KINEPHANOS

SPACE ODYSSEY: THE LONG JOURNEY OF *SPACEWAR!* FROM MIT TO COMPUTER LABS AROUND THE WORLD

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Abstract

Although *Spacewar!* is credited with inspiring the arcade videogame industry, little is recorded about the game outside its origins. It has been assumed that *Spacewar!* spread rapidly between computer labs and across computer platforms, but no systematic survey of its actual distribution and use has ever been attempted. Based on records and accounts from computer labs from 1962 to 1972, the authors propose a model wherein *Spacewar!* spread slowly, tied directly to the development of the interactive computer display industry around which communities of players developed, spreading more rapidly from 1967 on with the introduction of large numbers of CRTs.

Keywords

Spacewar!, Steve Russell, PDP-1, Stanford, MIT

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Spacewar! is considered one of the most important videogames ever made. The game was created by Steve Russell and a group of other hackers at MIT in 1962 as a demonstration program for the PDP-1 minicomputer by Digital Equipment Corporation (DEC). It went on to capture the imagination of players across the United States, eventually inspiring the first commercial arcade game, *Computer Space* (1971), helping launch a multibillion-dollar industry. In *Spacewar!*, two spaceships duel around a central star displayed in an overhead 2D perspective, firing torpedoes and using the star's gravitational pull to execute complex maneuvers. There are separate controls for rotating clockwise and counterclockwise, thrust, and fire; most versions also feature hyperspace, which allows a player's ship to disappear and

reappear in a random location with increasing chance of self-destruction. The tight controls, realistic acceleration, and strategies of orbital mechanics made *Spacewar!* extremely popular well into the 1970s. Steve Russell also made the code available for anyone to modify, resulting in dozens of variations.

Spacewar!'s origins have been well-documented by one of its creators, J. Martin Graetz (1981), and are in every general history book on games (Herz, 1997; Kent, 2001; Donovan, 2010; see also Levy, 1994). Equally well-known is Stewart Brand's 1972 *Rolling Stone* article, which chronicled the game's continued popularity at Stanford University and its impact on computing. These two articles served as 'bookends' for the history of *Spacewar!*, fitting it neatly into a historical nutshell.

However, in the 1960s, neither *Spacewar!*'s creators nor its players had any idea of its historical significance, perhaps even that they were witnessing the origins of something extraordinary. For one thing, *Spacewar!* was only available in computer labs, making it accessible only to a select group of students, scientists, and technicians, and on occasion their friends and relatives. In fact, it was only by the end of the 1960s that the general public was finally made aware of the game. In addition, computers in the 1960s were incredibly expensive, with costs often calculated in dollars per minute. Games were accessible only during computer downtime, which was often late at night, or they were simply banned outright. Finally, despite its high appeal, *Spacewar!* was conceived as an entertaining demo and never intended to be a mass-produced product, even though its open-source nature permitted its distribution to many computer labs and platforms. In sum, like a rare comic book whose value is only realized in hindsight, *Spacewar!* has gathered a certain degree of mystique, its scholarly and popular interest relegated largely to its “firstness” and creation rather than its later history.

As a result, little is known about *Spacewar!* between 1962 and 1972. According to popular wisdom, the game spread rapidly from MIT to computer labs virtually everywhere. Graetz (1981) wrote that after *Spacewar!*'s creators left MIT in the summer of 1962, “Program tapes were already showing up all over the country, not only on PDP-1s but on just about any research computer that had a programmable CRT.” Brand (1972) echoed this statement,

writing, “Reliably, at any nighttime moment (i.e. non-business hours) in North America hundreds of computer technicians are [playing *Spacewar!*].” In effect, programmers who encountered the game became addicted and eventually brought a copy to their own labs or programmed new versions based on what they remembered. Yet, by reducing an entire decade of *Spacewar!*'s history to a catchphrase, little to no interest has been made in locating these variations or understanding precisely how the game spread in the first place.

Recognizing the lack of scholarly work in this area, as well as the need to record the games, testimonials, and documentation from this period, we sought to explore in greater detail *Spacewar!*'s “lost decade.” We conducted an extensive survey of primary sources and in addition to collecting existing accounts, asked users on mailing lists and classic computer hubs[1] to share their *Spacewar!* experiences through a questionnaire.[2] We also identified different versions of the game published in *DECUS*[3] and tracked names, universities, and computer platforms to crystallize dates. In some cases, we were able to contact and interview the creators and collect source code. This is thus essentially an oral history of *Spacewar!* and provides a fascinating perspective on game history.

