Andy Uhrich
Handling Complex Media
Assignment 1: Video Game Preservation
March 11, 2010

ASTEROIDSSS: On Preserving the Varied Forms of Atari's *Asteroids*

INTRODUCTION

Along with Taito's *Space Invaders* (1978) and Namco's *Pac Man* (1980), Atari's 1979 arcade game *Asteroids* brought digital gaming into the mainstream. While its origin as an arcade game initially located it in the somewhat seedy world of coin-operated arcades, it was equally popular as a cartridge for Atari's 2600 console system made for the safer realm of the home living room. In both instantiations, the equally pointless and addictive goal of the game remained the same: the player uses their triangular shaped spaceship to destroy the rocks in a crowded asteroid field while avoiding attacks from enemy flying saucers. However, the different technical capabilities of the more advanced arcade game and the less powerful home system necessitated important differences between the two. The degree to which the experience of the original game was and wasn't maintained in the 2600 console version can be used as a case study for reconstructing/emulating legacy digital games in current operating systems. Such a study can be brought to today, since, as one of the golden age video games, *Asteroids* has not only been available in a form mimicking its original version on subsequent home console systems, but has found a new life in a myriad of copycat and authentic emulations on the web.

All of these competing and overlapping versions – the original housed in an arcade cabinet, the 2600 cartridge, online recreations of the arcade game, ROMS of the 2600 version, poorly realized flash versions made by young programmers seemingly as a rite of passage, versions for hand-held systems, etc. – were made for different audiences with slightly altered gaming experiences and player interactivity. This greatly complicates the decision of which iteration to preserve and in what form. Unlike the reconstruction of a film like Fritz Lang's 1927 *Metropolis* where every piece of extant footage is incorporated into a sort of meta-version that is unlike any one actual print but useful to more fully understand the work as a whole (and this is not to say that such an endeavor is not without its conceptual minefields) such a fusing together of these *Asteroids* is both technically impossible and senseless in terms of play. These *Asteroids* are not sequels or remakes or extended versions, but the same concept recreated for different platforms. However, they are all *Asteroids* and to understand *Asteroids* as a conceptual work one needs to take into account of all the iterations including those already mentioned, knockoffs by Atari's competition, and later updates that utilize more advanced 3-D graphics and begin to introduce a narrative to the game play – and perhaps even the Hollywood movie version currently in production which will surely result in a new video game called *Asteroids* that will more closely reflect the movie's plot than the original arcade game. The question then becomes whether to keep all of the versions up and running or whether only maintain one or two variants as representations of the game *Asteroids*. Such a decision is certainly outside of the scope or influence of

this paper, but the technical requirements for the preservation of the original arcade game, 2600 cartridge, and current online versions will be addressed.

ARCADE VERSION

Asteroids as an idea was initially conceived of by Atari's Lyle Rains in June of 1976. The original concept was a sort of interstellar colonial land grab with each player attempting to claim more planets than the other. Though quite different from the game's final release it does mention the ship's rotational control and other aspects adapted into the arcade game. Atari programmer Ed Logg is credited with turning Rains' brief suggestion into *Asteroids* only weeks after Rains' memo. During production, Atari had an inkling of the games' imminent success as an initial prototype was worn out through overuse and during the run of its factory production regular breaks were taken to allow factory workers to play the game they were manufacturing. The initial arcade cabinet version was released in November of 1979, and demand was so high that Atari had to stop production of an earlier game, *Lunar Lander*, and place the *Asteroids* CPU in the *Lunar* cabinet. The success of the game could not have come at a better time for Atari as it had found its previously unassailable domination of the video game market jeopardized by the immense popularity of *Space Invaders*. *Asteroids* outperformed *Invaders* in sales in the United States and it success doubled Atari's revenues in 1980 to $415 million dollars.

