

SAVE HOMESTAR RUNNER! :

Preserving Flash on the Web

by

Jacob Zaborowski

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Introduction

Preserving the Web and its contents is still evolving territory. Even though institutions like the Internet Archive have been doing so since 1996, it must be made clear: as with analog cultural heritage, preserving digital cultural heritage is a running target, and one that is never truly hit, as it were. Web preservation cannot exist in a vacuum, and neither can the materials used to create it.

Flash®, a proprietary graphics software, became an integral part of the Web for both back-end developers and front-end creators over a twenty-year period. However, as the Web's growth can attest, Flash is showing its age. Major internet and tech companies such as Google and Apple have taken note, reducing or eliminating support for Flash. Often, it is cited by them and others as a clunky gas-guzzler when it comes to bandwidth or battery life, as well as causing concern about security vulnerabilities that impact front-end users.

The first part of this thesis will give a historical overview of Flash's evolution, encompassing its roots in early graphics editors, its first incarnation as FutureSplash Animator, and its subsequent iterations as Macromedia, then Adobe Flash, before being rebranded as Adobe Animate. This section will explore the Flash software, detailing the major components of its interface along with its most common features (Symbols, Tweens, Actionscript). This explanation of Flash will be complemented by explaining some details of the SWF file format, specifically those that relate to rendering of interactive elements. In the second part, a case study of the animated web series *Homestar Runner* (2000-present) will be presented. This case study is considered from preserving the site's essential characteristics, including:

- Navigability of web interfaces that incorporate Flash;

- Adequate rendering and access of website assets (video, interactive games);
without reliance on proprietary playback, e.g. Flash Player;
- Maintaining interactive experience and dynamic content

Strategies for preservation planning will include capturing with the web-based applications Archive-It and Webrecorder, with a comparison made in regards to their strengths and weaknesses in preserving the essential characteristics of the site. Migration of .swf files embedded in the site to an open video format like Matroska (.mkv) will also be examined, with an accompanying comparison of three software packages designed for .swf conversion, and a discussion of open-source strategies for preserving .swfs.

The chief function of this thesis is to answer two questions: why preserve Flash on the Web, and why *Homestar Runner*? From a cultural standpoint, they represent a moment in time when media production and distribution were democratized by the emergence of the web in the 1990s. From an archival standpoint, Flash and the web are what made *Homestar Runner* possible; without preserving them, preserving *Homestar Runner* is impossible.

Part I: About Flash

I. Of Legos and Languages: A History of Flash

In the beginning, there were Legos. Young Jonathan Gay used the iconic plastic bricks to build a ship that could hold his toy cars while he transported them around the house. “Those bits of colored plastic taught me the basics of engineering design, how to choose a design problem, and the process of iterative refinement.”¹ In building his transport ship, Gay explained the seven step process he developed:

1. **Choose a problem:** Build a Lego ship.
2. **Develop a vision:** What sort of ship will it be? How big will it be? What will it carry?
3. **Build:** Build a framework of the ship.
4. **Fill in the details:** Design and build the details of the ship, ramps, doors, etc.
5. **Test:** Drive the cars around the ship and sail the ship while exploring the house.
6. **Refine:** Take parts of the ship apart and make them better.
7. **Learn:** Take what you learned from building this ship and use it to build a better one next time.²

This was “more or less the same process”³ Gay and his team used some twenty years later to develop Flash.

However, Legos did not give the world Flash fully formed. In fact, the circumstances that led to Flash could be called iterative refinements themselves. One of those refinements was teenaged Gay’s interest in architecture being supplanted by an interest in computer

¹ Gay, Jonathan. “The History of Flash”. 2005. Archived from the original on May 3, 2006. https://web.archive.org/web/20060706152351/https://www.adobe.com/macromedia/events/john_gay/.

² Ibid.

³ Ibid.

programming. With a (then new) Apple II computer, he used the Basic programming language to create a clone of the popular arcade game Space Invaders.⁴ After that, he moved to writing code in Pascal, and created a graphics editor called SuperPaint, which garnered an award after he entered it in a high school science fair.⁵

From there, the Apple II was replaced by a Macintosh. Gay and his father happened to attend a Macintosh User Group meeting organized by Charlie Jackson, an entrepreneur who was breaking into developing software for the new computer. After his father impressed upon him Gay's considerable programming skills, Jackson took the young man under his wing. The arrangement benefited both: Gay could use Jackson's \$10,000 Apple Lisa computer while being paid a small wage to write and program games for his new company.⁶

In 1985, Jackson and his wife Hallie invested \$10,000 and money from an unnamed party to start a company called Silicon Beach Software.⁷ Gay's first game for the company was *Airborne!*, "the first Macintosh game that used [...] smooth (for its era) animation. For a time, it was a big seller."⁸ The next game, however, cemented Silicon Beach's status and literally paved the way for Gay's future education.⁹ *Dark Castle*, a 1986 role-playing adventure game, paid for a computer science degree from Harvey Mudd College in California. As *Creative Review* noted in 2006, "Lego may have provided the building blocks for Flash, but *Dark Castle* was its inspiration."¹⁰ Far from hyperbole, it was backed up by Gay himself; he credited the experience

⁴ Ibid.

⁵ Waldron, Rick. "The Flash History." flashmagazine.com. November 20, 2000.

http://www.flashmagazine.com/News/detail/the_flash_history/.

⁶ Gay, "The History of Flash".

⁷ Kraul, Chris. "Seattle Firm Will Acquire San Diego Software Publisher", *Los Angeles Times*, January 17, 1990, D1.

⁸ "A brief history of Flash", in *Creative Review*, July 2006. London, England: Centaur Communications, Inc., 38.

⁹ Waldron, "The Flash History."

¹⁰ *Creative Review* 38.

of writing games with teaching him about animation, digital sound, and “that fast and responsive software is fun to use.”¹¹

PostScript and SuperPaint II

In 1982, John Warnock and his boss, Charles M. Geschke left their jobs at PARC, the research arm of Xerox. Warnock had developed a programming language for laser printers call Interpress. For two years, he and Geschke had tried to convince Xerox to turn it into a commercial product, unsuccessfully. On their own, the two founded Adobe, a company named after the Adobe Creek, which ran behind Geschke’s home in Los Altos, California. They developed and refined a language based off of Interpress. In 1984, they unveiled the first version of PostScript,¹² a “language for printing documents on laser printers, but it can be adapted to produce images on other types of devices.”¹³ PostScript is an “object-oriented language [...] that [...] treats images [...] as collections of geometrical objects rather than as bit-maps.”¹⁴ To clarify: a bitmap image’s size is based off the resolution assigned to its height and weight i.e, 640 x 540. An object-oriented, or vector-based image, is scalable to a desired resolution ,such as 1000 dpi (dots per image).

Geschke and Warnock had originally planned on manufacturing printers with PostScript, but opted instead to sell it standalone to manufacturers to use with other printers. In 1985, their technology caught the eye of Apple CEO Steve Jobs, who invested two and a half million dollars in Adobe and had Warnock create a PostScript controller for their LaserWriter printers. The

¹¹ Gay, “The History of Flash”.

¹² “The history of Adobe PostScript”. prepressure.com. Accessed May 7, 2017.
<https://prepressure.com/postscript/basics/history>

¹³ "PostScript." In *The Hutchinson Unabridged Encyclopedia with Atlas and Weather Guide*, edited by Helicon. Helicon, 2016.

¹⁴ Ibid.

syntax for PostScript was freely available, allowing programmers to write software that supported it.¹⁵ By doing so, the code could be generated by the software package being used.¹⁶

Jonathan Gay returned to graphics editors by incorporating PostScript into Silicon Beach's SuperPaint II, released in 1987 to critical acclaim. The *Journal-Gazette* (Oklahoma City)¹⁷ highlighted features that showed up in programs such as Adobe Photoshop, and later, Flash:

- Multiple screens (up to 10) displayed at once, which allowed for easy transfer of an image between files.¹⁸
- Screen-scrolling capabilities: rather than scroll manually to continue a drawing or rendering an image, SuperPaint II automatically scrolled a portion of it into place.¹⁹
- Scale-selection facility that allowed the user “to assign a precise expansion or contraction factor to an image.”²⁰
- Image scalability: Users could choose from a list of button choices (25, 50, 200, and 400 percent). But numbers outside of those could be typed in to reduce or enlarge images accordingly.²¹

The last two features, with the result of Gay's incorporation of PostScript, look forward to the vector-based scalability that would come to distinguish Flash. The *Journal-Gazette's* assessment of SuperPaint II ends with a prescient recommendation: while it is uncertain whether

¹⁵ “The history of Adobe PostScript”.

¹⁶ MacGregor, Cairn. “PostScript - calling up a demon from graphics hell”, in *The Gazette* (Montreal), November 8, 1989. E11.

¹⁷ Sandberg-Diment, Erik. “New Graphics Package, Macintosh a Great Combination”, in the *Journal-Record* (Oklahoma City), May 6, 1987.

¹⁸ Ibid.

¹⁹ Ibid.

²⁰ Ibid.

²¹ Ibid.

Gay read it and took the advice to heart, it is worth noting. “A useful addition to future versions of the program might be an allowance for distorted scaling. That is to say, there might be times when it would be useful to specify different percentages for enlargement or reduction of the vertical and the horizontal dimensions of an image.”²²

SuperPaint II was a crucial link in the history of Flash; it took Gay’s methodology of iterative refinement off the living room floor and put it into practice using emerging technology. The next iterative refinement was soon to come.

IntelliDraw

On January 16, 1990, Aldus Corp. signed a letter of intent to buy out Silicon Beach Software.²³ The Seattle, Washington firm was known for PageMaker, a high-end software package that “ushered in the age of desktop publishing” by letting “users integrate texts and graphics”.²⁴ By February 6, Aldus had signed an agreement to purchase Silicon Beach for \$25.5 million.²⁵ From February 8²⁶ to February 26, the company’s outstanding stock shares were acquired in exchange for 1.24 million shares of Aldus common stock,²⁷ a practice known as a “stock swap”.²⁸ Silicon Beach became a subsidiary of Aldus, while remaining in San Diego. Charlie Jackson remained for “several months to assist in the transition and the recruitment of a vice president and general manager as his successor.”²⁹

²² Ibid.

²³ LaLonde, James E. “Aldus buying company, upgrading own software”, *Seattle Times*, February 7, 1990, E9.

²⁴ Kraul D4.

²⁵ “Aldus Corp. purchase of California software maker is final,” *Seattle Post-Intelligencer*. Seattle, Washington: February 27, 1990, B11.

²⁶ “Silicon Beach Sale Set”, *San Jose Mercury News*, February 8, 1990, 3C.

²⁷ “Aldus Completes Silicon Acquisition”, *Seattle Times*, February 27, 1990, C5.

²⁸ *San Jose Mercury News*.

²⁹ LaLonde, *Seattle Times*.

While Jackson eventually left Silicon Beach behind, Jonathan Gay remained with Aldus. Two years later, Aldus and Silicon Beach had a graphics editor ready with the intent of breaking into the low-end drawing market. IntelliDraw, originally called Envision³⁰, was showcased at the 1992 PC Expo to positive reaction. In reading contemporary reviews, several features stand out. It shipped with cross-compatible support for both the Windows and Mac operating systems. The software's "symmetricon" feature allowed "users to draw symmetrical shapes automatically."³¹ This predated the Shape Tools option in Flash, which allows symmetrical shapes to be created automatically, but with more granularity. For example, the Polystar tool allows a user to determine the number of sides and points for a polygon, and the size of each point.³²

Intellidraw's other feature was one that became synonymous with Flash: Symbols, which could create clones of a graphic, or "object". In doing so, users could resize and color individual graphic shapes, or change the original once, with the change automatically reflected across every clone. Herb Bethoney, writing in *PC Week*, stated "This useful feature is a great time-saver when designing illustrations that feature fine details."³³ However, while it had basic animation capabilities, IntelliDraw was not targeted towards animators and motion graphic designers the way Flash would be. *PC Week* stated in a later review that it was "better suited for precise drawings and technical illustrations."³⁴ It was only one of the several "iterative refinements" that led to Flash.