***Spacewar!* on the PDP-1**

In the first few years of *Spacewar!*'s existence, the game could only be played on a PDP-1 with a Type 30 display, using source code originating from MIT. J.M. Graetz (1962) even encouraged *DECUSCOPE* readers to ask Steve Russell for a copy. There were several labs with PDP-1s near Boston, including BBN's Air Force Cambridge Research Lab (Cossell, 1995) and Princeton (Auslander, 2014).[4] Bruce Baumgart, winner of the 1972 *Spacewar!* Olympics at Stanford, was introduced to the version at Harvard while a student there in 1966 (Baumgart, 2014). Further afield, the University of Michigan in Ann Arbor had *Spacewar!* running on a PDP-1 at least as early as 1965 (Swartz, 2014a).[5]

1 These include the Google user group alt.folklore.computers (https://groups.google.com/forum/#!forum/alt.folklore.computers) and ClassicCmp's cctech mailing list (http://classiccmp.org/).
2 http://ataribook.com/book/spacewar-questionnaire/
3 *The Digital Equipment Corporation Users Society*, the official publication of DEC.
4 Yale, University of Rochester, and the Rutgers Physics Department are all known to have possessed PDP-1s, but it is unconfirmed if they had *Spacewar!*
5 The PDP-1 was installed March 1964 and the display in April.

At DEC, *Spacewar!* was advertised in a brochure illustrating the capabilities of the PDP-1 and also famously used for testing shipped units – salesmen would first load *Spacewar!* in the factory, and if the game started up correctly, the computer was deemed to be in good working order.[6] While this suggests widespread distribution, only 55 PDP-1s were ever built, and not all shipped in 1962 and 1963. Of these, perhaps 20 had a display, although not all shipped with it (Bell, 2014). Furthermore, it is questionable whether *Spacewar!* was played frequently, if at all, in facilities with strict security, such as military research centers.

Spacewar! could be played with the console switches on the front panel of MIT's PDP-1, but two of the game's creators, Alan Kotok and Bob Saunders, built a set of control boxes with two switches and a button.[7] However, not all locations adopted this method: Harvard and the University of Michigan used switches only, sometimes with interesting effects. In Michigan, one of the switches controlled gravity, and a particularly devious player could trick his opponent by switching it off (Swartz, 2014a). Still other places such as BBN initially used test switches, but eventually replaced them with controllers. Aside from contracting "Spacewar elbow" from playing in an uncomfortable position, the switches would eventually fail, and were difficult to replace, angering lab administrators and necessitating the upgrade (Wexelblat, 1996).

At MIT, *Spacewar!* continued to be played steadily, mostly at night, but also during Open House events such as "freshmen rush week" where Richard Greenblatt, a new student and future creator of Lisp, encountered the game in fall 1962. The students played with the lights off, immersed in the phosphorescent glow of the CRT – an iconic image that would be repeated throughout the history of videogames (Levy, 1994).

In September, Jack Dennis, a faculty member and one of the originators of the operating system Multics, developed a time-sharing system for MIT's PDP-1, allowing *Spacewar!* (or any program) to be played while other programs were running. Around this time, MIT also

6 Steve Russell heard this story secondhand while an employee at DEC. It is first recounted in Zito (1983) and told in greater detail in Levy (1984) and Kossow (2008).

7 This happened roughly after two months of play, which would place it around April (Zito, 1983). Interestingly, according to Russell, four-button control boxes were briefly used before this, but wore out quickly (Kossow 2008).

received a Type 23 Parallel Storage Drum from DEC. The drum had 32 tracks storing 4K of data each, and one of these was soon dedicated to *Spacewar!*, allowing it to load quickly off a two-foot-long paper tape, dramatically reducing startup time (Morris, 1993).

Most modifications to *Spacewar!* were subtle changes to existing code, as was the case on the PDP-1. Variables such as gravity, fuel, acceleration, and rate of fire could be easily altered to change play balance, but any major hacks required significant investments in time. *Spacewar!* continued to be modified throughout the spring 1963 semester by Monte Peronas, a graduate student. Peronas hacked the code to make it run more efficiently, such as by drawing the star as a dotted rather than solid line – a cosmetic change that is barely perceptible on-screen, but reduced CPU time significantly, allowing for the inclusion of a second star. He also recoded the hardware multiply/divide function to conduct gravity calculations more efficiently and tweaked the fuel consumption rate. Other collaborators added a patch for on-screen scoring.[8]

In fall 1962, Steve Russell left Harvard to work at Stanford, taking *Spacewar!* with him. Russell was tasked with creating a Lisp compiler and getting their PDP-1 timeshared. *Spacewar!* was one of the first programs available and was so popular staff immediately restricted its use (Yasaki, 1963). Russell found it as entertaining as pinball (Levy, 1994, p. 65).

