedures needed to ensure the long-term preservation of video artworks, requiring institutions to adjust their practices to this new environment.

This paper discusses the results of a small-scale survey focusing on current practices for the preservation of file-based video art in cultural institutions. The survey was conducted over two months in early 2012, in the context of Matters in Media Art (www.tate.org.uk/about/projects/matters-media-art). Matters in Media Art is a multi-phase collaborative project—supported by the New Art Trust—between the Museum of Modern Art, New York; the San Francisco Museum of Modern Art; and Tate, London. The aim of the survey was to understand the main problems institutions face in the shift to file based artists’ video and to identify common procedures, practice, training, and tools.

From interviews with staff actively involved in the preservation of media collections at twelve cultural institutions, four main challenges were identified:
works as digital video files and need to adjust their preservation practices to accommodate these new formats.

Given that videotape was never designed for long-term preservation, most collections operated a migration policy to transfer their videotape onto new stock and new formats every seven to nine years. These collections now need to consider the migration from tape to file formats, given that tape formats are likely to become obsolete in the next few years (Tadic 2012). Although it is difficult to predict how long current common tape formats like Digital Betacam and HDCam will stay in use, it is clear that they are set to become obsolete. Tapes which are now due to be migrated should be moved to file-based formats. Therefore now is the time for museums and other collections to plan their migration from tape to file formats and define the strategies necessary to preserve these files.

For custodians of video collections, this means not only adapting to a completely different set of storage media, but also adjusting to software and hardware systems for recording, editing, and playback. Although there is much that can be learned from the broadcast industry, digital archives, and the IT domain about the conservation and management of these new technologies, the solutions being developed in these other contexts are not directly applicable to collections of video artworks. The difference in scale of museum collections compared to broadcast archives, differences in budgets, and the particular requisites of high value video artworks in museums mean that many of the solutions used in other fields must be adapted before they can be used in an art museum context. A museum’s collection may be composed of less than a few hundred video artworks, but the value of each of these artworks can be very high. A broadcaster may have millions of hours of video, necessitating the creation of compressed files to reduce the amount of storage needed, while a museum may only have a few hundred hours of video, and will strive to preserve it at the highest quality, retaining original image quality and keeping the option to produce new, high quality formats.

Looking back at the results it is clear that in three years the field has evolved and in 2015 there are more and better tools available, standards are being defined, and best practices are emerging.

INTRODUCTION
From the late 1990s, contemporary art museums and other cultural institutions started developing and communicating emerging practices for the preservation of video art. One of the first examples is the Playback conference in 1996, organized by the Bay Area Video Coalition (BAVC). Institutions like Independent Media Arts Preservation, Electronic Arts Intermix, the Netherlands Media Art Institute, and projects such as Matters in Media Art have worked to develop and publish information to support those engaged in the preservation of video art. Initially, practices associated with video preservation followed the standards developed by the video production industry, which at the time were tape-based.

Between 2000 and 2010, the move to tapeless production and delivery of video gathered pace. In 2004 Panasonic released P2, a professional digital recording solid state memory storage media format, and in 2008 the BBC launched its Digital Media Initiative in an attempt to introduce a completely tapeless production workflow. The shift from tape-based to file-based systems in the production industry, together with the development of affordable editing software and hardware means that video art is now mostly produced digitally. As a consequence museums are now receiving newly produced video art-works • a lack of standards for technical metadata and file formats; • the need for integration of different hardware and software components required for a seamless preservation workflow; • the need for increased knowledge of digital video technologies, and • the need for a greater understanding of general information technology infrastructure.
It was against this background of rapid change that the Matters in Media Art project team agreed that it was important to create a snapshot of what those engaged with the preservation of video art were doing to preserve their video files. A survey was considered to be a good option for understanding the main problems institutions are facing and how they are solving them. The survey has helped identify common procedures and specific needs for training and tools.

Twelve cultural institutions with recognized experience in the conservation of video were contacted and staff members actively involved in the preservation of video and media collections were interviewed. All the institutions are involved in caring for video collections and all but one are actively involved in collecting video. Of the twelve institutions contacted, the Imperial War Museum (IWM), in London was the only institution chosen which did not have a focus on video artworks. It was chosen as a means of indicating whether there was a significant divergence in emerging practices and challenges faced by those working with video art collections and those working with other types of video collections.

In addition to the IWM, fine art museums, video art distributors, video transfer labs within larger institutions, and one private company that transfers video but also advises various museums on preservation, were contacted. The full list of interviewees can be found in the acknowledgements section. The interviews took place between March and April 2012. The information from the interviews was summarized in categories according to the questions asked with context or illuminating comments added. Video art and related media was the main focus of the discussions with the collecting institutions, with the exception of the IWM, where the bulk of the collection is documentary moving image and not just video. While preparing the survey, the team was aware that the IWM had experience in developing a digital preservation strategy.

The sizes of the video collection ranged between 300 and over 10,000 titles. The numbers varied depending on whether the institution was a fine art museum, a producer or distributor, or a documentary collection. Art museum collections ranged between 100 and 500 titles; the Museum of Modern Art (MoMA) was the outlier, with over 3000 titles. Distributors do not necessarily have ownership of the works they distribute, but still care for between 3,500 and 10,000 titles in total. Finally, the documentary collections, the IWM, and the Getty Research Institute (GRI), care for up to 50,000 titles.

Not all institutions were sure about the amount of data in their care. This was mostly due to the fact that often there were various copies of the same files, and also that these were kept in different storage media. The rough estimates are illustrated in Table 1 and 2.

It was clear from the interviews that most institutions were already developing new methods and procedures, and had started to address parts of the challenge presented by the move to file based formats. However, comprehensive preservation workflows have been slow to emerge. While it is always the case that the specific institutional context will determine many of the details, there were a number of shared challenges including the difficulty in sharing metadata over new and old platforms, the investment of time needed to establish new workflows, and the lack of easily accessible tools.

I have addressed the changing situation by adding current information and new tools and references where relevant, but, as was identified in the survey, the only way to stay up-to-date is by continuously talking to other experts and practitioners not only in the field of video conservation, but also in related fields.

**CHALLENGES IDENTIFIED**

The challenges identified were similar throughout the institutions and independent of the level of development of their preservation programs. Establishing or improv-
Respondents highlighted the lack of suitable tools for analyzing the integrity of video files, but also the need for better ways to carry out quality control for video files, in particular high definition (HD) video. They also identified the need to learn from different fields and work with different departments within the institutions, in particular working with internal information systems or technology departments. In the majority of interviews, respondents reported a need to know more about information technology and also digital preservation.

Each of these six key points will be developed in the following sections of this paper:

1. Systems and workflows
2. Archival storage and ingest
3. Media and standard file formats for preservation
4. Metadata
5. Quality assessment
6. Knowledge, skills, and tools

<table>
<thead>
<tr>
<th>Storage space in terabytes (TB)</th>
<th>Number of Institutions</th>
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Table 1.

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</tr>
<tr>
<td>Data tape (total of LTO (Linear Tape-Open) and DLT (Digital Linear Tape))</td>
<td>7</td>
</tr>
<tr>
<td>LTO (LTO-4 and unspecified generation)</td>
<td>6</td>
</tr>
<tr>
<td>LTO-4</td>
<td>3</td>
</tr>
<tr>
<td>DLT</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2.

An important finding was the level of agreement regarding the lack of a standard file format for preservation, with institutions agreeing that the formats they are currently using are not ideal, because they are proprietary and dependent on the production industry. This makes the need to monitor the developments in the industry critical. Metadata was explicitly named by six of the institutions as something needing development, particularly in terms of automation of extraction, but also in how the information is transferred between different modules of the preservation workflow. An example is the automatic extraction of technical metadata and its importation into a database. Another key point raised in relation to metadata was the lack of an agreed standard for technical metadata for video.

Respondents highlighted the lack of suitable tools for analyzing the integrity of video files, but also the need for better ways to carry out quality control for video files, in particular high definition (HD) video. They also identified the need to learn from different fields and work with different departments within the institutions, in particular working with internal information systems or technology departments. In the majority of interviews, respondents reported a need to know more about information technology and also digital preservation.

Each of these six key points will be developed in the following sections of this paper:

1. Systems and workflows
2. Archival storage and ingest
3. Media and standard file formats for preservation
4. Metadata
5. Quality assessment
6. Knowledge, skills, and tools

<table>
<thead>
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<th>Storage device</th>
<th>Number of Institutions</th>
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<td>Institutional server</td>
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<td>3</td>
</tr>
<tr>
<td>DLT</td>
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</tr>
</tbody>
</table>

Table 2.
SYSTEMS AND WORKFLOWS
The institutions contacted have different collections and structures in terms of departmental organization and team members. However, they share a number of key functions performed as part of the mission to preserve their collections. These functions can be closely mapped to what is defined by the Open Archival Information System (OAIS) reference model as the set of functions that an archival information system must perform: ingest, archival storage, data management, preservation planning, access, and administration.

Therefore, although in the interviews many institutions did not identify themselves as digital repositories, they are effectively performing this role. It is important to bear in mind that the OAIS model does not necessarily refer to an automated digital repository, nor must the information or metadata be in a digital format.

Different processes that form elements of the workflow associated with the long term preservation of video artworks are run in different parts of the institution, and newly added components such as a new storage system, are required to integrate with other systems already in place, like a central collection management system. The main issues appear in the interfaces between those different systems and particularly in sharing information between them. Depending on an institution’s organization, different departments or experts will be responsible for different parts of the OAIS processes.

All the institutions were aware of the need to adapt their preservation plans for digital files, and most institutions were (and still are) actively developing their systems and workflows. Even the larger institutions, like the IWM and the GRI, who have systems already in place, felt that a lot of development still needed to happen.

ARCHIVAL STORAGE AND INGEST PROCESSES
As expected respondents reported a rapid increase in the number and size of digital files, and discussed the challenges associated with the need to locate, manage, and store these files appropriately. This was also reflected in the need identified by those interviewed for more specialized IT knowledge. In Tate’s case, time-based media conservation had begun a much closer collaboration with the IT department. For smaller institutions, one highly specialized member of staff was engaged or an outside specialist was contracted to deal with the IT specific tasks associated with the bit preservation of digital files.

In all cases there was a clear distinction between those maintaining the IT infrastructure—servers, back-ups, and networks—and those people managing the data. People felt the need for specialists to ensure the IT infrastructure was adequate, but felt strongly about keeping control of the data and of how the data is organized and migrated. The line may also be drawn between bit preservation and long-term access and use.

A significant increase in in-house expertise around video technologies was reported, particularly in the museums. Museums are now hiring time-based media conservation experts. These experts are checking and migrating video in-house, activities that were traditionally done using external video facilities. Tate, MoMA, and the Solomon R. Guggenheim Museum now have in-house video suites. This is in part due to the decrease in cost of the video systems. For example, it is now possible to buy used professional Digital Betacam video decks for less than £5,000 ($8,500 USD), which would cost over £30,000 ($50,000 USD) if bought new. This means that it becomes more cost effective to have this equipment in-house, rather than using an external facility.

THE MEDIA
The hardware and software required for video editing have become simpler to use and more affordable. While in the past, producing video required the access to production houses with professional quality equipment and qualified video engineers, the advent of Apple Final Cut Pro and faster laptops means anyone can create their own videos at home. Furthermore, collections are
actively acquiring works from young and emerging artists, meaning that works may have been produced on extremely low budgets. This influences the type of video materials being supplied to museums.

The cameras and editing systems used in file-based production allow for a greater variety of file formats, and so, instead of the three common tape formats—Betacam SP, Digital Betacam, and DV or DVCAM— institutions now receive files using various combinations of containers and codecs (see Table 3).

On the other hand, there is a shift away from making a distinction between formats used as archival masters and those used for display. Artists are increasingly specifying that the high quality necessary for archiving also be achieved for the playback in the galleries. This has been made possible by recent developments in computer technology, enabling large uncompressed video files to be streamed.

**FILE FORMAT PRESERVATION STANDARDS**

Currently there is a lack of consensus regarding a file format for long-term preservation of high value video. The formats being used in 2012 were: Quicktime 10-bit uncompressed (four institutions), SAMMA MXF, JPEG2000 (two institutions) and AVI with uncompressed video (V210) (one institution). The other four institutions had no specific format for the preservation of video as files, either for standard definition or high definition.

Decisions about a suitable archival format were based on the file format being sustainable, mostly in terms of its adoption, disclosure, and transparency as defined by the Library of Congress (www.digitalpreservation.gov/formats/sustain/sustain.shtml).

There is a preference for uncompressed and widely supported formats with good documentation, such as Quicktime. The main drawback of Quicktime and the uncompressed codecs associated (Blackmagic uncom-

<table>
<thead>
<tr>
<th>Wrapper and codec (compression)</th>
<th>Number of institutions who referred them</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quicktime, DV</td>
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<tr>
<td>Quicktime, H.264 (as display format)</td>
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<td>Quicktime, Pro Res</td>
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<tr>
<td>MXF, JPEG2000</td>
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<tr>
<td>MPEG-4 (as display format)</td>
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</tr>
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<td>Flash</td>
<td>2</td>
</tr>
<tr>
<td>REDCODE RAW</td>
<td>1</td>
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<tr>
<td>AVI, V210</td>
<td>1</td>
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<tr>
<td>2K</td>
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<tr>
<td>DPX</td>
<td>1</td>
</tr>
<tr>
<td>Amateur</td>
<td>1</td>
</tr>
<tr>
<td>AVC Intra 100</td>
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</tr>
<tr>
<td>Quicktime, Pro Res HQ422 (HD)</td>
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<tr>
<td>Quicktime, TIF files</td>
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</tr>
</tbody>
</table>

*Table 3.*
pressed, for example) is the fact they are proprietary (JISC 2014), but given their wide user base, documentation and support in various platforms it becomes an acceptable risk.

However, all institutions noted that they were not happy with the formats they currently use; expressing the view that these were only temporary choices and that alternatives were badly needed. This situation has not changed since the survey was conducted.

In 2014 there is a growing interest in the use of open source formats, such as FFV1 within Matroska containers. This format is currently part of the Preforma project (http://www.preforma-project.eu) and is also linked to tools supporting the long-term preservation of video. For example, Archivematica, an open source tool for producing Archival Information Packages draws on the FFMPEG tool set and supports FFV1 as a normalization codec for archival video. The Austrian Mediathek has also been using FFV1 in an AVI container within their DVA Profession digitization tool, which they started developing in 2009.

Ten institutions mentioned the need to understand the production process to define what files they want to receive for preservation. Five institutions mentioned they prefer to transcode any files themselves, so as to control the quality of the transcoding. The requirements for production diverge from the requirements for archiving and it was widely recognized that there is often a need to support non-expert artists (or producers in the case of the IWM) to ensure the best possible masters could be supplied to a collecting institution.

The following quotes highlight a number of important points related to video preservation practice:

Normally we will ask for the original master or a clone of the original (if something is made on Apple Pro Res that is what we want). We feel we ought to be more competent at choosing the archival format than any donor. (Walsh 2014)

We sometimes need to reformat, for instance when codecs and containers are proprietary. As an example, an artist couple gave me an MTS file (MTS is a Sony format for consumer cameras, similar to a Handycam Digital8. It is a highly proprietary format that in 2012 needed the particular Sony software to open the file- that has since changed). I suggested that they save this file in a different file format, as this would be less harmful in the long-term. Many artists use video for documentation purposes and are not video artists as such; the mentioned artists just bought a camera, recorded and then needed to install the software that came with the camera. (Jarczyk 2014)

Transparency of the production process, documentation, openness of the codec and wrapper and archival best practices drive our acquisition policy. Whatever the artist considers the master should persist and we want to change nothing about the original file. Of course, sometimes we need to make changes such as when obsolescence requires us to transcode the file so that it will persist, but we still maintain the original. (Oleksik 2014)

These quotes address the importance of understanding and recording the production history of video artwork, specifically the master as supplied by the artist, which is widely viewed as significant in understanding the history of a work. It is also important for making key decisions regarding the choice of normalized formats and identifying any artifacts that might be visible in the video material. Creating a normalized format alongside the format supplied by the artist is not uncommon, but identifying a good option that supports all the characteristics of the original files, like color space or chroma subsampling can be challenging.

It is important to retain the files supplied by an artist or their representative in their original format, even if there is a policy to also produce a normalized version for preservation purposes. This is because it allows the possibility
of returning to the original files if any problems are detected in the normalized files at a later date, and it may also help to identify different versions of the same work.

METADATA

Metadata is one of the key issues for collection management and digital preservation. Metadata is essential to accomplish the basic functions of a repository, find the files needed, manage their storage, and plan for migration. There have been many developments in this field, mostly coming from the archive world, and three main standards are widely used by the archives community: Dublin Core, Preservation Metadata Implementation Strategies (PREMIS), and Metadata Encoding and Transmitting Standard (METS). These refer to descriptive, administrative, structural, and preservation metadata and METS refers specifically to the encoding of that metadata. For many types of digital files there are also standards for the technical metadata, but when asked in the interviews whether they had adopted a standard for the technical metadata of video files, none of the interviewees was doing so. Seven of the interviewees referred to using tools like Videospec, Mediainfo, or the media info tool in Streamclip to extract the metadata available within the files (see references for links to the tools).

At about the same time as the survey was taking place, one set of recommendations was published by the project Digitizing Contemporary Art (DCA), which expands the recommendations set forth in the Metadata Standards Framework from the National Library of New Zealand (2002). The DCA seems to be the first to attempt listing technical metadata required in the context of video art and digital preservation (Henriksen 2012).

Since 2011, when the second version of the Public Broadcasting Metadata Dictionary (PBCore) was released, the interest around this technical metadata schema has been growing. For example, compliancy with PBCore is mandatory for records in the American Archive (Rubin 2011). More problematic than extracting the technical metadata is to input it to collection management systems, a laborious manual process for all but two of the institutions. Given the number of files being created and copied it very quickly becomes impractical to manually input all the information recommended for the digital preservation of all the files. This is a core issue for all institutions, and a priority problem to be resolved, particularly in connection to developing a digital repository that takes advantage of greater automation. The solution will depend on the institutions’ pre-existing systems, and so it is likely that it will always have to be tailored to each individual institution.

Related to this is the question of how to ensure centralized access to metadata, with information coming from different parts of a workflow, be it from processes associated with ingest, or descriptive and tracking information from the collection management system or other databases. Even once metadata is entered into a database, it is still not easy to share it across different pre-existing components of the repositories.

KNOWLEDGE, SKILLS, AND TOOLS

A useful outcome of the survey was the identification of areas of knowledge interviewees felt they needed to deepen and skills they were lacking. The main knowledge gaps identified by most respondents related to the evolution of digital video technology, digital formats, digital preservation, and the digital systems that support all these strands. The particular areas referred to were:

- Migration and workflows
- Digital preservation
- Codecs, compression, and exhibition formats
- High Definition Video
- MXF
- Cloud storage
- Open source options
- Programming
- Conservation
- Copyright
This list reflects the work being done to establish new preservation workflows, the evolution in file formats, and changes in the production standards.

The interviewees were also asked to identify tools that they would like to have or see developed. Most tools were related to managing digital repositories, with requests for automated digital repositories, tools to handle metadata, automatic file quality control, and better tools to manage workflows. One point made by one respondent was that being able to find appropriate tools is as important as developing new tools. Institutions like the Library of Congress, projects like PrestoCentre or private companies like AVPreserve developed or are developing tools that are very useful, but it can be daunting to find, test, and implement all the different tools needed. Knowing who is using which tools and how they are being used would make the task easier. The creation of the centralized registry for preservation tools, Community Owned Digital Preservation Tool Registry (COPTR) is addressing this issue. The registry is the result of the collaboration between the Digital Curation Centre, Digital Curation Exchange, National Digital Stewardship Alliance, Open Planets Foundation and the Preserving Digital Objects with Restricted Resources project.

A good example of an institution’s strategy for keeping abreast of the technology evolutions is described in the following quote:

What we also do is to keep a permanent tech watch, so we see what new technologies appear. Every 5 years we make a serious survey and re-assess if there is something new that could help us in preservation but also for display and online presentation. We would for instance check what are the standards at museums, research institutes, EAI or ZKM. (Wijers 2012)

In this quote, Gaby Wijers points to the importance of keeping up to date with developments, and reflects on the need to do a thorough re-assessment, with the input from other institutions in the field. Changing the work environments for preservation can mean just adding a new tool to a workflow, but in the move from tape to file the disruption has been far more significant and has meant creating a whole new set of workflows. Given the specificities of the community and its small size, it is often easiest to contact people or institutions, which are at the forefront of testing new tools and systems. This issue was addressed by the project Presto4U, which worked with different communities of practice, for instance Fine Art Museums or Film Archives, to share the knowledge and experience in preserving video within those specific communities. The project finished in December 2014, but the information about the communities of practice was still available on their website in June 2015.

CONCLUSION

The preservation of digital video is a rapidly evolving field. There is no single source of information and those who are developing preservation plans need to look into current practice from the broader digital preservation community, video production, quality assessment, and developments in IT infrastructure and bit preservation in order to find suitable tools and strategies. Matching tools to needs involves producing a clear idea of the requirements for the preservation of digital video within a specific organizational context. This requires significant effort and time, which smaller institutions may struggle to find.

The staff involved in preservation is aware of the shortcomings of their current strategies and workflows and are actively working on making improvements; this is something that is best supported by establishing simple ways of sharing information and experiences through initiatives such as the Presto4U project. However there is also room for targeted training for this community in the development of workflows and the use of existing tools,
as the Open Planets Foundation is already doing for digital preservation in Archives and Libraries.

The question of a standard video format for preservation was the most requested area of development asked for from the respondents. FFV1 may be promising, however, wide adoption will be important to ensure that it continues to be supported, and this is difficult to predict. Hence rather than wait for consensus around a format for video preservation, which may in itself be unachievable, spreading the risk over at least two different formats and keeping a watch on the obsolescence risks for the formats in use may in fact be the most appropriate strategy. The issues with metadata standards sound easier to solve by combining different standards like Dublin Core and PREMIS which are already widely adopted in the digital preservation community.

It is encouraging to see the steady increase over the past ten years in the number of permanent staff dedicated to video or time-based media conservation. This indicates that collections are growing and that institutions are recognizing the need for specific knowledge and skills. There is also an increasing recognition of the importance of complementing this specific knowledge and skills with those of different fields, both from the digital preservation, video production, and IT communities.

This survey has provided a snapshot of the situation in 2012 as institutions address the challenge of moving from videotape to file-based production, delivery, and preservation of video artworks. In an area of rapid change it remains a dynamic and significant area of activity within the wider arena of digital preservation.

ACKNOWLEDGEMENTS
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The participants were:

**Matters in Media Art partners**
Kate Jennings, Time-based Media Conservator, Tate, London (currently at MoMA)
Peter Oleksik, Assistant Media Conservator, MoMA
Jill Sterret, Director of Collections and Conservation; Martina Haidvogl, Advanced Fellow in the Conservation of Contemporary Art, SFMoMA, San Francisco, CA and their collaborator Mark Hellar, Digital Media Consultant, Hellar Studios, LLC, San Francisco, CA.