³⁰ Borzo, Jeanette. "Aldus subsidiary to offer entry-level drawing package." *Infoworld*, v. 14 n. 17. April 27, 1992. 4.

³¹ _____. "Aldus carves niche with draw program." *Infoworld*, v. 14, n. 25. June 22, 1992. 1, 155.

³² LoCascio, Ted and Shupe, Rich. *Adobe Flash CS3 Professional: Video Training Book*. Berkeley, California: lynda.com/books and Peachpit Press, 2008.

³³ Bethoney, Herb. "Intellidraw draws on strength of its tools." *PC Week*, v. 9, n. 27. July 6, 1992. 15.

³⁴ Schroeder, Erica. "Early users tout Intellidraw's automatic drawing features." *PC Week*. v. 9, n. 30, July 27, 1992. 33.

Ensuing events showed that it would be just that. After having “coasted on PageMaker and Free Hand all these years”,³⁵ Aldus’s fortunes turned for the worst. By July 1992, it posted its first losses since 1987.³⁶ IntelliDraw was expected to be “a needed boost”, but all its bells and whistles did not offset the steep price of \$299.00, which was derided as “three times the right price”.³⁷ The company would declare bankruptcy two years later.

SmartSketch

IntelliDraw’s small success was not lost on Jonathan Gay. In fact, it emboldened him to leave Aldus and start his own company.³⁸ For this, he reunited with Charlie Jackson. In January 1993, FutureWave Software was founded with Gay as the CEO/CFO and Jackson as the primary investor.³⁹ Michelle Welsh, a former colleague from Silicon Beach/Aldus, joined them to market their new product.⁴⁰ Working out of his home, Gay and Robert Tatsumi wrote the code while Welsh came by in the evenings after her day job to help plan a marketing strategy.⁴¹

SmartSketch was designed with hand-held pen computing (such as Palm Pilots) in mind. It was created for an AT&T operating system called PenPoint,⁴² but the project was put on hold when financial troubles surfaced.⁴³ Gay and company examined their options and decided that redesigning SmartSketch for Windows and Mac, targeting low-end users, was their best bet.⁴⁴ SmartSketch saw release on October 17, 1994.⁴⁵ Its notable features included:

³⁵ Borzo, *Infoworld*.

³⁶ Andrews, Paul. “Aldus Posts First Loss For Quarter.” *Seattle Times*, July 21, 1992.

³⁷ Borzo, *Infoworld*.

³⁸ Gay, “History of Flash”.

³⁹ Welsh, Michelle. “Corporate profile for FutureWave Software, Inc.” *Business Wire*. November 12, 1993.

⁴⁰ Edwards, Larry M. “Trio sketches program for wave of the future.” *San Diego Business Journal*. September 5, 1994, 5.

⁴¹ Gay, “History of Flash”.

⁴² Welsh, *Business Wire*.

⁴³ Edwards, *San Diego Business Journal*.

⁴⁴ Gay, “History of Flash”.

⁴⁵ Edwards, *San Diego Business Journal*.

- a Brush tool that allowed lines to be created as objects to be moved and reshaped;⁴⁶
- Smooth and Straighten options⁴⁷ that could automatically refine freehand geometric shapes (circles, ovals, rectangles, and squares);⁴⁸
- lines that could be manipulated as objects, or set to close gaps between lines automatically, in order to create a area for filling with color;
- the ability to paint behind an object or within a selected area;
- using multiple floating objects in a workspace;⁴⁹
- multipage feature allowed users to “create anything from flipbooks to presentations”.⁵⁰

Contemporary reviews noted SmartSketch’s versatility and precision. As Gay and his team would find out, that would appeal to an untapped market base. In the summer of 1995, FutureWave was trying to package SmartSketch with Calcomp drawing tablets at the annual SIGGRAPH conference.⁵¹ People who tried it kept recommending that its tools would be good for doing animation and rotoscoping.⁵² FutureWave was hesitant to retool their software a second time, but ultimately, they made the jump.

FutureWave CelAnimator/FutureSplash Animator

Animation for the web was in its infancy in 1995, and as such the options for serving it to the public were limited. Netscape Navigator, one of the earliest web browsers, allowed for the creation of simple animations using server push, a type of Internet communication where the

⁴⁶ Welsh, Michelle. “FutureWave Software Inc. ships SmartSketch for Microsoft Windows”, *Business Week*, October 17, 1994.

⁴⁷ Martinez, Carlos Domingo. “SmartSketch 1.0”. *Macworld*, September 1995.

⁴⁸ Welsh, *Business Wire*.

⁴⁹ Martinez, *Macworld*.

⁵⁰ Ibid.

⁵¹ Simpson, Aaron. “Grandmasters of Flash: An Interview with the Creators of Flash”. *Cold Hard Flash*. February 12, 2008.

<http://www.coldhardflash.com/2008/02/grandmasters-of-flash-an-interview-with-the-creators-of-flash.html>.

⁵² Gay, “History of Flash”.

server requests information to be sent to the client.⁵³ However, this required a fast Internet connection between the server and the browser, which was a strain on the server.⁵⁴ As Gay remembered, “The only [other] way to extend a web browser to play back animation was through Java”, which was “terribly slow,” as the FutureWave team soon found out when they tried to design a player that used Java. However, Gay believed (rightly) there was a future in web animation, as it opened up an avenue once limited to theatrical, television, or home video release. FutureWave persisted in modifying their software and player; they were helped by the release of Netscape Navigator’s plugin API (application program interface), which allowed their player to be used through the browser.⁵⁵

By this time, the retooled SmartSketch was called CelAnimator (some contemporary publications referred to it by this name in their reviews).⁵⁶ Shortly before shipping in May of 1996, however, it was quickly renamed FutureSplash Animator.⁵⁷ In August, the FutureSplash Player was released to be used with Microsoft’s Internet Explorer browser via ActiveX controls,⁵⁸ which integrated media into the browser.

FutureSplash Animator was greeted with even more enthusiasm than SmartSketch; its features included two refinements that were the final building block for the soon-to-be Flash. The first was the ability to create interactive graphic buttons that with several states: up (the graphic untouched by a cursor), over (hovering the cursor over the graphic), and hit (the cursor clicking the graphic to access a webpage). The second feature predated Flash’s Actionscript

⁵³ *Wikipedia*. “Push technology”. Accessed May 7, 2017. https://en.wikipedia.org/wiki/Push_technology.

⁵⁴ Powell, Thomas A. “Spinning the well-animated Web page”. *Communications Week*, August 5,, 1996.

⁵⁵ Gay, “History of Flash”.

⁵⁶ “Get Your Web Site Moving”. *Australian MacUser*. September, 1996. 98.

⁵⁷ Gay, “History of Flash”.

⁵⁸ Welsh, Michelle. “FutureWave Software announces FutureSplash® Player”. *Prnewswire* August 13, 1996.

programming language: samples of HTML (Hypertext Markup Language) pages developers could paste into their own web pages, with scripts that could help the page determine the exact browser being used and whether it required enabling the FutureSplash Player plugin or the ActiveX controls.⁵⁹

FutureSplash's success was noticed by Microsoft and Disney. Microsoft was developing the MSN website and wanted a "TV-like experience on the Internet". Disney was gearing up to create their own company news site, the Disney Daily Blast. Through their work with the latter, FutureWave landed on the radar of a San Francisco based company called Macromedia. In November 1996, Macromedia approached them about working together. At that point, FutureWave had invested \$500,000 and four years of work. Merging with a company that had larger resources appealed to Jonathan Gay, and it appears to have appealed to the rest of his team, because in December 1996, FutureWave had been purchased by Macromedia, and FutureSplash renamed Flash 1.0.⁶⁰

Macromedia Flash

Flash lasted nine years under the Macromedia banner, continuing Gay's philosophy of iterative refinement with each release. To give a few examples: 1998's Flash 3 saw the introduction of movieclip symbols, which expanded the software's ability to work with kinetic type design, and a standalone Flash Player. Flash 5 in 2000 was the first use of Actionscript⁶¹, an object-oriented programming language designed by Gary Grossman, who had joined

⁵⁹ Greenberg, Ross M. "Make an animated splash". *Computerworld*, December 9, 1996.

⁶⁰ Gay, "History of Flash".

⁶¹ Bouhlel, Yassine. "A Nostalgic Rummage Through The History of Flash". *envatotuts+*. December 31, 2010. <https://code.tutsplus.com/articles/a-nostalgic-rummage-through-the-history-of-flash--active-6733>.

Macromedia in 1998.⁶² In 2005, with the release of Flash 8, Macromedia was bought out by Adobe,⁶³ and with it, the Flash software/player. By 2006, 97.3 percent of websites worldwide incorporated Flash animation and/or Flash Player.⁶⁴ Flash, as Jonathan Gay put it, had become “ubiquitous with animation on the web.”⁶⁵

Adobe Flash

To explain Flash’s decreasing use over a period of six years, it is necessary to focus on its development after Macromedia was bought out by Adobe. Flash went through five iterations under the Adobe banner, starting with CS3 in 2007⁶⁶; the last standalone iteration was CS6 in 2012.⁶⁷ Starting in 2013, Adobe moved to a subscription-based model called Creative Cloud. Flash continued under this iteration for two more years before being rebranded in 2015.

The name change came after five years of increased criticism of Flash, by tech giants such as Apple and Google. Steve Jobs led the call with a 2010 article where he pointed out Flash’s tendency to soak up battery life on mobile devices, in addition to persistent security issues. He also cited Flash’s lack of usability with open standards such as HTML5 and Javascript.⁶⁸

By 2015, it came to a head when zero-day vulnerabilities were found in the Flash Player plugin.⁶⁹ To explain: A zero-day vulnerability is a security flaw in a piece of software undetected

⁶² “Gary Grossman”. *Adobe*. Accessed May 7, 2017.

https://www.adobe.com/devnet/author_bios/gary_grossman.html.

⁶³ “Adobe Acquires Macromedia”. *Wired*, April 18, 2005.

⁶⁴ Pstatz. “The Numbers on Flash: 97.3%”. *Wired*, September 12, 2006.

⁶⁵ Gay, “History of Flash”.

⁶⁶ Malinao, Chris. “Now Shipping: Adobe Creative Suite 3”. *StudioLighting.net*. April 16, 2007.

<https://www.studiolighting.net/now-shipping-adobe-creative-suite-3/>.

⁶⁷ “Milestone Adobe CS6 Release Delivers Major Innovations for Design, Web and Video Pros”. *Adobe*. April 23, 2012. <https://www.adobe.com/aboutadobe/pressroom/pressreleases/201204/042312AdobeCreativeSuite6.html>.

⁶⁸ Jobs, Steve. “Thoughts on Flash”. *Apple.com*. April 2010. <https://www.apple.com/hotnews/thoughts-on-flash/>.