Although accounts from MIT and Stanford describe night-long *Spacewar!* sessions with dedicated cliques of players, this does not appear to have been common elsewhere. The University of Michigan, for example, had *Spacewar!* running on the PDP-1 in the basement of West Physics, but although the display was installed in April 1964 (University of Michigan, 1966, p. 35), only a trio of programmers played it regularly in 1966. Most of their interest came from discovering how it worked, and play was so infrequent that *Spacewar!* wasn't forcibly removed or regulated. As former student Fred Swartz recalled, “No one knew [about it] as far as I remember. We loved programming so playing was just done when we

8 Version 4.8 by DFW, dated July 24, 1963.

felt like taking a break" (Swartz, 2014a). Later, Michigan had *Spacewar!* running on a PDP-4 purchased in 1963 (Kuniavsky, 1996),[9] and a DDP-224 in 1967.

Bruce Baumgart tells a similar story about his experience with *Spacewar!* on a PDP-1 at Harvard.[10] The PDP-1 was installed in the Physics Department Dunbar Lab, next to the Cambridge Electron Accelerator. Baumgart worked in the lab over the summer starting in late June 1966. The game was occasionally shown to visitors, and sometimes the programmers brought their girlfriends, but space warfare left little impression (Baumgart, 2014).

Harvard's PDP-1 was used primarily for conducting tests on the Cambridge Electron Accelerator, and *Spacewar!* could only be played when the Accelerator was down, which happened infrequently. Contrary to MIT and Stanford where the PDP-1 could be blocked off for *Spacewar!* all night, graduate students at Harvard often used the late night blocks to conduct experiments. Additionally, Baumgart worked alone in the lab from 12:00 AM to 6:00 AM, giving him few opportunities to play.

While it is possible the game saw more frequent use when it was first installed, by 1966, *Spacewar!* on the PDP-1 had only a limited audience in at least two universities, and probably elsewhere as well. In some cases, even when the PDP-1 was replaced by newer machines, *Spacewar!* was only infrequently used for demo purposes, as at Sanders Associates around 1969 (Gorin, 2014).[11]

Spacewar! On Other Computers

Due to the incomplete nature of the record, it is difficult to document where and when versions of *Spacewar!* first began to appear on other platforms. Furthermore, identifying the programmers – let alone tracking them down – is often next to impossible. However, what

9 Steve Russell thought Bob Saunders may have programmed a version for the PDP-4 (Kossow, 2008).

10 Harvard had a second PDP-1 at the Jefferson Lab where Ivan Sutherland conducted 3D modeling experiments. It would have been rarely used for *Spacewar!*, if at all.

11 Ralph Baer developed the Magnavox Odyssey prototype at Sanders in 1966-1971. He reported never seeing *Spacewar!*, suggesting the PDP-1 was in a different department. Ralph Gorin saw it just once.

survives does provide an interesting glimpse at *Spacewar!*'s distribution and its variations, which is far more complex than the familiar distribution narrative – particularly when considering the hundreds of hours involved in each adaptation.

Location	Platform	Platform Release	Install Date	Earliest Known Date	Programmers
MIT	PDP-1	November 1960	September 1961	January 1962	Steve Russell, Bob Saunders, J. Martin Graetz, et. al.
University of Michigan	PDP-4	1963			
University of Michigan	DDP-224	May 1964		1967	
MIT Computation Center	IBM System/360 Model 65	1965		1965	Edson Hendricks
Stanford University	PDP-6	October 1964	June 6, 1966	Fall 1966	Steve Russell
Cambridge University	PDP-7	1965	May 19, 1966	1969(?)	M.S. Peterson, John C. Viner
University of Minnesota	CDC-3100	February 1965	April 1, 1966(?)	1967	A.W. Kuhfeld
DECUS	LINC-8	1966		August 12, 1968	E. Duffin
Fall Joint Computer Conference	Data General NOVA			December 9, 1968	

Stanford University	PDP-10	September 1967		1969	Ralph Gorin (1971)
University of Illinois	PLATO/ILLIAC			1969	Richard Blomme
	IBM 1620	October 21, 1959		1969	Jim Burroughs
	Imlac PDS-1	1970		1970	
University of Pittsburgh	PDP-7	1965		1970	Russell Randshaw
DECUS	PDP-8	1965, 1966, 1968		January 11, 1971; March 22, 1971	Evan Suits

