

Before It's Too Late: Preserving Games across the Industry / Academia divide

Henry Lowood Andrew Armstrong Devin Monnens Zach Vowell Judd Ruggill Ken McAllister Rachel Donahue Dan Pinchbeck

International Game Developers Association Games Preservation SIG
preservation@igda.org

ABSTRACT

This paper is an edited version of the International Game Developers Association's Game Preservation Special Interest Group's recent white paper. The specific threats to preserving digital games are outlined, as is the importance of games as cultural objects. The current strategies for preservation across a range of stakeholders are presented followed by an argument for why preservation matters to industry and what industry can contribute. Finally, the unique potential relationship between academia and industry in this matter is explored, and a call for partnership projects and strategic dialogue is made.

Author Keywords

Games, preservation, industry, developers, IGDA

INTRODUCTION

The Game Preservation Special Interest Group was founded in 2004, only five years ago. Even in that short time, however, interest in the preservation of digital games and virtual worlds has intensified remarkably. Today, cultural institutions such as universities, libraries, and museums have begun to collect, display, and make available artifacts of game culture, and opportunities for the practical or critical study of game content and technology are increasing rapidly. Game studies, a field that barely existed ten years ago, now boasts of annual conferences, journals, and organizations dedicated to it.

All of these developments are fine and good. In this white paper, however, we address a threat not just to academic game studies and the historical appreciation of game culture, but also to game developers and the industry itself: the potential disappearance of original game content and intellectual property through media decay, obsolescence, and loss.

We wish to be very clear about one point, so at the risk of repetition, allow us to say it again in other words: if we fail to address the problems of game preservation, the games currently being made will disappear, perhaps within a few decades.

This paper was originally written with a target audience of developers in mind, and presented at GDC2009. Here, we present the arguments for preservation from the perspective of the SIG, and what is required from industry in order to achieve this. We will also consider the importance of collaboration between industry and academia in this process.

SPECIFIC THREATS TO GAME PRESERVATION

Digital games are in dire need of preservation. Every year, thousands of games move one step closer to oblivion as a result of the same threats to longevity that affect all digital media: bit rot and obsolescence. Digital media have a shockingly short life span due to the natural decay of the original materials and the rapid obsolescence of older media forms, as well as the failure and obsolescence of the hardware necessary to run them. Many digital games that are only a few decades old are already at-risk and require immediate preservation attention. Libraries and archives around the world have only just begun to pay serious attention to digital games, yet they already face the immediate problem of working together. If no concerted action is taken to save these games before they disappear forever, we will have lost the foundation of our industry's history. It will not be enough simply to hand the problem over to libraries and archives that are beginning to collect digital games – these repositories lack the expertise and funding to solve the many problems of digital preservation. They will also need the industry to help, because preservation methods are further complicated through current business practices of digital rights and distribution.

In short, thousands of digital games are on their last life. Once they reach that final Game Over screen, we will not get a replay.

Media Decay, or Bit Rot

The greatest threat to the longevity of digital games is media decay, also known as bit rot. Bit rot is the gradual and natural decay of digital information and storage media over time, resulting in eventual unreadability. Bit rot affects different storage formats at different rates depending on the format's durability. Magnetic storage and optical discs are

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especially subject to varying forms of digital decay. For the time being, masked ROM cartridges appear to be fairly durable while EPROMs are at greater risk.

Magnetic storage media such as floppy disks, magnetic tape, and hard drives are particularly susceptible to bit rot. In magnetic storage, media decay results from the weakening of the disk's magnetic properties over time, causing them to "fade" and become unreadable [13]. Floppy disks are at the greatest risk of decay due to the flimsy nature of these disks and their age, which in many cases now exceeds their life expectancy, while games stored on magnetic tape are also at risk. Current estimates place the lifespan of floppy disks at between 10 and 30 years, with disks from 1985 and earlier already showing considerable signs of decay and unreadability.