⁶⁹ Hern, Alex. “Flash is dead, and YouTube dealt the killing blow”. *The Guardian*, January 30, 2015.

by either the vendor or the front-end user. It can be exploited by hackers before the vendor is aware of it to insert malware. Usually, when this occurs, the vendor must work to resolve it by creating a patch. Microsoft is famous for what is called “Patch Tuesday”, where on the second Tuesday of every month, they patch any flaws detected in their software. Zero-day vulnerabilities can also affect out-of-date browsers, which is why updates are recommended.⁷⁰ The backlash was swift: soon after, YouTube eliminated of the Flash plugin for serving its videos to users.⁷¹ This lead *Wired* magazine to proclaim in 2015: “FLASH.MUST.DIE.”⁷² By December of that year, Flash had been rebranded as Adobe Animate.⁷³

⁷⁰ “What is a Zero-Day Vulnerability?” *PCTools*. Accessed May 7, 2017.
<http://www.pctools.com/security-news/zero-day-vulnerability/>.

⁷¹ Hern, *The Guardian*.

⁷² Barrett, Brian. “FLASH. MUST. DIE.” *Wired*. July 15, 2015.

⁷³ Amidi, Amid. “Adobe Kills Flash Name, Rebrands It As Animator-Friendly Animate CC”. *Cartoon Brew*. Accessed May 7, 2017.

<http://www.cartoonbrew.com/flash/adobe-kills-flash-name-rebrands-animator-friendly-animate-cc-124189.html>.

II. What Does Flash Do?

Or rather, what is Flash, and what can one do with it? A capsule description would be something like this: Flash is a graphics editor with web design capabilities that allows users to create scalable vector-based motion graphics and animation for the web. Prominent examples of its use in animation outside the web include the television series as *Foster's Home for Imaginary Friends*(2004-2009)⁷⁴ and the feature film *Sita Sings The Blues*(2008).⁷⁵

The Interface

When opening Flash, a welcome screen appears which allows the user the options of creating a new Flash (.fla) project or opening a recently used one. A dialog box allows for creating files from a series of templates to publish Flash video of different . For example, Banner, measuring 468 x 60 pixels, is a default template for creating website banners This template is in a category called Advertising, one of several that are listed when creating from a template.⁷⁶ The user also has the ability to create a new document by selecting File > New, revealing a dialog box. In it, the user has the option of selecting Templates can also be accessed by clicking the Templates tab within the same dialog box.

The typical components of the interface include:

- **Stage:** A white area containing the portion of the video that will be visible when exported.⁷⁷

⁷⁴ "List of Flash animated series". Web. Accessed May 7, 2017.

https://en.wikipedia.org/wiki/List_of_Flash_animated_television_series.

⁷⁵ Paley, Nina. "Frequently Asked Questions". Web. Accessed May 7, 2017. <http://sitasingingtheblues.com/faq.html>.

⁷⁶ LoCascio, Ted and Shupe, Rich. *Adobe® Flash® CS3 Professional: Video Training Book*. Lynda.com/Peachpit Press, Berkeley, CA. 2008,16.

⁷⁷ LoCascio and Shupe 20.

- **Timeline:** Shows the progression of an animation frame-by-frame. Allows user to decide when and where content appears.⁷⁸ Also includes a panel showing how many layers of animation are in the file.
- **Properties Panel:** Allows users to see information about a particular graphic object or asset being used.⁷⁹
- **Tools Panel:** Contains tools for creating and editing objects/assets in Flash.⁸⁰
- **Library Panel:** Allows for assets used in Flash to be stored and organized. Also has capability of making folders within the panel.⁸¹

Symbols

One commonly used tool in Flash are Symbols. Symbols are graphics which can be converted into scalable objects, cloned, and altered either without touching the original, or altering the original and having that change reflected in its clones. There are three types of symbols in Flash: Movie Clip, Button, and Graphic. All symbol types have their own timelines where the user can manipulate them accordingly within a Flash project.⁸²

A movie clip symbol can contain frame-by-frame animation or static images, as well as be modified in the Properties window. This is particularly useful for working with assets that repeat, or loop, as movie clips are set up to loop by default.⁸³ For example, if the user is animating the sun rising and setting multiple times, they can sequence it in the timeline, then alter it in the Properties windows to change color from light to dark as it sets.

⁷⁸ LoCascio and Shupe 20.

⁷⁹ LoCascio and Shupe 21.

⁸⁰ Ibid.

⁸¹ LoCascio and Shupe 66-67.

⁸² LoCascio and Shupe 54.

⁸³ LoCascio and Shupe 62-63.

A Button symbol allows the user to add user interaction elements to a Flash animation. In its timeline, there are four frames representing a button's four states: Up: when the button is not being touched by the cursor; Over, when the cursor is hovering over it; Down, when the user presses the mouse down while the cursor hovers over the button, and Hit, which shows the response of the button when pressed by the cursor.⁸⁴ This type of symbol can be used to implement a wide variety of interactive elements, such as linking two separate timelines within a Flash movie. This was most commonly used in interactive games where the user activated a series of commands linked to buttons.

The Graphic symbol can be used for reusable static assets and animated accordingly. To return to the example of animating a rising and setting sun, the sun drawing can be converted into a Graphic symbol and repurposed. Like movie clip symbols, it can be looped independently of any other assets being manipulated in the main timeline, with the additional capability of indicating how long the Graphic symbol is to appear on screen.⁸⁵

Animation and Tweening

Animation is usually done by drawing the start and end stages of an action, called keyframes, and filling in the drawings between both, a process called “inbetweening”. Flash refers to this as ‘tweening’. Flash supports two types of tweening effects, motion tweens and shape tweens. Motion tweens are an automated way of adding movement from one keyframe to another. For example, if animating a circle moving from one end of the Stage, to the other would insert the first keyframe in the timeline, insert the second at a later point, and then insert a motion tween by selecting the first keyframe and choosing Motion from a dropdown menu in the Properties panel.

⁸⁴ LoCascio and Shupe 60.

⁸⁵ LoCascio and Shupe 64.

Shape tweening allows the user to animate a transformation, such as that of a square morphing into a circle. The transformation can also be applied to the color of the shape by selecting the first keyframe and choosing Shape from the Tween dropdown menu in the Properties panel.⁸⁷ From there, a Selection tool can be chosen, and then the dropdown prompt Modify >Shape > Add Shape Hint, which allows the user to guide the movement of the tween from one shape to another.⁸⁸

Actionscript

Actionscript is an object-oriented programming language built into Flash in order to add interactivity by generating specific actions using scripts.⁸⁹ For example, a script can be written to control animations using different frames in a Timeline. This is done by accessing the Actions panel, which is where the user types the code and selects the actions from a list of available options.⁹⁰ If a user wanted a particular piece of animation to play when my website loaded into a web browser and then stop once it was fully loaded, one could select a series of actions telling it to do both at a specific frame. Actionscript also allows for content to be embedded in websites as .swf files that can be changed by way of user interaction,⁹¹ e.g., clicking the buttons to play interactive games.

The SWF file format

SWF originally stood for ShockWave Flash since Macromedia also had a web plugin

⁸⁶ LoCascio and Shupe 104-105.

⁸⁷ LoCascio and Shupe 99.

⁸⁸ LoCascio and Shupe 101.

⁸⁹ “Actionscript”. techopedia.com. Accessed May 7, 2017. <https://www.techopedia.com/definition/1942/actionscript>.

⁹⁰ LoCascio and Shupe 148.

⁹¹ “Actionscript”.

called Shockwave to play back multimedia.⁹² Since then, it has been renamed Small Web Format in reference to its use as a file format for playing back video on the web.⁹³ SWF is a binary file format, meaning it is composed primarily of binary data, i.e., not human-readable. Binary files are designed to be optimized for computation. It is one of multiple video outputs from Flash, and the one of major focus here due to the prevalence of .swfs as the output video for the website being discussed in the case study. The following explanation is not an attempt to fit 243 pages of file format specifications on the head of a pin, but to describe several important components of a the .swf format in relation to preservation issues that arise.

Anatomy of a .swf

The header of a .swf file contains a three-byte signature⁹⁴. The first byte is distinguished with the character F, S, or Z. ‘F’ indicates the file is uncompressed, ‘W’, the file is compressed with ZLIB⁹⁵ after the first eight bytes, and ‘Z’, the file is compressed with LZMA⁹⁶ after the first eight bytes. The second and third bytes in the signature are marked ‘W’ and ‘S’ respectively.

The signature is followed by a one-byte version number (ex.: 0x04). FileLength is the total length of the file and header. If the file is uncompressed (FWS), the FileLength should match the size of the file; if compressed (CWS), it “generally does not match the file size.”⁹⁷ FrameSize⁹⁸ defines the width and height of the onscreen display and is stored in the file as a RECT structure.

⁹⁹ The FrameSize will always have an Xmin/Ymin value of 0, while the Xmin/Ymin values

⁹² “Shockwave”. pcmag.com. Accessed May 7, 2017. <http://www.pcmag.com/encyclopedia/term/51275/shockwave>.

⁹³ “SWF”. pcmag.com. Accessed May 7, 2017. <http://www.pcmag.com/encyclopedia/term/55333/swf>.

⁹⁴ *SWF FILE FORMAT SPECIFICATION, VERSION 19*. Adobe Systems Incorporated, 2012. p. 27.

⁹⁵ ZLIB: software library used for data compression.

⁹⁶ LZMA: Lempel-Ziv-Markov chain Algorithm compression.

⁹⁷ *SWF* 27-28.

⁹⁸ *SWF* 28.

⁹⁹ A RECT (rectangle) structure, in relation to the FrameSize, means that the size of the display will vary according to the number of bits used to encode the x/y coordinates. For further information on RECT structures in a SWF, see “Rectangle record”, p. 21, *SWF FILE FORMAT SPECIFICATION, VERSION 19*.

define width and height.¹⁰⁰ FrameRate is the desired playback rate,¹⁰¹ or frames per second (fps). The FrameCount is the total number of frames in the file.¹⁰²

The header is followed by a series of tagged data blocks. They share a common format and allow programs reading .swfs to skip over data blocks it cannot read. The data inside a particular block can point to offsets within that block, allowing tags to be removed, inserted, or modified by tools that process .swfs (i.e., Flash Player.)¹⁰³ The header and tags are sequenced as shown below:

```
Header | *FileAttributes | Tag | Tag | End Tag
```

*File Attributes are only required for SWF Version 8 and later.¹⁰⁴

Each tag in a .swf begins with a type and a length. The header for a given tag can be short or long. According to the published file specifications, “Short tag headers are used for tags with 62 bytes of data or less. Long tag headers[...] can be used for any tag size up to 2GB, far larger than is presently practical.”¹⁰⁵

There are two categories of tag in a .swf: definition and control tags. Definition tags define the content of the file (shapes, text, sounds) and assign a unique character ID to the content defined. The definition tag is stored in a repository called the dictionary by Flash Player. However, they do not cause anything to be rendered.¹⁰⁶ The control tags manage some overall

¹⁰⁰ *SWF* 28.

¹⁰¹ *Ibid.*

¹⁰² *Ibid.*

¹⁰³ *SWF* 28.

¹⁰⁴ *Ibid.*

¹⁰⁵ *SWF* 29.

¹⁰⁶ *SWF* 29.

aspects of the .swf file, such as playback.¹⁰⁷ They also create/manipulate the renderings of the characters in the dictionary, and control the flow of the file.¹⁰⁸

Tags are ordered according to these parameters:¹⁰⁹

After the header, The FileAttributes tag must come first (applies to SWF 8 or later).

A current tag should only depend on tags that preceded it, not ones that succeed it later in the file.

The definition tag must occur before a control tag that refers to a character.

The end tag must always be last in the file.

The dictionary, as stated previously, is a repository for storing content assigned a unique character ID by the definition tag. The ID must be a unique ID, with no duplicates. The control tag retrieves it from the dictionary and performs an action on it (playing a sound, for example). However, use of the dictionary is not limited to the control tags; the definition tags can also retrieve tags from the dictionary to define more complex characters, such as DefineButton, one particular tag that will be discussed later on in this section.¹¹⁰

¹⁰⁷ SWF 54.