Though it seems perhaps primitive today, at the time it was seen as a major technological advancement in video games. Its use of vector graphics provided smooth straight lines as compared to the blocky shapes in *Space Invaders*. Vector graphics allowed the ship to retain the same shape as it rotates, which was not possible in the later raster version for the 2600. Further, play was not just limited to only top down as in *Invaders*, but in a 360-degree area around the player. The game design is an exercise in maximizing a gaming experience with a minimum of elements: black and white lines, a limited array of on-screen objects (the player's ship, two sizes of enemy saucers, and the three sizes of asteroids), and the minimal electronic heartbeat music that increases speed through each round raising the player's anxiety with its increasing tempo. Additionally, *Asteroids* was the first game to allow players to record a three letter initial next to their high scores which introduced a competitive element across all players of the game and is credited with creating many return customers coming to defend their brief and highly localized notoriety.

The initial arcade version was housed in a cabinet with a black and white 19" monitor. Atari choose vector graphics for its much higher resolution than was available in raster graphics at the time: 1024 by 768 for vector versus 320 by 240 for raster. Initial runs of the game utilized a monitor from Electrohome, the G05-801, while later cabinets housed an Electrohome G05-805 or Wells Gardner WG15V2000. The game itself, coded in the Assembly language, was located on printed circuit board that contained a MOS-6507 CPU with 6K of ROM. The audio was found on a separate circuit board. Additional hardware needed to operate the game included the coin slot and the power supply.

The player controlled the ship with 5 buttons: rotate left, rotate right, fire,

thrust and hyperspace. Important behaviors of play include: the speed at which the player can rotate the ship; the number of missiles the player can shoot at one time (4); how the asteroids are broken into smaller rocks and the change in their direction and velocity when this occurs; the high frequency at which using hyperspace causes the player's ship to spontaneously explode; the degree, or lack thereof caused by the near frictionless environment of the gaming world; and the torus shaped field of play where an object leaving the screen reappears on the opposite side of the screen when piloting the ship around the screen. Other behaviors important to the way the game was originally played were either undiscovered bugs which the players exploited or known to the programmer but assumed that it wouldn't affect play. Two examples of the former is the unplanned safety zone created by hiding under the high score in the top left of the screen and that the player can avoid the missiles of the enemy saucers by placing their ship on the edge of the screen in the in-between zone of leaving one side of the screen and returning on the other. The main example of the latter is the technique of clearing off all of the asteroids except for one small one and then waiting and destroying the enemy saucers as they appear. Since there is no time limit on the game, a player can play this way for as long as they can avoid the enemy fire. Logg mentions that he discovered this technique in testing, but since he was not a good enough player he didn't think it would become the secret to attaining high scores that players turned it into. A further idiosyncratic behavior is that the game's high score tops at 99,990 before flipping back to zero – perhaps another example of the designers underestimating the skill level of the players. While it is not a behavior or interactive element, per se, the look and design of the cabinet is an important part of the player's experience of the game (an element less apparent with console or pc gaming).

In terms of preservation, practically everything related to the original arcade game is technologically obsolete. While 70,000 units were sold, they haven't been manufactured since around 1980 making all of the mechanical parts nearly 30 years old with no new possible replacements. Any operating arcade version of *Asteroids* has been kept alive through harvesting parts from similar games and an intensive expenditure of repair time. Since the game did receive one of the largest production runs in arcade history the original version of *Asteroids* is fairly common in collector circles and the few remaining arcades – which are often transitioning into hybrid arcade/museums. The website for the Classic Arcade Preservation Society lists 389 members who own an original arcade version of *Asteroids* making it seventh on its list of most collected games. A census of the collectors' copies of the game lists the name of the collector, whether the cabinet is original, a grade rating of the condition of the game, serial number, high score, the repair knowledge of the collector, a comments field, and befitting an organization of collectors, whether it is for sale or not. What is unclear is how often this list is updated. What is abundantly clear is that regardless of its relatively common occurrence in collector circles, especially in relation to a obscure game like the 1999 *Airline Pilots*, which is only owned by one member of CAPS, maintaining the original arcade game over a long time span is not feasible. Vector CRT monitors burn out, buttons stick, and chips fail.