**UK**
Roger McKinley, Research and Innovation Manager, FACT, Liverpool
David Walsh, Head of Digital Collections, Imperial War Museum, London

**Europe**
Gaby Wijers, Head of Collections & Conservation, Netherlands Media Art Institute, Amsterdam, Netherlands (currently at LIMA, Amsterdam)
Christoph Blase, Head of the Laboratory for Antiquated Video Systems, ZKM Center for Art and Media Karlsruhe, Karlsruhe, Germany
Agathe Jarczyk, Video Conservator, Atelier fuer Video-konservierung (Studio for Video Conservation), Bern, Switzerland

**United States**
Joanna Phillips, Associate Conservator of Contemporary Art, Solomon R. Guggenheim Museum, New York
Jonathan Furmanski, Associate Conservator, and Mary Kay Woods, Conservation Assistant, Getty Research Institute, Los Angeles
Sara Gordon, AV Technician; Jeff Martin, Time-based Media Conservator; Al Masino, Head of exhibitions; Gwynne Ryan, Sculpture Conservator, Hirshhorn Museum and Sculpture Garden, Washington DC
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EXPANDING INTO SHARED SPACES AT THE SAN FRANCISCO MUSEUM OF MODERN ART

MARTINA HAIDVOGL

ABSTRACT
Teamwork and communication between curators, technicians, registrars, and conservators are invaluable in the preservation of media art installations. Furthermore, engaging artists in these discussions may be among the greatest contributions contemporary art museums can make to the future care and legacy of these works of art. The San Francisco Museum of Modern Art has been committed to such interdepartmental collaborations for some time. With the expansion of the museum scheduled to open in 2016, two zones of physical working spaces have been conceived and designed to reflect, affirm, and advance these practices of staging, documenting, and conserving installations. A series of adjacent and shared spaces—a black box studio, a media conservation studio, and technical workrooms—can be seen as the architectural analog for the activities of expert teams of media conservators, exhibition technicians, curators, registrars, and artists. This article explains one museum’s response to the requirements of its rapidly growing media arts collection, its commitment to artists and rich interdisciplinary modes of operating, and how this culture will hopefully be served by the building’s architecture.

INTRODUCTION
The San Francisco Museum of Modern Art (SFMOMA) broke ground in June 2013 for its building expansion, which is being designed by the Nor-
With a commitment to art from the Bay Area and California in particular, SFMOMA has built significant collections in painting, sculpture, photography, prints, drawings, and artist books, architecture and design, and media arts. As one of the first US museums to embrace time-based media artworks, SFMOMA hosts a dynamic collection of over 200 media artworks that spans the history of the genre and includes a large variety of technologies, among them video and audio installations, computer and software based art, slide projections, films, and websites.

**ENGAGING MULTIPLE VOICES**

SFMOMA staff has long been committed to working collaboratively and interdepartmentally. In particular with media art installations, teamwork and communication have proven to be invaluable in the conservation, display and interpretation of complex, multi-part artworks. Even

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1. SFMOMA's collection of modern and contemporary art includes more than 29,000 artworks from both national and international artists and continues to grow steadily. Norwegian-American architecture firm Snøhetta and is slated for completion in early 2016. To house the museum's growing collection, SFMOMA is constructing an expanded building that will include approximately 325,000 sq. ft., with seven levels dedicated to diverse art experiences and programming spaces, and enhanced support areas for the museum's operations. The building will provide approximately 142,000 sq. ft. of indoor and outdoor gallery space, as well as nearly 15,000 sq. ft. of art-filled free-access public space. The design more than doubles SFMOMA's capacity for the presentation of art while also complying with San Francisco's Green Building Ordinance, one of the most rigorous sustainable building standards in the nation (fig. 1).
more, the museum is committed to enduring and trusted relationships with artists and to involving them in thoughtful dialog about their art. Engaging multiple voices is integral to SFMOMA’s working processes and these practices are manifest in a number of ways throughout the museum, from monthly Team Media meetings to exhibition planning as well as acquisitions research. These modes of operating prosper through multi-voice, documentary records. Curators, registrars, exhibition technicians, IT specialists, intellectual property managers, conservators, outside experts, and artists contribute to compiling a record for each work that includes the following essential components: a curatorial description, a technical narrative, installation documents and images, a statement of preservation requirements, existing artist interview transcripts, correspondence, exhibition and loan histories, and contracts. These records are seen as an organic and ever-growing source of information. SFMOMA’s approach to information management acknowledges that records relating to artists and their works will be revisited and expanded over time, as knowledge deepens through activities such as research, imaging, conservation, exhibition, and publication.

This collective of expert voices helps to address the many different aspects of the life of an artwork. Moments of actual exhibition and display might rank as the most important to address challenges and open questions and revisit them over time. Installing a work with the artist and maintaining it over the course of an exhibition is a rich and crucial opportunity serving its legacy.

**CREATING COLLABORATIVE SPACES**

With the expansion of the museum, SFMOMA staff members—who were directly engaged throughout the whole planning phase—began to explore the potential of extending the benefit of collaborative operating modes and multi-voice documentary records by designing and situating new functional spaces to support this work so critical to the preservation of contemporary art. This exploration also embraced the museum’s financial imperative to utilize costly urban real estate to its maximum efficiency. Two innovative zones serving the conservation, display, and interpretation of media arts emerged from these interdepartmental conversations (fig. 2):
1. A time based media workstation is situated within the conservation department, where five disciplines are represented: paintings, objects, photography, paper, and time-based media. Located on two consecutive floors, the conservation department is directly adjacent to staff offices on the 8th floor and accessible to the galleries on the 7th floor via the collections workroom. This workroom is a newly-conceived, 600 sq. ft. project room designed to function as a studio space for visiting artists, a conservation laboratory, an interview suite, and a classroom and meeting space for students, scholars, and staff.

2. On the lower level of the museum building, a series of five spaces have been located to accommodate staging, studying, and documenting installations, as well as object photography, image post-production, interviews, digitizing and migrating media, designing exhibition formats, equipment repair, and storage.

THE BLACK BOX STUDIO

Shared between the museum’s conservators, exhibition technicians, and photographers, a black box studio will provide ample space to serve two core activities of the museum’s program: staging installations for exhibition preparation, documentation or acquisition, and photographing works of art (fig. 3). With conditions designed to simulate the galleries, the black box studio will feature the following characteristics:

- It will measure 1120 sq. ft. with 12 ft. ceilings.
- A retractable, light-tight and acoustically-treated wood panel system will divide the space equally.
so that it can be used all of the time for photography on one side and for staging installations on the other. The retractable wall enables the occasional need for either activity to expand into the entire space.

- A man door and separate light switches on each side will allow both areas to operate independently.
- A roll-up door will be located on the photography department’s side to accommodate large objects.
- In either area, eight floor and three ceiling outlets on individual circuits will fulfill the power and data requirements for the anticipated activities. They will be isolated from the general building power.
- White walls and a movable grey curtain will accommodate flexible wall colorings for different needs.

A significant challenge awaits in terms of organizing the times of sharing the entire space. However, this room will maximize SFMOMA’s potential and provide a great opportunity for visual and in situ documentation, collaboration with artists, and therefore care of the museum’s collection.

THE MEDIA SUITE

The media suite was designed to actively support the established workflows for media conservators and exhibition technicians (fig. 4). The suite is comprised of three areas:

1. A time-based media conservation workroom, where treatment, condition reporting, digitization, quality control, digital editing, and encoding will take place.

![BASEMENT MEDIA SUITE ENLARGED FLOOR PLAN](image)

Fig. 4. SFMOMA expansion: basement floor plan. Detail: Media Suite. Courtesy of Snøhetta.
MarTina Haid Vogl

Figure 5 shows an overview of the whole basement, with the locations of the black box studio, the media suite, and a new and larger media storage room marked within the architectural floor plan.

CONCLUSION

All the spaces described are new to the expanded museum. With the media arts collection growing steadily, SFMOMA did not just grow out of its old building, the museum also needed new spaces that will accommodate collaborative ways of working with artists. Honoring interdisciplinary, multi-voice workflows, the areas have been designed and built for cross-departmental exchange. A culture of working together is thus manifest in our building’s architecture.

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NOTES
1. In 2009, the City of San Francisco implemented sustainable building codes that required every new large-scale commercial building or any major renovation to existing buildings over 25,000 sq. ft. to achieve Leadership in Energy and Environmental Design (LEED) Silver Certification, water reduction of 30%, and energy-cost reduction of 15% (San Francisco Building Inspection Commission 2008).

2. Formed in 1993, Team Media is a working group of experts from various departments throughout the museum dealing with media arts. Meetings occur monthly, with topics ranging from very current matters regarding the museum’s program to long-term preservation care questions of SFMOMA’s media arts collection.

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THE ROLE OF THE TECHNICAL NARRATIVE FOR PRESERVING NEW MEDIA ART

MARK HELLAR

In 2009, the San Francisco Museum of Modern Art (SFMoMA) initiated a project to develop a sustainable, long-term preservation strategy for software-based artworks. Two web-based artworks were examined for this research. The primary goal of the project was to migrate the works onto a virtual server environment. In preparation for the migration, a system was developed to document the operational requirements of the works.

The first work was Julia Scher’s (b. 1954) Predictive Engineering (1998, SFMoMA). This web-based artwork accompanies a large media installation and mirrors the formative years of HTML programming in the 1990s (fig. 1).

SFMoMA began to host online artworks soon after launching its website in 1995, with Predictive Engineering as its first commissioned web project. For Scher’s 1998 solo exhibition, she updated and reconfigured an earlier, site-specific multimedia installation, Predictive Engineering (1993) for the new museum building. She developed an online project to accompany and expand on this second iteration of the work.

The second work, Agent Ruby (2002, SFMoMA), was created by San Francisco-based artist Lynn Hershman Leeson (b.1941), a pioneer of media-based and con-
conceptual art. *Agent Ruby* is one of many female avatars conceived by Hershman as an expanded cinema experience of her film, *Teknolust* (2002). In *Agent Ruby*, a web-based chat agent has developed her persona by conversing with users online, which has influenced her memory and knowledge. Visitors to the website can engage *Agent Ruby* in a direct online dialogue. Hershman’s work features custom artificial intelligence software, embodied by an avatar that can talk back to viewers.

In 2013, Hershman explained the creation of *Agent Ruby* in relation to the film *Teknolust*,

> Around 1996 I had an idea to do an Internet bot that viralized and talked to people. No one understood the concept, so I wrote the film *Teknolust*, which, weird as it was, still was easier to grasp than *Agent Ruby*. So we got funded for the film and wrote into it this bot that appeared online, which is what gave birth to her (Leeson 2013).

While they were featured on the museum’s website in a specifically designed E-space (www.sfmoma.org/exhib_events/exhibitions/espace, accessed 04/25/15) none of these works officially entered the collection. In 2008 the museum acquired the two works as a statement about the intention to take on the job of proper handling, maintenance, and display of web-based artworks.

Each of these works offered a unique set of complexities. *Predictive Engineering* consisted of a number interlinked web pages, each containing an Adobe (previously Macromedia) Flash multimedia file object containing hundreds of animation layers images and sounds.
In the case of Agent Ruby, the work was composed of a complex set of software components and processes interacting with each other (fig. 2).

Users interact with Ruby's web-facing multimedia interface, which is served to the Internet via a web server and rendered in the user's browser. This dialog is sent and received by an artificially intelligent natural language processing program called Program D, which was written in the Java programming language. Program D matches user input against a set of possible responses, which Lynn's programmers created to reflect Ruby's personal-
An analysis of the current technology platform and an evaluation of its longevity against the current state of technology. Here we consider the long-term stability of the piece upon acquisition. It calls out strategies and concerns in preserving the work over the long term and informs ongoing conservation and maintenance protocols including possible strategies for migration or emulation.

The technical narrative is now a standard piece of documentation for all digital based artworks that are acquired by SFMoMA including video, audio, and software-based art. This presentation will describe the technical narrative in detail and the processes involved in its creation. Some real world examples from the documentation of software-based artworks and multi-channel video installations will be covered.

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CONSERVING CUSTOM ELECTRONIC VIDEO INSTRUMENTS

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ABSTRACT

Electronic video instruments are custom devices developed during the 1970s and 1980s that were used to make video art and other time-based media works. The devices include synthesizers, colorizers, keyers, sequencers, video capture devices, computer interfaces, and oscillators, to name a few. They may be modified commercial devices or machines built from scratch. This presentation will consider theories, guidelines, and practices within instrument conservation, industrial conservation, and time-based media conservation that are relevant to the conservation of machines. A central question is whether these machines can and should continue to be “worked” after they are collected. Also, the presentation looks at user and institutional efforts to save video instruments, as well as new instruments being developed for artists’ use.

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PERICLES AND PRESTO4U—TWO EUROPEAN FUNDED PROJECTS
PROGRESSING RESEARCH IN THE CONSERVATION OF DIGITAL ART

PIP LAURENSON

ABSTRACT
This paper aims to provide an overview of two European funded projects which will begin in early 2013, and which include the conservation of digital arts within their purview. The four-year project, Pericles (http://pericles-project.eu/), includes as one of its case studies the conservation of digital arts. The other project, Presto4U (http://www.tate.org.uk/about/projects/presto4u), focuses on video preservation and includes art museums and collections as one of its communities of practice. Both of these projects ask why previous research has had such small acceptance within the museum sector, specifically among those dealing with the conservation of digital arts. These projects aim to develop tools and methods that will help support the conservation of these works of art in our care. The author will describe the aims of these research projects, the importance of building partnerships and developing a common understanding and vocabulary with those working within digital humanities and the archive community, and how participation in this research is impacting approaches to the conservation of digital arts. The paper aims to develop alliances and dialogue between these research projects and those working in this area within the United States.

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THE LEGIBLE CITY—ONE ARTWORK, MULTIPLE EMBODIMENTS

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ABSTRACT

*The Legible City* (1989–1991) is one of the major works of the Australian media artist Jeffrey Shaw (b. 1944) and a milestone of 1990s interactive, computer-based new media art (computer-graphic installation, dimensions variable, ZKM | Center for Art and Media Karlsruhe). In this installation, the spectator rides a stationary bicycle in a dark room, experiencing a virtual journey through projected views of the cities of Manhattan, Amsterdam, and Karlsruhe. The real physical exertion on the bicycle is converted into the virtual distance covered. Since the beginning of his career, one of Jeffrey Shaw’s main preoccupations has been overcoming the traditional, institutionally laid-down distance between the artwork and the viewer. From the mid-1970s on, Shaw moved from sculptural to computer-based work, seeing the computer as a particularly efficient medium for his work since programmed software configurations could function as modules that could be adapted to create new artworks. Jeffrey Shaw’s *The Legible City* illuminates numerous problems specific to the emerging field of digital art preservation. On the one hand, the interactive installation is based on proprietary, i.e. work-specific and licensed, software. On the other hand, it uses obsolete hardware and custom-made components. Both factors contribute to the high cost of maintaining this work. By tracing the complex evolution of this artwork since its first presentation in 1989, this paper aims to illuminate the various strategies employed by the ZKM for the maintenance and
preservation of this installation over the course of the past twenty years. In his double capacity as artist and director of the ZKM | Institute for Visual Media from 1991 till 2003, Jeffrey Shaw carried out several changes to *The Legible City*. Since the creation of a 1988 prototype of the artwork—which could be interactively operated by a joystick—the interactive installation has undergone several technological modifications, partly owed to the artist’s desire to take advantage of enhanced software possibilities, and partly caused by the obsolescence of components. Since the artwork was acquired by the ZKM, the institution has adopted the strategy of hardware preservation for the conservation of the artwork. *The Legible City* is one of ten case studies in the European Union funded research project Digital Art Conservation (http://digitalartconservation.org), which took place from January 2010 to December 2012, and part of the traveling exhibition *Digital Art Works: The Challenges of Conservation*, held at the ZKM from October 29, 2011 to February 12, 2012. As part of the case study, an in-depth retrospective documentation of the different stages of alteration of the work was carried out for the first time, with the aim to formulate recommendations for the long-term preservation of this artwork with regard to its authenticity and integrity. In addition, in dialogue with the artist, a porting of the software was carried out. This paper will examine the measures undertaken over the course of the installation’s twenty-year history as well as this most recent undertaking.

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WRANGLING ELECTRICITY: LESSONS LEARNED FROM THE MASS MIGRATION OF ANALOG AND DIGITAL MEDIA FOR PRESERVATION AND EXHIBITION

PETER OLESIK

ABSTRACT
In 2011, the Museum of Modern Art (MoMA) began a process of making its extensive video art collection of over 1500 works available to the public through an installation of interactive monitors in the galleries. With a collection that spans the history of independent video production, the project was especially urgent because of video degradation in some of the early works, technology obsolescence, and the availability of some of the original artists. To facilitate the project, an in-house transfer and monitoring station was established at the museum. Numerous systems were developed for transport, in-house migration, metadata capture, working with artists, and outsourcing some of the migration. Now with over half the material migrated and the launch of MoMA’s media lounge in February 2012, a large body of information has been collected that helps inform best practices in migrating and managing video art. This presentation will detail the project workflow that was formulated in collaboration with MoMA’s media conservators, curators, registrars, audiovisual staff, and IT department. Special attention will be paid to the question of in-house migration vs. vending out to specialized transfer houses. Examples will be drawn from the project to illustrate challenges in migrating analog and digital material and the impact of performing migration and other media conservation work within the museum. Whether one is dealing with one analog source or 100,000, this presentation will hopefully further the discussion on the conservation of analog and digital moving image material.
MAGNETIC MEDIA AT MOMA

Founded in 1929, the Museum of Modern Art is “dedicated to helping people understand and enjoy the visual arts of our time” (MoMA 2015). While originally tasked with collecting and exhibiting traditional art forms of painting, drawing, and sculpture, the museum quickly realized that it needed to both collect and exhibit what many saw as “the” art form of the 21st century—the moving image. Responding to this in 1935, the Film Library was established and the first film exhibition program was exhibited in 1939 when the museum opened its permanent home on 53rd Street in Manhattan. At the same time, the first film curator at the museum, Iris Barry, began actively acquiring film into the museum’s collection, which now contains over 25,000 titles.

As new moving image technologies were being utilized by artists, the museum kept pace with the exhibition and acquisition of these emerging art forms. In 1968, the exhibition The Machine Seen at the End of the Mechanical Age opened at MoMA and is seen largely as the beginning of video entering the museum’s purview. This marked the first time that video was present in the gallery, namely Nam June Paik’s (1932-2006) Nixon Tapes (1965), McLuhan Caged (1968), and Lindsay Tape (1967). This landmark exhibition was followed by another Manhattan exhibition in 1971 at the Howard Wise Gallery, TV as a Creative Medium, which was the first exhibition in New York City dedicated solely to works created for television and video (Electronic Arts Intermix 2015).

Concurrent to the Wise Gallery exhibition, curator Barbara London was working in MoMA’s Department of Prints and Illustrated Books. Barbara was focusing on artist’s books that were cheap, mass-produced material, which fit into the same curatorial context as The Machine Seen at the End of the Mechanical Age, drawing largely from Walter Benjamin’s theoretical work on art and mechanical reproduction. In 1973, London took advantage of a National Endowment of the Arts grant that was awarded to the museum to purchase a video deck and two monitors and began exhibiting early video works by Paik, Lynda Benglis (b. 1941), and others (Cook 2001). In 1974, the museum dedicated a specific Projects gallery to the presentation of video art and continued this interest in video by starting the lecture series Video Viewpoints in 1977. Largely spear-headed by London, the museum began to actively acquire video artworks into its collection as a result of exhibitions both in the Projects gallery and programs for Video Viewpoints in the newly rechristened Department of Film and Video in 1980. London would continue to build the collection over the next decades, creating a significant permanent collection containing over 1,500 landmark works.

In 2006, the museum recognized the growing trend towards both analog and digital media works and established a new curatorial department to respond to these newly emerging forms, the Department of Media and Performance Art (MPA). As a result of this, the video material that was housed within the Film and Video Department was branched off and now constituted the bulk of this newly formed curatorial department’s collection. Klaus Biesenbach, the first chief curator of the MPA department, began to build the collection by acquiring more installation-based media works. When Mr. Biesenbach left this position to become the chief curator of MoMA PS1, Sabine Breitwieser was appointed chief curator with a goal to continue building and contextualizing the fledgling department’s collection. In 2010, Breitwieser made it one of her missions to “...draw a more complete narrative of media and performance art through its representation in videos and photographs in MoMA’s collection and exhibitions” (Breitwieser 2012). Recognizing the fact that MoMA’s collection of over 1,500 single-channel pieces was only accessible to the public either in gallery rotations or on request within the Media and Performance Art department’s Study Center, the idea was hatched to make this material available to the general public “to hand the curatorial power over to the audience” (Breitwieser 2012).
Each video booth or viewing space utilized Dotronix DNR Series 27 in. Cathode Ray Tube (CRT) monitors to display the video, with a custom-designed Apple iPad interface (fig. 2). The interface contained curatorial information about the works in the collection and allowed the user to browse either the entirety of the collection or specially curated sections that were assembled from different themes presented by curators, artists, or scholars.

**MIGRATION OF ANALOG MATERIAL**
A critical component allowing the media lounge initiative to function was the mass migration of original analog material to a digital preservation file and, subsequently, an access derivative for the public to view. In 2006, Glenn Wharton joined MoMA’s conservation department to focus on the time-based media in the collection and survey it for conservation needs. A result of Wharton’s survey was an awareness of the increasing risk of video and audio technological obsolescence, which increas-
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The best practice for the preservation of analog video material is migration to a new signal carrier. In the past, this was accomplished by migrating the original analog tape to a newer, higher resolution format. MoMA’s collection was largely cared for in this manner throughout the 1980s and 1990s by migrating U-matic tapes to one inch tape, for example. U-matic tape has an inherent resolution of approximately 250 lines and migrating it to one inch, which has a resolution of over 300 lines, allows for the entirety of the signal to be preserved on this new analog format (resolution in analog video is measured by the height of the picture). However, inherent to this process is the inevitable signal loss caused by analog copying. The signal loses a bit of its strength every time it gets copied from format to format, due to the loss of electrical impulses. This loss was mitigated as new technologies emerged and effectively diminished with the introduction of digital tape formats such as the Digital Betacam. Digital Betacam converts the analog video signal to a digital data stream, which does not suffer from the same generational loss that analog video does.

Fig. 2. Media Lounge iPad interface, 2012. Courtesy of MoMA.
As technology has progressed and analog tape formats have become partially or completely obsolete, the current best conservation action for original analog material is to migrate the signal to a digital file format for long-term preservation. This allows the material to be captured without any generational loss and for the entirety of the signal to be preserved in a digital format. The best practice for digital migration of analog material is to apply little-to-no compression to the original signal, known as a lossless encoding process. For analog, standard definition material, all of the signal characteristics can be effectively captured faithfully by encoding the video signal to with no compression and a bit depth of 10 (also known as uncompressed, 10-bit) and the audio signals to pulse-code modulated (PCM) audio at a sample rate of 48Khz and a bit-depth of 16. MoMA has adopted this conservation strategy for its analog video material.

**DIGITIZATION WORKFLOW**

Starting in 2011, work began on the large-scale preservation of the single-channel video works within the Media and Performance Art collection. Working closely with DuArt, a film and video post-production facility in New York City, Glenn Wharton began planning to systematically assess and migrate over 1,500 works in the collection. Maurice Schechter, Preservation Engineer at DuArt, assisted greatly in designing the workflow of the migration process and lent his significant experience and knowledge to the endeavor.