¹⁰⁸ SWF 29.

¹⁰⁹ SWF 30.

¹¹⁰ SWF 30.

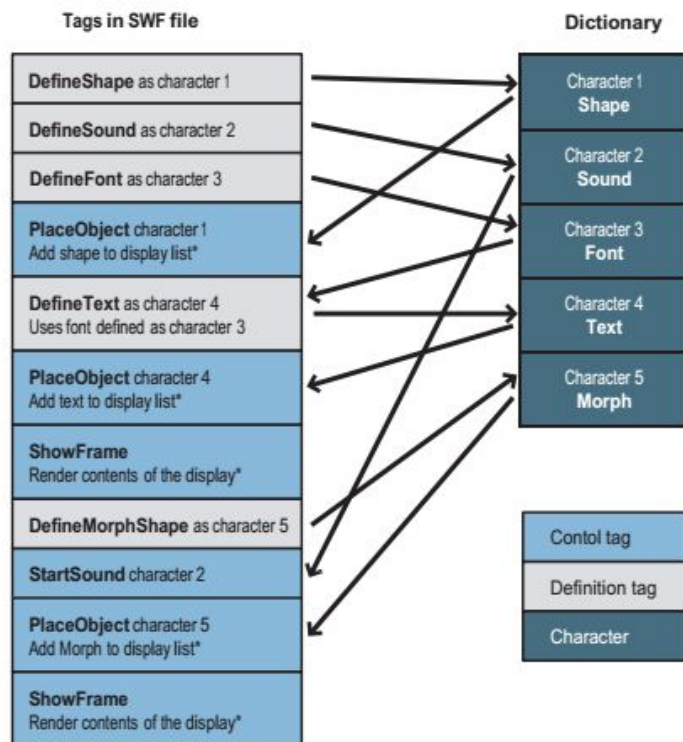


Fig #. Interaction between definition/control tags that use the dictionary.¹¹¹

Control tags, like the display list, have their own set of tags. For the sake of brevity, only a handful will be mentioned. The processing and compression of .swf files are done with the intent of being compact in order to be delivered via a network connection (such as a WiFi connection). Since SWF files are frequently delivered over a network connection, they should be as compact as possible. One technique used to facilitate this is reusing elements in the file. This is possible due to the character dictionary being structured to allow an asset, such as a sound file or bitmap image to be stored once and referenced again and again when the file is played.¹¹²

The display list is a list of characters which will be shown in a frame. This is part of a three step process by which a frame in a .swf is displayed. An object will be given a definition tag such as DefineButton, assigned a unique character ID, and stored in the dictionary. That

¹¹¹ SWF 31.

¹¹² SWF 32.

object will be copied from the dictionary and placed on the display list. The contents in the display list will be rendered with the ShowFrame tag.¹¹³ The ShowFrame tag is one of several tags used to control the display list.¹¹⁴

PlaceObject2/3 supersede and extend the functionality of the original PlaceObject tag. It can add a character to the display list as well as modify it.¹¹⁵ RemoveObject2 supersedes the original RemoveObject, but performs the same function of removing a character at a specified depth (position in the stack of characters) from the display list.¹¹⁶ ShowFrame is the tag that indicates to Flash Player to display the contents in the display list, pausing the file for one frame.

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Returning to control tags, like the display list, they have their own set of tags. Two of them will be mentioned here. FrameLabel gives a name to the current frame; starting with SWF 6, FrameLabel has an extension named anchors, a special kind of frame label that can label a frame using an ActionGoToLabel script or HTML anchor syntax.¹¹⁸ Protect marks a file as unable to be imported into an authoring tool for editing; this is indicated by the tag length equaling zero.¹¹⁹ An End tag, as stated previously, is the last tag in the file, and is required to be so. This also applies to sprites/movie clips, which will be discussed later.¹²⁰

ExportAssets “makes portions of a SWF file available for import by other SWF files”. The example given by the file format specifications is that “ten SWF files that are all part of the

¹¹³ *SWF* 33.

¹¹⁴ *Ibid.*

¹¹⁵ *SWF* 34-35.

¹¹⁶ *SWF* 50.

¹¹⁷ *SWF* 51.

¹¹⁸ *SWF* 52.

¹¹⁹ *SWF* 53.

¹²⁰ *Ibid.*

same website can share an embedded custom font if one file embeds the font and exports the font character.”¹²¹ ExportAssets is used in conjunction with ImportAssets2, which supersedes the ImportAssets tag as of SWF 8, imports characters from another .swf. Just like the earlier tag, it references the .swf exporting the characters by the URL (uniform resource locator) where it is located. It is also required to occur earlier in the frame before tags that rely on imported characters. The imported character is added to the dictionary just as the ones defined in the .swf.

¹²² FileAttributes (required to be the first tag in a .swf as of SWF 8) defines characteristics of a SWF file. It also has a flag called HasMetadata that identifies whether a Metadata tag is contained in the .swf; this is considered especially useful for search engines, though it is not required by Flash Player.¹²³

There are two control tags related to symbols. Symbol Class is similar to the ExportAssets tag, but in this case, it is meant for creating associations between symbols and Actionscript 3.0 classes.^{124, 125} If a class is listed in the Symbol Class tag, it is available for creation by another .swf file. The earlier example of the ten .swf files in a website being able to use the same embedded font, as long as one embeds and exports the font character, applies here as well.¹²⁶ The DefineSceneAndFrameLabelData tag is specifically designed to contain scene/frame label data for a Movie Clip symbol. This is due to Movie Clip symbols being

¹²¹ SWF 53-54.

¹²² SWF 54.

¹²³ SWF 57.

¹²⁴ SWF 59.

¹²⁵ A class, as per Adobe’s website, is defined as: “an abstract representation of an object. A class stores information about the types of data that an object can hold and the behaviors that an object can exhibit.”

http://help.adobe.com/en_US/ActionScript/3.0_ProgrammingAS3/WS5b3ccc516d4fbf351e63e3d118a9b90204-7f36.html

¹²⁶ SWF 59.

exported separately from scenes in the main Timeline in Flash.¹²⁷

Actions are a major component of interactivity in a .swf file because they allow the file to react to such instances as a mouse movement or button click. The action model is a list of action instructions for Flash Player. How it would look on the front end is this: if a user clicks on a button symbol within a .swf, the action linked to that particular button is selected from the action model and added to a list of actions to be processed. It is subsequently executed using a ShowFrame tag, or if the state of the button changes (up to down, for example). The chosen action is not an end in itself; it can cause other actions to be triggered, which are selected from the action model and added to the list, to be processed until the action list is empty.¹²⁸ Not all actions are limited to the .swf that contains them. One in particular, SetTarget (Tell Target in the Flash user interface), can be used to issue a command to another .swf or movie clip.¹²⁹

There are a few other actions worth touching upon briefly, since they are the most commonly encountered in a .swf:

- DoAction: This performs the task of telling Flash Player to perform a list of actions once the current frame is complete, once the ShowFrame tag is encountered in the frame.¹³⁰
- ActionGoToFrame: Instructs Flash Player to go to a specified frame in the file that is currently playing.¹³¹
- ActionNextFrame/PreviousFrame: Flash Player goes to the next or previous frame in the file.¹³²

¹²⁷ SWF 62.

¹²⁸ SWF 63.

¹²⁹ SWF 63-64.

¹³⁰ SWF 64.

¹³¹ SWF 64.

¹³² SWF 65.

- **ActionPlay:** Flash Player begins playing the file from the current frame.¹³³
- **ActionStop:** Flash Player stops playing the file at the current frame.¹³⁴
- **ActionStopSounds:** Flash Player stops playing all sounds.¹³⁵

Sound playback in .swfs is broken into two types: Event and Streaming. Event sounds are played at a specific occurrence in a .swf, such as a mouse being clicked. It can also be reused for multiple occurrences. An event sound must be defined, or downloaded, before it is used in the file, and there are several control tags and records required to play it.¹³⁶ DefineSound includes the audio samples in the event sound, audio coding format, sampling rate and size (8/16 bit), and a unique SoundID for the sound being played. SOUNDINFO is a record that defines styles applied to the event sound, such as fade-ins and fade-outs.¹³⁷ StartSound/StartSound2 starts or stops sounds defined by DefineSound.¹³⁸

A streaming sound, once downloaded, is played in tight synchronization with the frame. Streaming sounds are stored in packets contained within each frame.¹³⁹ A feature of streaming sound in .swfs speaks to their design for playback with limited bandwidth: if the playback CPU (central processing unit) is too slow to maintain the framerate, it will skip frames in order to maintain synchronization while executing actions from the frames skipped. Streaming sound can only be played one at a time in the main timeline of a .swf file, but a movie clip can have its own streaming sound.¹⁴⁰

¹³³ Ibid.

¹³⁴ SWF 66.

¹³⁵ Ibid.

¹³⁶ SWF 177.

¹³⁷ SWF 178.

¹³⁸ SWF 179-180.

¹³⁹ SWF 177.

¹⁴⁰ SWF 181.

The SoundStreamHead tag must be located before the first sound data block in the .swf if the timeline contains streaming sound data. They define the sound data format, recommended playback, and average number of samples per block.¹⁴¹ There is an additional SoundStreamHead2 that additionally allows different values for the compression and size.¹⁴² The data block, called the SoundStreamBlock, has to be preceded one of the SoundStreamHead tags, and can only occur once per frame. It defines sound data interleaved with frame data in order to play sounds as the .swf is streamed via a network connection.¹⁴³

Interactive buttons and their four states consist of instances from the data dictionary. Each instance is defined by a Button record. In a button definition, it is the equivalent of the PlaceObject tag. When the button enters a specific state, the characters are placed on the display list, and define the button's active area.¹⁴⁴ Button tracking "refers to how a button behaves as it tracks the movement of the mouse. A button object can track the mouse in one of two modes, as a push button or as a menu button."¹⁴⁵ In push button mode, mouse movement is directed, or captured, until the release of the mouse button.¹⁴⁶ However, mouse movement is not captured by menu buttons; for example, clicking a menu button and then dragging the mouse cursor away for it will cause the button's state to revert to Up.¹⁴⁷

A state transition is when the button changes from one state to another. It occurs as a result of the mouse interacting with the button through clicking or entering the button area. When the state transition occurs, a button object can perform the appropriate action. For example,

¹⁴¹ SWF 181-182.

¹⁴² SWF 183.

¹⁴³ SWF 184.

¹⁴⁴ SWF 193.

¹⁴⁵ SWF 193.

¹⁴⁶ SWF 193.

¹⁴⁷ SWF 194.

IdleToOverUp is the mouse rolling over the button, entering the Hit area while the button is in the Up state. To a front-end user, the button changes from the Up state to the Over state.¹⁴⁸ Both push and menu button modes have state transitions that are unique to them, like OutDownToOverDown (push), and IdleToOverDown (menu).¹⁴⁹

Button tags in a .swf file consist of:

- Buttonrecord: Defines “a character to be displayed in one or more states.” State(s) that the character belongs to are indicated with ButtonState flags.¹⁵⁰
- DefineButton/DefineButton2: Defines button character for use by control tags e.g., PlaceObject. Includes button records for each of the four states, and must contain at least one of them.¹⁵¹ DefineButton2 allows state transitions to trigger actions.¹⁵²
- DefineButtonCxform: Defines color transform (the button changing color as it is interacted with) for shape/text characters in a button. Only applies to DefineButton.¹⁵³
- DefineButtonSound: Defines possible sounds synchronized with state transitions.¹⁵⁴

Sprites correspond to movie clips in Flash; they are .swfs contained inside a single .swf, and supports many features of that main .swf, including support of control tags, an independent timeline, and a streaming sound track mixed with the main sound track. When defined, it is displayed in the main .swf by a PlaceObject2 tag, and stops playing once removed from the display list.¹⁵⁵ The DefineSprite tag is unique to the sprite; it contains a character ID, frame count,

¹⁴⁸ SWF 194.