Thousands of games were published on 3.5" and 5.25" floppy disks up until the mid-1990s. Many of these are now over twenty years old and well on their way to oblivion. It is therefore critical that preservation methods be undertaken to preserve games stored on magnetic media before the large and significant part of the history they carry is lost forever.

Optical discs can be damaged physically by pits and surface scratches as well as chemical deterioration due to inks, adhesives, and other materials, but they are also affected by bit rot. The physical material of optical discs breaks down over time; physical and chemical destruction of the reflective layer of the disc causes pits on the disc surface, known as CD rot or laser rot, and discoloration of the disc, known as CD bronzing. Any of these will eventually cause a disc to become unreadable.

The lifespan of disc-based media is unknown. Based on rapid aging tests [12, 7], media decay has been shown to affect discs created through lower-quality manufacturing and using low-quality materials, such as silver-based dyes. While beta discs and other media printed on CD-R's are at particular risk, bit rot has also been documented in formats as recent as Blu-Ray discs [10] and Sega Dreamcast discs [11], and so will continue to be a problem well into the future.

Uncertainty about the long-term stability of optical discs means that their longevity is of great concern. It is imperative that measures be taken to better understand the life expectancies of different kinds of optical disc-based games and the need to preserve them before the problem becomes as dire as that of magnetic storage media.

ROM cartridges are less affected by bit rot than other digital game storage media. ROM cartridges are made of durable material, and most commercial cartridge-based games are burned to masked ROM cartridges, which have considerably longer lifespans than most other digital media. However, ROM cartridges require protection to mitigate corrosion from moisture and battery acid, while restoration may also be necessary to preserve such functions as battery-backup. The ultimate lifespan of masked ROM cartridges is

unknown, but it is possible that some cartridge-based games will last longer than the copyrights associated with them.

However, EPROM (Erasable Programmable ROM) cartridges are subject to more rapid digital decay [1]. EPROM cartridges store data by charging electrons inside the chip; over time, these charges will slowly leak through the chip insulation, causing irretrievable loss of information. Current estimates suggest that EPROM cartridges can last upwards of 25 years; many early cartridge-based games have already surpassed this age and demonstrated the effects of bit rot. This places games stored on EPROM cartridges at risk and requires the implementation of measures to ensure their long-term preservation.

Battery failure is another form of data loss, as in the case of digital information stored in RAM chips, which is deleted once the chip loses power. For example, games based on Capcom CPS-2 arcade boards contain security codes stored in a staticRAM (SRAM) chip powered by a battery. When the SRAM loses power, the board "commits suicide" and the security code is erased, making the game unplayable. Capcom currently offers a service for repairing the boards, though this service is not guaranteed to be available even ten years into the future [14].

Obsolescence

Digital games, like all digital media, are also subject to obsolescence. Obsolescence occurs when older media formats are replaced by newer formats with greater speed, storage capacity, and functionality. When old media are replaced, there are no longer systems to support them, and they will not run on the latest software and hardware platforms. As a result, even if the medium on which a game's data is stored is able to last a hundred years, after only a fraction of that time, its data will be unreadable in the latest hardware and software environments. Additionally, media that are less durable and stored on obsolescent hardware will be more difficult not only to use, but to preserve for long-term use.

Every media format undergoes obsolescence, and the media of today are no exception. When the VHS tape was introduced, few foresaw how quickly it would be replaced by the optical disc. The optical disc, while currently backwards compatible from Blu-Ray to DVD to CD, may not be a viable format even 20 years from now. And so on. Format longevity is never guaranteed. Market forces, rather than the needs of long-term preservation, usually determine the survival or disappearance of media formats.

Digital games are particularly susceptible to media obsolescence. Digital game technology evolves rapidly, and therefore game hardware becomes obsolete faster than most other technologies. Only a few game platforms have ever had backwards compatibility, and even then, compatibility of older games with newer platforms has rarely been 100%. Several competing game platforms are released with each generation so that the number of obsolete game systems

presents a daunting challenge to those trying to preserve console games. Additionally, the personal computer platform is exponentially more complex, given the wide range of customizable hardware systems available, each of which affects game presentation and performance. These different hardware environments must also be considered when dealing with digital game preservation.