Since the collection spans nearly the entire history of video art, many, if not all, video formats are present in the collection. In addition, many different formats may be present for a single piece. The need to assess each iteration, or format, of the work before migration was deemed critical to get as close to what the artist considered the master. This is specifically important as subsequent generations of a piece would exhibit degradation and signal loss, not only from possible wear and tear on the tapes, but also because of the loss inherent in analog migration. This generational loss and degradation becomes a part of the signal the further away you get from the master. These visual and aural anomalies could be misidentified as part of the work. To allow MoMA’s conservation team to properly assess each videotape, Schechter and the other engineers at DuArt designed and installed a video assessment workstation at MoMA (fig. 3). This station consisted of the following:

![Fig. 3. Media Conservation Assessment Station, 2012. Courtesy of MoMA.](image-url)
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- Apple Mac Pro computer
- Blackmagic Multibridge
- Blackmagic Digital Scopes
- Tektronix 1620/1630 Waveform monitor and vectorscope
- SDI, component, and composite PAL/NTSC Sony CRT Monitor
- Genelec 8020b audio monitors
- J-30 Digital Betacam deck
- Sony U-matic Deck
- Samsung multi-standard VHS deck
- Pioneer Laserdisc deck
- DVD deck

It was necessary to hire an assistant media conservator to manage the migration process and perform all of the necessary assessments. The assistant media conservator (full disclosure, the author of this paper) brought on had a background in video engineering and system design and integration. This background and familiarity with both analog and digital video characteristics was critical in the proper assessment and management of the digitization process.

In conversation with the curatorial, conservation, and registrar departments, a workflow was devised for the project to allow for the systematic assessment and migration of the single-channel video works in the collection, as well as a timeline to populate the media lounge interface.

**STEPS OF THE WORKFLOW**

To begin the migration process, the curatorial department began researching each work in the collection to determine how, and how accurately, this material was catalogued, whether any preservation work had been already carried out by the artist or gallery, as well as determining the rights held by the museum in terms of exhibiting the work. It was determined that a new non-exclusive license (NEL) from each artist represented in the collection was needed to allow for the digital migration of their original analog video material. As most of this material was acquired well before the technology and methodology existed for this type of conservation action, this new license was necessary to both conserve and exhibit the work in a digital form.

The returning NEL agreements from the artists dictated the priorities for the migration workflow. Because the entire collection was targeted for migration, no other priorities were considered. Once a significant amount of NELs arrived to the curatorial department and the catalogue records were updated, a list of initial works was built for shipment to media conservation. All video material was stored off-site at MoMA's Celeste Bartos Film Preservation Center in Hamlin, PA, which necessitated batches of tapes to be called in at one time. The Film Preservation Center is geared towards the long term storage and preservation of both film and magnetic media material, with an HVAC system that is regulated to each format's preservation needs. All of the magnetic material is stored in vaults at a temperature of 60 degrees Fahrenheit with a relative humidity of 30%, which aligns with the ISO standard for the storage of magnetic media (Bigourdan 2012, 7). While the collection constitutes approximately 1,500 works, this equates to roughly 5,000–6,000 total tapes. The conservation and curatorial departments determined that about 200 tapes at a time could be safely called in to be assessed and sent out for migration.

The registrar department coordinated the shipment of the material to media conservation on a climate-controlled truck. This material was then unpacked and sorted by conservation at MoMA's offsite storage in Queens, NY. Each tape was labeled and sorted to get an accurate picture of each work. For example, Laurie Anderson’s (b. 1947) *Sharky’s Day* (1983) was present in the collection on five U-matic tapes, each with an unknown provenance. These were all re-labeled according to the museum’s revised cataloguing system and the catalogue entries edited if there were discrepancies between the record and the actual tape format. These multiple tapes were then assessed and viewed to determine the highest...
WRANGLING ELECTRICITY: LESSONS LEARNED FROM THE MASS MIGRATION OF ANALOG AND DIGITAL MEDIA FOR PRESERVATION AND EXHIBITION

In analog media migration, as there is far less latitude in the digital realm versus the analog realm, so any luminance, chrominance, or audio information that was either above or below the acceptable limits of the analog to digital converter were adjusted using a processing amplifier. This was all documented within the actual digital video stream using a calibration tape that DuArt developed for MoMA (fig. 4). To observe and document the changes, MoMA uses their own copy of the tape to compare that signal with the signal on the transferred digital file. All adjustments to the transfer (raising or lowering the luminance and black, adjusting the phase and hue, etc.) can be seen and quantified by this comparison (fig. 5) and

In the workflow discussion with DuArt, it was determined that they could accommodate two tapes from each work to determine the best possible source for migration. In the case where the museum had multiple tapes (often in multiple formats) of a work, each tape was viewed to determine which two would be best to send to migrate. However, when works consisted of formats that we could not pre-assess (mainly one inch open-reel), conservation would use descriptive metadata on the containers (such as labels, markings, etc.) to try and determine the best source to send for transfer.

At DuArt, the tapes were then viewed again by the experienced eyes of video engineers Maurice Schechter and Erik Piil, to compare visual quality. In conversation with MoMA, DuArt would make a decision on which tape to migrate. During the migration process, DuArt would perform “full set-up” for each tape. This consists of calibrating all equipment used in the signal path prior to migration using SMPTE reference bars and a 1 kHz tone. Once calibrated, the tape being migrated would be inserted into the deck and adjustments would be made to bring the tape within legal limits to prevent any signal loss during the digitization process. This is a critical step in analog media migration, as there is far less latitude in the digital realm versus the analog realm, so any luminance, chrominance, or audio information that was either above or below the acceptable limits of the analog to digital converter were adjusted using a processing amplifier.

Once the tape was assessed and determined to be in good condition for playback, it was inserted into the proper deck and assessed visually. If any damaged was noticed during this inspection, it was flagged for further conservation treatment. As of this writing, zero tapes exhibited any damaged or necessitated treatment.

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then documented in a written conservation report, which is filed in MoMA’s artwork records.

Once the preservation file was created on DuArt’s local hard drive, an MD5 checksum value was generated to track the fixity of the file after copying onto external hard drives for delivery to MoMA. A Digital Betacam was also generated from this file as a protection element, so that two copies of the preservation master were created. The Digital Betacam data stream is equivalent to the uncompressed, 10-bit nature of the digital video stream so it is a 1:1 copy (Poyton 2003). Upon completion of a batch of tapes, DuArt would retain the original material on-site while MoMA’s media conservators were able to assess each file and confirm that the migration process was accurate and true to the original source material. If any discrepancies were noticed in the transfer on MoMA’s side, the tape would be re-assessed by DuArt and re-transferred if necessary.

MoMA’s conservation assessment was two-fold once the analog material had been migrated. First, the assistant media conservator would confirm the fixity of each file by matching the checksum value that was created for the file. The file’s characterization metadata was confirmed using MediaInfo software to ensure that the digital video and audio streams were encoded properly according to the collection policy specifications. After these processes were run and confirmed manually, the file was then watched in its entirety, played back via Apple Final Cut Pro 7 on a calibrated CRT monitor, while monitoring the signal levels on both analog and digital oscilloscopes to make sure the signal was captured faithfully and no digital clipping or loss occurred during the process. Any visual or digital anomalies or errors were noted by conservation and either confirmed to be inherent to the piece or required further investigation to determine the origin of the error and any possible corrections or re-transferring needed.

The second critical assessment was performed by media conservation with Barbara London, who was responsible for the original acquisition of a large portion of the collection. This assessment was completed to both confirm that the transfer was done accurately and to add any contextual or curatorial information to the artwork files to further document the provenance, visual characteristics, and any other relevant information that could be useful to the collection in the future.

All of this information was gathered and entered into The Museum System (TMS), which is the museum’s cataloging and database software for the collection. Different surveys were populated in three categories:

1. Conservation assessment: Where any visual or technical characteristics of the work were recorded.
2. Migration: Documented who performed the transfer and the signal chain used for each transfer, noting the make, model, and serial number of each piece of equipment used in the transfer.
3. Curatorial: Any information gathered from viewing the piece with a member of the curatorial department, specifically Barbara London.

IN-HOUSE TRANSFERS AND DERIVATIVE CREATION

Shortly into the migration process described above, it was realized that this workflow could not be sustained financially and within the timeline of the exhibition. However, it became clear that with a relatively small investment in additional video equipment, transfers could be performed on-site at MoMA by media conservation. It was agreed upon to purchase a Leitch DPS-290 time-based corrector, a BVU-950 U-matic deck, and a DVW-A500a Digital Betacam deck (fig. 6). These three pieces of equipment, when installed into the system that DuArt had originally designed for MoMA, allowed the museum to perform its own migration of analog material. The project was then readjusted to focus on sending to DuArt only material that fell outside of the technical capabilities of this new transfer station, mainly open-reel video formats and any material recorded in the PAL format.
As the installation of the Media Lounge exhibition drew near, the focus shifted to creating the exhibition files for each piece that would be exhibited in the first iteration of the Lounge. Working with the Manhattan-based firm 3Byte, who designed the user interface for the Lounge, the exhibition files had to fit within the technical capabilities of both the iPad interface and the media players that would stream files to the monitor, as well as the IT infrastructure of the museum. Because the system had to allow for up to eight streams of data to be played back at any given time, a suitable compression codec and data rate had to found that would faithfully reflect the artwork while also allowing for a flawless exhibition.

Numerous tests were conducted with various players and it was decided that an H.264 compression with a data rate of 8 Mbps was suitable for the parameters of the equipment and was visually comparable to the original material for exhibition. All of the preservation masters were then manually prepared by media conservation, sometimes requiring that bars, production slates, or any other superfluous material either before or after the tape was removed. These were then batch compressed using the compressor software and encoded using a Matrox hardware encoder PCI card to allow for a significantly shorter encode time, coupled with the benefits of a more agile encoding algorithm. All of the exhibition files generated were kept in their original standard, frame rate, resolution, and scanning method.

CONCLUSION
As of this writing, the digitization of the single-channel artworks is nearly complete with over 1,400 works digitized and documented. The level of access this project allowed has not only provided the public with the ability to look at an enormous collection of video art, but has also brought a new curatorial interest to exhibiting this material throughout the museum. Because this content
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is now easily accessible for curatorial consideration, new connections can be made, and exhibitions now regularly incorporate this material when before it would have been cost prohibitive to do so.

A significant result of this migration process has been the increased technical capabilities that media conservation now has at its disposal. This has resulted in an increased commitment to the digitization of analog magnetic media material that originally fell outside of the initial digitization initiative. In addition, because of the storage requirements necessitated by the generation of terabytes of digital collections, a trusted digital repository is currently in development to house and monitor this precious material.

Finally, the most positive outcome of this project has been the complete digitization of the museum’s single-channel analog video material. This has allowed the material to be assessed and conserved properly, which has made the museum’s significant collection secure for future researchers, curators, and the public to experience.

REFERENCES


PRESERVATION AND RESTORATION OF PHOTOGRAPHIC AND AUDIOVISUAL MATERIALS AFTER LARGE-SCALE DISASTERS

FENNA YOLA TYKWER

ABSTRACT

After the collapse of the Historical Archive building in Cologne in 2009, after which about 90% of the holdings were either resting beneath a mountain of rubble or among debris found in an underground railway shaft outside the building, a number of problems arose. More than five hundred thousand photographic and five thousand audiovisual objects were among the salvaged holdings. Each item was in need of a thorough cleaning and adequate repackaging, and, in many cases, additional conservation intervention will be needed. It is estimated that all in all, more than six thousand years will be necessary for conservation alone. Therefore, processes for the mass treatment and restoration of these materials, as well as an exchange of experiences in terms of how this is achieved will be needed, and will be discussed here. The general workflow distinguishes between a first phase of basic conservation measures that can be taken with all items, regardless of catalog number or other criteria. Later on, more sophisticated and costly restoration processes will be prioritized with respect to collections, the individual value of the object in question, and the availability of sponsorship. The presentation looks at the perspectives for the work in a newly organized studio for conservation and restoration of photographic and audiovisual materials at the branch Office in Wermsdorf, Germany. Apart from normal processes of conservation and restoration, the possibilities of reuniting negatives and damaged photographs will be presented and different ways of re-using...
these negatives will be shown. The presentation will also address the possibilities and problems of co-operation with other institutions to make use of available records—in the case of live recordings—from other archives.

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I KNOW A GUY: COLLECTING TECHNICAL DOCUMENTATION—LOCALLY

STEVEN VILLEREAL

ABSTRACT
In determining which materials can be responsibly digitized in-house, open reel video formats are frequently written off as too problematic to tackle and so remain in the purview of specialized vendors. In many cases this assumption is absolutely correct—scarcity of functioning playback equipment and the technical skills to operate it are logical deterrents. Here we take an alternate tack; we focus on collecting technical knowledge and equipment, and we document period production practices, keeping an eye towards in-house reformatting. The proposed case study is a collection of 1-in. IVC (International Video Corporation) video, salvaged by a former employee of Charlottesville, Virginia’s early local origination cable station. Through contact with former station staff, we have sought to document the technical and production expertise needed to understand how equipment was operated and how tapes were produced. This outreach work has helped us to acquire rare playback equipment, while also putting us in contact with video engineers conversant with this archaic 1-in. format.

INTRODUCTION
As cultural heritage institutions have recognized the urgency of migrating rare and unique analog video content from unstable carriers, many have begun to establish facilities for in-house reformatting. The Preservation Services Department
at the University of Virginia Library, Charlottesville, has in recent years targeted audiovisual preservation as a critical area in which to expand our work, establishing reformatting labs for our most commonly held audio and video formats. Our initial estimation of what was worthwhile, cost-effective, and technically feasible to transfer in our video preservation lab focused on cassette-based formats. However, in creating more granular inventories of our legacy audiovisual holdings we have begun to find some rare early video formats. Here the focus is on the 1-in. IVC content comprising the Jefferson Cable Corporation collection, which led us down the unlikely path of carrying out our own digitization work of this open reel format.

In 2002, a curator in The Albert and Shirley Small Special Collections Library at the University of Virginia was approached by former station employee Steve Ashby. He had salvaged approximately three hundred 1-in. IVC tapes from the Jefferson Cable studios in Charlottesville shortly before they were gutted and sold to another cable conglomerate. He hoped to donate these tapes to the library. The tapes were accessioned by Special Collections and moved into off-site storage, though the lack of specialized audiovisual conservation staff meant that they received minimal attention. Perhaps more critical, these tapes became divorced from the context in which they were created as very little background information about the people who produced the tapes and the equipment they used was collected at the time of acquisition.

THE JEFFERSON CABLE CORPORATION
The Jefferson Cable Corporation was founded by Robert Monroe (1915–1995) in 1963 to serve Charlottesville as well as Waynesboro, Virginia, 40 miles to the west over the Blue Ridge Mountains (Stockton 1989). Monroe had an extensive radio production background, moved into managing radio stations in North Carolina and Virginia, and became intrigued by the developing market for cable television systems. Monroe is an unusual figure in that his passion outside of broadcasting was the exploration of human consciousness—he popularized the term “out of body experience” and experimented extensively with attempting to alter brain patterns via sound. He would go on to sell the station in 1973, founding The Monroe Institute in nearby Nelson County, Virginia to focus full time on such research.

As in other areas where topographical variation limited the ability to reliably receive broadcast television signals, this early community antenna system gained a healthy pool of subscribers. We know their customer base exceeded 3,500 subscribers at the time of the Federal Communications Commission’s (FCC) 1969 ruling that cable stations of this size would be required to provide some locally originating programming, rather than simply aggregating the content of other stations. Production of local origination content began in Charlottesville in 1970 with the launch of the station WJCC 11. It is this locally produced television content that is found on the Jefferson Cable Corporation tapes acquired by the University of Virginia’s Library.

A TRIP TO THE BASEMENT
I first became aware of this collection in 2012 during the renovation of our Library’s off-site storage facility. Shortly after I began to work with the materials I arranged to meet collection donor Steve Ashby. I was extremely intrigued to hear that, in addition to salvaging the tape library, he also had been allowed to take the station’s three IVC-800 decks that had been used to produce these tapes. This prompted an expedition to the basement of Ashby’s home, where the equipment had been stored since he had rescued it. Two of the IVC decks did not function, but one of them powered up and we were able to play tapes, albeit with some major transport and picture issues. When Ashby had originally offered the Jefferson Cable collection to the library there was no interest in the accompanying hardware. However, the prospect of the University’s own functional IVC deck, with which we could preview and hopefully digitize content, redoubled my curiosity about this collection.
1-IN. IVC AS A FORMAT
Originally launched in 1968, the International Video Corporation targeted the industrial and education market, offering a way to meet FCC broadcast standards on a budget. In terms of the type of content it engendered, 1-in. IVC can be seen as occupying a space between 2-in. quadruplex and early ½-in video. This format was introduced before the creation of the Electronic Industries Association of Japan (EIAJ) standard for ½-in video and was seen as a step forward for interchangeability, as tapes were playable between IVC decks, unlike many contemporary ½-in machines.

Like its main 1-in competitor format Ampex Type-A, IVC machines used a 360° alpha wrap to provide a reasonable balance between tape speed, runtime of a reel, and the bandwidth it offered. As in Type-A recordings, this results in a small signal gap at the point where tape is entering and leaving the scanner assembly (fig. 1). During playback, the visibility of this signal gap can be minimized by adjusting a tracking knob. However, as the sync signal is adjacent to this gap, operators frequently have to strike a balance between the visibility of this gap in the picture and acceptable signal stability during playback.

The type of IVC decks used by Jefferson Cable were the first non-quadruplex format to support the direct color system, and advertised the capability of recording full NTSC color information without resorting to a color subcarrier (Leman and Eldridge 1968). However, faithful rendering of this information was dependent on tape transport functioning perfectly—some initial playback tests with archival tapes have shown difficulties with color lock. It is debatable how successfully IVC implemented direct color, perhaps an example of the disparity between stated technical capabilities and actual performance in the field (Redlich 2001).

KEEPING IT LOCAL
Ashby was able to put me in contact with many former employees of the WJCC 11 station, and I was fortunate to attend a reunion of Jefferson Cable staff in the summer of 2012. I was also introduced to the station’s former video engineer Larry Ritchie. He had been my original contact for diagnosing the semi-functional IVC-800, and he helped me document some of the modifications that had been made to this equipment. These included the addition of an expansion board that allowed for a heterodyne system output as an alternative to direct color. Ritchie showed initial interest in carrying out the intensive work.
required to refurbish the IVC-800, but eventually declined. Through the invaluable advice of my colleague Erik Piil, I learned that engineer Maurice Schechter of DuArt Restoration in New York City had recently rebuilt an IVC-800. He graciously took on this project and, with spare parts from the two non-functioning machines, was able to get the deck running such that it may be used to carry out preservation transfers.

My goal in reestablishing local contacts is to begin creating quasi-ethnographic documentation of the station’s production environment and technical practices. While manuals and production literature inform us about legacy technologies, they don’t tell us how technology was actually implemented and deployed. My broader research on this front is ongoing, with the hope of documenting not just the technical but also some of the cultural environment of this early cable system. Local origination programming represents some of the first vernacular television, and I hope this research can help serve to supplement the existing historical record of early cable culture.

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CREATING A PRESERVATION AND ACCESS FRAMEWORK FOR DIGITAL ART OBJECTS

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ABSTRACT
In February of 2013, with the support of the National Endowment for the Humanities, Cornell University Library and the Cornell Society for the Humanities began a 2-year project to develop a preservation and access framework for complex, interactive born-digital media art objects. The test collection for this project comes from the Rose Goldsen Archive of New Media Art, part of the Library’s Division of Rare and Manuscript Collections, and includes more than 300 interactive born-digital artworks created for CD-ROM and DVD-ROM optical media, and web distribution. Though vitally important to understanding the development of media art and aesthetics over the past two decades, these materials are at serious risk of degradation or obsolescence. Many date back to the early 1990s, and are currently unreadable without legacy computers and software. The project’s goals are to create preservation frameworks, workflows, and access strategies that will be scalable and transferrable to other kinds of complex digital collections, yet grounded in a thorough understanding of media art researchers’ needs and priorities. This paper describes some major findings of the project so far, focusing on disk imaging practices, investigation of emulation environments, and survey of users of media art archives.

BACKGROUND OF THE TEST COLLECTION
Though we anticipate that our findings will be of value to other kinds of complex digital media collections, this project focuses on interactive born-digital artworks in the Rose Goldsen Archive of New Media Art. As a research archive located in...
the special collections unit of a major academic library, the Goldsen Archive was founded with a clear mission to offer the broadest possible access to artworks and documents of their historical contexts, for research and teaching purposes. The Goldsen collections now include extensive holdings of analog videotape in various formats, paper archives from major media art foundations, exhibition catalogues, monographs, and ephemera, in addition to the interactive born-digital materials that comprise the test collection for our preservation project. The test collection includes artworks created for personal computers as well as interactive small screen adaptations of installation works, research compendia of the works of major media artists, and offline versions of artworks created for web distribution.

NATURE AND SIGNIFICANCE OF THE ARTWORKS

Even before the advent of advanced, high-bandwidth digital networks, the interactive, multimedia, nonlinear capabilities of digital media technologies made them an attractive medium for artistic expression. Yet the same elements that make such works so rich aesthetically also make them complex to preserve—far more so than assets that adhere to a uniform digital file type. An interactive digital work usually comprises an entire range of digital objects, each with their own risks and dependencies; these may include media files, applications to coordinate between them, operating systems to run the applications, hardware on which to mount the operating systems. If any part of this complex system fails, the entire asset can become unreadable.

As an example of the complexity of the works in our test collection, consider Norie Neumark’s (b. 1947) *Shock in the Ear* (1998, CD-ROM). Created for small-screen individual interaction, this artwork engages all the senses of the user as they navigate through stories, painterly visuals (by Maria Miranda, b. 1956), and immersive soundscapes. The screen’s responsiveness to cursor movements offers the user some degree of agency in orchestrating their own experience. At the same time, the work invokes two notable modes of arbitrariness: first, in the algorithmically random appearance of sequences from different storylines, and second, in the occasional imposition of waiting periods on a user before they may advance to a new screen, which obliges the user to experience the work at a circumscribed pace. Challenging the presumptions of productive clicking or rapid surfing from one link to the next, *Shock in the Ear* slows down the motions to better engage the user in a contemplative experience. These techniques enable Neumark to explore thematic concepts of trauma, dislocation, and the eerie calm after the shock of traumatic experience—a calm that is shattered when memories of trauma present themselves once more.

Access to such artworks is necessary for an appropriately nuanced understanding of contemporary media art history. The Goldsen Archive’s complex born-digital holdings span 20 crucial years of development of such interactive interfaces, from about 1993 to the present day. At the start of our grant project, however, approximately seventy percent of the CD-ROM artworks in the Goldsen collection could not be viewed at all without access to now-obsolete hardware and operating systems.

THE PRESERVATION WORKFLOW

Preserving these artworks can be viewed as two separate, yet interconnected, actions. The first action is preserving data from the work’s original storage media. The second action is preserving (or restoring) access to the work, which may include running the original software (or viewing the work’s original files) on an emulated or virtual machine set up to match the work’s stated system requirements. These actions are interrelated, because the method of data transfer can directly affect the ability to provide proper access to the work.