¹⁴⁹ SWF 194-195.

¹⁵⁰ SWF 195.

¹⁵¹ SWF 196.

¹⁵² SWF 197.

¹⁵³ SWF 199.

¹⁵⁴ SWF 199.

¹⁵⁵ SWF 201.

series of control tags, and an End tag. It cannot contain definition tags. It defines the sprite, and any characters that refer to control tags in the sprite must be defined in the main .swf before defining the sprite.¹⁵⁶ Below are a list of valid tags in DefineSprite¹⁵⁷

- ShowFrame
- PlaceObject
- PlaceObject2
- RemoveObject
- RemoveObject2
- All Actions (see Actions)
- StartSound
- FrameLabel
- SoundStreamHead
- SoundStreamHead2
- SoundStreamBlock
- End

.Swfs contain tags that can be used to embed video within them.¹⁵⁸ DefineVideoStream defines a character for later placement on the display list,¹⁵⁹ and VideoFrame provides a single frame of data for that character.¹⁶⁰ Metadata can be contained in a .swf, but is not required. The FileAttributes tag has a flag called HasMetadata for this purpose, and is used by search engines, but ignored by Flash Player.¹⁶¹ There is another metadata tag worth noting: DefineBinaryData, which allows arbitrary binary data to be embedded in the file. It is a definition tag that can associate a blob of binary data with a unique character ID to be entered into the dictionary.¹⁶²

¹⁵⁶ SWF 202.

¹⁵⁷ SWF 203.

¹⁵⁸ SWF 204.

¹⁵⁹ SWF 217.

¹⁶⁰ SWF 217.

¹⁶¹ SWF 219.

¹⁶² SWF 220.

A Case Study of *Homestar Runner*

Introduction

As stated previously, Flash represented a moment in time when media production and distribution were democratized by the emergence of the Web. *Homestar Runner* (2000-present) is a contemporary example of Flash's use to that end, and therefore a perfect object for this case study. The case study was conducted to assess preservation needs and consider strategies for preservation planning. For the purpose of scope and focus, a basic delineation was made between the front-end (the public-facing side website) and the back-end (the code and assets used to generate the website). Among the front-end preservation issues to be considered were interoperability of web interfaces that incorporated Flash templates and layouts, in addition to rendering of dynamic assets such as video and interactive games. Back-end preservation issues consist of (but are not limited to) compatibility of *Homestar Runner* with the HTML5 standard, and security and vulnerability issues.

III. About *Homestar Runner*

While FutureSplash Animator was taking off in the summer of 1996, Mike Chapman had graduated from the University of Georgia with a degree in photography, and at the time had a job rigging lights for an Australian Olympics broadcast (the Summer Games were being held in Atlanta).¹⁶³ On one of his afternoons off from work, he and a friend, Craig Zobel, created a children's book. *The Homestar Runner enters the Strongest Man in The World Contest* featured a title character with no arms and several others who would become part of his animated universe.

¹⁶³ Aucoin, Don. "Lookin' at a thing in a bag...and other loony tales from Homestar Runner, the Web's hottest cartoon site". *Boston Globe*, August 9, 2003.

After running off “ten or fifteen copies” at the local Kinko’s for friends, Chapman explained in 2003 “that was it, really, for several years.”¹⁶⁴

By 1998, Matt, the younger Chapman brother, had graduated from Florida State University with his degree in film. Both he and Mike were employed respectively as graphic and web designers.¹⁶⁵ Teaching themselves Flash, they revived their children’s book character Homestar Runner, writing, animating, and voicing the characters in the software. By January 2000, their work had resulted in a live website, homestarrunner.com. By September of that year, *Homestar Runner* was being mentioned in the London-based *Independent*: “Silly, strange and nonsensical fun is on offer as you tune into the adventures of [...] a loopy anti-hero who enters "Jumping Jacks" contests, searches for "Yello Dello" and stars in some excellent long-lost toons in "Kick the Can". Refreshingly bonkers.”¹⁶⁶ The name had its roots in the two brothers’ local baseball team. Matt Chapman explained:

It actually comes from a friend of ours. There was an old local grocery store commercial, [...] and it advertised the Atlanta Braves. It was like, “the Atlanta Braves hit home runs, and you can hit a home run with savings here!” And so there was this player named Mark Lemke, and they said something like “All star second baseman for the Braves.” And our friend knows nothing about sports, and so he would always do his old timey radio impression of this guy, and not knowing any positions in baseball or whatever, he’d just be like, “Homestar Runner for the Braves.” And we were like, “Homestar Runner? That’s the best thing we’ve ever heard!”¹⁶⁷

¹⁶⁴ The Brothers Chaps, interviewed by Kevin Scott, May 20, 2003. *hrwiki.org*. http://hrwiki.org/wiki/UMFM_Interview_-_20_May_2003.

¹⁶⁵ Aucoin, *Boston Globe*.

¹⁶⁶ Pro, Ash. “World Wide Web: 10 best sites of the week”. *The Independent*. December 9, 2000.

¹⁶⁷ Matthew Chapman to Kevin Scott, May 20, 2003.

The beanie-wearing title character was soon joined by a sprawling cast: there was Coach Z, who encouraged Homestar in his pursuit of the Yello Dello to win the heart of Marzipan, his on-again, off-again paramour (voiced by Missy Palmer, Mike Chapman's girlfriend); the King of Town, who employed a Poopsmith for reasons he cared not to disclose; Homestar even had his own doppelganger, Homsar, who wore a homburg akin to Wimpy from *Popeye*. The major antagonist was Strong Bad, a masked wrestler who was as much the brunt of Homestar's antics as he was the instigator.

By late 2001, the series was taking off to the point that Homestar and the other characters were showing up on bootleg t-shirts to fulfill the demand for merchandise. Mike and Matt's father, Donald, helped them assert their legal right to the characters in order to stop it. By 2003, the two brothers were able to live off the merchandise being sold through the site's *Homestore Runner* portal.¹⁶⁸ The site itself was drawing 200,000 viewers every day. Each Monday,¹⁶⁹ people logged onto the Internet to follow the adventures of the armless athlete and the residents of Free Country, USA. To give an idea of its fanbase, among them was *Buffy the Vampire Slayer* creator Joss Whedon, who referred to Trogdor in the show's series finale.¹⁷⁰

A 2003 feature from the *Atlanta-Journal Constitution* stated, "Its artistic flair makes it a favorite among Web designers; the style and humor draw from classic cartoons but retain the computerized look popularized by "South Park" in the 1990s."¹⁷¹ This quote is interesting because it points to the anomalous nature of *Homestar Runner*, popular as it was. The

¹⁶⁸ Gumbrecht, Jamie. "Toon Bros. Atlanta pair's animation has become a Web sensation, with a cult following of more than 200,000 visitors a day". *Atlanta Journal-Constitution*, July 21, 2003.

¹⁶⁹ Hirsch, Deborah. "The curious characters on Homestar Runner look to be more than just an Internet fad. The site's 200,000 daily hits and a legion of fans mean they're a genuine phenomenon." *Orlando Sentinel*, July 22, 2003.

¹⁷⁰ Brothers Chaps to Kevin Scott, May 20, 2003.

¹⁷¹ Gumbrecht, *AJC*.

irreverence and sarcasm of Strong Bad aside, the series was (and still is) infused with a sweet sensibility. A good early example is “In Search of the Yello Dello” (2000). The premise is simple: Marzipan’s birthday is coming up, and Homestar doesn’t know what to get her. He bemoans to Coach Z “I guess I just don’t UNDERSTAAAND the ladies.” Coach Z give him a ridiculous explanation of the female psyche using a gameplay diagram; they’re “like a great sports play. You can't just rush into the score zone! You kiddin' me? You'd be clobbered! You've gotta stick and move and zig and zag to get past the defenses, so youse can score!” After advising him to get the rarest, most exotic gift as evidence of his love for her, Homestar proceeds to sit on a rock and think for several days.

He finally hits on the idea of capturing the Yello Dello, “the most rare and beautiful bird in this entire cartoon!” After assembling a team consisting of himself, Strong Bad’s brother Strong Sad, and his friend Pom Pom, they venture off to Potamia, risking life and 8-bit limb along the way. They capture the Yello Dello and take it back to Free Country, where Marzipan has already been informed by Strong Bad of Homestar’s intentions; he also takes care to emphasize that *he* got her “A-NAHHHH-THIIING!” The big day arrives, and Marzipan arrives at Homestar’s house - to be greeted by Homestar holding a roast turkey. Thinking he has cooked the Yello Dello, she slaps him and storms off. The Yello Dello pops out of a box and wonders, “Gee what’s her problem?” Homestar is left to reflect again, “I guess I just don’t UNDERSTAAAND the ladies.”

However, the one character that came to signify *Homestar Runner*’s popularity was Strong Bad. A self-avowed graduate of Crazy-Go-Nuts University, his antics gave rise to a series called Strong Bad Emails, where he answered queries with snarky responses and outlandish

solutions to whatever was proposed to him. A major highlight was sbemail58, “dragon”, where he attempted to show visitors a la Bob Ross how to draw a dragon, with an animated theme song, “Trogdor the Burninator”, to hilariously complement it. By 2003, Homestar himself had been eclipsed somewhat due to Strong Bad’s popularity (he pulled in 7,000 emails a day).¹⁷² By 2005, thanks to Strong Bad, the site had reached one million viewers a week.¹⁷³

By that time, the site had also expanded its focus from just cartoons. Since the site’s inception, it had featured interactive games. An early example of the Chaps’ ability to take advantage of Flash’s interactivity was “Dancin’ Bubs”, which featured Free Country’s favorite (and only) concession stand owner cutting the rug through a series of user-activated buttons.¹⁷⁴ Not only were supporting characters mined; Trogdor, Strong Bad’s singly beefy-armed dragon, had his own game within two months of his first appearance in “dragon”.¹⁷⁵¹⁷⁶ In 2008, the desktop game *Strong Bad’s Cool Game for Awesome People* was released. A collaboration between the Brothers Chaps and Telltale Games, the game was released on PC, Mac, PlayStation Network, and the Nintendo Wii.¹⁷⁷

In 2010, Mike and Matt Chapman reduced the amount of toons and other content posted to total of five cartoons and a new addition to their gallery of rotating main pages. By comparison, they had posted a total of fifty-three toons, games, and other material in 2006.¹⁷⁸ In the interim, both brothers married, and had children. In December 2010, they made the decision

¹⁷² Gumbrecht, *AJC*.

¹⁷³ Powell, Naomi. “Flash gods; Two U.S. entrepreneurs among small army of animators making characters come alive with popular Flash software”. *Guelph Mercury*, March 12, 2003.

¹⁷⁴ “Dancin’ Bubs”. hrwiki.org. Accessed May 5, 2017. http://www.hrwiki.org/wiki/Dancin%27_Bubs.

¹⁷⁵ “TROGDOR!”. hrwiki.org. Accessed May 5, 2017. <http://www.hrwiki.org/wiki/TROGDOR!>.

¹⁷⁶ “dragon”. hrwiki.org. Accessed May 5, 2017. <http://www.hrwiki.org/wiki/dragon>.