Further, the environment in which these games were mainly experienced –

the arcade – for all intents and purposes no longer exists. The existing games still in operation and available for play by the public are most likely to found at an exhibit of video game technology, such as last year's exhibit entitled *Videotopia* at the National Center for the History of Electronic Games at the Strong Museum in Rochester, or from a willing collector. While these give at least one aspect of playing an arcade game surrounded by the clashing lights and sounds of other games, the anodyne settings remove a important part of the thrill of attending the uncontrolled social spaces of arcades in their prime. This ever-changing social aspect is something difficult to preserve of all media experienced in group settings and not just video games, the Edison Kinetograph parlor for example, but this social setting, while outside of the actual operation of the game itself, is crucial to understanding how players experienced *Asteroids* in 1980.

Unfortunately, this suggests that any preservation of the original arcade version of *Asteroids* has to be an emulation of its code to a new computing environment. This will require both programmed impediments to recreate the speed on newer and faster systems and a commitment to updating the emulator as operating systems evolve. This preservation method will allow players the opportunity to play the game in the current way people play video games: at home on their computers or new gaming consoles. As will be discussed below, Atari has more or less chosen this method to a large degree of success.

What the collectors and early video game enthusiasts have amassed online is an amazing collection of original documents relating to the arcade version of *Asteroids*. These documents include the original proposal for the game, technical schematics, operating and service manuals, pdfs of the design on the side of the cabinets, wiring diagrams, promotional flyers, TV ads, screen grabs, detailed reports on the recent repair and upkeep of a game, news articles, fanzines, and video interviews. Regardless of the fact that many of these sites call themselves archives or museums and often use the term *preservation* none of them appear to be associated with larger cultural institutions that will ensure their longevity and the availability of the documents. To safeguard these vital documents, one of the recently established video game archives/museums – the National Center for the History of Electronic Games, the University of Texas Videogame Archive, or Stanford's How They Got Game project – should, if they don't already have them, download these documents off of the enthusiasts' sites.

2600 CONSOLE VERSION

In 1981 Atari released a home version of *Asteroids* for its 2600 video computing system. Programmer Brad Stewart recreated the experience of the arcade version for the significantly less powerful home console. The code had to be totally reconstructed and could not be simply imported into the 2600 as the chips, monitors, input devices, and speed were completely different. Translating *Asteroids* to the home system essentially required creating a new game that mimicked the arcade version. What Atari was able to keep in the home game was the basic form of the game, operation of the ship, and, very importantly, the music.

The changes, however, are quite obvious. The most obvious difference between the two is the different looks based on the arcade using vector graphics and

the 2600 using the raster display of the TV screen. Where the arcade version is in black and white, the 2600 game is in a garish color scheme of browns, purples and blues. The smooth vector lines of the ship are replaced by 8–bit graphics that cause the ship to visually contort when it rotates. The outline-only angular looks of the arcade asteroids look like pixilated popcorn in the 2600 version.

Game play is also subtly transformed. Using a joystick, especially the notoriously clunky 2600 model, is quite different than pressing five buttons. The motion is still the same though achieved by different actions of the player: moving the joystick to the left or right rotates the ship in that direction, up is thrust, down is hyperspace, and the button fires the missiles. The point is not that the joystick is any harder or easier, just that to play the game most effectively a player needs to internalize the hand-eye coordination necessary with the specific form of input controls to successfully maneuver the ship. Hyperspace in the home version never causes you to self-destruct as it does in the arcade game which makes it a much more useful tool. While it is not a major difference, in the arcade game the medium size asteroids break up into two smaller size asteroids while in the home cartridge they break up only into one small asteroid. The asteroids also behave differently in the 2600 version. Instead of coming at the player from all directions they mostly move in an up or down direction, though this can be somewhat adjusted in picking a harder level where the asteroids move more randomly. A more subtle though actually quite transformative difference is the size of the game field. In the 2600 version the player's ship and the asteroids are larger in relation to the screen than the arcade game. This gives a slightly more claustrophobic feel to the home version and gives the player significantly less room to maneuver around in. Also, in the 2600 version the player can only fire two missiles at a time on screen versus the four in the arcade version.