The most time-sensitive action in our preservation workflow was migration of the data from optical media to more stable storage media. CD-ROMs are inherently fragile: the lifespan of a prerecorded CD-ROM is dependent
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on multiple factors, including environmental conditions of storage and handling and even the original manufacturing process (Shahani et al., 2009). While many of the CDs in the Goldsen collection fall into this category and are pressed silver CDs, a significant number are burned retail CD-Rs, which may be even more fragile and susceptible to decay than silver CDs. Leaving the works in their original form—or even making additional copies on the same type of media—was not a viable or sustainable plan for long-term preservation.

The OCLC report You’ve Got to Walk Before You Can Run: First Steps for Managing Born-Digital Content Received on Physical Media (Erway 2012) outlines two distinct strategies for migrating data from fragile media. The first method is to copy files from the source to a suitable destination (for long-term storage); the second is to create a sector-by-sector image of the source media. Our initial review of the stated system requirements for works in our test collection immediately indicated that the first strategy—simply copying files—would not adequately capture the data we would need in order to support restoration of access by emulators or virtual machines. Many works in the collection were compatible on both Apple and Microsoft Windows operating systems. Subsequent analysis confirmed that these discs supported multiple file systems concurrently. From a user’s perspective, this means that when viewing the work on a PC running Windows, one subset of the disc’s total files would be visible, and when viewing the work on an Apple computer, another slightly different subset of the disc’s total files would be visible. In either case, making logical copies of the source media would result in an incomplete representation of the original source material, since only one file system’s representation of the files could be copied at a time. Sector-by-sector imaging of source media is the only transfer method that captures the full structure of the original disc, including all supported file systems present on that disc.

We evaluated a number of different disk imaging programs to determine which was most suitable for our collection. We evaluated only those tools that would generate a sector-by-sector image of the original optical disc. In the end, we opted to make disk images of data-only CD-ROMs (which constitute the majority of our collection) using Guymager forensic imager, and the Microsoft Windows-based tool IsoBuster for more complex discs that have multiple sessions or include both data- and audio-reader formatted content. The Guymager software automatically writes out an extensive log file for each disk imaged, an enormous benefit from an archival and preservation perspective. The log file includes the time and date of imaging, technical specifications of the source (in our case, the CD drive used), and checksums of the image file and source file to prove that the image file created is an accurate copy of the original CD-ROM.

THE UNEXPECTED IMPORTANCE OF EMULATION

One of our original assumptions at the outset of the project was that emulation would not be a viable strategy for preservation of access to these materials. We soon discovered that emulation is a far more viable and scalable option than we originally suspected. Initially, we tested out two emulators to simulate obsolete Apple hardware, BasiliskII and SheepShaver. After some trial and error, we were able to build the software successfully. We then loaded various disc images in emulated environments (simulating a number of obsolete Apple Macintosh operating systems, from OS 7.6 through OS 9) and found that it was possible to interact with the works in a manner that closely approximated our “control” interaction on a legacy machine that ran the older OS natively. We noted some patterns in emulation quirks, including works that performed much faster in emulation than on the original (due to faster processor speeds on modern machines) and some infidelities in colors (often a product of viewing the work on an LCD screen rather than a CRT screen).

We further tested emulation by creating virtual machines with Windows-based environments using QEMU and Oracle VM VirtualBox and loaded disc images of works that ran under Windows. We noted some of the same is-
sues observed when testing the Macintosh emulators, but again observed that, overall, many of the works ran smoothly under emulations without extensive fine-tuning.

It is important to note the level of technical knowledge needed to fully test these emulators. Specifically, for BasiliskII and SheepShaver, it was extremely important to read through documentation and bug reports on the project’s GitHub repository in order to understand the current limitations of the software. As our project continues, it will be important for us to keep track of any changes made to the software—especially changes that fix previous problems or issues with the software—and update our emulators accordingly. In our experience, while it would not be necessary to understand every component of the source code for this software, some level of technical understanding was necessary to compile it for our specific environment. Recognizing this, we have been excited to note the development of programs like the bwFLA project (Baden-Wuerttemberg Functional Long-term Archiving and Access), Emulation as a Service. We have learned much from developing an emulation program and archiving strategy, but expect that a model like that of the bwFLA project is likely to be an attractive option for the future, especially for smaller institutions without digital archivists or digital conservation staff expertise.

Though we initially considered emulation as an access strategy, we have also discovered that emulation has functioned as a valuable conservation tool. To give an example, discs in our collection that are formatted for Macintosh computers most often are formatted using the HFS file system. One notable feature of this file system is the existence of a resource fork associated with a file, which can include information about how a file is displayed in a Finder window on the Macintosh operating system. Specifically, this can include a custom icon to display with the files, and the coordinates for where the file should appear in a Finder window. The technical metadata that we create for files on an HFS-formatted volume includes the size of a file’s resource fork, but not what that resource fork contains. On one disc, we noticed the presence of many files whose filenames were a unique combination of whitespace characters, and were empty except for a resource fork. This pattern typically suggests decorative icon files (since the resource fork can specify an icon’s placement on the screen) but the presence of multiple files with essentially no visible name puzzled us. Only when we viewed the work in emulation did we see that the “whitespace” files were meant to function as a mosaic when viewed in Icon View in a Finder window. Similarly, through emulation we have been able to identify additional aesthetic components of a work that would not have been visible through technical metadata alone.

**TECHNICAL CLASSIFICATIONS: RECOMMENDATIONS AND DISCOVERIES**

Identifying technical classifications with clear preservation recommendations is one key element of our proposed scalable preservation framework. Over the course of our project, we noticed that many of our initial classifications were not necessarily mutually exclusive, and that their preservation and access implications were more nuanced that we originally perceived. In our initial test of works in the collection, we noted several key technical categories. One of the most striking technical distinctions was the presence (or absence) of executable files on a disc. It was tempting to suggest that access to works with executable files would, as a rule, constitute the more challenging use case, and that works consisting of web-related files (e.g., HTML, image files, audio, or video) would be more straightforward. In theory, web-related files could be run in a standard browser and would not be reliant on specific hardware, as, for example, executable files often are.

As we became more comfortable and familiar with the process of setting up emulators and virtual machines, however, it became apparent that, in many cases, works that involved executable files with no other software
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dependencies were quite straightforward to access. In contrast, a work consisting of web-related files could be quite challenging. In one case, we found a work that was intended to be run in Microsoft Internet Explorer, but also included embedded video, audio, and used “world files” written in Virtual Reality Markup Language (VRML) for navigation. While the plugins for the video and audio were still available on the web, the recommended VRML plugin ceased development in 1998. We could technically still install the older plugin on a modern system, but this caused conflicts with other plugins on our system—to such an extent that launching the web browser completely froze the machine. Ultimately, this one plugin determined our conservation and access strategy for the entire artwork; to run the work, it became easier to install all necessary plugins on a virtual machine running a much older version of Windows.

Noting that web-based works could be considerably more complicated than executable-based works, we looked deeper at the source for the web-based works. Even without any external plugin requirements, web-based works may be coded in a way that is no longer standard. These works may not properly render anymore on a modern browser. Even if emulator dependence is not immediately indicated by an initial technical analysis of a digital asset, providing patrons with access to an older browser in a virtual machine may provide a closer aesthetic experience to the original.

We have begun drafting classification documents to address both broad and specific properties and recommendations discovered through our analysis and experimentation. Often, works will reside in several categories, where implications for access of one classification (e.g., an executable-based work) will be modified and informed by another (e.g., dependence on multiple external plugins in order to access the work’s audiovisual content). As our investigations continue, we plan to refine, alter, and add new categories and classifications as needed.

EMULATION AND OUR PRESERVATION FRAMEWORK

We have discovered that emulation may be part of a first-pass technical analysis very early in the preservation workflow, as in the scenario described above. It may also, of course, be a way to provide access to digital materials. In either case, we recognize that our increasing commitment to a preservation and access strategy that involves the emulation of obsolete operating systems will profoundly impact our preservation metadata framework, which aims to capture essential information needed to provide access to artworks as well as requirements for ingesting them to the Cornell University Library Archival Repository (CULAR), for long-term preservation.

In some sense, we have expanded the scope of our preservation project to include emulators themselves, as well as media artworks. This means that we must, for example, capture preservation metadata specific to emulators and we must document the compiling environment and compiling process used to set them up, noting any adjustments made by a digital conservator. We must confirm rights information, and also conduct a long-term risk assessment for the emulator itself. At the same time, the technical metadata we capture from the artworks will be informed, in part, by emulator requirements or dependencies. The descriptive metadata we record for artworks will also need to note recommended emulation environments for each work, as well as any rendering infelicities a user might encounter when accessing the artwork in such environments.

We consider it a given that such rendering infelicities will occur in emulation environments. Indeed, as we readily acknowledge, some audiences may consider the fact of embracing emulation as an access framework to be infelicitous from the start. By its very nature, however, our project embraces the real limits of large-scale institutional archival work. Our goal is not to painstakingly approximate a perfect rendering for a select few artworks, but to offer the best-possible imperfect rendering for the widest possible range of works in our test collection. To
do so effectively requires that we both acknowledge and document the distance between the emulation and a more ideal experience “authentic” to any given artwork.

**SIGNIFICANT PROPERTIES, AUTHENTICITY, AND ASSESSING USER NEEDS**

In order to better understand and anticipate the needs of researchers, and address them adequately in our descriptive metadata and preservation priorities, we created and distributed a questionnaire in January 2014 to assess the interests, preferences, and needs of media art researchers and curators. The online questionnaire was disseminated via email to media art, art history, digital library, and digital humanities listservs as well as to artists and researchers with personal connections to the Goldsen Archive. The questionnaire was very qualitative, designed to take a “sounding” of a diverse group of media art users representing a variety of disciplines and contexts. Questions tended to be open-ended and aimed at eliciting information about respondents’ priorities, preferences, frustrations, and desired ideal scenarios when working with interactive digital media artworks in archival settings.

We initially hoped that our results would enable us to create user studies or profiles that would, in turn, help to guide our metadata framework and access strategies. Instead, our results confirmed a range of concerns and priorities that did not necessarily resolve into tidy profiles, but that were nonetheless extremely instructive (Rieger and Casad 2014).

On the broadest and most general level, questionnaire responses indicated a tension between desire for accessibility and desire for authenticity. This may seem to be stating the obvious, but our responses led us to a much more informed, and much more nuanced, sense of what goes in to creating a sense of authenticity for media art users. Authenticity can be a contentious or problematic concept, and is especially so when discussing born-digital artwork. It is, however, an important and useful way of denoting an archive patron’s faith that the curating authority has taken into account a wide range of considerations. These considerations include, for example, accurate preservation of the work’s significant properties, fidelity to the artist’s vision or intention in creating the work, and acknowledgement of the work’s historical contexts.

During our initial project planning stages, we had naively understood authenticity largely in terms of the need to preserve, if only through documentation, an artwork’s most significant properties. Our survey results were an excellent reminder that a user’s sense of authenticity in fact derives from many overlapping factors, and that different kinds of cultural heritage institutions will have different potentials and limitations in their capacity to provide a strong sense of authenticity to visitors. Because of the Goldsen Archive’s unique position as a media art collection within a major research library, we knew from the start that we would be limited in our capacity to provide perfectly accurate renderings of artworks’ significant properties to users. At the same time, we were confident in our capacity to provide excellent access to artworks’ historical, cultural, and media-technological contexts.

Our questionnaire results alerted us to the fact that we had not taken enough action to include input from artists in our preservation and access framework. With this in mind, we recognized the need to add artist interviews to our preservation workflow. Toward this end, we are developing a simple questionnaire and follow-up interview procedure. In addition to asking for the artist’s own evaluation of the artwork’s most significant properties, we will inquire about:

- Original hardware and system requirements
- Original compiling environments and software
- Whether the artist has already adapted the artwork for contemporary operating systems
- Whether the artist would share (or has already shared with another institution) original working files or source code from the artwork.
• Whether the artist has archived any online aspects of the artwork or would have an interest in doing so

The artist survey and interview will provide an opportunity to disclose our intention of using emulation as an access strategy, and inquire about the artist’s position on emulation, especially with regard to specific emulator shortcomings that might be anticipated (for example, alterations of color fields, changed animation speed, or a zero-sum relationship between sound and video quality). We will also revisit deposit agreements with our new access framework and conservation strategies in mind.

NEXT STEPS AND SHARING RESULTS

Our hope is that the scalable preservation and access framework and workflows we develop through this project may be of value for other institutions and other kinds of complex born-media collections. Toward that end, we will publish a full white paper at the close of the project term. This will include final versions of our preservation and access framework and workflow, full versions of our questionnaires, and recommendations for similar initiatives.

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NOTES

1. A more complete report to Rieger and Casad 2014 is forthcoming. Contact the authors for more information.

2. Models like those of the Variable Media Network and Variable Media Questionnaire have been enormously instructive during this process. See www.variablemedia.net.

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SUSTAINING PLAYBACK THROUGH TECHNOARCHEOLOGY: A VTR REFURBISHMENT PROJECT

MICHAEL ANGELETTI

ABSTRACT

To those archivists working with magnetic media, it is apparent that all analog tape formats face veritable extinction in the long term. Not only are the physical carriers at risk, but the machines used to play endangered tapes are also facing extinction.

Audiovisual archives may have access to legacy videotape machines, but no way of restoring them for use in video reformatting. Using a recently completed refurbishment project at the Stanford Media Preservation Lab as an example, this presentation will focus on how archivists can take steps to refurbish their old videotape machines, enabling them to handle the antique video in their collections, as well as consider acquisition of new collections containing valuable but at-risk videotape. Through detailing the process of refurbishing an EIAJ videotape machine (Sony AV-3650), attendees will gain insight into why these old machines are costly and problematic to repair and maintain. It will also cover basic processes related to the handling, treatment, and playback of this open reel video format still commonly found in archival media collections.

Based on examples from the project undertaken at the Stanford Media Preservation Lab, this presentation will highlight some of the pitfalls in finding parts
and repairing or making new parts, as well as the advantages of working with legacy equipment specialists.

Adding capability for in-house playback of these machines can have a direct effect on the way that money is allocated for video reformatting work in archives where there isn’t funding available for outsourcing to a vendor. Replicating the work examples from the session would require an in-house reformatting program; however, for those without a working video lab, this presentation will offer a valuable look into the challenges faced by media preservation vendors and other institutions.

The PowerPoint presentation and a link to the accompanying EIAJ videotape machine playback demonstration are available at http://purl.stanford.edu/nv468td2285.

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A ROADMAP TO PRESERVING DIGITAL OBJECTS

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ABSTRACT
The University of California, Los Angeles Library produces and collects a steadily growing amount and widening variety of digital objects and collections. Libraries act increasingly as stewards of archival audio and video files digitized from analog magnetic tape. Video files produced with cell phone cameras, email correspondence of professors and literary authors, social media accounts, and computer-aided design architectural files are among many other types of reborn digital and born-digital files. Along with the varied nature of these digital collections comes a diverse set of preservation risks and needs. Here we present the forces that compel an institution along the path toward increasingly robust digital preservation practices. With reference to Anne R. Kenney and Nancy Y. McGovern’s five organizational stages of digital preservation, the discussion illustrates how the varieties of digital collections, from reformatted analog videotape to activist cell phone videos to digital archival collections, can drive organizational change. Effective uses of conceptual frameworks and tools aid workflow efficiencies.

INTRODUCTION
At what point in the course of a cultural heritage institution’s development does a digital preservation program become imperative? When and how does an institution determine that typical backup and replication of digital assets is insufficient?
The following discussion illuminates the main forces coalescing to bring a formally articulated and implemented digital preservation plan into the foreground of a research library’s planning activities. Each institution must design its own model for a digital preservation framework, based on its multifaceted needs – needs which arise from the types of materials in its collections, modes of access, human resources and funding. Our article examines these forces and some of the processes and tools we have used to begin to address the needs of the University of California, Los Angeles Library. The effort is ongoing and will continue to evolve. Digital preservation policies and workflows comprise something of a journey for institutions. By demonstrating the dynamic interplay between specializations and departments, this story highlights the complexity of the journey—where there is no “package tour” but where institutions can find traversable routes and expedient tools to preserving digital content.

ROADMAPS

UCLA’s path towards digital preservation can be described, with small modifications, according to Kenney and McGovern’s 2003 article, “Five Organizational Stages of Digital Preservation,” which identified five stages that an organization moves through on their way to establishing digital preservation workflows:

1. Acknowledge: Understanding that digital preservation is a local concern;
2. Act: Initiating digital preservation projects;
3. Consolidate: Seguing from projects to programs;
4. Institutionalize: Incorporating the larger environment, and
5. Externalize: Embracing inter-institutional collaboration and dependency.

At UCLA these five stages of developing digital preservation are interlayered with three important driving elements: collections, staff, and tools. Within this context, stage one, the acknowledgement that digital preservation is a local (i.e., intra- rather than extra-mural) concern, means that the institution, across several departments, began to recognize the increasing scale of digital content for which it was responsible, as well as the heterogeneity of the digital collections themselves. The UCLA Library produces and collects a growing variety of digital materials. We are the stewards of archival audio and video files digitized from magnetic tape; video files produced with cell phone cameras by activists; email correspondence; social media; digital architectural files; and many other types of “reborn-” and born-digital files. The heterogeneity of these digital collections brings with it a diverse set of preservation risks and needs that can only be addressed within a local context.

The next phase, or action, can only be accomplished with the help of staff armed with the expertise and bandwidth to pursue digital preservation objectives (Atkins et al. 2013; Bermès and Fauduet 2011; Nadal 2007). An examination of the growth within the UCLA Library of its overall preservation program demonstrates that appropriate staffing remains essential to establishing a digital preservation effort. The instar of preservation at the UCLA Library may be regarded as the establishment of the Library Conservation Center in 2004, launched by the hiring of a full-time collections conservator. Four years later, in 2008, UCLA hired its first full-time Preservation Officer. With the help of externally sourced funding (an indicator of stage two activities in Kenney and McGovern’s framework) UCLA Library was able to hire its first audiovisual preservation specialist (co-author Siobhan Hagan) to work within the preservation department in 2011. The audiovisual preservation specialist assembled an audiovisual lab with facilities for the care and inspection of film and the reformatting of video and audio. The arrival of this key staff member brought new capacity for preserving and reformatting audiovisual materials. Reformatting activities then introduced new digital content to the collections, and this added pressure and a sense of urgency to digital preservation concerns.
Another significant type of collection drives digital preservation efforts, albeit from a slightly different angle. Recently, the Library’s Special Collections Department has started to acquire archival materials that include digital manuscripts materials. Along with such acquisitions come new exigencies for accessioning and preservation. A prominent example is the Susan Sontag (1933–2004) papers. This collection includes a variety of media, including a hard drive containing Ms. Sontag’s emails as well as 16 mm black and white home movies. Responsible ingest and preservation planning for such digital objects in the archival setting falls under the purview of co-author Gloria Gonzalez, who joined the Special Collections Department in 2012.

COLLECTION DRIVEN ACTION—AUDIOVISUAL MATERIALS
To demonstrate how collections themselves drive us toward digital preservation, we take as examples two very different types of audiovisual materials, the Garry South collection and the Iranian Green Movement collection. Any moves toward the preservation of audiovisual content necessarily engender a subsequent digital preservation component. The total cost of transfers for most content, including the staff time to generate the transfers, perform quality assurance of resultant files, and create metadata as well as provide access via the digital library, means that audiovisual content draws a great deal of attention within an institution to digital preservation. Thus, collections themselves spur the institution into Kenney and McGovern’s first two phases: acknowledge and act.

Garry South was a political consultant who managed Gray Davis’s campaigns for Lt. Governor of California in 1994, and Governor in 1998 and 2002; among his papers are included many video recordings of broadcast media, news coverage and campaign ads. The Iranian Green Movement collection encompasses thousands of cell-phone videos providing coverage of the Green Movement in Iran during the contested 2009 elections, produced by activists on site and brought to the UCLA Library by activist Ali Jamshidi.¹

Through the generosity of the Arcadia Fund, the Library was fortunate enough to have the resources to reformat the unique analog videocassettes from the Garry South collection. With that initial hurdle surpassed the inevitable digital preservation dilemma presented itself.

The impetus for a managed digital preservation program very often arises as a consequence of the sheer size of the audiovisual files. Roughly calculated, one hour of analog video reformatted to a digital file takes up 100 GB of space; replication of files for basic security quickly doubles or triples the necessary disk space. Reformating the Garry South collection left the library with approximately 11 TB of data and 120 digital video files to preserve.

With some types of audiovisual formats, though, these rough calculations diverge significantly. The 2,000 or so born-digital videos recorded on mobile phones during the 2009 Iranian Green Movement provide an instructive contrast (fig. 1). Resulting from the need to smuggle them out of Iran and protect the anonym-

![Comparing AV Collections](image-url)

Fig. 1. AV comparison charts.
ity of their creators, the videos had been substantially compressed from their original state. In any case, a one-minute MOV file recorded on an iPhone takes up approximately 140 MB and, typically, cell phone videos run only a few minutes long.

Thus, these thousands of born-digital cell phone videos require only 10 GB of storage space leaving the library with two vastly different collections to preserve (fig. 1). The production workflows that created the videos were completely different along with their technical specifications. Therefore the preservation master format standards had to be different. It doesn’t make sense to use the exact same standards for analog audio and visual (AV) items reformatted to digital files: an extremely large preservation master file will be created that has no additional audiovisual information than the much smaller original. The UCLA Library decided to treat the ingested file as the original master, and generate a separate preservation master file utilizing the standard wrapper, but using as close to the same technical specifications in all other aspects as the original video file as possible. The library will conduct regular obsolescence monitoring and planned migration of the preservation master file specifications of this cell phone video collection.

The plan for the digital preservation of analog-to-digital reformatted AV files and born-digital AV files is in place, but resources are still limited. With already too much to do, too few people, and restricted time and money, the decided workflow can be technically complicated for many, and time consuming for all. These files and their accompanying metadata require a detailed preservation plan workflow that is as automated and efficient as possible.

Choosing your preservation master file standard is only one part of the enormous whole of digital preservation strategy. As discussed, based on the original specifications, UCLA Library creates a digital preservation master file. Then, utilizing the National Digital Stewardship Alliance (NDSA) Levels of Digital Preservation (table 1), the library assigns a level to a collection which then also helps to inform what tools and services are needed to preserve it digitally (table 1).

If the library assigns an NDSA level 4 to the Garry South digitized video collection, it needs to address everything in the previous levels as well. These various activities require various tools to complete: how should the library check fixity; how will it virus-check content; how can it batch migrate files when that time comes? There is a plethora of tools available to aid in the digital preservation of complicated AV files that are documented in several blog entries, presentations and articles online. Ideally, these tools need to be as automated as possible and need not require much translation from an IT professional, and preferably they could all be accessed in one place. The multifaceted needs of organizations undertaking digital preservation must be addressed by equally changing models that are timeless yet trendy, while accessible and practical to the already overcommitted archivist, librarian or conservator.

COLLECTION DRIVEN ACTIONS—DIGITAL OBJECTS

Over the past three decades, the UCLA Library Special Collections Department has seen a gradual increase in what we call “hybrid acquisitions,” collections containing both analog and digital media. More recently, new accessions now regularly include digital materials in the form of images, documents, email, and many other digital formats. In 2012 Special Collections engaged co-author Gloria Gonzalez as the digital archivist in a contract position. Her responsibilities include in-house digital archives training and coordination with our Library information technology group to fulfill technical requirements for processing, storing, preserving, and providing access to digital files.