¹⁷⁷ “Strong Bad’s Cool Game For Attractive People”. hrwiki.org. Accessed May 5, 2017. http://www.hrwiki.org/wiki/Strong_Bad%27s_Cool_Game_for_Attractive_People.

¹⁷⁸ “All Toons”. hrwiki.org. Accessed May 5, 2017. http://www.hrwiki.org/wiki/All_Toons.

to go on hiatus, partly because of the need to support their families, and partly from creative burnout: they had been working on the site for ten years at that point. Matt moved to Los Angeles to work as a writer and voice actor on Disney's *Gravity Falls*,¹⁷⁹ while Mike worked as a writer on the children's show *Yo Gabba Gabba!*¹⁸⁰

On April 1, 2014, the Brothers Chaps updated the site for the first time in four years, with a cartoon about Homestar's attempts to update the website. Since then, they have resumed posting, with a new cartoon every two to four months. One recent highlight was "Flash Is Dead!". Released on August 3, 2015, it depicts Strong Bad scrambling to find enough "classic motion tweens and deprecated actions [...] to last us at least six months until we can learn HTML5."¹⁸¹ In 2016, *Homestar Runner* celebrated its twentieth anniversary with "Homestar Runner Goes for the Gold", an adaptation of a second (unfinished) children's book begun by Mike Chapman and Craig Zobel.¹⁸²

¹⁷⁹ Winkle, Luke. "An Oral History of Homestar Runner, the Internet's Favorite Cartoon." io9.gizmodo.com.. January 24, 2017. <http://io9.gizmodo.com/an-oral-history-of-homestar-runner-the-internets-favor-1791519879>.

¹⁸⁰ "Mike Chapman". Internet Movie Database. Web. Accessed May 5, 2017. <http://www.imdb.com/name/nm1053635/>.

¹⁸¹ "Flash Is Dead!" hrwiki.org. Accessed May 5, 2017. http://www.hrwiki.org/wiki/Flash_is_Dead!.

¹⁸² "Homestar Runner Goes For The Gold". Web. Accessed May 5, 2017. http://www.hrwiki.org/wiki/Homestar_Runner_Goes_For_the_Gold.

IV. Preservation Issues

However tongue-in-cheek the Brothers Chaps' reaction was to the death of Flash, the reality is much more sobering. *Homestar Runner* is a complex digital object that is heavily dependent on Flash for generating and playing back the majority of its content. In this section, the author will highlight some of the issues that arise when preserving a website, and explore several strategies for preservation planning. In order to propose meaningful solutions to those issues, it is necessary to define the essential characteristics of *Homestar Runner* as a digital object. Those characteristics are:

- **Navigability:** Is it possible to navigate an archival representation of the object in a manner equivalent, or similar to, the original?
- **Playback:** Is playback of dynamic or interactive assets still possible in the archival representation of the object? Can they be migrated to a format that is not reliant on proprietary software or plugins for access?
- **Interoperability:** Is the object, or its archival representation, compatible with the environment it was designed to be rendered in?

A. Digital Obsolescence

Earlier in this paper, the issue of reduced/eliminated support for Flash and Flash Player was discussed. Currently, Flash is no longer supported on iOS (Apple) or Android (Google) mobile platforms. Numerous websites such as YouTube no longer support Flash video playback. As mentioned when describing both Flash and the .swfs format they are proprietary; the source code is not available for analysis. In a preservation context, these circumstances constitute digital

obsolescence, wherein the following occurs: older, or legacy, file formats are not supported as software used to access it is upgraded; the format is replaced by another or evolves drastically compared to its original iteration; software that is compatible with the format is unavailable, or the format fails to catch on; software used to access the format is unsuccessful, abandoned/withdrawn by the manufacturer, or purchased by a competitor and then abandoned/withdrawn.¹⁸³

While the file format specifications for the SWF format are available to disseminate, the fact of the matter is that as a closed, proprietary format tied to proprietary playback software, Flash video has a shelf life, and one that is coming to an end on the web as support is reduced or eliminated in favor of the open HTML5 standard.¹⁸⁴

B. HTML/CSS

To clarify what HTML is in the context of a website like *Homestar Runner*: if one opens Google Chrome it is possible to view the structure of the website by choosing the Inspect or View Source options. HTML stands for HyperText Markup Language, and is defined by the American Heritage Dictionary as being “used to structure text and multimedia documents and to set up hypertext links between documents, used extensively on the World Wide Web.”¹⁸⁵ CSS stands for Cascading Style Sheets, and is “used to format the layout of Web pages.”¹⁸⁶ To use a real-world analogy of a house, HTML is the structural elements such as the frame, walls, and

¹⁸³ Digital Preservation Management Workshop. “Obsolescence: File Formats and Software”. dpworkshop.org. Accessed May 5, 2017. <http://dpworkshop.org/dpm-eng/oldmedia/obsolescence1.html>.

¹⁸⁴ W3C Recommendation 4.7.6. “The video element”. w3.org. Accessed May 5, 2017.

<https://www.google.com/url?q=https://www.w3.org/TR/html5/embedded-content-0.html%23the-video-element&sa=D&ust=1494109981470000&usg=AFQjCNG2uPsshrC2JTxN8eQoR8dPfexssQ>.

¹⁸⁵ “HTML”. *American Heritage® Dictionary of the English Language, Fifth Edition*. Houghton Mifflin Harcourt, 2017.

¹⁸⁶ “CSS”. techterms.com. Accessed May 5, 2017. <https://techterms.com/definition/css>.

roof beams of the house, while CSS is the coat of paint used on the front door, or the type of shutters placed on the windows.

C. Whose Hierarchy Is It, Anyway?

This explanation of HTML and CSS merit a brief look at the back-end of a typical Homestar Runner page, seen below:

```

1 <HTML>
2 <HEAD>
3 <TITLE>Everybody! Everybody!</TITLE>
4
5 <link rel="alternate" type="application/rss+xml" title="Homestar Runner" href="http://feeds.feedburner.com/HomestarRunner" />
6
7 <link rel="alternate" type="application/rss+xml" title="Homestar Runner" href="http://feeds.feedburner.com/HomestarRunner" /></HEAD>
8 <BODY bgcolor="black">
9 <center><OBJECT classid="clsid:D27CDB6E-AE6D-11cf-96B8-444553540000"
10 codebase="http://active.macromedia.com/flash2/cabs/swflash.cab#version=4,0,0,0"
11 ID=newintro WIDTH=550 HEIGHT=400>
12 <PARAM NAME=movie VALUE="welcome.swf"> <PARAM NAME=quality VALUE=high> <PARAM NAME=bgcolor VALUE=#000000> <EMBED src="welcome.swf" quality=high WIDTH=550 HEIGHT=400
13 TYPE="application/x-shockwave-flash" PLUGINSOURCE="http://www.macromedia.com/shockwave/download/index.cgi?P1_Prod_Version=ShockwaveFlash"></EMBED>
14 </OBJECT></center>
15
16
17 <center>
18 <embed src="main_nav.swf" quality="high" loop="false" menu="false" bgcolor="#000000" width="550" height="10" name="main_nav" align="middle" allowScriptAccess="sameDomain"
19 type="application/x-shockwave-flash" pluginspage="http://www.macromedia.com/go/getflashplayer" />
20 </center>
21
22 <script type="text/javascript">
23 var gaJsHost = (("https:" == document.location.protocol) ? "https://ssl." : "http://www.");
24 document.write(unescape("%3Cscript src='" + gaJsHost + "google-analytics.com/ga.js' type='text/javascript'%3E%3C/script%3E"));
25 </script>
26 <script type="text/javascript">
27 try {
28 var pageTracker = _gat._getTracker("UA-10465668-1");
29 pageTracker._trackPageview();
30 } catch(err) {}</script>
31
32 </BODY>
33 </HTML>

```

There is evidence of some HTML, some Javascript, and embedded Flash video with the plugin for Flash Player, indicated by the .swf file nested in `<EMBED src = "">` and `"application/x-shockwave-flash"` nested in type. There is also a .swf titled `main_nav` that represents the navigation toolbar at the bottom of each page on the site. This view source shows that the navigation, one of the aforementioned essential characteristics, and structure of the site are more or less locked away inside the .swfs, which the site relied on to present a hierarchy that

doesn't exist when we looking at it from the back-end. This complicates preservation due to lack of a concrete understanding of the site's structure since it is locked away in a closed format (.swf). In the next section, several preservation tools will be assessed and preservation planning strategies will be discussed.

V. About Web Archiving/Web Preservation

In discussing the case study of *Homestar Runner*, there is the need to briefly define web archiving, web preservation, and what they seek to do. Web archiving, as per the International Internet Preservation Consortium, is a “process of collecting portions of the World Wide Web, preserving the collections in an archival format, and then serving the archives for access and use.”¹⁸⁷ Web preservation is a series of actions designed to manage and extend a website’s contents and metadata for posterity. The two most prominent tools for archiving the live web are Archive-It, designed by the Internet Archive, and Webrecorder, designed by Rhizome ArtBase. Both are web-based applications for collecting and managing content from the live web. These applications were used to crawl *Homestar Runner* as part of the case study.

Archive-It

Archive-It is a web-based subscription service that allows users to capture and retain static “copies” of websites. It also allows them to shape a collection according to scoping rules (what will/won’t be crawled), schedule, and manage captures of the live web. The central piece of technology utilized by Archive-It is a web crawler, a web-based robot that searches and indexes parts of the live web.¹⁸⁸ Archive-It’s crawler, Heritrix, an “open-source, extensible, web-scale, archival-quality web crawler” was developed by the Internet Archive.¹⁸⁹ Archive-It’s nomenclature for a web URL is a seed. Users manage the URLs selected for crawling in a given collection in the Applications “Seeds” Tab.¹⁹⁰ Seeds can be an entire website, part of it, or a

¹⁸⁷ “Web Archiving”. International Internet Preservation Consortium (IIPC). netpreserve.org. Accessed May 5, 2017. <http://netpreserve.org/web-archiving/overview>.

¹⁸⁸ “Web crawler”. Wikipedia. Accessed May 5, 2017. https://en.wikipedia.org/wiki/Web_crawler.

¹⁸⁹ Internet Archive. “Heritrix”. Accessed May 5, 2017. <https://webarchive.jira.com/wiki/display/Heritrix>.

¹⁹⁰ Praetzellis, Maria. “Overview of the Collections section”. archive-it.org. Accessed May 5, 2017. <https://support.archive-it.org/hc/en-us/articles/208331853-Overview-of-the-Collections-section>.

specific document (asset) located in the website.¹⁹¹ Seeds can be added by selecting the Add Seed button in the Seeds tab. A dialog box will appear, allowing the user to enter the URL to be crawled, its visibility (private or public), its frequency (how many times it is to be crawled), and its scope (how much will be crawled).¹⁹² Checking off the box next to a seed URL and clicking on edit settings¹⁹³ allows the user to select Standard +, which tells Heretrix to crawl the entire site along with any external sites linked to it.¹⁹⁴ The Crawls tab is where current and completed crawls are managed. The following tabs are located under the Crawls tab: Crawl Reports allow users to access a specific crawl, each assigned a unique ID.¹⁹⁵ Clicking on a crawl's ID number links to the Crawl Overview, which shows the status of the crawl, how much data the crawl obtained, how much of that data is new to that particular URL, how many documents in total, how many are new, and how many have been unchanged.¹⁹⁶ Crawl 'Scoping' refers to modifying the parameters of the crawl to determine how much data will be crawled. The scope is usually determined by the seed URLs being crawled and any advanced scoping rules incorporated into the Crawl Scope. These rules can be established by navigating to the Crawl Scope tab and adjusting the parameters in the Host Rules tab or in the Expand Scope Rules.¹⁹⁷

The Hosts tab shows the host sites crawled, as well as any external host sites that are in

¹⁹¹ Praetzellis, Maria. "Select 'seeds'". archive-it.org. Accessed May 5, 2017.