Software compatibility is also a significant issue for digital games. Personal computer games and other software are only compatible with specific versions of operating systems, such as Windows XP and Mac OS, and these same operating systems only function within specific hardware environments. Furthermore, all computer hardware use drivers, which are also only compatible with specific operating systems, further complicating requirements for preservation.

As a result of obsolescence, it is imperative that we preserve the hardware and software environments that are required to run the games we wish to preserve: without the platforms to run them, the games themselves are useless. Unfortunately, the maintenance of old hardware and software environments is ultimately not feasible for long-term preservation due to the high costs of maintenance and inevitable failure of computer components [3]. Long-term preservation will require methods such as data migration, which means transferring information from one hardware or software format to another, and emulation, which means replicating the exact operation of another hardware and software environment. These methods, in turn, raise significant issues with regard to ownership, copying, and migration of game software.

None of these problems can be solved without industry support. Indeed, the problems themselves are sometimes exacerbated by industry practices. Unfortunately, it is usually the case that the consequences of these problems are experienced by companies, consumers, and academic repositories only after the technical, marketing, or legal decisions behind them are themselves history. By then, it may well be too late.

THE IMPORTANCE OF GAME PRESERVATION

It is important to note that the diverse stakeholders in the business of saving games often come from quite radically different perspectives, and it is equally critical to recognize and value each of these. Having done so, we can turn to the many components of games as cultural artifacts with a better understanding of why each and every game brings with it a large quantity of additional data, or objects, that may be of equal importance to the bitstream itself.

Games are History

Digital games need to be preserved because they are history. They chronicle the rise of an industry that today rivals that of film and document the genesis of an art form for the 21st Century. We must preserve that history because it defines who we are today and reminds us of our roots. Games are our legacy for the future, and we must take pride

in our history. The past shows us how far we had to go to get to where we are today, and it puts into perspective how far we still have to go: the past is the prologue to the future [2]. In addition, we should preserve digital games out of gratitude to the developers who made them – many of whom are still alive today. Maybe you are one of those developers. Digital game development isn't something that began a hundred years ago like film production did; it is still a very young industry, and that makes it even sadder that these games are being lost so quickly. We need to preserve our history lest we forget who we are and forever lose an important part of what defines us.

Games are Property

Digital games are owned, as intellectual property, by the companies that design, produce, and distribute them. They are owned as tangible property by the consumers who support the game industry with their purchases of games and an associated spectrum of materials ranging from clothing to published game guides. Both forms of ownership are jeopardized if the assets in question are too easily lost.

Games are Design

Digital games need to be preserved because they tell us about design. Just as good filmmakers learn from the films of the past, the developers of today can learn a lot from the games that others have made. Game development is an art form, and as in any art form, we should not have to continue reinventing the wheel. Some studios recognize the need to teach their employees the history of the industry and to use old prototypes to help inform the creation of new titles. A game library or archive can serve as an excellent teaching tool for future developers, just as it can be used by critics to examine the games of today in relation to the past. Such an archive also provides access to games we may have only heard about and which are no longer easy to find, making it a boon for students of game development as well as scholars.

Further, many games possess a certain uniqueness in their designs that makes them worth preserving in their own right. Games like *Adventure* (1979, Atari) and *Donkey Kong* (1981, Nintendo) were as much solutions to limitations of computer hardware as they were fun games. And yet, we should not limit ourselves to preserving the best designs, the "masterpieces of fun": we have the potential to learn something from every game, regardless of how well or poorly it was made, for without failures, how can we know what failed to work and learn from it?

The past serves as much as a learning tool as a gallery of design, so it is important for the maturing game industry to recognize the significance of the past and apply it towards the future.