Until recently, Library Special Collections managed the digital media in its collections by treating it the same way as analog materials, by placing the media in boxes and placing them on shelves. The first step to address-
This survey gave us a better understanding of our digital backlogs while, at the same time, attention was focused on addressing new acquisitions, including a digital addition to the Susan Sontag papers, which proved to be a major catalyst for our progress. To accession the Sontag files, an archival ingest computer workstation was set up. The workstation's key features include a write-blocker, which prevents the computer used to ingest digital materials from inadvertently altering any of the source files in any way. This first iteration of the workstation served as a type of "sandbox" allowing the digital archivist to explore a wide variety of tools for acquisition.

Table 1. NDSA Levels of Digital Preservation. Derived from Phillips et al. 2013.

<table>
<thead>
<tr>
<th>DOMAINS:</th>
<th>Level 1 Protect your data</th>
<th>Level 2 Know your data</th>
<th>Level 3 Monitor your data</th>
<th>Level 4 Repair your data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage and Geographic Location</td>
<td>Two complete copies that are not collocated</td>
<td>At least three complete copies</td>
<td>At least one copy in a geographic location</td>
<td>At least three copies in geographic locations with different disaster threats</td>
</tr>
<tr>
<td></td>
<td>For data on heterogeneous media (optical discs, hard drives, etc.) get the content off the medium and into your storage system</td>
<td>At least one copy in a different geographic location</td>
<td>Obsolescence monitoring process for your storage system(s) and media</td>
<td>Have a comprehensive plan in place that will keep files and metadata on currently accessible media or systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Document your storage system(s) and storage media and what you need to use them</td>
<td></td>
<td></td>
</tr>
<tr>
<td>File Fixity and Data Integrity</td>
<td>Check file fixity on ingest if it has been provided with the content</td>
<td>Check fixity on all ingests</td>
<td>Check fixity of content at fixed intervals</td>
<td>Check fixity of all content in response to specific events or activities</td>
</tr>
<tr>
<td></td>
<td>Create fixity info if it wasn't provided with the content</td>
<td>Use write-blockers when working with original media</td>
<td>Maintain logs of fixity info: supply audit on demand</td>
<td>Ability to replace/repair corrupted data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Virus-check high risk content</td>
<td>Ability to detect corrupt data</td>
<td>Ensure no one person has write access to all copies</td>
</tr>
<tr>
<td>Information Security</td>
<td>Identify who has read, write, move and delete authorization to individual files</td>
<td>Document access restrictions for content</td>
<td>Maintain logs of who performed what actions on files, including deletions and preservation actions</td>
<td>Perform audit of logs</td>
</tr>
<tr>
<td></td>
<td>Restrict who has those authorizations to individual files</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metadata</td>
<td>Inventory of content and its storage location</td>
<td>Store administrative metadata</td>
<td>Store standard technical and descriptive metadata</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ensure backup and non-collocation of inventory</td>
<td>Store transformative metadata and log events</td>
<td></td>
<td></td>
</tr>
<tr>
<td>File Formats</td>
<td>When you can give input into the creation of digital files encourage use of a limited set of known open formats and codecs</td>
<td>Inventory of file formats in use</td>
<td>Monitor file format obsolescence issues</td>
<td>Perform format migrations, emulation and similar activities as needed</td>
</tr>
</tbody>
</table>

Table 1. NDSA Levels of Digital Preservation. Derived from Phillips et al. 2013.

ing the issue was to examine holdings, by searching finding aids, and producing a clearer picture of what kinds of digital media we held. In fall 2012, we began a survey of our holdings, using steps outlined in Ricky Erway's 2012 report for OCLC Research, “You've Got to Walk Before You Can Run: First Steps for Managing Digital Content Received on Physical Media.” As a result of this survey, a wide variety of media was identified in 42 manuscript collections, among them punched cards, magnetic tape, video games, floppy disks, CDs, DVDs, Zip disks and hard drives. We estimated the maximum required disk space for the digital media surveyed in our collections to be around 5 TB.
One of the main tools used is an open source software application called BitCurator (www.bitcurator.net), the result of a project led by University of North Carolina and the Maryland Institute for Humanities at the University of Maryland. This suite provides robust forensics applicable to archival practice. With BitCurator in place, perfect copies of digital media can be generated without altering any metadata. The software also allows archivists to identify the file formats present in collections, such as audio files, software, geospatial files, images, presentations, spreadsheets, databases, text documents, and videos.

In identifying relevant digital media in the collections and establishing a secure ingest workstation, the Special Collections Department was able to implement NDSA’s second level of digital preservation, at least in certain domains, in less than a year (Owens 2012). However, our preliminary workflows were time intensive when it came to migrating files into access and preservation formats. The Sontag files alone measured at only 6 GB but included over 25,000 text documents and 17,000 emails. It took a few hours to migrate about ten email databases one at a time; however, this kind of time requirement is not scalable.

In order to move forward efficiently, we needed to find a comprehensive, automated approach. One approach that is under consideration is the utilization of Archivematica, a free, open-source suite of software tools designed to maintain standards-based, long-term access to collections of digital objects (www.archivematica.org). It processes digital objects from ingest to access in compliance with the ISO standard functional model for Open Archival Information Systems, by integrating of a number of open-source tools with a “micro-services” approach. A system built using micro-services combines many small, lightweight service modules. The services are arranged in independently deployable groups and communicate with each other via a well-defined interface. Together, these micro-services multiply the system’s value (Abrams 2010). Archivematica automatically performs many processing tasks including virus checking, checksum verification and file format conversions. File migration and preservation planning are controlled using a file format policy registry. The format policy sets rules or commands for each file format type. Archivematica comes with a solid format policy that can be adjusted to meet particular institutional needs. The strengths provided by Archivematica micro-service architecture are key (Van Garderen 2010a; Van Garderen 2010b).

Loosely-coupled is an attribute of systems that refers to a modular design approach. By combining simple, self-sufficient commands, Archivematica reduces interdependencies across modules or components. This reduces the risk that changes within one module will create unanticipated changes within other modules. This approach specifically seeks to increase flexibility in adding modules, replacing modules and changing operations within individual modules. The opposite would be a tightly coupled system, which often require difficult and taxing upgrades. With Archivematica, you can replace one service at a time, instead of the entire application. This supports healthy evolution to meet user needs. Additionally, the micro-services Archivematica allows for highly scalable configurations (Van Garderen 2010a).

NEXT STAGES
To move into Kenney and McGovern’s third stage—consolidation—an institution begins to create policies, identify ongoing funding streams, and generally consolidate efforts and resources. In the UCLA context, this is evidenced by the transition to permanent the roles of AV preservation specialist and digital archivist. At the time of this writing, recruitments for these positions are underway. In addition, we are reaching across several library departments, including Preservation, the Digital Library and Information Technology, Special Collections, and Administration to establish a digital preservation working group. This group meets regularly to build inter-unit relationships, expose new digital preservation
efforts, discuss strategies and bring new collections or developments in technology to the foreground.

We are also leveraging a web-based collaboration and project management tool, Confluence, to improve communication about projects and workflows among staff members who have a stake in the process. Reformatting activities require input from cataloging and metadata teams, conservators, curators, imaging specialists, vendors, and digital library mavens. Improving communication and building teams is helping us move from one-off projects to programs, where decisions and processes can happen automatically.

Stages four and five—institutionalize and externalize—respectively, have begun to occur as we start to establish formal relationships with campus partners for storage, such as the UCLA Institute for Digital Research and Education Data Center, or Chronopolis at the University of California, San Diego Supercomputing Center. We are also looking at partnering with external organizations to develop new models, such as the Digital Preservation Network (DPN).

Resources, not surprisingly, remain limited. At the time of this writing, the Library supports one full-time staff member with audiovisual preservation expertise, yet we somehow accomplish much more with far fewer staff members and less money. Still, our digital collections and their accompanying metadata require a detailed preservation plan workflow that is as automated and efficient as possible.

The lifecycle of managing digital collections remains familiar to librarians and archivists, in as much as the acquisition, ingest, processing, metadata, preservation, and delivery of materials correlate to analog materials. The specialized technical skills surrounding hardware and software selection, along with the myriad preservation needs of the new varieties of digital media and evolving standards in audiovisual preservation can present overwhelming challenges to any organization. While they may seem initially daunting, by employing new frameworks and software, organizations can advance along the path towards a digital preservation program. Together, librarians, archivists, curators, conservators, and other information professionals, can work together to find our way to digital sustainability.

ACKNOWLEDGEMENTS

The authors wish to acknowledge our colleagues and friends at the UCLA Library: Sharon E. Farb, Todd Grappone, Tom Hyry, and Stephen Davison, and Howard Besser at NYU, for their support and encouragement.

NOTES

1. A detailed account of the Green Movement Collection and an examination of issues surrounding its collection and dissemination is to be found in Besser et al. 2014.

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ESTABLISHING TIME-BASED MEDIA CONSERVATION AT THE NATIONAL GALLERIES OF SCOTLAND: CREATING MORE IN TIMES OF LESS

KIRSTEN DUNNE

ABSTRACT
The National Galleries of Scotland houses a collection dating from the Renaissance to the modern day over three main sites in the city of Edinburgh, Scotland. Six conservators working across the disciplines of paper, paintings, and frame conservation care for over 96,000 objects, including 20 time-based media art works in the core collection. In 2012 the opportunity arose for one of the paper conservators to begin to establish time-based media within the disciplines covered by the department. This paper will present a case study of the approach taken and the aims, challenges, and solutions proposed and addressed along the way.

INTRODUCTION
The National Galleries of Scotland (NGS) are based in Edinburgh and houses a collection of over 96,000 artworks dating from the fourteen hundreds to the modern day. The collection is split across five gallery buildings at three sites in the city, and includes easel paintings, prints, drawings, photographs, miniatures, furniture, sculpture, modern installations, archives, and time-based media. NGS also co-own the ARTIST ROOMS collection with Tate and this includes over 1000 artworks from thirty-three modern and contemporary artists.
Six full time conservators are employed at NGS covering the disciplines of paper, paintings, and frame conservation. Due to the breadth of media types found within the collection, as a team they are often faced with situations that fall outside their expertise based on training and background. This is an issue that is growing as the collection expands and diversifies. As a result opportunities can often arise within the department for diversification of skills beyond the conservation discipline in which the conservator was trained. The situation described in this paper is by no means unique, nor are the methods and approaches taken. However, the desire is to describe the aims, challenges, and issues faced by a conservator beginning the transition to caring for electronic media as a case study for others in a similar situation.

CONTEXT

In 2012 one of the paper conservators began to consider ways in which their job description and approach could be widened to include time-based media. This was motivated in part by a professional desire to ensure that this area of the collection was being safeguarded and a personal interest in all things technical, digital, and film. The conservator found themselves responsible for caring for a media type previously unknown to them. Additionally, in times of financial constraint, economically viable choices and solutions for addressing not only the backlog of documentation and preservation decisions, but to deal with new acquisitions and loans into the collection, needed to be found within the boundaries of existing work programs. Some of the issues faced were potentially time sensitive in terms of the formats used, and this needed to be understood and a course of action decided.

It was thought that there were around twenty time-based media artworks in NGS holdings, but their exact number and nature were unknown. These artworks were occasionally going on display and loan. However, this was facilitated by the curator dealing directly with the Audio Visual (AV) technician, who is part of the IT department, and conservation staff were not involved in the process at any point. The focus was on getting the artwork on display on a case by case basis. As a result, little consideration was being made in terms of the cost impact of equipment needed, the formats being purchased, or how the institution would preserve these artworks long term, including the skills, equipment, and resources required. It seemed that artworks based on video, DVD, pen drive, or similar were being viewed as having a different status than more traditional media, and their display and use were not being approached in the same way as other media types in the collection where procedures were clear and well established. This was one of the dominant issues that needed to be addressed; procedures needed to be written, agreed upon, and implemented to clarify the situation and to create a robust management structure for the long term preservation of this section of the collection. A role needed to be created for the conservation department where one previously did not exist. Documentation methods needed to be developed alongside procedures, guidelines, and processes to support staff working in this area. Importantly, these processes needed to be integrated into core working practices across all departments involved.

The tone of the approach taken was set by two factors. First, it was not possible in the foreseeable future to create a specific post for time-based media within the department. This was due to a combination of financial constraints and the needs of the collection; with only twenty items to care for, it would be difficult to argue for an entire post dedicated to this area, even a temporary one. This was also an opportunity to gain skills and knowledge and build upon them in-house. Second, the conservator taking on this responsibility had to be able to do so within their existing work program, which included areas of paper and preventive conservation. It was possible to argue for about 15% of the staff member’s time to be dedicated to time-based media, equating to about thirty days across a year. However, this was only possible by using the needs of the pre-existing exhibition and loan
program that happened to include several electronic media artworks, and which needed to be facilitated.

With no history of the discipline at NGS, an on-going concern was how to reconcile a lack of knowledge of this field with meeting the immediate needs of the collection. Both of these areas had to progress together in a symbiotic manner. Spending time studying through a formal program in this field prior to the project beginning was not logistically possible. Initially this was a seemingly overwhelming and daunting task. Realistic aims and a project timeline were established to help focus the tasks and staff involved. The purpose of these aims was build confidence, both personally and professionally across the organisation at a pace that was manageable.

AUDIT

One of the first tasks was to understand what was in the collection. This information was not initially clear and this was due in combination to a lack of a consistent approach and the collection database, Multi-Mimsy, not being used to record this type of artwork effectively. The conservator worked with a member of the audit and documentation team to undertake a formal audit of holdings. This was a quick win solution that provided a clear foundation for all future work; knowing exactly what was held in the collection allowed learning and development to be targeted to the necessary media types and crucially, it aided in writing a preservation management plan for the collection to meet its long term display and preservation needs. This plan was the foundation for all future work, including addressing the documentation backlog and creating budget and funding submissions for any equipment and training needed.

As a result of the audit, all of the components of each artwork were found and physically corralled into one storage location. The keywords used to describe the artworks in the collection database were clarified to ensure consistency across all records and a method was developed of using two of the database fields to record the component parts of each artwork and any associated accessories. By cataloguing each artwork in this manner in the collection database, each component of each artwork can be location tracked separately, which was not previously possible. Another issue that had to be faced was the easy portability of this type of artwork, meaning that master copies had previously ended up all over the gallery, including in people's offices, which presented non-ideal storage spaces. By corralling all of the artworks in one store, managed by one staff member and by giving all components an accession number, a system was created to manage the movement of this area of the collection, as all requests for access pass through an established system for accessing items from this specific store.

DEVELOPING SKILLS AND KNOWLEDGE

The process of gathering, understanding, and documenting the items held in the collection was used as a means for the conservator to develop the expertise required. This was made possible through the use of the Matters in Media Art project website, which was the result of a collaborative project between the New Art Trust, MoMA, San Francisco MoMA, and Tate (Documenting Media Art, 2014). This website provides downloadable documentation templates and a narrative for the processes needed to surround this documentation. It was used as a key source of guidance and from this documentation templates and draft processes were evolved to meet the NGS specific context. Each of the templates provided included a list of all of the questions that need to be asked for each section of the documentation and thus the user is led through the process of gathering the necessary information. Creative solutions were required to be able to address the necessary professional development. Though a time-consuming route, using completion of the documentation as a means of development allows information on the collection to be developed alongside the necessary expertise.

The National Galleries of Scotland are in the fortunate position of being connected to Tate through the shared ARTIST ROOMS collection. Tate currently has the only
Some interesting issues have arisen. For example, one question discussed related to how we could ensure a digital file was disposed of in a legal sense if a lender had asked us to delete it at the end of a loan. In the absence of having a framework in place for this situation, until we establish a process, we are returning files to lenders as this allows us to log the entire process in our collection database. Another interesting question was raised by a colleague who asked: “If we own an artwork as a digital file, why can’t we create two exhibition copies of that single file and have them both on display at different venues at the same time?” While multiple editions of artworks of course exist and so can be on display in different venues at the same time, this is different to a collection owning one copy of an artwork and having it on display in multiple places in parallel, unless this is explicitly agreed upon with the artist. None of the artists held in our collection have agreed to this, so if we are approached by multiple venues wanting to display one of our artworks at the same time we cannot lend and we refer the venue to the artist’s studio to find another edition that can be used. Both of these situations are interesting examples of the benefits of a multi-disciplinary approach to the management of this area of the collection. It is also an example of the need for a conservator to be able to represent the ethical object based perspective of what we are doing.

In tandem to the establishment of this group, a strategy document was written by the conservator and agreed upon by the group. This has acted as a reference document for the organization concerning our short and long term aims and includes the principles behind some of the decisions that have been made. For example, it describes our choice of approach for acquisitions where we have chosen to commit to buying master copies of artworks, as opposed to exhibition copies. This means we have accepted that the collection will have continued preservation needs with the associated implications of resources for in-house skills and budgetary requirements. The document also looked at how the team would deal with acquisitions, including creating a processing
Establishing Time-Based Media Conservation at the National Galleries of Scotland: Creating More in Times of Less

Team for each artwork; working as a team aims to ensure communication structures are developed and confidence in the processes built. The strategy document also encapsulated that we would use the documentation process and the pre-existing loan and exhibition program as a means of development for all staff involved.

The working group also created smaller groups to facilitate specific sections of the project. For example, the conservator, documentation officer, and AV technician are currently working on an equipment asset register that will be housed within the collection database. Every piece of equipment that can be used in the display of the collections’ time-based media artworks will be listed along with information of maintenance schedules, when guarantees expire and where the equipment is located. It will describe which artworks that piece of equipment can be used to display and the aim is to use this as a tool to assist with planning and management of the equipment pool and the co-ordination of exhibition installations.

Equipment Sharing Network

One of the other areas NGS still need to address is access to equipment to be able to view the formats owned in our collection. The long term aim may be to acquire the equipment and develop the skills to use it in-house, but in the short term, the aim is to build links to those who do have the equipment and develop methods of collaborating with them, working in a cost neutral manner for mutual benefit. One model being considered is to create an equipment sharing network. In this case, organizations would trade time using equipment with a skilled user. For example, NGS might trade a week of analysis using our micro-fader for a week of time with a deck digitizing our video collection. Hopefully, this approach will be a cost neutral endeavor with the added bonus of developing visible partnerships with other organizations, while helping us to cover our short term skill and equipment shortages.

The NGS Conservation department also uses a professional freelance register for conservators and conservation and art handling technicians. During projects where the full complement of in-house staff is insufficient to meet the demands of the work program, freelance staff can be brought in through this mechanism for a fixed daily rate. The aim is to add conservators and technicians with skill bases relating to time-based media to the freelance register to assist with the various exhibitions and projects scheduled. In this way we can bridge gaps in skills and staff and by working alongside freelance staff, we can build experience, knowledge, and a network of related professionals that will benefit the collection.

Conclusion

The National Galleries of Scotland is still at a relatively early stage of the process of developing time-based media conservation expertise in-house. The nature of the approach taken means that this is a prolonged process, but it is one that can be completed to the long term benefit of the collection. The process is also an iterative one and despite having already visited and developed documentation templates, process and procedure guidance, a strategy, and despite having completed an audit and clarified and developed our use of our database, the conservator and working group will continue to re-visit all of these areas as we progress as an organisation.

One of the unexpected elements of the project for the conservator involved has been the personal mental shift required in dealing with this new discipline. However, despite initial appearances, the conservator has found that the same conservation principles and conceptual approach can be applied as with more traditional formats. If you apply the fundamental principles of the profession and respect your skill base, research what you don’t know and think carefully about the short and long term implications of decisions, hopefully decisions can remain sustainable and robust.

In the current climate, with collections growing but staff numbers not necessarily reflecting this growth, creative solutions and opportunities are a positive way forward.
to challenges faced by a collection, particularly if they can be combined with collaboration with more experience professionals to mutual benefit. The proliferation of online learning either as full academic programs or individual modules and short courses may further assist conservation professionals already established in the profession to embrace this interesting and diverse area.

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XFR STN: OPERATING AN OPEN-DOOR MEDIA CONSERVATION LAB

WALTER FORSBERG AND BEN FINO-RADIN

ABSTRACT

For three months during the summer of 2013, New York’s New Museum of Contemporary Art played host to a public, open-door, artist-centered media conservation laboratory called XFR STN. Derived from a project proposal to preserve the massive collection of video materials produced by the Monday/Wednesday/Friday Video Club, XFR STN sought to address the wide need for artist access to media migration and recovery services. Throughout its ten-week run, XFR STN offered artists the opportunity of scheduling three-hour appointments with trained technicians to recover work from a wide variety of obsolete analog video and digital media formats. Moreover, the project sought to eliminate the prohibitive costs associated with such migration services, addressing the fact that many artist’s media-based materials may not survive beyond their lifetime if they have not already achieved commercial success.

The XFR STN project also inherently addressed issues of distribution, scale, and the economics of preservation for small institutions. By partnering with the Internet Archive to host all digitized material, XFR STN offered a nuanced approach to common institutional challenges surrounding the cost and maintenance of a long-term digital repository, while twinning conservation of material with widespread public access to resulting preserved content.
This presentation will offer a practical case-study surveying the nuts and bolts of such a lab; detail the day-to-day logistics of running a public and appointment based service; provide background on streamlining metadata capture and processing; outline pedagogical approaches and educational outreach to artists and the public; and relate practical and technical lessons learned throughout the course of the exhibition. The presenters will also enumerate strategies by which XFR STN rallied institutional support and expertise from a wide array of cultural organizations’ preservation departments to realize the project’s equipment and resource needs. The aim is to provide guidance with which other institutions may build upon for the successful operation of similar conservation recovery services.

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THE A/V ARTIFACT ATLAS: CREATING A COMMON LANGUAGE FOR AUDIOVISUAL ERRORS

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The Audiovisual Artifact Atlas (AVAA), available at http://avaa.bavc.org, is an online resource for the identification and diagnosis of errors and anomalies discovered during the reformatting of audiovisual media. For original archival audiovisual materials, the recorded signal must be reformatted in order for the content to remain accessible. Errors and anomalies become most apparent during the process of reformatting, and the origin of the artifact may not be evident. A number of factors may be the cause: equipment malfunction, media damage, an imperfect transfer, file corruption, or the error may be inherent to the original media. Conservators must be able to reliably identify such artifacts to ensure high quality in reformatting work. Once the error is identified, examination determines whether or not it can be remedied. In cases such as equipment malfunction, file corruption, or a flawed transfer, the error may be resolved through repair and retransferring; however, in the cases of media damage or when the error is intrinsic to the original recording, there is usually nothing to be done. Unfortunately many conservators often lack the formal training in audio and video engineering or equivalent experience that is necessary to correctly identify a problem, or they may not be familiar or comfortable with the terminology required in order to describe it. This gap can create hurdles in communicating with a reformatting service provider.
In addition, terms may originate from either the artifact's mechanical functions or from the content's visual and audible attributes. This can create confusion for conservators. For example, video head clog is exactly what it describes: when the video heads in a playback deck become dirty or clogged, they are unable to properly reproduce the video signal. This problem can generate different visual errors depending on the format. On the other hand, ghost or echo is so-called because its cause produces a translucent image in the received picture, offset either to the right or to the left of the primary image.