<https://support.archive-it.org/hc/en-us/articles/208331753-How-to-select-seeds->

¹⁹² _____. "Select 'seeds'". archive-it.org. Accessed May 5, 2017.

<https://support.archive-it.org/hc/en-us/articles/208331753-Select-seeds->

¹⁹³ _____. "Manage seeds". archive-it.org. Accessed May 5, 2017.

<https://support.archive-it.org/hc/en-us/articles/208332733-How-to-manage-seeds->

¹⁹⁴ _____. "Assign and edit a seed type". archive-it.org. Accessed May 5, 2017.

<https://support.archive-it.org/hc/en-us/articles/208332843-How-to-assign-and-edit-a-seed-type->

¹⁹⁵ _____. "Reading your crawl report". archive-it.org. Accessed May 5, 2017.

<https://support.archive-it.org/hc/en-us/articles/208002126-How-to-read-your-crawl-s-report->

¹⁹⁶ Ibid.

¹⁹⁷ _____. "Modify your collection's crawl scope". archive-it.org. Accessed May 5, 2017.

<https://support.archive-it.org/hc/en-us/articles/208001046-How-to-modify-your-collection-s-crawl-scope->

scope to be crawled. It also shows how much data was accumulated from crawling each URL, how many documents captured, and how many documents from that site were not, or considered “out of scope” of the crawl as set up.¹⁹⁸ In the File Types tab, the various file formats that were captured are listed.¹⁹⁹ In viewing the file types for the *Homestar* crawl, there were 412 instances of the file type “application/x-shockwave-flash”. Clicking on the hyperlinked number next to it showed a text readout listing all of the .swf files that are embedded in the site. In going through them, one could even find the .swf for sbemail58, “dragon”, seen below:

```
http://homestarrunner.com/sbemail206.swf
http://homestarrunner.com/sbemail58.swf
http://homestarrunner.com/sbemail87.swf
```

Wayback Machine

Many are familiar with the Internet Archive’s Wayback Machine, where users can see captured websites through a browser environment. Clicking on the Wayback hyperlink for any seed in the Seeds Tab pulls up a page with dated links to the Wayback capture. Clicking on one of them brings the user to the Wayback URL for that date. The URL of a captured webpage, <http://www.homestarrunner.com:80/run2x.html>, will be appended to a Wayback URL for a crawl, <http://web.archive.org/web/20000609120813/>, as thus:

<http://web.archive.org/web/20000609120813/http://www.homestarrunner.com:80/run2x.html>.

The capture also includes a banner stating that it is an archived site captured using Archive-It.

Here is where the first critical issue rose with crawling *Homestar Runner*: in clicking any of the interactive elements inside the embedded .swf, the Wayback capture is still being

¹⁹⁸ Blumenthal, Karl-Rainer. “Read your crawl hosts report”. archive-it.org. Accessed May 5, 2017. <https://support.archive-it.org/hc/en-us/articles/208333883-Read-your-crawl-hosts-report>.

¹⁹⁹ Praetzellis, Maria. “Read your crawl’s file types report”. archive-it.org. Accessed May 5, 2017. <https://support.archive-it.org/hc/en-us/articles/208333873-Read-your-crawl-s-file-types-report->.

navigated. However, clicking any of the links in the navigation bar underneath redirects the user to the live site. This is a major issue in terms of preserving the navigability of the original site; in an archival context, the navigation is broken. Earlier, the author discussed how the hierarchy of the site is nonexistent, being locked away inside the .swfs embedded in the site. This issue with the navigation in the Wayback capture is the result of that hierarchy being locked away.

This type of navigation issue is not limited to Archive-It's internal Wayback capture; it is evident in public-facing Wayback captures. The Internet Archive began crawling *Homestar Runner* on May 11, 2000,²⁰⁰ and when accessing that capture, all that has been preserved is the splash page of the website. Clicking on the logo should ostensibly link to the main page, however, nothing appears to have been captured beyond the splash page.²⁰¹ This compromises the integrity of the capture as per the live site's various iterations. This is not limited to this first capture of the site; if one tries to access a capture of the store page from 2003, the page has been crawled, but the embedded .swf is missing.²⁰² These two examples point to Heritrix's limitations in crawling dynamic content, or content that is generated by the end-user as they interact with it.

Extracting and accessing WARC files

```
wget --http-user=<user> --http-password=<password> --no-clobber --
recursive --accept gz,txt https://warcs.archive-it.org/cgi-
```

²⁰⁰ Wayback Machine capture of homestarrunner.com, May 11, 2000. archive.org. Accessed May 5, 2017. <https://web-beta.archive.org/web/20000511162548/http://www.homestarrunner.com:80/run2x.html>.

²⁰¹ Author's Note: When attempting to access the Wayback capture in May 2017, it did not even render the splash page. Only after copying and pasting the URL appended to the Wayback URL into the Internet Archive's search engine was it possible to access it.

²⁰² Homestore Runner Wayback capture. January 24, 2003. archive.org. Accessed May 5, 2017. <https://web-beta.archive.org/web/20030124011421/http://www.homestarrunner.com:80/store.html>.

```
bin/getarcs.pl?c=1\&c=2
```

In spite of these limitations, it was still possible to utilize the captured content for analysis. Utilizing a Unix-like system or an emulator, e.g. CYGWIN, a `wget` command (shown above)²⁰³, furnished by the Archive-It support team, was run to download a WARC file. A WARC (WebARChive) file is an open file format that, states the Library of Congress, “combines multiple digital resources into an aggregate archival file together with related information.” It was based off the earlier ARC file format developed by the Internet Archive. It is used for accessing web-based content in an archival state, and designed to be accessed through a browser environment.²⁰⁴ In the case of *Homestar Runner*, the WARC is taking all the harvested .swfs, html, and, and putting it into their own content blocks under a record header. To the layperson, it can be imagined like Excel spreadsheet columns: the record header would be the name of the column, and the content blocks would be the two cells underneath it containing information. The harvested resources would be the equivalent of the information written in those cells.

The main benefit of downloading and accessing this WARC from Archive-It is that in viewing it through a web browser, the author was able to access the view source and manually extract some .swf files for analysis by right clicking on them and downloading them to local file storage desktop. Going forward, it is useful to find a means of automating the mass extraction of .swfs from the WARC to do more in-depth preservation analysis. It is also important to note that more recent posts on the *Homestar Runner* site, such as “Homestar Runner Goes for the Gold”,

²⁰³ Praetzellis, Maria. “Using wget and md5sum to download and verify Archive-It data”. archive-it.org. Accessed May 5, 2017. <https://support.archive-it.org/hc/en-us/articles/209644093-Using-wget-and-md5sum-to-download-and-verify-Archive-It-data->.

²⁰⁴ Library of Congress. “WARC, Web ARChive file format”. loc.gov. Accessed May 5, 2017. <https://www.loc.gov/preservation/digital/formats/fdd/fdd000236.shtml>.

cannot be downloaded from the view source; the .swf has been embedded in a manner that does not permit manually downloading it; in order to do further analysis or preservation of later files placed on the site, other means of extracting them will have to be explored.

Webrecorder

Webrecorder is a web-based application to “create high-fidelity, interactive recordings of any web site you browse and a platform to make those recordings accessible.”²⁰⁵ It is designed, built, and maintained by Rhizome ArtBase, a non-profit organization that exhibits and preserves born-digital art.²⁰⁶ Webrecorder is predicated on the concept of “human-centered”, symmetrical web-archiving, or archiving a website as a user interacts with it. As per Webrecorde’s chief developer, Ilya Kreymer:

For example, if a site includes some kind of custom scrolling, or a custom interaction that requires a user to hover or to click somewhere, an automated crawler would most likely miss that, because a crawler if unable to do that. But if an actual user performs these behaviours when recording, when playing back the site, they perform the same behaviours, or even—not necessarily in the same order, but some of the same interactions—then they should expect that the content generated by those interactions can be replayed. That’s what is meant by symmetrical web archiving.²⁰⁷

²⁰⁵ “Webrecorder FAQ”. webrecorder.io. Accessed May 5, 2017. <https://webrecorder.io/faq>.

²⁰⁶ Ibid.

²⁰⁷ McKeehan, Morgan. “Symmetrical Web Archiving with Webrecorder,a Browser-based Tool for Digital Social Memory. An Interview with Ilya Kreymer”. ndsr.nycdigital.org. February 23, 2016. <http://ndsr.nycdigital.org/symmetrical-web-archiving-with-webrecorder-a-browser-based-tool-for-digital-social-memory-an-interview-with-ilya-kreymer/>.

This is a different approach to web archiving from Archive-It. Archive-It is largely automated in order to crawl websites in aggregate, while Webrecorder is designed to do it on a granular, or micromanaged, basis.

A user seeking to crawl a webpage can create an account on the Webrecorder site to both capture and store data, or crawl anonymously without being able to share or save it. For the benefit of this explanation, let's say an account has been created. As described in an instructional video for Webrecorder, it is "based around Recording Sessions that are grouped in Collections."²⁰⁸ The main page contains fields for naming both the session and the collection. The URL being captured is copied and pasted into a box marked "URL", and activated by hitting the Record button next to it.²⁰⁹

In Recording Mode, the user determines what is captured as they interact with the site. As described by Rhizome's Preservation Director, Dragan Espenschied, "Webecorder puts itself in between your browser and the whole web. Your web browser communicates with all types of web servers via requests and responses."²¹⁰ To the front-end user, this communication could be clicking on an image to view it in a new tab. "Webrecorder stores this exchange to restage your personal encounter with the web from that information."²¹¹ Espenschied also points out that the user determines what is being archived and preserved. In order to record something in Webrecorder, the user must interact with it in some form, i.e., clicking on a link to a page. This also applies to such dynamic resources as video; they will only be captured when played by the

²⁰⁸ Espenschied, Dragan. "Introduction to Webrcorder". YouTube. Accessed May 5, 2017. <https://www.youtube.com/watch?v=n3SqusABXEK>.

²⁰⁹ Ibid.

²¹⁰ Ibid.

²¹¹ Ibid.

user.²¹² This is a marked difference from Archive-It, which captures websites using broad-based scoping rules.

When interacting with pages during the Recording Session, Webrecorder will create a bookmark of the URL for a given page in order to be accessed later. All of the actions performed during recording will be saved continuously until the user hits the Finish button, completing the session. Having created an account, Webrecorder gives the user access to a Collections page, which lists the following: amount of storage space taken up by the collection, number of bookmarks, and the time spent recording. As stated previously, clicking on any of the bookmarks for the corresponding URLs captured will open up the recording session for that URL, in what is called Replaying mode. Replaying the capture is not dependent on the order in which a user captured the site; it is only dependent on what the user interacted with. If the user attempts to access a page that they did not capture, a page stating “Content Not Found” will appear.²¹³ It should be noted that there is an option called Patch this URL, accessible in a dropdown menu under Replaying, that enables uncaptured pages to be recorded by the user.²¹⁴ There are several other options in addition to Patch this URL: the user can select Record this URL again, or Static Copy, which captures the site as displayed, but with limited interactivity. There is also an Autoscroll button that can scroll through a page without having to do it manually, but that is the visible extent of automation in Webrecorder.

Using Webrecorder, the author performed a capture of *Homestar Runner* that accessed it both via the interactive buttons in the embedded .swf as well as the navigation bar .swf beneath

²¹² Ibid.