That there are multiple game variants, 66 to be exact, in the home game is another major difference between the two. The variations increase the difficulty and replace hyperspace with shields or the ability to flip in the other direction. The arcade game was made with a certain kind of gamer in mind: likely a teenage male who goes out of their way to play video games and to spend the time it takes to master a rather difficult game like the arcade version of *Asteroids*. The home version was meant for the entire family and therefore accommodates a wide range of skill sets necessitating the large number of variants.

In many ways, the preservation needs for the console mirror those of the arcade game in that the technology of the game console is obsolete. The difference, however, is one of scale as Atari sold around 30 million 2600 systems. *Asteroids* was one of the most popular and common games for the 2600. This makes acquiring a working console and cartridge rather easy. On eBay the 2600 console goes for approximately $100 and an *Asteroids* cartridge for around $5 to $10. However, while the sheer number of 2600 consoles sold makes replicating the original experience easily achievable there are a number of dependencies and risks that make simply maintaining original systems untenable as a long-term preservation strategy. Atari 2600s have not been manufactured since the mid-80s so any parts must be scavenged from other consoles. The consoles operates with a measly 128 bytes of RAM on a MOS-6507 processor but added a proprietary chip, the Television

Interface Adaptor, to optimize graphics' quality at the cheapest price possible for the home system. The output to the monitor is an RF output which new TVs do not accept anymore requiring the purchase of an adapter from Atari enthusiast websites. The input cables from the joysticks are made only to work with Atari 2600 joysticks so legacy joysticks are required. The cartridges – and *Asteroids* was the first dual 4K cartridge – themselves are prone to breaking from misuse often shattering the circuit board or causing it not to interface with the console. As with the arcade version, emulation is the only way to ensure future access to the 2600 iteration of *Asteroids*. Since the 2600 was intended for home play, translating it to the gaming systems of today does not lose as much of the extra-game experience as found in loosing the communal experience of the arcade when emulating the original for home play. Gaming enthusiasts have, though not without some complications for long term viability, for all intents and purposes realized this form of preservation as will be discussed,

ONLINE VERSIONS OF ASTEROIDS

Asteroids exists in a surprising number of versions online both embedded and downloadable. Jumping ahead to the current day does skip over many instantiations of the game – replicating both the arcade and 2600 versions – for gaming consoles and computers subsequent to the 2600. Such versions existed for the Atari 7800; Nintendo's Game Boy, DS, and Game Boy Advance; Sony's PlayStation 1 and 2; Sega's Saturn and Dreamcast; the Apple II, and a variety of PC versions. (It also ignores the variety of games that more accurately fall under the category of sequels or updates of *Asteroids*, such as *Asteroids Deluxe* and *Blasteroids.*). However, since these versions follow similar preservation needs as the 2600 version – a mixture of hardware system and game on separate cartridge/disc, dedicated controllers, eventually obsolete technology if not already so – it will be assumed that the preservation strategy for the 2600 relates to these systems also. An issue to be discussed elsewhere is whether it is of any value to preserve in working forms these intermediate forms. Is it really worth the effort to maintain, for example, a working version of the Game Boy *Asteroids*? Does having access to all of these variants add to an understanding of *Asteroids* as a work? Or since they mainly exist to replicate the game on new platforms is there nothing added other than minor compromises necessary to port the game into the technical situation of the specific operating systems?