The purpose of the AVAA is to address these challenges through establishing a common language for use by media preservation professionals. Originally produced by the Stanford Media Preservation Lab (SMPL) and the Bay Area Video Coalition (BAVC), the AVAA is a community-oriented wiki focused on building a living glossary of video and audio reformatting errors and artifacts supported by detailed descriptions and, when possible, remedies to correct them. Since its inception, the AVAA has been recognized as a resource for educators and students, as well as audio and visual preservation practitioners in museums, libraries, and archives. While many professionals often discuss these concerns informally amongst one another, there are few widely available and easily accessible resources catering to the preservation, archiving, and library fields at large. Through outreach by BAVC and SMPL, the AVAA wiki has flourished with contributions from the greater audio and visual preservation community. As Geoff Willard, Media Production Coordinator at SMPL, wrote, “There was a learning opportunity here for all involved, but more importantly it was an opportunity to involve people other than us at SMPL in the creation of something that would be greater than what we could produce on our own” (2013). The team at SMPL contributed their time, expertise, and content to launch the resource in 2011. As described by Frost, to host the wiki, SMPL “…approached BAVC as an able partner because BAVC demonstrates an ongoing commitment to the media community and a genuine interest in furthering progress in the media archiving field” (Murray 2014).

AVAA users have access to several sections of information on media digitization and preservation. The Table of Contents enables one to browse listings of terms organized into several categories. The Contributor’s Guide is a starting point for users who are interested in contributing content or in supplying more information about existing content. The Resources page provides links to information about analog and digital preservation, storage and handling, and digitization.

The AVAA content has been cross-referenced with two authoritative resources on audiovisual error terminology: the *Compendium of Image Errors in Analogue Video* by Johannes Gfeller, Agathe Jarczyk, and Joanna Phillips, and BAVC’s online Preservation Glossary. As a result, new entries were created and many existing entries were enhanced. As of October 2014, there are 75 identified artifacts, including: 40 analog video errors, 11 digital video errors, 19 digital audio errors, and 5 digital audio errors.

In 2013 BAVC’s Preservation department received a grant from the National Endowment for the Humanities (NEH) to develop Quality Control Tools for Video Preservation (QCTools), an open-source software tool that reports and graphs data to document video signal loss and identifies common reformatting errors. As part of this larger project, BAVC hosts the AVAA wiki and includes it as a dissemination point for QCTools. In a basic QC workflow, the software reveals an anomaly and then enables the user to access the online resource for assistance in diagnosing it.

As the NEH grant progressed, the AVAA and the QCTools software became increasingly integrated. Software users can directly link to the AVAA through the user guide, which helps them understand how their error might manifest, offers possible causes, and provides potential resolutions if applicable. From the AVAA side, the artifact is supplemented by cases from the QCTools graphs and
filters, which are examples of what one might observe when they come across the error in their QC workflow.

The AVAA illustrates how people can share their wisdom and expertise and work together in order to enhance the general knowledge base and empower others. To reiterate, the AVAA has relied on the audio and visual gurus of the archiving, engineering, and preservation fields in order to grow and become more robust. However, it also depends on the novice users; every time the AVAA is shared or referenced it becomes more relevant and more meaningful to the communities it serves. There is rarely a single word or phrase to describe an artifact: what looks like a “comet tail” to one person will look like a luma trail to another. Nor do all artifact origins produce the same error every time; a video head clog will visually manifest differently on a U-Matic playback deck compared to a Hi-8 mm deck, or a VHS deck, and so on. Yet, by calling attention to both of these artifacts and the discrepancies in vocabulary, we have begun to bridge the gaps and improve information exchange within our field. The AVAA, along with QCTools, serves as a model for future endeavors in building open resources that encourage community involvement and advocate education and awareness.

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ABSTRACT
The Online Computer Library Center has released several reports since 2012 that attempt to demystify born digital for archivists. The positive response offers more proof that the world of archives is beginning to firmly face the challenge of how to deal with born digital collections and objects. The reports are just the starting point, however, and while they are incredibly helpful and provide an overview of mandatory tools for born digital curation and preservation, they are written for a broad audience and, because of that, do not address some of the finer points of this potentially confusing, time consuming, and, thus, often passed-over work. This article gives an example of a born digital workflow at one academic institution, and describes how it is very likely that no one report or tool will answer all of an institution’s born digital questions, but that by being flexible, drawing from many sources, and understanding institutional requirements, it is possible to create a viable born digital process that is scoped appropriately, leading to quicker preservation of and access to materials.

INTRODUCTION
In an effort to help provide a clear path for archivists to begin work in a challenging and overwhelming domain the Online Computer Library Center (OCLC) began publishing a series of reports under the title “Demystifying Born Digital” in 2012.
The release of these reports and the active and positive response to them offer more proof that the archive and conservation world is not on the brink of, but is, rather, firmly facing the challenge of how to deal with born digital collections and objects. This comes as no surprise to many who have advocated for such awareness, but it is a reminder that plans need to be made immediately to start appropriately caring for this material for the long-term, while also making it accessible.

Media archivists predict that legacy video and audio formats provide preservationists a 10–15 year window to safely and completely migrate content to a more manageable form. Data—floppy disks, hard disks, USB drives, CD-Rs, etc.—is at least as volatile, if not more, than heartier media formats that came before it. Film, for example, can be examined and the content understood without a working projector by simply holding it to the light. While this is not an ideal situation for examining content, it can provide clues until an appropriate projector or other playback device is found. A floppy disk, hard drive, or magnetic card hides its content, like a magnetic cassette tape might. But unlike a magnetic cassette tape, a working 5.25” floppy drive that interfaces easily with current equipment is not a ubiquitous sight at thrift stores, especially considering that, on modern computers, an additional controller card is needed to read the data. And, unlike a cassette deck, 5.25” floppy drives are no longer being made en masse, and new stock is often prohibitively expensive.

Knowing that the clock is ticking can be motivating, and the OCLC reports attempt to foster motivation into a plan. They, however, are just the starting point, and overworked archivists who are, perhaps, not keen on learning command line operations at a born digital workstation, for example, may not put these quickly degrading, sometimes already obsolete and certainly un- or under-used collections at the top of their list to process appropriately and quickly. And even ubiquitous born digital materials—USB flash drives, external hard drives, DVD-Rs—are overwhelming, often disorganized, and erroneously thought to last forever if just kept in the box with the papers they came with, or on the shelf until the institution figures out a plan to deal with them. The OCLC reports outline tools and techniques for minimally viable born digital curation and preservation but, as their intended audience is a broad one, they cannot get as granular as an overworked and overwhelmed archivist may wish.

Additionally, the plethora of options may seem overwhelming to an archivist who is largely unfamiliar with the landscape, and while the reports are comprehensive, they are not case studies. They do, however, present the main concerns in a cohesive, understandable, and important way. In a way, the reports are like the Born Digital Processing “food pyramid,” the backbone of the needs of a world that wants access to these items. The truth is, though, that even the food pyramid needs recipes to make it understandable and usable at a family level, and the same is true for the born digital reports. Recipes—case studies, testimonials, and reports on results—are imperative for archivists who are embarking upon this daunting frontier for the first time. For the majority of us there is no single tool or solution for born digital processing and access, and likely there never will be because of the diversity of our institutions. Understanding that this gray area is powerful and exciting is a step that general reports can only hint at; specific examples of active communication across institutions that are working on similar challenges are good first steps.

**BORN DIGITAL PROGRAM, TAKE 2**

I began my two years of work at the North Carolina State University (NCSU) Libraries Special Collections Research Center (SCRC) in August of 2013 as part of a NCSU Libraries Fellowship strategic initiative to start a born digital curation program. As a Fellow, I split my time as part of a home department (User Experience) and the SCRC. That means I got to devote a full twenty hours a week to born digital, but was still not full time in the SCRC.

Prior to my arrival, the SCRC had attempted to implement a born digital curation program, but was thwarted
by the same thing that thwarts so many: a lack of support for the chosen technology. The IT department could not devote the time and resources we thought we needed, so plans that involved IT building a workstation with our guidance and their expertise were hatched. This allows them to have a say in and an understanding of our technical requirements, but also allows us to have more control and flexibility in testing tools. Using sources like the OCLC reports as guidance, staff purchased write blockers, external drives, and a dedicated computer.

Those previous born digital program creation attempts were very well-documented in-house, including helpful descriptions about using open source tools, their strengths and weaknesses in our institution’s context, and suggestions for more robust usage in the future. So the failure to implement a program actually led to success in that it laid the groundwork for contextual understanding of what a born digital project should look like at NCSU Libraries. This was not the full picture, however, as our institution’s needs regarding born digital had evolved.

At this stage the commitment was set: I was hired and we had equipment. And while those may seem to be the main ingredients for a successful project, that, of course, is not the whole story. We needed our SCRC staff to buy-in, too, and we began building that buy-in through the implementation of a Born Digital group and then, even more importantly, learning how to talk about what we were doing with people who were not necessarily well-versed in the lingo of born digital. While words like write blocker and ExifTool make sense to people who are actively working on these problems, curators in other parts of the department may not. Learning how to communicate what these things actually do in a standard archival way was, and remains to be, important, as it enables us to approach institutional requirements with a common understanding. When others are enthusiastic and understand what these tools do, it helps the digital archivist scope born digital workflows appropriately for their particular institution, and which are in line with existing workflows.

Once effective communication levels are reached, an issue that often plagues similar technical work in more traditional library environments—imposter syndrome—is mitigated. Since there are very few specific recipes for this kind of work, it is a challenge to even decide what kind of questions need to be asked to reach the answers we need, or even think we need. Effective communication—and practicing this communication both locally and through online user groups, conferences, presentations, etc.—leads to a greater understanding of both the problems facing institutions regarding born digital and the possible solutions.

For this project we divided the two years into quadrants. The first, and most talked about, was processing and ingest. In the course of working inside of that quadrant we made the somewhat obvious discovery that access—our main goal at NCSU Libraries—was inextricably linked to processing and ingest. Thus, imagining how future access might work completely colored our way through the first quadrant. Other quadrants—arrangement and description, and sustainability—have changed throughout the course of the project, and our adapting to unforeseen needs shone light on how flexible an institution needs to be when implementing such a program.

What drives us is the need to free the content from its media “jail” in the most archival-appropriate way. We consider digital forensics to be the way: we gather all of the evidence we can, let forensics tools do the hard work of translating the bits into information we can use, and we do all of this so that we can, potentially, allow researchers unprecedented access to material. When an archive receives a donation of a box of papers, it is highly likely that the papers inside have either been arranged for the donation or that they have been moved from a different organizational container into that box. When we receive a hard drive straight out of a work terminal, however, we have the chance—if the creator hasn’t changed it purposefully for the donation—to see inside the organizational mind of the person who gave us the drive and, in turn, let researchers see it, analyze it, and work with
it in ways we only wish we could do with other kinds of physical items. This involves providing access to disk images, for example, and that depends on the donor agreement. It is possible to plan for every step of this process so long as buy-in exists by all members of the team, enthusiasm regarding access is maintained, and an understanding of the kind of unprecedented, easy-to-get information afforded to us by digital objects is attained.

We came to these conclusions by reading general reports and then embarking upon environmental scans, striking up conversations at conferences, keeping abreast of professional work, but, most importantly, comparing all of this against what we thought we actually needed at our institution. Confidently approaching born digital with our institution’s requirements makes the whole process easier to both sustain and grow. While this work is being done, we have been documenting it so that our future selves—whether actually us, or the librarians who will have taken our positions—can understand what it is we left them, and in what form. That is our job as librarians, after all: creating a network of information that can be accessed later so that understanding passes through time. Be transparent and foster repeatability. It’s our only chance.

RELEASE THE KRAKEN (OUR BORN DIGITAL WORKSTATION)
Born digital is not an IT problem; it is a universal problem with IT solutions. One of the most important things you can do to ensure support for your program is to run it yourself with IT as background support. In other words, stop at nothing to get administrator privileges on your machine. This is important because your institution may find one free tool to be better suited than another for whatever your requirements may be. You can only properly test this if you can download and install freely. Your time is limited: be in charge. If you run into issues, work with IT to have them maintain an image of the machine as they delivered it to you. When you tell them that you ran into some trouble and all you need is to reinstall the image, they’ll thank you for being organized enough to know the issue and that they don’t have to learn new software to support your particular stack.

At NCSU Libraries we have purchased a relatively low-powered (for now) Dell running Windows 7, outfitted with free tools. We call it The Kraken because of all the tentacles running to and from it, those being the connections between the drives and write blockers when everything is plugged in (fig. 1). Those tentacles, in particular, are a WiebeTech Ultradock, a WiebeTech USB writeblocker,

THE KRAKEN

Fig. 1. The Kraken: NCSU’s Born Digital Workstation.
FILLING IN THE GAPS: FINDING YOUR WAY TO CONSCIENTIOUS CURATION AND PRESERVATION OF BORN DIGITAL COLLECTIONS AND OBJECTS

THE TENTACLES

![Image](https://via.placeholder.com/150)

Fig. 2. The Tentacles: the main hardware used with The Kraken to process born digital objects.

... led as if through a standard online survey. By the end of the form, disk images, and logical copies are made, metadata is extracted, personal and private information is searched for, viruses are scanned for, a readme file is generated to help future us decipher what's in our pack-age, finding aids are updated, and all of the data is sent to storage with fixity checks put into place.

THE WORKFLOW

There is not a single recipe for everything, and it took trying out different media to figure out what hardware and software needed to be used in concert with that media to reach our goals. Our workflow is, thusly, determined by the media that needs to be processed. After DAEV knows what one is working on, it loads the particular path that is required to get the object processed correctly (fig. 3). Once an item has an accession number, it is given to the born digital processor. That person uses the appropriate “tentacle,” attached to a write blocker (or using an appropriate write-blocking method) to connect to The Kraken. FTK Imager (the free version) is then used in...
most cases to make a disk image of the item (we use RAW because RAW comes to close to ensuring that the created file can be opened by widely supported applications versus forensics specific file formats). Once the image is created, we generate a logical copy of the image, for future access reasons. We then use many tools packaged in BitCurator to extract metadata, scan for viruses, and look for personal and private information. Metadata is created automatically, as part of the DAEV form, by the free tools we use for processing. We also take pictures of the object to provide more human readable metadata.

**ACCESS**

In all cases we generate RAW image files so that we can run the BitCurator reporting tool over it easily. In some cases we do not retain the image file, because that means storing empty space. We determine these cases based on how the object was given to us. If it’s a hard drive that was simply removed from a working terminal, then we will retain the image. If it’s an external hard drive that only has specific files copied to it for the sake of donation, we will retain the logical copies, since there will (likely) not be dependent information or hidden files that may shed light on the creative process.

We envision, eventually, sharing a logical copy of the data and the extracted metadata with our Digital Libraries Initiatives department who can use this information to generate a virtual disk browsing environment, linkable through our finding aid for the collection that the digital object came from. In other words, in the finding aid under digital objects, we have the chance to, for example, write “internal hard drive” and provide both a link to a sortable .CSV for local searching, in addition to a link that allows a researcher to browse the hard drive on their terminal, replicated exactly as the hard drive came in. While, in most cases, one could not actually access the files, they can see the file and folder lists and, by hovering over the filenames, could also see file metadata. This can potentially save time for the researcher and for our department, as the researcher can either identify specific files they wish to see ahead of time or find out that, perhaps, none of the files add to their work. By linking this virtual browsing environment to a logical copy of the files, previewing media files and text files would also be possible (subject to the donor agreement).

We have decided to let the bits describe themselves. In other words, aside from linking a virtual browsing environment to the finding aid (and potentially running word list programs to determine what might be on the disks, based on the lists they create, and then providing this in the finding aid), we do not plan on rearranging the files or describing the disks. The disks are contextualized within the collection already, and increasing use of automated tools helps achieve higher processing rates,
while reducing the time it takes to make these files available to patrons. If a patron wants to see the whole disk image, we will first ensure that this is in concert with our donor agreement, and then make arrangements for them to come to our reading room and use a non-networked laptop with the image mounted and indexed for easy searching. We will do this on a Mac, and utilize the already-familiar Spotlight tool for searching. The browsing environment allows them the chance to see the disk contents. All in all, we’ve decided to use tools to make arrangement and description easier (because the bits can do it), and then provide other tools to let the patron make the choices about what they want to see as easily as we can.

**CONCLUSION: DON’T LET THE PROBLEM OVERWHELM YOU**

Again, this is a universal problem with technical solutions. Prepare requirements with the help of colleagues and find the tools that fit them. Do this by talking to others working on similar challenges, who are at similar institutions, and who are willing to share their discoveries. Don’t let the possibility that this work is challenging prevent you from even beginning it. Learn from the failure of others (and yourself), and document every step to make sure you don’t repeat what doesn’t work, while ensuring that what does work gets repeated. Use your favorite search engine to wade through previous discussions about problems that you’re also encountering, and do not hesitate to ask questions. Workshops, articles (like this one), and reports help, but they can never address problems specific to your institution. It is possible to begin this kind of work with something as simple as a surplus laptop and an optical drive or a multi-thousand dollar setup; again, it depends on your institution, but both scenarios achieve results. Make sure you have administrator privileges. Remain flexible—there is no single solution that will work for everyone. Don’t be afraid to make mistakes, because the biggest mistake of all would be to let this potentially very important information be imprisoned forever in its soon-to-be, if not already, obsolete media prison.

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IMAGING DIGITAL MEDIA FOR PRESERVATION WITH LAMMP

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ABSTRACT
Hardware/software obsolescence and bit-level corruption pose a serious threat to the ongoing accessibility of digital media storage devices, both magnetic (floppy and ZIP disks) and optical (CD/DVD, USB drives). The Legacy Archival Media Migration Platform (LAMMP) was developed to rescue potentially valuable digital content from rapidly aging digital media formats. LAMMP automates the generation of bit-for-bit disk images suitable for preservation as well as disk and file-level metadata for future appraisal and access. Beyond basic preservation, there is also archival value in reliably capturing the work environments of digital content creators. Migrating media to a digital image format and ingesting it into a digital repository ensures its continued authenticity for future investigation, emulation, and access. Built on open-source software, digital forensics tools, and a combination of modern and legacy hardware, LAMMP is low-cost and highly customizable. Along with disk imaging and metadata generation, LAMMP performs essential digital preservation workflow tasks such as virus checking, hash checking, and file extraction. Finally, automation via Linux command line tools and shell scripting allows for non-technical staff to perform the LAMMP preservation procedure for most common digital media formats.
INTRODUCTION

In late 2011, the Special Collections and Archives department (SCA) at The University of California, Irvine (UC Irvine) had a pressing problem without an obvious solution. Like many collecting institutions, SCA had for a number of years been acquiring hybrid collections containing both paper-based materials such as records, books and correspondence as well as digital media such as floppy disks, CDs and USB thumb drives. Whether used for transfer, versioning, or storage, these digital media objects often formed a crucial part of the collection creator’s work environment and output; they were therefore just as worthy of appraisal, arrangement, description and eventual access as their more “traditional” counterparts. However, unlike paper-based materials, SCA had no established workflow for processing digital media, so disks and drives remained on the shelf with no more than a guess at the potentially valuable content that lay within.

Unfortunately, digital media storage is basically a ticking time bomb from a preservation perspective. One issue is access: interpreting legacy content on legacy media requires legacy hardware and software. Legacy hardware means acquiring and maintaining specialized tools that are often no longer being manufactured or supported by vendors. Assuming the media loads, there is no guarantee that its technical structure or the content within can be identified and read. Potentially valuable information may have been saved in an obscure and proprietary format by programs that fell out of use 20 years ago.

Beyond the access issues posed by hardware and software obsolescence, digital media carriers themselves have a tendency to degrade over a relatively short span of time. Such degradation can be caused by user error, material disintegration and damage, or “the silent corruption of data on disk or tape,” a phenomenon known as “bit rot” (Salter 2014). To put this in perspective, well-preserved paper materials under normal use and storage conditions have the capacity to last several hundred years (ANSI/NISO 2009), while recordable and rewritable DVD media in certain conditions may become unreadable in less than 15 years (Zheng and Slattery 2007, 17). Magnetic mass storage devices such as USB thumb drives or even the hard drive within a computer are also at risk; when it comes to hardware failure, it is never a question of if, but when.

Thus, SCA needed a system for processing digital media objects that could address these technological and temporal concerns and produce a verifiably authentic version of the object while still adhering to archival concepts of acquisition, appraisal, arrangement, and description. Further, to ensure that digital media collections were processed in a timely manner, the system needed to be straightforward enough to be operated by a staff member who may have never even seen a computer command line. Finally, to have any hope of being implemented in the near future, this system needed to be budget-friendly, ideally costing less than $500.

The solution became the Legacy Archival Media Migration Platform (LAMMP), designed and developed within the UCI Libraries’ IT department. LAMMP uses tools and techniques borrowed from the digital forensics community to rescue valuable content from digital media carriers. By capturing an exact binary copy of the digital media and extracting content files soon after the media collection is acquired, LAMMP lessens the risk of obsolescence and bit rot and increases the potential for accessing content stored within. Because it is built entirely on free or low-cost hardware and open-source software, LAMMP was inexpensive to build and is easily customizable. Best of all, using LAMMP is easy: just follow the manual, run a script, enter basic metadata and the system will do the rest.

USING DIGITAL FORENSICS IN LIBRARIES & ARCHIVES

Capturing and authenticating digital media content is extremely important in the legal and law enforcement communities. Hard drives, CDs, USB drives and more are routinely seized as evidence; and the content within must be extracted, tested, and held to strict standards in order to be admissible in the court of law. Much like
a traditional crime lab analyzes physical evidence, practitioners of digital forensics must capture and analyze a suspect’s digital media in order to recover as much data as possible, then verify this data to serve as evidence. The digital preservation community centered around libraries, archives, and museums shares this concern for capturing and authenticating born-digital content, and has adapted several digital forensics concepts and tools for its own work.

The first step is capture. The easiest and most complete method for capturing digital media content is imaging, which involves generating an exact bit-for-bit copy of a disk or other piece of digital source media. A disk image can be thought of as a purely digital clone of the physical media carrier: the exact technical structure, metadata, and content of the media is stored in a single file which may then be analyzed and accessed by technicians or future researchers, without the risk of physical degradation or failure to read that comes with loading the original media carrier. Released by Access Data as a free but more limited alternative to their full Forensic Tool Kit (FTK) suite, FTK Imager is widely used software for generating and verifying disk images as well as extracting technical metadata (available at Access Data Product Downloads: http://accessdata.com/product-download). FTK Imager allows for exploration of disk image content and provides a wealth of technical metadata for in-depth investigation. The tool generates disk images in two of the more popular image formats, RAW (.001) and Advanced Forensic Format (AFF).

To verify both the fidelity of a disk image as an exact copy of a digital media carrier and its continued authenticity over time, a cryptographic hash function known as a checksum algorithm is used. Running this algorithm on a file or other discrete digital object produces a string of characters known as a checksum hash that uniquely represent the content and state of an object. If the object is changed in any way, whether due to human intervention or data corruption via bit rot, a different checksum will be produced by running the checksum algorithm. In this way, a checksum functions as a sort of digital fingerprint, verifying that digital content remains unchanged during imaging, transfer, and preservation. Different checksum algorithms use their own methods to generate different hash values; two checksum algorithms widely used in the digital preservation community are MD5 and SHA-1.