Games are Art

Digital games need to be preserved because they are an art form: they have things to say about culture and the human condition through the languages of play, simulation, and

narrative. Games have proven their capacity to explore and critique the nature of human culture and the world we live in, as well as reflect on their own nature as a medium.

The recognition of games as an art form is slowly becoming more widespread [5]. Some scholars argue that early games like *Pac-Man* (1980, Namco) and *Final Fantasy* (1987, Square) may be considered art [6, 9], and it seems clear that games possess an innate ability for expression. Certainly, modern games such as *Ico* (2001, Sony Computer Entertainment), *Braid* (2008, Number None), and *Passage* (2007, Jason Rohrer) meet the requirements some artists, critics, and curators would place on defining art, and the body of work reaching and exceeding this level will only become larger as the years pass. Like comic books or animated films before them, digital games compose a media form that is gradually becoming accepted as a valid form of artistic expression. The medium's future expressive potential is slowly emerging as it extends its reach into new venues such as art museums.

As such, digital games need to be preserved both in order to document the history of an emerging art form and as works of art in their own right. We have lost many early films due to their lack of preservation, many of which had something meaningful to say about the world in which they were created; won't we also mourn the loss of early digital games a hundred years from now if we allow them a similar fate? Digital games must be preserved to save their artistic values as well as their messages for posterity before they, like many early films, are lost.

Games are Culture

Digital games need to be preserved because they are part of contemporary culture. As a multibillion-dollar international industry with digital games in 65% of American homes [4], as a social phenomenon frequently covered in the news, as a staple of contemporary pop culture, or as an emerging art form, digital games have had a profound impact on our culture that cannot be ignored. The significance of this impact has yet to be fully realized, particularly since the digital game generation is still growing to adulthood. What will be the impact of digital games on the way we see the world? Will it be an influence as profound as that of other visual media, such as film or photography? The games we play tell us a lot about ourselves, and we play a lot of games. They are as much a part of our culture as television, the newspaper, and the book. Through understanding culture, we better understand ourselves, and how can we understand our culture if we fail to preserve it?

Games are Fun

Digital games need to be preserved because they are fun. Fun is not something to fear or dismiss; fun and play are as much about being human as they are about enjoying our world. We enjoy many forms of entertainment, whether they are games, film, books, or television, and indeed, fun and entertainment are things that make some of the best books and films last for generations. Games and play are an

important part of human culture and may even be seen as a guiding force behind it.

As much as we love personal entertainment, we also love to share things that we enjoy with others: if we read a book that we find compelling or enjoyable, we naturally want to tell others about it, to share the experience and make others happy. When we see a beautiful sunset, we want to share it with our friends and loved ones to appreciate it together. And when we play a game we enjoy, we want to share it with others. What parent has not tried to introduce their child to a game they played when they were young? As much as a game developer's job is to produce a salable product, he or she also wants to make something that will bring enjoyment to others. We should preserve what gives us joy so we can share that happiness with future generations and continue to make the world a better place.

In other words, we should care that future generations might not be able to play our games. And with this in mind, we should turn to the list of objects that group together to constitute the archiving of each individual game.

The central preservation priority would seem to be the games themselves. After all, if a future game developer or historian cannot experience the gameplay, then all other issues might seem pale in comparison. There is certainly some truth to this notion, but if we place too much emphasis on preserving only published games, we relegate much of the history behind games to the shadows. To challenge this over-emphasis on the game itself, we may consider whether a future historian can learn how a game was made by only playing it, or whether that historian could learn about the history of a development studio and the culture of the development team simply by playing their games. Similarly, could apprenticing game producers compare successful development processes to unsuccessful ones simply by playing a AAA-title alongside an unreleased game, or could biographers write histories of key developers only by playing the games those developers worked on?

Decidedly, the answer to all these questions is *no*: the stuff of game history encompasses far more than the games themselves.