While such questions are also relevant to these newer online versions these instantiations present new preservation needs and strategies that make them worth discussing separately. Currently *Asteroids* exists online in official and unofficial versions, as downloadable ROMs for downloading for play on a variety of emulators, and as embedded versions in Flash and Java on websites. Interestingly, the embedded versions are all recreations of the arcade version with the 2600 version only available as a ROM. In many ways combining the ROM versions with the embedded Flash/Java versions muddies preservation issues, but since they are both available through the Internet both will be addressed here.

Downloadable ROMs (or ROM Image) are essentially the code of the original games that are run on an emulator. There are two main kinds of video game

emulators: MAMEs, and console specifics emulators. A MAME, or Multiple Arcade Machine Emulator, plays the ROMs from arcade games and as such is agnostic in relation to the original platform. Console specific emulators replicate the operations of a particular gaming console such as the Atari 2600 or the Sega Genesis. They can only play ROMs from that specific gaming system. Since ROMs and the programs that run them emulate the original game code, they come close to fulfilling the technical preservation needs for both original versions of *Asteroids* – arcade and 2600. However, since the ROMs available online infringe copyright they cannot be seen as reliable preservation or access copies. Atari still holds copyright over *Asteroids* and is still exploiting it in a variety of platforms. However, for the sake of preservation one of the video game collecting institutions mentioned above should be collecting these ROMs even if they cannot make them accessible to the public. This would have some similarities to the beginnings of film archives when they were collecting films under copyright since copyright owners were not adequately concerned with the longtime survival of the works which the own. This is not the case with Atari, there were a large number of companies who created games for the 2600 who have since gone out of business putting the games into copyright limbo. While such institutions likely collect original video game cartridges/disks, as does the Library of Congress, they should also collect ROMs as the original cartridges/disks require hardware which might be obsolete in order to read them and the ROMs have already been disassociated with their original physical packaging and are available for play on emulators.

There are ROMs for both the arcade and 2600 versions of *Asteroids*. Unfortunately, the main MAME for Macs, MAME Mac OSX, is not executable on the Mac used in research for this paper, so a testing of the accuracy of the ROMs for the arcade was not possible. That MAMEs may not work on every computer is a very strong point against them as reliable emulating systems for preservation. The ROM for the 2600 was run on an emulator for the console called StellaOSX. The gaming experience seems extremely accurate to playing it on a 2600 with the main difference being how a higher resolution computer screen precisely represents the graphics versus the softer and slightly blurry look of the game on a standard definition CRT television. In fact it even represents a glitch that often occurred when trying to start the game but instead the asteroids just vibrate back and forth with the game never starting. That the glitch is in both the hard copy cartridge and the ROM suggests it is a bug in the code and not a problem with the physical interface between the cartridge and the console.

The other versions of *Asteroids* online are embedded in sites as either Java or Flash programs. These are only variants of the arcade version and there are no embedded versions of the 2600 game. They are split into two loosely organized categories: those that are closer to re-imaginings than a precise recreation and those that seem to be a mixture of emulation and migration. The former, all unofficial, do not seem to be based on the original code and appear to be new programs written to recreate the bare minimum of the arcade gaming experience. As would be expected, there is a very wide range in the degree to which they faithfully reproduce *Asteroids*. Interestingly, they all keep the name of *Asteroids* and only one mentions that it is not the original Atari game.

Perhaps the most accurate of these is the Flash version made by Neave Games found at http://www.neave.com/games/. Calling it a *remake* Neave is careful to point out that they are not associated with Atari, even going so far as requiring players to confirm that they understand that the Neave version is "an unofficial clone of the original *Asteroids*® game and is **not** endorsed by the registered trademark and copyright owners *Atari Interactive, Inc."* The graphics faithfully represent the vector look of the original and the ship and asteroids behave the same as in the arcade game. While not an exact copy the sound effects and music are close enough to be indistinguishable unless both are playing at once. One minor difference between the Neave version and the arcade game is that hyperspace is much safer in the Neave version than the spontaneous self-destruct that often happens in the arcade game. The major difference in game play is the size of the ships and the asteroids in relation to the size of the gaming field. The Neave version is even worse in this respect than the 2600 version with very little space to avoid oncoming asteroids. That everything else is a faithful rendition of the original, making the objects approximately 4 times as large – and concomitantly shrinking the game field to a ¼ area even on screens of the same size – is an odd choice.