A write blocker is another tool used to ensure authenticity while accessing or imaging digital media. Its basic function is self-explanatory: to prevent the imaging workstation from compromising the original authenticity of the digital media by blocking the workstation from writing to the media while under investigation. A hardware write blocker is a physical device that connects via USB or other standard interface and blocks all write activity from the imaging workstation to the digital media. A software write blocker is a program that runs on the imaging workstation’s operating system, monitoring and disabling all potential write activity to the digital media. While some argue that write-blocking via software is more flexible and efficient, hardware write blockers are generally seen as more reliable, owing to the basic nature of hardware (device) vs. software (system): “systems that are designed to write but rely on some type of control system to prevent a write can experience a failure of the controlling system...media protection devices are systems that are designed not to write and thus have no controlling system to fail” (Menz and Bress 2004, 6).

Combining these concepts, we arrive at the basic process for generating and verifying a purely digital surrogate of a source digital media object:

- Attach appropriate media drive via hardware write blocker to the imaging workstation
- Insert media into drive
- Generate checksum of source media
- Generate disk image from source media
- Generate checksum of disk image
- Compare checksum of disk image to checksum of source media to ensure exact match
The checksum of the disk image file can then be used to ensure the file remains unchanged after any digital forensic analysis or future access, and to verify future versions of the disk image file as authentic representations of the original digital media object.

INSPIRATION FOR LAMMP
The main source of inspiration for LAMMP was the Frankenstein machine, a purpose-built digital forensics workstation found within the Digital Archeology Lab at the University of Texas, Austin School of Information (UT iSchool). While attending UT iSchool, the author used Frankenstein to image both 3.5” and 5.25” floppy disks as part of a course on preserving electronic records. The knowledge gained and connections made with Frankenstein’s developers were then used to develop a similar digital forensics workstation at UC Irvine.

Beyond the general idea of constructing a low-cost and purpose-built digital forensics workstation instead of purchasing a more expensive commercial solution, the Frankenstein machine directly influenced LAMMP in its use of the Linux Ubuntu operating system and its output of basic metadata file formats.

In his seminar “Digital Forensics using Linux and Open Source Tools,” forensics expert Bruce Nikkel outlines the many advantages of using Linux for digital forensics work, including ease of automation and scripting, an active support community, open and vendor-neutral standards, and a wide range of supported media and hardware, as well as free and open source software tools useful for forensic analysis such as dd, dd_rescue, sleuthkit, md5sum, and more (Nikkel 2005). Linux is also much less susceptible to any computer viruses that may be encountered while imaging and analyzing digital media. The Ubuntu Linux distribution was chosen for its graphic user interface, which is more immediately familiar to users accustomed to the graphic interfaces of Windows and Mac operating systems. Usability was also the deciding factor in choosing to generate simple text (.txt) and comma-separated value (.csv) files to store metadata. Widely used and small in size, both formats can be easily edited from many command line tools and can be accessed by nearly any word processing or spreadsheet software.

WALKTHROUGH OF LAMMP PROCESS
The high level LAMMP process involves four steps, each of which generates one or more image or metadata files (fig. 1).

First, a photograph is taken of the digital media object to capture label markings, branding, and other physical aspects. Next, the appropriate drive is attached to the LAMMP workstation, using a Tableau USB Forensic Bridge write blocker wherever possible. The remaining steps are performed by a script file named imageScript written for the Bash shell Linux Command Line Interface (CLI).

Before any imaging begins, imageScript connects to the campus Ethernet network to update the virus definitions of the open source ClamAV software used later in the LAMMP process for virus scanning. The script then disconnects from the network so that LAMMP is safely quarantined during imaging, preventing any viruses or other malicious content found on digital media from spreading to other machines on the network. After disconnecting, imageScript asks the user to enter their name, the digital collection number and digital media object number, and digital media object type (3.5” floppy, 5.25” floppy, data CD, DVD, etc.). The digital media type determines which tools are used to generate image and metadata files.

For 3.5”/5.25” floppy disks, the command line version of FTK Imager is used to generate a full-size raw disk image file. Ideally, the LAMMP process would generate a full-size disk image file for all media types, as it is the most authentic digital object for future access and investigation of the source media. However, media such as data CD/DVDs can often hold several hundred megabytes of data, and many USB drives now come with a capacity of 16 gigabytes or more. It was decided early on in the development of LAMMP that UC Irvine Libraries
did not wish to allot storage for exact images of these larger media objects, especially since many of the media contained allocated content comprising less than 50% of total capacity. Thus, for all digital media objects with a capacity of more than 100 megabytes, a .zip package containing only allocated content is generated in lieu of an exact disk image.

After imaging, the image file or .zip package is loaded in a forensically sound read-only way by passing specific parameters to the Linux `mount` command. This mounted directory is then scanned by the previously mentioned FTK Imager for viruses or other infected content. If infected content is found, the files are removed and their names noted in the disk metadata file below. Another virus scan runs on a digital media object’s boot sector to look for infected data there. If no infected content is found, the “clean” result is printed to the disk metadata file.

Next, imageScript generates two metadata files. The first is a disk image metadata text file containing:

- Basic metadata of agent name, collection number, and object number entered above
- Technical metadata on the size and logical mapping of the disk
- Technical metadata generated by the Linux `disktype` command
- MD5 checksums of both the source media and resulting image to ensure a match

The second is a content metadata .csv file with a single line of metadata for each file found on the media including:

- Filename with extension
- Full file directory path
- File size in kilobytes
- Date created, if possible (this information is not saved on the Mac or Linux OS)
- Date last modified
- MD5 checksum of file
Finally, a line containing the following information for each media is added to an overall collection imaging log in .csv format:

- Image/.zip filename
- Date imaged
- Imaging agent
- Earliest date last modified of content found on media
- Image successful?
- Virus found?
- Notes

After examining the disk metadata file, the user records in the collection imaging log whether the image was successfully generated, whether infected content was found and removed, and any further notes on the media or imaging process. Unsuccessful images are later revisited to attempt a successful read via manual forensic investigation.

These steps are repeated for each media item in the collection. To link each image or .zip file with its associated metadata, all files are labeled according to a naming convention derived from the collection and object number. When all media for a collection have been processed, the files are grouped in a collection directory and ingested into Merritt, a preservation service provided by the California Digital Library (UC3 Merritt 2009).

The hardware and software required for accessing and imaging depends entirely upon the type of media being processed. PC-formatted 3.5" floppy disks are accessed via a USB floppy drive and imaged with FTK Imager. Although the Tableau USB Write Blocker is not compatible with the USB floppy drive, 3.5" floppy disks can be easily write-blocked by setting a small tab on the disk itself from read/write to read-only.

Accessing Mac-formatted 3.5" floppy disks is more complicated. This is because older Macintosh computers used a variable-speed system to write to floppies, which allowed more data to fit on each disk but results in a physically distinct magnetic encoding on the disk that cannot be interpreted in a PC-compatible floppy drive. Because of this, the LAMMP process uses a Powermac G3, the latest Mac model with an included Apple SuperDrive, to access these Mac-formatted 3.5" floppy disks and generate an .img disk image file. The .img files are then transferred to the main LAMMP workstation via a closed Ethernet network and converted to the raw disk image format with FTK Imager.

5 ¼" floppy disks are accessed via a TEAC floppy disk drive connected to LAMMP via the FC5025, a read-only USB floppy disk controller developed specifically for disk imaging and preservation. Though the LAMMP process uses a software tool included with FC5025 to read and image the disk, the raw command line output is still piped to FTK Imager to generate a raw disk image.

CD/DVD data discs that contain logical directories and content (i.e., not primarily audiovisual) are processed in the same way as USB drives. For audio CDs, the open-source CDParanoia tool is used to convert audio tracks to .wav files, which are then stored in a .zip package. For audiovisual DVDs, another open source tool called IMG-Burn is used to generate an ISO image of the entire disc.

**ENHANCEMENTS**

Since 2011, a number of enhancements have been made to the LAMMP environment to improve reliability and allow for appraisal and eventual access of disk image contents. First, the Ubuntu Builder tool was used to create a customized Ubuntu OS environment that mirrors LAMMP's hardware, software and customization. This customized OS was then stored in an .ISO package and loaded onto a USB thumb drive to create a portable, bootable version of the LAMMP environment. This USB drive can then be used to re-create LAMMP if the original workstation gets permanently corrupted due to a virus or hardware/software failure. The drive could also be used to easily clone the LAMMP environment to another workstation set up with the proper hardware.
IMAGING DIGITAL MEDIA FOR PRESERVATION WITH LAMMP

A virtual appraisal environment was also developed based on the open source BitCurator suite of digital forensics tools (http://wiki.bitcurator.net/index.php?title=Main_Page). BitCurator is a customized Ubuntu OS environment that comes packaged with tools for imaging, analyzing, searching and extracting metadata from disk images. The Basilisk II emulator (http://basilisk.cebix.net/) was also installed to enable viewing of legacy Mac images in their original environment, as many early Mac files cannot be interpreted in modern PC or Linux environments. Using these tools, the archivist may identify and appraise the value of the content found within each disk image.

After appraisal, disk images identified for further processing and eventual access are transferred to the content migration environment. This is a Windows OS environment with a series of Windows CLI scripts that, like the LAMMP process, have been designed to automate the extraction of disk image content and its conversion to modern preservation formats. Figure 2 gives an overview of this process.

After running the script to extract each disk image’s content to a WORKING directory, a user examines this directory to identify file types. If image files are found, a batch conversion process is run using a file-type specific open source conversion tool and output files are saved in an ACCESS directory. The user then checks each file to ensure the conversion resulted in legible content. If so, the files remain in the ACCESS directory and are recorded in a .csv migration log. If not, files are removed from ACCESS and remain in the WORKING directory for further conversion. A similar process takes place for any audio, video, or text files found within the WORKING directory. Any files not converted at the end of the process are recorded as such in the migration log for further investigation. Although there are many old and esoteric file formats that cannot be converted via this batch approach, the process can successfully automate the conversion of most well-known file formats.

CONCLUSION

The initial collection processed by LAMMP contained 437 digital media objects, 396 of which were accessed and imaged, resulting in a success rate of 92%. A documented workflow has been implemented to deliver, track, and preserve SCA digital media objects via LAMMP. LAMMP itself is built mainly from donated hardware and open-source software—the only necessary purchases were the FC5025 5 ¼” floppy controller, the TEAC 5 ¼”

Fig. 2. LAMMP content migration process.
floppy drive, and the Tableau USB Write Blocker, which cost less than $500 total. By all accounts, UC Irvine Libraries succeeded in building a system to access and preserve legacy digital media as well as integrating archival concepts of acquisition, appraisal, arrangement, and description into the process.

That said, an important byproduct of LAMMP development was the learning process involved. The SCA and IT staff members who worked on the project now know much more about the realm of digital forensics and its application to the world of collecting institutions. In addition, identifying the weak points of this solution will help in asking the right questions about its eventual replacement. There are pros and cons of developing a home-grown technological solution using open source software instead of purchasing a commercial off-the-shelf solution. The gains in monetary savings and freedom to customize with open-source software come with a much heavier investment of time. However, the time spent installing, coding, and debugging develops local expertise and results in a much better understanding of the final tool, as well as ways of fixing and improving upon it.

The most important lesson: start dealing with digital media now! As stated previously, this media has a limited shelf life, and an automated solution such as LAMMP isn’t necessary to perform meaningful digital forensics work. Potentially important content can be imaged with just a USB floppy drive and a free copy of FTK Imager, and active projects such as BitCurator are consistently finding new ways to bring the tools and methods of digital forensics to the world of collecting institutions. As relics of the recent past, digital media objects can form an important part of the research corpus of the future—but only if they are sought out, captured, and properly preserved.

NOTES
1. Information on the development and use of the Frankenstein machine (including manuals, tools and oral histories with its creators): http://pacer.ischool.utexas.edu/handle/2081/21808.

2. Information on the FC5025 can be found at Device Side Data – FC5025: http://www.deviceside.com/fc5025.html.

REFERENCES


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ABSTRACT

Since 2006, the staff at the Denver Art Museum have been working towards establishing a comprehensive program for the care of its variable media collections. This paper will focus on electronic media (video, audio, digital image, and software-based artworks), the initiatives and accomplishments to date, and future goals, as well as how institutional support for the program was garnered.

The Denver Art Museum holds electronic media in both its fine arts and design collections, with 64 works in its fine arts collections and an additional 700 works in its design collection, all dating from the 1980s to the present.

Rigorous steps towards establishing protocols began in 2010 for *Blink!*, an exhibition in which 55 electric and electronic media artworks were on display. The experience of preparing the works for *Blink!* reinforced the need for a systematic preservation program for this class of artworks.

Since *Blink!*, the museum has dedicated space and equipment to an electronic media preservation lab and a systematic migration program for video works in the fine arts collections has begun. Collaboration with a range of colleagues of varying expertise has been crucial in establishing protocols for documentation and preservation, includ-
ing Non-Exclusive Licensing Agreements, review of media and determining formats for preservation and display, as well as developing relationships with outside vendors.

**INTRODUCTION: HISTORY OF COLLECTION**

The Denver Art Museum (DAM) holds electronic media in both its fine arts and design collections. The holdings consist of video, audio, digital image, software-based, and photographic-based artworks and are spread across several curatorial departments: Modern and Contemporary, Architecture Design and Graphics, Native Arts, and the Institute of Western American Art. The majority of the works among the fine arts holdings have been given to the museum by collectors, and only a relative few have been acquired directly from galleries or artists.

Holdings also include those from the American Institute for Graphic Arts (AIGA), a professional association for design located in New York City. Through an agreement made with the AIGA in 2007, the DAM became the repository for the award-winning entries made to the organization’s annual competitions. The competitions date back to 1984. The first group of award winners was received by the museum in 2007. The vast majority of these pieces were paper-based, along with some plastic objects, t-shirts, and hundreds of food and toiletry items, noted for their packaging.

The competition entries have evolved from traditional materials to an increasing number of electronic-based media that require some form of migration or related preservation measures. At present, roughly 700 of these objects are flagged for migration and include CDs, DVDs, videocassettes, flash drives, 35 mm slides, etc.

**ELECTRONIC MEDIA PRESERVATION INITIATIVES AT THE DAM**

Inspired by the complexity of the works themselves and resources such as Matters in Media Art (a consortium of curators, conservators, registrars, and media technical managers from the New Art Trust, the Museum of Modern Art, the San Francisco Museum of Modern Art and Tate) along with other emerging publications and conferences, staff members from conservation, collection management, and registration formed a time-based media discussion group. The periodic meetings culled information and provided a basis of reference for creating guidelines related to processing. Approaches to preserving object formats and dedicated components, artist’s interviews, and installation parameters were also being synthesized. This effort—in its infancy—began in 2008.

In late 2009, planning for the exhibition, *Blink! Light, Sound and the Moving Image* began. *Blink!* would be the first exhibition exclusively dedicated to electronic media from the DAM’s collection, along with a few loans from local private collectors.

In 2010, the time-based media discussion group officially morphed into the Variable Media Task Force. Representatives from conservation, registration, collection management, curatorial, technology, and installations departments began to convene on a monthly basis. Not surprisingly, the discussions of individual objects began to inform broader policies and procedures that in the future would be adopted as a matter of routine.

In spring 2011, *Blink!* opened and 55 works were exhibited for seven weeks. In conjunction with the exhibit, the museum published a companion guide of the entire DAM holdings.

**INSTITUTIONAL SUPPORT**

Planning and execution of *Blink!* was intense, and the adolescent phase of our conservation program emerged. There were multiple transitions involving education and training, as well as navigating one unanticipated circumstance after another—all in a very compressed timeline. At times, it was frustrating and the process misunderstood. Yes, it built character. We were nonetheless fortunate to have had the experience guided by the task force. Ultimately, the institution recognized the task force’s value and presence, and has since supported it as the variable media working group.
FROM INFANCY TO ADOLESCENCE: GROWING AN ELECTRONIC MEDIA CONSERVATION PROGRAM AT THE DENVER ART MUSEUM

Successive trips to New York City were made by the authors with the objective of learning first-hand about various facilities, equipment, and the kinds of expertise that would be necessary to activate and ensure current and future preservation needs. Being able to communicate what other institutions were doing was important.

A vital and informative resource has been the TechFocus workshops, sponsored by AIC’s Electronic Media Group. The dissemination of shared expertise from these workshops has been indispensable in unraveling and effectively communicating the inherent complexities and long-term needs of electronic media to museum administrators. In the case of the DAM, the argument was made that a relatively small number of holdings—in the fine arts collections at least—made establishing a program to make future conservation efforts that much more viable.

The variable media working group, collegial interface, and TechFocus have all given credence to and thereby enabled implementation of strategic planning and fiscal support.

Fiscal needs were based on what we learned from Blink!. Expenses related to migration were itemized and as a result, we have been able to strategically budget based on real costs. Since Blink!, we have been working with national and local expertise for playback and migration purposes.

In fiscal year 2012, the conservation department was given a budget to purchase a range of playback and display equipment as well as dedicated furniture, as detailed below. Since fiscal year 2012, we have had a budget line specifically for the conservation of variable media. It supports expenses related to migration, equipment and supplies, and contract labor.

CURRENT APPROACH
Since 2009, working methods and protocols surrounding the conservation of electronic media works have developed and solidified at the DAM. The variable media working group now meets every other month to discuss new and ongoing projects. The group includes representatives from two curatorial departments (Modern and Contemporary and Native Arts), conservation, registration, collections management, and technology. Recent topics of discussion have included questions from the curatorial departments about status and rights over editioned video works, budgeting for migration work, logistics of sending video works to outside vendors for migration, contracts for acquisitions, and status of display equipment.

Here is a summary of the departments involved with the working group and their roles:

- **Conservation**: oversees migration work, manages media lab, documentation.
- **Registration**: contracts, rights and non-exclusive licensing agreements, cataloguing.
- **Collection Management**: storage and space resources, inventories collection server.
- **Curatorial**: communicates with artists and galleries (with conservation), programming.
- **Technology**: installs electronic media artworks, advises on digital storage, provides knowledge related to computer based artworks.

Outside the working group meetings, the conservation department has been mainly responsible for migration work, establishment of a media lab, and documentation of electronic media artworks, with assistance from curatorial assistants, registrars, and technology staff. The conservation department at the DAM is comprised of five staff conservators, a mountmaker, and two assistants. In addition, interns and fellows develop their specialized expertise. Beginning in 2011, approximately one-third of one full-time conservator’s time has been dedicated to electronic media, with administrative support from the director of the department. Prior to 2011, the director of conservation, one part-time paintings conservator, and one conservation assistant devoted time to these activities as other duties allowed.
Electronic media works make up only a small portion of the collection, less than 1%, but a far greater amount of conservation time, in tandem with other museum departments, is needed to support its preservation, including time to establish and uphold new protocols and for ongoing education of participating museum staff. While the specializations of the conservators are not specifically in media conservation, they have worked earnestly to gain education through a course in collection management at the New York University Moving Image Archiving and Preservation Program and the TechFocus I and II workshops conducted by the Electronic Media Group of AIC.

Conservation work has focused to date on video works within the fine arts collections, mainly within the Modern and Contemporary and Native Arts departments. In addition, migration was carried out of a few video works from the AIGA collection that were considered for display. The focus on video works has been due to better familiarity with this medium on the part of the conservators, as well as momentum in this area after the work done for the Blink! exhibition.

ACCOMPLISHMENTS
Two of the early accomplishments of the variable media working group were the establishment of a cataloguing approach for electronic media works and drafting of a Non-Exclusive Licensing Agreement (NELA). The latter was specifically for electronic media and gives the museum limited rights to copy electronic media materials for exhibition and preservation purposes. The NELA is a key part of the preservation plan for electronic media. The working group seeks to obtain these from artists at the time of acquisition, though there is a backlog of works that are without NELAs. These are actively being sought from artists or their estates.

Electronic media works are fully catalogued using the museum’s collection management system, ARGUS.net. The working group is seeking to consolidate as much information as possible about electronic media works in the database. A numbering system is employed that allows quick differentiation between original elements provided by the artist or gallery and later exhibition copies or archival masters created by the museum or other parties. Detailed information for each element is recorded in individual part records. Location information for digital files includes file names and paths on the collection server. The overall whole record for the artwork includes an Installation Notes field where specifications and a log of each installation of the work are kept. The ARGUS.net platform allows for installation instructions in digital file formats to be easily attached to the records. At this time, most of the electronic media-specific data is stored in just one field on the database. The working group aims to add more electronic media fields to the database to ease data entry and retrieval.

In preparation for Blink!, the majority of the video works in the collection were evaluated for possible display in the exhibition. Some works were migrated at that time with the main intent of making them displayable once again. However, a systematic survey of formats was not completed at that time, and cataloguing was found to be incomplete in many cases. In 2011-2012, the video works in the fine arts collection were surveyed. All tapes were inspected for physical condition, and videotape formats were identified. Formats of digital files on the collection server were likewise identified. Then the works were given priority codes based on the quality and risk of obsolescence of the masters. The survey was crucial in identifying which works were most at risk of obsolescence or degradation and also for identifying which works were ready for migration. For many of the video works in the collection, the master format is DVD or VHS. For these works, the artists or galleries are being actively contacted to determine if a higher quality master is available.

The first round of systematic video migration work was completed in 2013, with funding allocated from the museum’s general budget. Eight video works were identified for migration. To increase the conservators’ familiarity and experience with migration work, the video restora-
tion department at DuArt Film and Video in New York was selected as the vendor. Maurice Schechter, an engineer specialist at DuArt, has worked regularly with museums to carry out migrations and establish media labs. In addition, Maurice was a key contractor for migration work in preparation for Blink! This round of migrations was successful and enlightening for the conservators. However, transport of valuable masters to and from New York proved to be complex and further reinforced advice from colleagues to seek out a local vendor.

With the experience of working with DuArt in hand, the working group began looking for a local vendor. In addition to simplifying transport logistics, collaboration with a local vendor allows museum staff increased oversight of migration processes and questions of interpretation that might arise. For screening and evaluation of acquisitions, a local vendor provides an accessible resource when outside expertise is needed. The Modern and Contemporary curatorial department suggested Denver-based Postmodern Company, which specializes in post-production work. The company’s president, David Emrich, is the brother of Denver-based video artist Gary Emrich, and has deep ties with the Denver artistic community. Representatives from the conservation and curatorial departments visited Postmodern Co. and interviewed David Emrich about the possibility of working together. With more than 25 years experience in video postproduction, a love for and collection of vintage equipment, and an understanding of both artistic and commercial approaches to content, Emrich and Postmodern Co. seemed a good fit. Emrich’s forthrightness about his limitations in working with degraded tapes was also a positive. Since then Postmodern Co. has successfully carried out migration of 6 public service announcements from the AIGA collection.

For working with vendors—either local or afar—a migration report was drafted to assist in documenting the process, cataloguing the new elements, and improving cataloguing of the source elements. The completed migration report is logged in the collection management system as a conservation report under the whole record for the artwork, so that the preservation history of the work can be easily tracked.