We face a host of missed opportunities if we do not confront this universe of documentation head-on. Perhaps digital games will retreat from their impressive advance into contemporary culture; they might be relegated to a passing fad – who knows? Players might continue to play these games in the future, but their understanding of digital games' place in society would lessen, and their estimation by the same degree would be lower. To be clear, people would not revile games; they simply would not care about them as much. Games of the past would become objects of pure nostalgia, found only in cabinets of curiosities rather than archives, libraries, and museums.

On the other hand, proper documentation places digital games in their proper context and opens them up to serious

attention – at the level of histories of art or government. Archival documentation reveals among many other elements of humanity the thought, time, innovation, toil, and inspiration that go into the making of games.

So, we feel compelled here to *begin* a list of materials (and types of materials) besides the game software itself that would be suitable in an archive where historians, writers, and other researchers, as well as companies, players, and fans, could find them and use them in their work. We say *begin*, because this is only a beginning of a list of things that could constitute game history. The list is necessarily incomplete: ideas about what is important will change in the future.

- Design documents of all kinds
- Development-related correspondence
- Artwork, such as conceptual art, sketches, and storyboards
- Versions of games, from original prototypes to patches, sequels, and mods
- Game development source code, assets, tools, and the resulting binary executables
- Machinima, replays, and other recordings of gameplay
- Development-related maps (shadow maps, influence maps, texture maps, etc.)
- Wikis, subversion/sharepoint/perforce directories, internal websites, notice board notes and posters, and other collaborative/group media
- Scheduling/planning documents
- Developer or publisher budgets, forecasting, market research, and other business-related documentation
- Other documentation related to the developer/publisher relationship
- Company newsletters and circulars
- Information on projects, teams, and company structure over time
- Photographs and videos of the company, people, and events (both internal and external)
- Advertising and marketing materials, especially pieces used for unique, one-time purposes
- Press kits and demos
- Legal documentation
- Books on game design, development, and game studies

- Research papers produced by academics for developers
- Source materials (i.e., writings, film, art, etc. that inspired a game)
- PowerPoint and other presentations for conferences and meetings
- Game magazines, including clippings files
- Archival and business records or personal papers from groups, organizations, and individuals who are associated with the game industry, but are not involved in game development

What should be overwhelmingly clear from this list is that if preservation is to be systematic and aim for a complete record of current practice, then industry must play a central role in the process. Archivists alone simply do not have access to many of the important sources of data that constitute a full and accurate record of a historical object.

THE STATE OF PLAY OF PRESERVATION, AND THE ROLE INDUSTRY CAN PLAY

The history of the game industry cannot be saved without support from its creators. Currently, there is no single institution within the game industry or in any government that is responsible for archiving digital games. There is no Library of Congress for games, only various independent efforts made by libraries and archives throughout the world, and there are few industry-operated archives for the preservation and documentation of a company's history. Because preserving digital game history requires methods such as migration and emulation, support from the industry is required to overcome the many legal and technical barriers that currently prevent the preservation of its own history.

Legal Support

The first line of support that game companies can give libraries and archives is legal support. Digital Rights Management (DRM) licensing and copyright laws present barriers to the long-term preservation of digital games. While these laws were created to protect the intellectual property of the industry, they prevent the only viable techniques of long-term preservation: migration and emulation.

In order for digital media to survive decay and obsolescence, the information must be transferred, or migrated, from one storage format to another, which involves creating a copy. Sometimes, copy protection schemes prevent this process and must be overridden to secure a copy of the data, and often the physical act of simply copying the data may violate contract agreements and copyright laws. Additionally, the software and hardware platforms must be emulated, which can conflict with copyright laws governing hardware and software environments.

For long-term preservation to occur, exceptions must be given to libraries and archives so these tasks can be performed. It may well be that game companies and owners of game-related intellectual property do not object to game preservation by these institutions, but protocols for assigning these rights have yet to be worked out in a clear manner.