There are two versions, both in Java and, while not as accurate as the Neave both achieve some modicum of the experience of playing the arcade version of *Asteroids*. Mike Hall created at least three versions from 1998 to 2001 and can be found on a variety of websites. While the look mimics the see-through quality of the original vector graphics, the shapes of the asteroids are completely wrong. Further the asteroids only break up into the medium sized rocks and not the smaller sized ones. To compensate the asteroids move at a significantly faster pace. There is only one size of enemy flying saucer versus the two in the original and it shoots out a heat-seeking missile that flies directly towards the player's ship. The other major difference is the fact that the player can hold down the fire button and shoot out missiles at a machine gun pace. The background of the screen includes a sparse star field and is available in two ratios: one close to 4x3 and the other a bit longer than 16x9.

The second version in Java is by Alexander Jean-Claude Bottema and can be found at http://www.tripletsandus.com/80s/80s_games/asteroid.htm. As experienced on the site, this version has no sound though whether that is the original idea of this version or a glitch as the code gets older is unknown. The asteroids both look incorrect and rotate in a manner not found in the original. Also, the missiles shot from the player's ship do not go to the edge of the screen – they only make it ½ way. One idiosyncratic function found on the Bottema version is a button that sets the speed of the game from very slow to ultimate, which is faster than the human eye can comprehend. Presumably this allows the game to respond to varying operating speeds as computer technology improves, but the lack of sound suggests that buggy code will cause this version to be unplayable before that becomes an issue.

The forth of these online re-imaginings is by a programmer named Loze and can be accessed at http://www.lohze.com/asteroids/get_code.html. Programmed in Flash, it is by far the least faithful of these four adaptations. The graphics have a cartoony feel to them and when the asteroids are destroyed they disappear in a puff

of smoke. Additionally, the asteroids are filled in instead of clear and the background is what looks like a photo of a distant galaxy taken by the Hubble telescope rather than the stark black background of the original. While the other three versions are close enough to salvage at least some essential quality of the arcade game, the Loze version is too radically different to offer even a partial idea of what it was like to play the arcade game.

Like the question over the value of saving iterations of *Asteroids* for post-2600 gaming systems, there exists uncertainty over the necessity of preserving all of these versions. It does seem important to note that more than 30 years past its release, *Asteroids* retains enough of a hold on gaming enthusiasts that these versions continue to pop up almost like a form of digital folk art. The code for these programs is easily available and some form of migration should be easy to achieve. The main risk for preservation is the eventual obsolescence of the software they are written in. As seen with the Bottema version older versions of Java are causing trouble with current systems. The fairly ubiquitous nature of Flash will likely ensure access of the Loze and Neave versions, but its important to remember that Apples iPhone, iTouch, and iPad do not support Flash. New versions will have to be created in programs that those platforms support if the programmers want their games to play on them.