Finally, a media lab has been outfitted at the museum to support migration efforts, evaluation and preparation of works for display, and access to and organization of the collections server (figs. 1–2). Initial research to de-
velop the lab comprised visits to the media labs at the Guggenheim Museum and the Museum of Modern Art in New York, as well as DuArt. Advice was sought from conservators, archivists, and outside video specialists. It was first necessary to determine what could realistically be expected to be accomplished with a media lab, given limited video technology expertise in-house. It was concluded that the first goal should be to establish the capability to screen video files in a manner that would allow effective quality control and determination of correct appearance and sound. It is anticipated that as expertise grows, the capability to screen tapes can also be established. To these ends, CRT and LCD broadcast quality monitors were purchased to allow screening of works in our collection ranging from a 1982 piece by Gary Emrich up to new acquisitions in full HD. The monitors both offer a “blue gun” mode for calibration and features such as underscan and varying color systems to aid in screening and examination of a wide range of formats and standards. High quality active sound monitors were also obtained, as well as a Blu-ray and DVD player with multi-standard capabilities. Other key acquisitions were a Mac Pro tower and a Blackmagic video card that allows video and sound signal input and output. A RAID 5 storage array functions as the collections server, which is backed up to the museum’s network. In addition, U-matic, Laserdisc, and VHS decks were collected from the museum’s AV department for possible future reconditioning and use.

FUTURE GOALS
Addressing the conservation needs of works already in the fine arts collection will be ongoing. In 2014, efforts are underway to contact artists and galleries in order to obtain missing NELAs and investigate if better quality masters are available for works that are only on DVD. At the same time, questionnaires are being sent out to establish information such as the production history and display specifications. It is uncertain how effective these efforts will be, and the results of this process may help to inform our collecting policies in the future.

Software-based works are a highly vulnerable area of the collection. A survey of the eight software-based works in the collection, seven in the Modern and Contemporary department and one in Native Arts, will be taking place within the next year or two. Current state of functioning will be established as well as vulnerabilities and needs. Artists will be contacted and interviewed. Software files will be backed up and preservation timelines and plans established for each work.

Finally, it is anticipated that work on the AIGA collection will begin within the next year. The registration department completed basic cataloguing and storage of the electronic media items in the collection between 2007 and 2013. In-depth cataloguing and rights assessments need to be addressed next. This collection poses many interesting questions, such as the role of the museum in the collection of commercial electronic media objects and the locus of meaning/significance for electronic graphic design. Rights assessment and licensing has proven a challenge for even the non-electronic holdings of the Architecture, Design, and Graphics department, due to the commercial nature of many of the materials. Contract or on-call assistance will likely be needed with in-depth cataloguing of the various formats in the collection and with rights assessment. Then the difficult task of determining what to preserve and how, will be able to commence.

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FROM INFANCY TO ADOLESCENCE: GROWING AN ELECTRONIC MEDIA CONSERVATION PROGRAM AT THE DENVER ART MUSEUM

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CONSERVATION OF TIME-BASED MEDIA BEFORE ACQUISITION OR:
HOW I LEARNED TO STOP WORRYING AND LOVE HD VIDEO

PETER OLEKSIK

Sustainable choices in collections care, when applied to time-based media, are constantly evolving. This technological area requires the collaboration and active engagement with a variety of individuals and industries. Focusing on the ever-shifting medium of digital video (in particular, so-called “high definition”), this presentation will highlight how working closely with curators, artists, and media professionals at the pre-acquisition phase is imperative to the long-term storage and care of this material. Case studies of recent acquisitions by different curatorial departments at The Museum of Modern Art will highlight the variability of this media and how to make sustainable conservation decisions before the work even enters the collection. Particular workflows and best practices, in both the acquisition and long-term conservation of these types of works, will illustrate how conservation starts before acquisition.

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LIFE AFTER TAPE: COLLECTING DIGITAL VIDEO ART

JOANNA PHILLIPS AND AGATHE JARCZYK

The shift of artist-created video towards file-based formats and the approaching obsolescence of digital videotape challenge collecting art institutions in regard to the preservation, storage, and display of contemporary video artworks. In the previous era of digital videotape, the museum’s choice of master formats, migration cycles, and storage parameters was guided by established archival standards and best practices. Importantly, tape formats also defined the image geometry of the recorded video and ensured its compliance to broadcast standards and its compatibility to standardized playback and display equipment.

In art production today, many artists make use of the rapid advancement of consumer technology and no longer rely on semi-professional vendor-supported production and post-production software. As a result, artist video files arrive at the museum in an abundance of different codecs, containers, frame rates, and pixel resolutions. Artists’ use of proprietary formats, especially of proprietary codecs, raises the concern of limited file sustainability. In addition, the quality of mastering of artist video can reflect differing levels of technical expertise, and in some cases artist-provided files might be operational only on a computer, but are incompatible with standardized video playback and display equipment in the galleries. The latter can necessitate reformatting the artist-provided, native master files—a measure that touches on the notion of authorship and authenticity and can create an ethical dilemma for
the conservator. In this context it has to be discussed how far the museum interferes with the artistic process when making sustainable format recommendations or stipulations regarding acquisition deliverables.

Regardless of the question of which file formats to acquire, museums must develop protocols and implement workflows for quality and condition checking video files. Not only may the artist’s video lack established standardization, but different playback and display environments have a severe impact on the visual rendering of digital video. Thus, when defining a reference for the quality and condition of video artworks, a conservator should consider determining factors such as the computer’s graphic card, the player software, and the display technology. In addition to evaluating the video content, it is important to also adopt digital preservation standards and establish procedures for metadata creation, checksumming, and redundant server storage.

This paper is based on a joint research initiative between the Solomon R. Guggenheim Museum and the University of the Arts Bern, Switzerland. It identifies the challenging factors of collecting video art in digital file form and discusses possible approaches and tools the museum can employ to ensure the quality and integrity of the digital video material that enters its collection.

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SUSTAINABLE DIGITAL PRESERVATION FOR AUDIOVISUAL CONTENT

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ABSTRACT
Preserving digital time-based media and born-digital art is resource-intensive. Digital content can be the result of analog-to-digital transfers, or be born-digital. To preserve these works into the future, conservators must be familiar with proprietary file formats, systems used to create and render content, and production workflows behind content creation. Performing managed digital preservation actions are more complex than with static content: files are larger (making fixity checks and storage requirements intensive); the analog-to-digital preservation process must be carefully tracked through metadata; and proprietary formats must be migrated to newer generations or open formats while being mindful of content file interdependencies. Many museums and custodial institutions—as well as the creators themselves—lack infrastructure and staff expertise to perform managed digital preservation actions on this content. This paper will provide an overview of the issues surrounding preserving digital time-based media, and describe the Audiovisual Archive Network (AVAN), a non-profit digital preservation service for educational, arts-based, cultural heritage, and government organizations as well as individual creators.¹
NOTES
1. Shortly after the AIC conference, AVAN’s institutional partner, the UCLA Library, withdrew from our partnership and the Mellon Foundation proposal we were drafting. AVAN dissolved and became a new entity called Digital Bedrock, offering the same services, but expanding beyond cultural institutions to anyone with digital content.

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THE CALIFORNIA AUDIOVISUAL PRESERVATION PROJECT: A STATEWIDE COLLABORATIVE MODEL TO PRESERVE THE STATE’S DOCUMENTARY HERITAGE

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National studies on the preservation and access of media holdings by the Council on Library and Information Resources (CLIR) of the Library of Congress as well as a research survey of special collections and archives conducted by OCLC Research Group underscore the magnitude of the challenges facing cultural heritage institutions. Primary source sound and moving image recordings of the 20th century are seriously endangered by physical deterioration, lack of playback equipment, and rapidly advancing format obsolescence. Preserving them, including addressing metadata needs, potential rights issues, and technological complexities of audiovisual materials and the digitization processes, can be intimidating. Few institutions have the staff and resources to begin preservation planning, and very few have in-house facilities to accomplish audiovisual preservation work.

The California Audiovisual Preservation Project (CAVPP) is a preliminary example of how a collaborative model can work as one proactive solution to many of these challenges. It is the first statewide initiative in the country to collaboratively facilitate access and accomplish audiovisual preservation work most individual organizations are unable to undertake. The Project helps libraries and archives move from the analog to the digital age. Perhaps most importantly, it teaches libraries and archives how to help themselves with their audiovisual preservation challenges. Based on best archival practices for moving image and sound preservation, the CAVPP es-
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establishes low-cost, practical, standards to guide partner institutions through the preservation planning process: from collection assessment, selection, description, digitization, and metadata management to quality control, long-term storage, and online access. It also brings to light hidden media collections via the Internet Archive (IA), a repository that is freely available for non-profit and educational use. To date, the California Light and Sound (CLS) collection includes 5,500 previously endangered and historically significant audiovisual recordings, contributed by 108 museums, archives, and libraries across the state.

This session will discuss how the CAVPP is developing a collaborative, increasingly sustainable, statewide audiovisual preservation infrastructure.

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MUSEUM AND UNIVERSITY COLLABORATION IN MEDIA CONSERVATION RESEARCH

GLENN WHARTON AND DEENA ENGEL

ABSTRACT

Media art conservation requires many forms of research to implement strategies for long-term preservation. Standard research includes investigating original playback equipment, staying abreast of emerging audio, video, and software technologies, and communicating with artists about technologies they use and their exhibition preferences. Media conservation also requires primary research to develop strategies for new technologies that artists use in their production. Museums are well served by establishing relationships with local universities to conduct some of this research. Academic faculty and students can assist media conservation in many ways, from answering technical questions to engaging in more extensive collaborations.

In this article the authors present a model for collaborative university and museum research based on an extensive three-year project they conducted at the Museum of Modern Art and New York University. Students from the university worked with the authors to carry out technical research on three software-based artworks. The model is described in terms of pedagogical goals, project development, and project implementation. The aim is to stimulate similar cross-institutional research in which no funding is required, all parties benefit, and findings are disseminated through publication.
INTRODUCTION
Over the past seven years a number of collaborative projects conducted by the Museum of Modern Art (MoMA) and New York University (NYU) provided valuable information to the museum, learning opportunities for students, and research data for publications. Programs and departments involved in these projects at NYU include the Courant Institute of Mathematics, the Moving Image Archiving and Preservation Program (MIAP), the Museum Studies Program, and the Institute of Fine Arts.

The aim of this article is to present a model for conservators at museums to work with university professors and their students in collaborative research projects. The research needs are well known to readers of publications by the Electronic Media Group. Rather than focus on these needs, we address structural and logistical issues associated with joint museum and university research. Given the limited resources available to museums, joint institutional research projects in which no funds are required can benefit all parties. The success of each project depends on clear articulation of and agreement on project goals, as well as an understanding of the responsibilities of everyone involved and a well-conceived schedule of activities.

Although there is considerable overlap of institutional and individual interests in university and museum research projects, they are not perfectly aligned. On the highest level, the mission of most museums includes the acquisition, exhibition, and conservation of their collections, as well as public education. Museum mission statements usually do not include collections research. Therefore resources, including staff time, are rarely devoted to research that is not linked to exhibition or remedial conservation projects. Media conservators often find it difficult to allocate the considerable time required for research and deep documentation that is necessary for long-term conservation needs.

The mission of most universities is to educate students and advance knowledge. Strategies for achieving these goals include teaching, research, and publication. There is considerable common ground between universities and museums regarding research, yet there are important differences of which everyone should be aware. A primary difference is that conservators need applied results from their research. They need to make use of their findings, whether it is for a specific conservation intervention or for technical documentation to serve staff in the future. University faculty seek research projects that offer pedagogical and publishing opportunities. Academic publications focus on the production of new knowledge, although they are often based on data from applied research.

Another important difference between universities and museums is in the dissemination of knowledge. Unlike most museum staff members, university professors are required to publish to advance their careers. Academic faculty need to publish articles in peer-reviewed journals and write books with university presses. They must publish new, defensible conclusions based on careful research and analysis. Any conservator who has published in a peer-reviewed journal such as the Journal for the American Institute for Conservation or Studies in Conservation is well aware of the amount of time required to satisfy professional reviewers and editors. Conservators are encouraged by their museums to communicate their work to the public online through blogs, videos, and reports describing results of their technical analysis. Although some conservators may want to publish academic articles, the goals of their institutions are more directed towards attracting people to websites and expanding visitation and museum membership.

The success of any joint research project depends on understanding individual and institutional goals, as much as the actual research problem. It also depends on careful planning in advance. We found that clearly defining the scope and aims of the project at the beginning helped structure the project stages. For pedagogical purposes, museum staff need to spend time with student researchers by giving them behind-the-scene tours, describing how conservation functions in the museum, and providing an opportunity for them to present their
results at the museum. Museums in turn need concise reports with data from students and faculty, with recommendations for conservation and future documentation strategies. Faculty need access to the research data to draft their publications. This access includes the rights to publish the data and images generated during the research. At times, permission must be gained from artists to publish information about their work. It is helpful to define the roles and responsibilities of all key players at the beginning, and make sure that other impacted staff, not to mention supervisors, are well aware of time commitments and project resource needs.

After defining research aims, project stages must be developed that fit within other staff commitments and institutional needs. The university schedule has an annual rhythm. Faculty have more time to develop projects and write between semesters, whereas students need to be introduced to projects, perform their research, and write their reports within a semester time block. Museums have their own scheduling rhythms, often associated with exhibitions and acquisition projects.

**MOMA AND NYU JOINT RESEARCH PROJECTS**

The position of Media Conservator at MoMA was established in 2007, although author Glenn Wharton, who assumed the position, began researching the collection in 2005 on a part time grant from the museum. Since he was already a half-time faculty member at NYU, student and faculty research was part of the initial focus of the media conservation program he developed. This included museum staff lectures in classrooms, symposia at the university and the museum, and both student and faculty research projects on individual artworks in the collection. Several projects that characterize joint research between the museum and the university are described below.

Starting in 2007, classes from the Museum Studies and MIAP programs regularly conducted research on MoMA’s media collection. Under faculty supervision, students studied the museum’s internal documentation and researched artwork technologies and artist concerns for artwork presentation. Often the students interviewed the artists at the museum, in participation with staff conservators and curators. Reports from class projects greatly extended the museum’s capacity to conduct its own research. For instance, students from the Handling Complex Media class in the MIAP program performed research on Max visual programming language and interviewed two programmers who used it to program two artworks at MoMA. Their technical report and the interview transcript help museum staff in their risk assessments of the two artworks.

In 2009-2010, a one-year project at NYU, titled the Conservation of Computer-Based Art Working Group, explored research interests at the university. The project was co-directed by Howard Besser, Deena Engel, Mona Jimenez, and Glenn Wharton. It was funded by the Visual Arts Initiative at New York University, as detailed in the *Conservation of Computer-Based Art Working Group Project Report* (Wharton et. al 2010) The group conducted four meetings that enabled faculty and graduate students to learn about the research concerns of media conservation within museums. The aim of the project was to identify individuals within the university with research interests in the conservation of software-based art, and to develop strategies for future research. During the fourth meeting, professors Deena Engel and Mona Jimenez interviewed artist Sep Kamvar (b. 1977), who is represented in MoMA’s collection.

In 2011, Fernando Domínguez Rubio, a post-doctoral fellow in sociology, co-taught a graduate seminar with Glenn Wharton at NYU, and in 2012 he interned in media conservation at MoMA. Through participant observation research, their combined aims were to investigate the conservation of media art in the context of challenges to traditional framing of authenticity and authorship, along with a larger analysis of collective memory in our contemporary digital culture. As an intern, Fernando Domínguez Rubio performed basic tasks in the media conservation lab, while keeping a journal of daily activities and interviewing staff at the museum. This embedded approach
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to qualitative research and knowledge production led to a number of co-authored presentations and publications. 2

In 2009, Deena Engel was invited by MoMA to conduct risk assessments of three software-based works as part of a Matters in Media Art project. 3 Risks assessed in this study included the potential impact of changes and upgrades to hardware, operating systems, and programming languages that would render the software obsolete. Based on the three risk assessment reports generated from the study, we developed a risk analysis template that could be applied to additional works in the collection. The template was later published as an appendix to an article (Engel and Wharton 2014). Following the initial risk assessments performed by Engel, MoMA conducted ten more assessments. A number of these assessments were aided by student research from classes in the MIAP Program at NYU.

After analyzing the risks associated with these thirteen artworks, we concluded that artist generated source code is a primary concern that needed further research. In addition to the risks associated with source code for all software applications (such as changes to the underlying operating system, changes to the hardware used, changes to the programming language, and other factors), we were concerned that the custom designed source code developed by the artist or contracted programmers is frequently at additional risk due to the lack of technical documentation provided with the source code.

In 2010 a new project was launched to investigate the potential of adapting models from software engineering to create technical documentation of artist rendered source code. This documentation will provide information to future programmers to recompile or re-write the code for new operating environments. Over the course of three years, small teams of undergraduate students in Computer Science and graduate students in Museum Studies at NYU were selected by the authors to create technical documentation for the source code of three artworks. The initial results of this research were published in 2014 (Engel and Wharton). A second article, titled “Source Code Analysis as a Tool for Technical Art History,” was published the following year (Engel and Wharton 2015). It describes the potential for using source code analysis in art historical research. In the following sections we describe the development and implementation of this project, and offer suggestions for other museums that are interested in conducting similar projects with local universities.

PEDAGOGICAL GOALS

The pedagogical goals of the source code documentation project include introducing students to the experience of doing original research, writing up their results, and presenting their results in a formal setting.

Most works of software art are written at a level of complexity that is appropriate for advanced undergraduate computer science major students so these artworks pose an unusual opportunity for students at this level to do original research. The students are required to write up their research including contextualization of their work, a description of their methods, a summary of their findings, suggested next steps, and a bibliography. These projects each concluded with a final meeting with museum staff to give the students the opportunity to present their work in a formal setting so that they gain the experience of giving a formal talk and handling a Q&A period thereafter.

The model of museum and university collaboration described here is not about getting free student labor. It is an exchange in which both institutions contribute to fulfill all of the goals. Considerable time is required by the museum staff to prepare for the research and by the faculty member to supervise and guide the students. In order to make these projects work so that they are truly a win-win for both the museum and the academic institution, it is important to partner with one or more faculty members who are aware of specific pedagogical goals and can tailor the projects to meet departmental academic standards, who are familiar with the museum’s goals and needs, and who have a deep interest in the research that is generated. These goals can be accom-
plished in ways that serve the needs of the students and faculty and benefit the museum.

There is a long lead-time required for these projects in order to coordinate and identify strong students and appropriate artworks. The time spent on preparation serves to insure valuable results for the museum, good academic experience for the students, and valuable results for faculty in their need to conduct and publish research.

Preparation for each project begins with selecting the work of art to study. The selection of the artwork is the result of collaboration between the conservator and faculty member. The museum benefits from selecting one or more works of art that are significant to the museum’s collection so that the artwork and its conservation are important to the museum and future exhibitions. Additional criteria include whether the museum can reasonably anticipate the artist’s permission for such a study and possibly benefit from the artist’s participation. The museum must address any copyright issues that require attention before embarking on the study. The museum staff must also evaluate the work of art under consideration to insure that it has suitable components (e.g., the data files are available, special hardware is not needed for the study, and there is no cost).

From an academic perspective, the faculty member provides guidance on selecting one or more works of art that are sufficiently complex—both with respect to the source code and to the configuration of the work as a whole—as to support a research project; and to select a variety of works of art over time in order to ensure valuable research outcomes. The faculty member assesses the works of art for the project by asking whether it poses interesting research questions. The faculty member further evaluates potential works of art for study by examining a number of aspects, including the state of the source code to determine the programming language and version (e.g., whether it is a dead or living programming language); the level of programming difficulty in the source code itself; whether the work of art was programmed by the artist or a hired programmer; how “clean” the code appears to be and other guidelines. In some cases, the faculty member also considers the hardware environment, operating system, and other factors.

**PROJECT DEVELOPMENT AND IMPLEMENTATION**

Upon selecting one or more works of art, the planning can begin. The faculty member decides how many students may participate and in what structure (e.g., is this a class project, a small group project, etc.) in order to define how many students to accept and the skills the students must have in order to participate. From a planning perspective, one must also bear the academic semester calendar in mind so that projects can begin and end within appropriate time frames for the students to get academic credit for their work and coordinate their research with other academic responsibilities. Depending on the nature of the artwork, qualified students might come from one of several computer science academic programs such as advanced undergraduate computer science major students, graduate students in computer science, or undergraduate students with a major in the arts or the humanities and a minor in computer science.

It is the faculty member’s responsibility to select the students. It is also the faculty member’s responsibility to ensure that the research project is set up to meet academic research requirements within the computer science department so that the students can receive either independent study or research credit towards graduation for these projects.

Once the artwork has been selected and the project has begun, it is important to have an initial meeting at the museum or conservation lab so that the computer science students can learn about art conservation in general and about conserving time-based media in particular. This is also an opportunity to introduce the computer science students to a museum staff member, graduate student in art conservation, or a museum fellow who will work with the students with respect to answering questions about
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the artwork and contextualize the work within the artist’s oeuvre and the museum collection. Collaboration with an expert outside of the computer science field is another benefit for computer science students who often find that they need to think carefully about how they explain technical aspects of the artwork to a non-expert.

During the course of the semester, students are expected to meet with their faculty advisor on the project on a weekly basis to discuss their research and to ensure that the project is progressing in a timely manner. The students work throughout the semester to prepare three deliverables to the museum at the end of the semester: the final report, the presentation at the museum, and slides for the presentation.

The museum staff representative schedules, hosts, and participates in the students’ presentation near the end of the term. This is an opportunity for the students to discuss their research and the results. In addition to giving a 20–30 minute talk, the students prepare for a Q&A period so that they can answer questions for the museum staff about the work of art and their recommendations for future conservation.

The students submit a collaboratively written report that is the result of their research to the museum staff at this meeting (typically 20–40 pages including narrative, charts, citations, diagrams, etc.). Students provide a list of software and hardware resources (e.g., URLs for programming languages and libraries) and other resources (e.g., transcripts of artist interviews). The report is prepared during the course of the semester and is co-edited by the faculty member. Students focus on an in-depth analysis of the technical structure of the work, documentation of the source code, conservation risks that they anticipate based on their research, and recommendations for conservation practices for the artwork. Students also submit their lecture slides that they prepared for the presentation to the museum.

In the final stage of the project, at the end of the semester, students receive a grade on their official academic transcript. Student assessment by the faculty member is based on the quality of their research; their oral presentation at the museum; and the written report.

CONCLUSION
Our intention in this article is to advocate for more joint university and museum collaborations in order to work towards solving media conservation problems and advance the field through research and scholarly publications. The model that we describe contains details that may be specific to the case of source code documentation, but our hope is to help frame research projects to accommodate the conservation needs at other institutions and for other electronic media in the future.

We are experiencing an exciting moment, as the field of media conservation continues to evolve and digital art technologies rapidly advance. Today’s students at universities and interns at museums will be the professionals and scholars of the future. Both museums and universities will serve the next generation well by fostering collections research that preserves our contemporary media heritage for future re-exhibition while providing pedagogical opportunities and disseminating knowledge produced through this research.

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REFERENCES


NOTES

1. Fernando Domínguez Rubio received a Post-Doctoral fellowship (2010–2013) from the Marie-Curie Foundation, European Research Council. The Open University in London sponsored the fellowship, and New York University hosted him. The 2011 graduate seminar was titled *The Museum Life of Contemporary Art.*

2. For instance, the lecture “Co-Production at MoMA,” was presented on February 13, 2013 at the College Arts Association annual conference, and an article titled “The Contemporary Art Museum and Fragile Memories of the Digital Age” is currently being completed for publication.

3. The Matters in Media Art project is a collaboration of the New Art Trust, the Museum of Modern Art, the San Francisco Museum of Modern Art, and Tate. More information can be found on the project website: www.tate.org.uk/about/projects/matters-media-art (accessed July 21, 2014).

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