Additional legal support involves tracking ownership of copyrights and intellectual property rights for games that need to be preserved as well as verifying the existence of "lost" or missing games. Often, little information is known about older titles, making it difficult to determine ownership. The establishment of clearinghouses for such information, perhaps by trusted academic institutions or repositories, would benefit the industry as well as game preservation activities.

Technological and Business Practices

Developing sustainable distribution formats and business practices that support long-term preservation would benefit both game companies and repositories such as libraries, museums, and archives. Certain business practices such as digital distribution, server-side authentication, and installation verification are only some of the challenges that future preservation efforts will face.

Digital distribution causes considerable problems for archives due to its reliance on remote storage. For instance, games distributed through Xbox Live Arcade (XBLA) are almost wholly dependent upon the longevity of the XBLA service. If a title were to be delisted from XBLA, it would only be available on systems whose owners had purchased and downloaded the title [8]. Other streaming digital distribution services do not even allow the creation of local copies. Industry attention is therefore required in order to ensure the long-term preservation of digitally distributed games because preservation efforts will ultimately depend on the distributor.

Installation licenses and encryption key verification tools introduce further problems for preservation. Installation licenses require that a game be installed only a limited number of times. This limitation is useful in helping to prevent piracy but causes problems for long-term preservation. These practices ultimately tie copies of a game to a particular computer that is prone to failure and obsolescence rather than to a particular user, who has greater permanence. Moreover, encryption key verification tools often run on company servers whose lifespans may be limited to decades or, more likely, years. These services may not be operational in the future; when a validation service fails or is dissolved, games associated with it can no longer be verified and almost certainly cannot be run. Overcoming both problems will ultimately require industry support, because companies create, own, and operate these services.

Lastly, online games provide a unique challenge, particularly Massively Multiplayer Online games (MMOs);

these persistent game worlds require servers run or operated by game companies for a variety of functions. Libraries and archives are currently exploring various methods for how to best preserve MMOs, but most of the preservation efforts may ultimately rely on a developer or publisher's ability to preserve these titles for the long-term after their virtual world has shut down.

Support for Industry and Company Archives

The IGDA Game Preservation SIG also encourages companies to set up their own archives or records management programs. Studios will ultimately benefit from having these local archives. Corporate records held in a company archive or records management program let companies preserve materials for games currently in development and track copyright ownership. This same material can also pay dividends through practical applications such as training new developers and providing resources for game development: simply put, old code and prototypes can inform the development of new games. Additionally, some of these materials may have commercial value, as they can be used to create products such as retro game collections, art books, and soundtracks. Finally, an archive can be used to record the history of a company to demonstrate pride in employees and their creations as well as for annual reports and marketing.

Due to the complex nature of digital preservation, some companies may not have the knowledge required to create their own archives. As a result, even their current production archives may already be at risk of data loss, to say nothing of their archives of years-old data stored on dusty floppy disks, creaky hard drives, and fading optical discs. The IGDA Game Preservation SIG can work with game companies interested in better managing their data and records by providing advice and assistance in creating long-term archives.

HOW INDUSTRY AND ACADEMIA CAN WORK TOGETHER

Without question, the additional resources archiving necessitates must make the exercise have clear value for any commercial business. The reissue of old IP through platforms such as the Nintendo Wii Store and Sony's PlayStation store, as well as independent digital distribution channels such as Steam provide some support for why developers should ensure they are hanging on to old games. But the reality of the games industry is that a large number of developers are hardly long-term entities: they are often assimilated into other companies, or fold for a variety of reasons. Their unique capacity to archive data is thus tempered by the pragmatics of business and the harsh reality of industry.