The two final online versions discussed here each employ a combination of emulating the original code of the arcade game with some rewriting to migrate the program to a new programming language. As such the look of the two games is almost exactly the same as each other and the original arcade game though the differences are telling. The first is an unofficial version created by Norbert Kehrer and is written in Java. The game is found, along with a note explaining the method Kehrer employed to port the game in 2005, at http://web.utanet.at/nkehrer/sbt/Asteroids.html. Kehrer used a static binary translation to migrate the original assembly code into Java. This process "converted each 6502 instruction of the original game to semantically equivalent Java Code. Then, some optimization techniques like removal of redundant flag calculations were applied to the translated code, and the resulting program was embedded in a Java environment, which simulates the graphics and sound hardware of Asteroids." Kehrer was completely successful in this simulation as the game almost perfectly mimics the look and feel of the original game. This can be seen in the fact the use of hyperspace causes the player to self-destruct with a similar regularity to the original, which is something that none of the others do, besides the Atari Flash emulation discussed below. The very major problem with the Kehrer version is the incredibly fast speed at which it running. That it is essentially too fast for human play is surprising since this version was realized in 2005. The instructions do list "Keypad +/-: Frame Skip incr./decr.," which presumably slows down the game speed, but pressing the minus key during play does not affect the rate of play. This problem suggests that emulation of an interactive digital work cannot just be a direct and unaffected copy, but needs to include insertion of new code that slows the program down to replicate the original rate of response.

The second online version that mixes emulation and migration is the official version of Atari's found at http://www.atari.com/arcade/asteroids. Perhaps aware of all of the unofficial versions mentioned above, in 2009 Atari launched a site that

allows for online play of a number of their arcade games in versions nearly indistinguishable from the original, except of course that play occurs on a laptop and not in a gaming arcade. The only noticeable difference between Atari's Flash version and the arcade game is a very slight overabundance of verisimilitude in replicating the look of the original's vector graphics into a Flash environment. In the Flash version, the juncture where two line segments meet juts out a little too far. Perhaps the goal was to mimic the phosphorous glow of the original screen. Nonetheless, it's very a minor error. The opposite is true in the flash of the missiles when shot from the player's ship or enemy flying saucer. In the original the shots left a glowing trail, but in the new Flash version the missiles are merely little dots. The Atari flash version interprets the original's ability to record the initials with high scores in two ways. The first is on the embedded window where the game is played. Here the game records the high scores achieved on the local computer. Off to the side and out of the game screen is an internet wide list of high scores, where, like the original, the highest score achievable is 99,990.

The emulation work was done by a company called Code Mystics. Their website somewhat explains the process but in a vague business speak. Their proprietary technique of emulation, which they dubbed FOCAL for Flow-Optimized Code AnaLysis, combines emulation "with a new data-driven approach that can achieve solid frame rates on modest platforms." To do so they have built a "cross-platform engine" called Prometheus that allows for the designs of games that can be immediately run on a wide array of operating systems – PCs, iPhones, and Nintendo's Wii – without alteration.

Preserving these two versions that mix emulation with migration seem fraught with difficulties. The Nehrer version is already unplayable and it is unclear if it was ever totally successful in replicating the speed of the original game. What would be worth repeating from the Nehrer version is the process used to translate the original code into new languages. This seems to have resulted in more accurate graphics than the Atari Flash version with its reinforced points of intersection. The Atari Flash version seems problematic because of the proprietary nature by which Code Mystics recreated the game. Presumably, Atari will continue to exploit *Asteroids* for new gaming systems and platforms making the proprietary nature of the program less of an issue for preservation, but one advantage of the otherwise potentially copyright infringing world of enthusiast programmers who create these public emulators is their sharing of code and emulation techniques.

CONCLUSION

As of 1981 there were two versions of *Asteroids*: the arcade and 2600. (Again, this is ignoring sequels such as *Asteroids Deluxe* and bootleg versions.) Atari realized they would have to translate the experience of the arcade game to the less powerful and different graphics of the home console. While this translation went from a more powerful computing system to a less advanced one, and the opposite direction is more likely in an emulation today, the basic idea of emulation as translation remains. Ideally, the degree of change that occurred in the conversion from the arcade to the home for *Asteroids*, will not be necessary, but some amount of transformation is unavoidable. Perhaps it merely the introduction of new code to introduce

roadblocks to slow down the game when it is played on significantly faster operating systems, but the necessity of such new code implies that emulation of interactive digital works is not just a simple porting from one platform to another. It requires an understanding of how the work and player interact with each other. It's an aesthetic as well as technical undertaking.