²¹³ Espenschied, “Introduction to Webrecorder”.

²¹⁴ Ibid.

it. To assess Webrecorder's capabilities with other dynamic content, *Trogdor!*, an interactive game, was captured, along with some cartoons. In replaying it through the browser, the navigation was preserved successfully (albeit only the pages accessed). Webrecorder also enabled the download of a WARC file without the use of CYGWIN or wget in the command line, as well as providing a desktop application for playing back the WARC locally through a browser environment, called Webrecorder Player.

While documenting the navigation was successful with Webrecorder, it is important to consider the limitations it has in terms of a site like *Homestar Runner*. As stated when discussing Archive-It, there were 412 embedded .swfs documented as being embedded in the site. Not counting the main_nav.swf, over 400 .swfs in the site have their own .html page. Therefore, while capturing the site in Webrecorder is feasible, it is a time-consuming task, and would require an individual's sole attention for a period of time; in any cultural heritage institution, this is not always feasible due to the amount of archival collections being overseen.

This is not to say that neither Archive-It or Webrecorder are without their strengths. Archive-It's ability to crawl sites from the live web, and produce aggregate numbers of the data embedded in them, are useful to the web archivist in determining which file formats are at the most risk of obsolescence or loss. Webrecorder's emphasis on human-centered web archiving allows for a means of capturing dynamic content utilized by a specific user group, as well as documenting that group's unique experience of the content.

VI. MIGRATION

The preceding discussion of .swf and the preservation issues surrounding it call for exploring other strategies. In addition to crawling the live site, other preservation strategies include migration and emulation (not discussed in this paper). The Consultative Committee for Space Data Systems (CCSDS) defines digital migration as “the transfer of digital information, while intending to preserve it”.²¹⁵ Migration is often undertaken due to the following: file format obsolescence, the need for access to the materials, or avoiding media decay.²¹⁶ There are four types of digital migration, broken into two classes by CCSDS:

The bit sequence is not altered by these types:²¹⁷

- **Refreshment:** The media is moved from its original file format to a newer version of its original file format.²¹⁸ A common example is migrating PDF files to PDF/A, a version of PDF designed for preservation concerns, and listed as an ISO standard.²¹⁹
- **Replication:** A one-to-one duplicate of the media and original file format is made.²²⁰

The bit sequence is altered by these types:²²¹

- **Repackaging:** The media is migrated to a new format, with some of the underlying bits altered.²²²

²¹⁵ Consultative Committee for Space Data Systems. *Reference Model for an Open Archival Information System (OAIS)*. Magenta Book, June 2012, 5-2.

²¹⁶ *Reference Model for an Open Archival Information System (OAIS)* 5-2,5-3.

²¹⁷ *Reference Model for an Open Archival Information System (OAIS)* 5-4.

²¹⁸ Ibid.

²¹⁹ The ISO standard for PDF/A can be accessed at <https://www.iso.org/standard/38920.html>.

²²⁰ *Reference Model for an Open Archival Information System (OAIS)* 5-4.

²²¹ *Reference Model for an Open Archival Information System (OAIS)* 5-5.

²²² Ibid.

- **Transformation:** The bits are altered while attempting to preserve the media.²²³

.swf is not a preservation file format, and requires migration to more sustainable formats. The Library of Congress (among other institutions) points to diminishing use of .swf as a hurdle to sustainability.²²⁴ Digital preservation expert Priscilla Caplan also characterized .swf sustainability as “relatively poor”.²²⁵ Since .swf files from *Homesestart Runner* were able to be extracted from the WARC files created during crawls in Archive-It, the benefits and difficulties of migrating a closed format like .swf to a preservation format like .mkv (Matroska Video) should be discussed given the known preservation problems with the format. This section will analyze several tools for migrating .swfs, both free/shareware and open-source.

Freeware/Shareware Tools

ILike-Share

ILike-Share is able to import .swfs and some crucial technical metadata, such as the version of Flash used, the framecount, framerate, video size, and Flash Player plugin version. In the Setting tab, I can select a variety of video outputs, .mkv among them, set a video bitrate, and audio sampling rates. The audio settings are defaulted to a bitrate of 128 kbps and a sampling rate of 44100 Hz, This caused trouble with the initial final output from Ilike-share, because when the migrated .mkv was played, the audio was noticeably out of sync.

20	kbps	11025	Hz	Mono
18	kbps	11025	Hz	Mono
16	kbps	11025	Hz	Mono
8	kbps	11025	Hz	Mono

²²³ *Reference Model for an Open Archival Information System (OAIS)* 5-5.

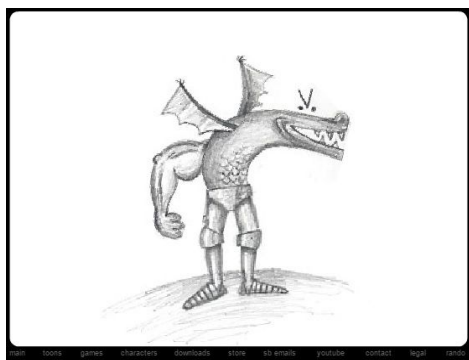
²²⁴ Library of Congress. “Macromedia Flash SWF File Format, Version 7”. loc.gov. Accessed May 6, 2017. <https://www.loc.gov/preservation/digital/formats/fdd/fdd000130.shtml>.

²²⁵ Caplan, Priscilla. “File Formats and ETD Preservation”. March 26, 2007. Web. Accessed May 6, 2017. http://www.fcla.edu/dlini/susETD_pdf/Caplan.pdf.

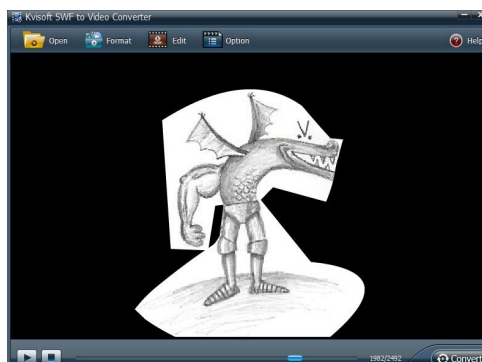
As mentioned when discussing the .swfs, the audio bit/sample rates are based on CD sample rates; these lower rates were used in order to minimize the file size of .swfs in order to generate playback across a network with limited bandwidth. Therefore, the audio bit and sample rates had to be lower than the default. In the excerpted chart above,²²⁶ there is a range of audio bitrate and corresponding sample rates. Using them as a guide, a command line tool called MediaInfo was used to generate the technical metadata for the .swf with MediaInfo, including the audio sampling rate. After outputting the MediaInfo information as a text file, the audio settings were adjusted in Ilike-share. After rendering, the video and audio synchronized perfectly.

Kvisoft SWF to Video Converter

Kvisoft, while able to convert .swf to .mkv, had limited capability for adjusting the audio output to match the original file's sample rate. The available sample rates were 32000, 441000, and 48000 Hz, with bitrates of 64, 96, 128, and 192 kbps. There were also noticeable changes in the content as rendered by the final output from Kvisoft. Using sbemail58 "dragon" as a test case, the background was missing from some shots as seen below.



Original .swf



Render in Kvisoft

²²⁶ Anderson, Gabe. "Flash-Supported MP3 Settings". blogs.articulate.com. Accessed May 5, 2017. <http://blogs.articulate.com/word-of-mouth/flash-supported-mp3-settings/>.

VIP Video Converter

VIP Video Converter, unlike ILike-Share, did not require adjusting the audio settings to match the original file before converting. In selecting .mkv, there were several default profiles for converting, among them one called Same Quality that allowed for a one-to-one transfer. However, upon viewing, a drop in video and audio quality was noticeable when compared with the original .swf. In addition, VIP suffers from similar limitations in audio bit/sample rate settings that Kvisoft did; the bitrate can be set no lower than 48 kbps, while the sample rate has no setting for 11025 Hz, which has been the average sample rate for the .swfs analyzed.

Open-Source Tools

Preservation migration and access for .swfs in the open-source community does not appear to be well supported as of this writing. The Archivemata digital preservation system supports .swf by implementing ffmpeg's utilities to migrate the files to .mkv and .mp4 for preservation and access respectively. Below we see the default command for migrating swf files to .mkvs²²⁷

```
ffmpeg -vsync passthrough -i input.swf -vcodec ffv1 -level 3 -g 1
-acodec pcm_s16le > output.mkv
```

However, it is difficult to migrate .swfs using this workflow, since the .swf cannot be monitored for interactive elements. A good example is sbemail58 “dragon”, where during one scene, the viewer can click on a letter R button symbol embedded in the background to reveal an Easter Egg scene featuring another character. Relying solely on the command line is problematic

²²⁷ Archivemata File Policy Repository. “Transcoding to mkv with ffmpeg information”. archivemata.org.. Accessed May 7, 2017.
<http://sandbox.archivemata.org/fpr/fpcommand/2d991241-e352-4a77-b104-e7e82fb119c4/>.

for .swfs with such interactive elements, though the three converters previously discussed allow for interaction during migration in order to document existence of those elements. me to do that, but not the command line.

As for open-source alternatives to Flash Player for interacting with .swf files, there are two of note: Media Player Lite, and GNU Gnash. Media Lite Player can play back the raw .swf, but it is worth pointing out that it is sometimes unsuccessful in rendering video fully; as with Kvisoft, the background behind the character was missing while the .swf was playing. A visit to the Media Player Lite website did not yield any information; in fact, clicking on any links to its pages, apart from the Download link, redirected to the main page. The sustainability of open-source tools themselves should be considered as well. For instance, a look at the GNU project's site for Gnash shows that the last update made to it was in January of 2012,²²⁸ and that it does not fully support the .swf format beyond SWF 7.²²⁹

²²⁸ "Index of /gnu/gnash". gnu.org.. Accessed May 7, 2017. <http://ftp.gnu.org/gnu/gnash/>.

²²⁹ "Gnash". gnu.org. Accessed May 7, 2017. <https://www.gnu.org/software/gnash/>.

Conclusion

The web has evolved by leaps and bounds since the *Homestar Runner* first went live in 2000. Moving forward, the challenges facing preserving Flash on the web will increase. This has been proven as sites from the 1990s/2000s become inaccessible due to their reliance on outdated and vulnerable playback technology like Flash. Having outlined some of the options currently available, there are a few others not discussed at length, but that still merit consideration.

Homestar Runner, tied to proprietary software/playback as it is, is in a better position to be preserved than most websites of its vintage. It benefits from a sizable fan community, who document it using a wiki page that lists every cartoon posted on the site, information about the games, and goes as far to include links to the .swf for each. Compared to the scant preservation documentation on .swfs, there is at least documentation of the site itself. This is worth mentioning because this information is also at risk, and much worse, one day it could also be the only document of the site's existence. As part of the case study, it has been crawled using Archive-It, and should be part of any long-term project dedicated to preserving *Homestar Runner*. In addition, further analysis of .swfs can be explored through the use of decompilers. A decompiler is software designed to take an executable file and attempt to create a new source file that can be recompiled in a new file format. It should be noted, however, that the legality of this practice is shaky at best, especially in the case of the .swf format, which is still the property of Adobe.

It is worth concluding with this quote from Strong Bad: "The internet is a place where nothing ever happens. You need to take advantage of that." Were that the case, the task of preserving Flash on the web would be easier. However, the internet is a place where much

happens, and it is the duty of cultural heritage institutions to preserve its footprint for posterity. Hopefully, this paper has highlighted the need to preserve this material, and stressed that there can be no one size fits all approach to web preservation, but rather one that is multifaceted and that takes into consideration the web as the complex and constantly evolving entity that it is.

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