Academies, on the other hand, operate on an entirely different time, and have a huge vested interest in preserving games. Not only will a time come when games pass from the specific field of game studies into general history and other cultural subjects – as part of late 20th and early 21st century history – but the teaching of games from both an

analytical and vocational perspective is a nascent but booming subject. The nature of the game changes once it becomes an object of study and although this shift may be a principally philosophical one, it nevertheless means that games preservation can be conducted through two separate but complimentary methodologies simultaneously. To put this simply, the games industry has a series of reasons for becoming involved in game preservation, as this paper has argued. These range from the education of future developers – a direct investment in the future of the medium, to the more personal desire to see ones achievements recorded. On the other side, academics see games as important historical and cultural artefacts for research and education, and this extends past the boundaries of game studies into other disciplines. A third major set of stakeholders, archives and libraries, have a civic and often legal duty to preserve culture, and this presents yet another reason why we should push forwards the idea of games as serious cultural artefacts, on a par with other, more established, media.

Each of these stakeholders brings a different set of capabilities, strengths and methods to the table. The games industry has unprecedented access to data. Archives offer generalist preservation strategies and long-term protection and access. Academia offers a space to keep this access live and ongoing, plus the conceptual and methodological space to explore and enhance preservation and access strategies. Each stakeholder also operates under constraints: time and money primarily for industry; freedom from legal barriers to preservation and overcoming the specific technological issues surrounding game preservation for archives; communication with other stakeholders for academics. But there is a great synchronicity between the three. Simply, a weakness in one stakeholder is often countered by a strength in another. Given this, working together, there is no reason why we should not be able to overcome the challenges facing the preservation of the medium we work in.

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REFERENCES

1. Blackjax (2005, Dec. 8). A small lesson in Bit Rot. *System Failure*. Retrieved from <http://my.ais.net/~xtreme/SF/Bit-Rot/>

2. *Digital Preservation Tutorial*. Cornell University Library. Retrieved from www.icpsr.umich.edu/dpm/dpm-eng/timeline/index.html
3. L. Guttenbrunner, M. (2007, Oct.). Digital Preservation of Console Video Games. Vienna University of Technology. Retrieved from http://www.ifs.tuwien.ac.at/~becker/pubs/guttenbrunner_games2007.pdf
4. Industry Facts. *The Entertainment Software Association*. Retrieved from <http://www.theesa.com/facts/index.asp>
5. Jenkins, H. (2000). Art Form for the Digital Age. *Technology Review*. Retrieved from <http://www.geocities.com/lgartclass/handouts/ArtfortheDigitalAge/ArtFormfortheDigitalAge.html>
6. Kelman, N. (2005). *Video Game Art*. Assouline Publishing: New York, NY.
7. Lampson, D. (1995, Sept.). CD Bronzing. *Classical Net – Koussevitzky Recordings Society Journal*. Retrieved from <http://www.classical.net/music/guide/society/krs/excerpt3.php>
8. Pigna, K. (2008, Oct. 12). TGS 08: Microsoft Holding Off on Delisting XBLA Games. *Iup*. Retrieved from <http://www.iup.com/do/newsStory?cId=317>
9. Poole, S. (2000). *Trigger Happy*. Arcade Publishing: New York.
10. Quilty-Harper, C. (2007, June 16). Blu-ray disc coatings starting to rot? *Engadget*. Retrieved from <http://www.engadget.com/2007/06/16/blu-ray-disc-coatings-starting-to-rot/>
11. Shadow460 (2008, Oct. 12). Laser rot occurs on Dreamcast games [Msg 1]. *Atari Age*. Message posted to <http://www.atariage.com/forums/index.php?showtopic=132948>
12. Shahani, C. J., B. Manns, and M. Youket. Longevity of CD Media Research at the Library of Congress. Preservation Research and Testing division, Library of Congress. Retrieved from <http://www.loc.gov/preserv/studyofCDlongevity.pdf>
13. Software Preservation Society (SPS) (2006, Mar.). Bit Rot. *Software Preservation Society*. Retrieved from http://www.softpres.org/glossary:bit_rot
14. The CPS-2 Suicide Information Page. *CPS-2 Shock*. Retrieved from <http://cps2shock.retrogames.com/suicide.html>