Table 1 – Known Spacewar! Versions, 1962-1972

The First Adaptation at MIT

One of the first documented *Spacewar!* adaptations was programmed in 1965 by Edson Hendricks (creator of VNET, which became a foundation for the Internet) on MIT's IBM System/360 Model 65 running a 2250 Model 1 display. Unlike previously discussed versions, this wasn't a strict hack – Hendricks was paid to program it as part of his job at the MIT Computation Center. At the time, he was offered one of two positions: washing light bulbs and operating a computer. Choosing the obvious, Hendricks quickly became adept at the System/360 and was put in the role of system programmer. As fate would have it, soon afterward, the Computation Center's entire lead system programming team quit, leaving Hendricks as senior programmer (Hendricks, 2014a).

When IBM installed the 2250, someone needed to figure out how the display worked so it could be used by faculty and students. Although he never played it, Hendricks remembered seeing *Spacewar!* running on MIT's PDP-1 and decided to implement the game based on his

observations. Because Hendricks was being paid to program the demo, he was able to complete it after working two weeks straight. He ended up making two versions: the first was scrapped, but everything worked right on the second try (Hendricks, 2014a).

Spacewar! on the Model 65 was seen as a run-of-the-mill project by MIT staff: Hendricks (2014a) recalled, “Really, nobody regularly there at MIT thought the game was anything extraordinary, including myself.” However, to the children of faculty and staff at MIT's Open House, *Spacewar!* was far from dull, with kids clustered around the display “stacked eight or nine deep” (Jones, 2011). Many parents ended up dropping their children off at the Computation Center and picking them up on the way out after touring the campus, the children understandably reluctant to leave (Hendricks, 2014b). Hendricks was later asked to remove *Spacewar!* because it was “wasting too much expensive computer time” only to reinstall it each year for the Open House. Students attempted to hide the game elsewhere on the system under unassuming names; these were summarily removed. One frustrated student even broke into Hendricks's office to steal the code (Hendricks, 2014b)!

Hendricks was not the only programmer paid to make *Spacewar!* Imlac produced *Mini Space War* in 1970 for distribution with the PDS-1 as a demonstration. Until additional software could be programmed, the game was a nice distraction during breaks (Palmer, 2014). Data General also produced a version for the NOVA, which was demonstrated at the Fall Joint Computer Conference in San Francisco in December 1968. According to advertisements, *Spacewar!* was capable of running on a standard television monitor using the 4K NOVA, which retailed for $7950 (Data General Corporation, 1969a, 1969b). Ironically, Atari founders Nolan Bushnell and Ted Dabney considered creating a coin-operated version of *Spacewar!* using a NOVA in fall 1969, but deemed the hardware too expensive and not powerful enough to run the game time-shared, unaware a version had already been developed for it.

Spacewar! Ports at Stanford

With the help of other programmers, Steve Russell ported *Spacewar!* to Stanford University's PDP-6 in fall 1966 (Gorin, 2014). Stanford installed the machine on June 6 (Ernest, 2009) in

the Stanford AI Lab (SAIL), and Russell described it as one of the first things programmed once they got the displays (Goldberg, 2014; Markoff, 2005, p. 103). The game used four-button controllers and likely ran off a PDP-1 simulator (Kossow, 2008).

As new hardware arrived, the game continued to evolve. When the displays were upgraded in 1967, Stanford's programmers developed a special time-sharing system called Spacewar Mode that allowed users to run *Spacewar!* at full speed alongside other programs. Spacewar Mode used only as much computer time as necessary to run the game smoothly while allowing the computer's idle microseconds to be applied to more serious research projects and resource-intensive programs like computer music or physics simulations (Levy, 1984). In an era when every minute of computer time was valuable, anything that allowed users to conduct research more efficiently was a boon. In November 1968, a PDP-10 was installed at SAIL and hooked up with the PDP-6 to create a dual-processor machine. *Spacewar!* was modified to run on it. When SAIL connected to the ARPANET in 1970, *Spacewar!* was distributed freely across the network. Yet despite *Spacewar!*'s popularity, it was superseded by other activities, such as SAIL's afternoon volleyball matches.

In October 19, 1972, *Rolling Stone* sponsored a *Spacewar!* tournament at SAIL. Dubbed the Spacewar Olympics, this event may have been the first videogame tournament. The version played here was modified by Ralph Gorin, a graduate student in computer science who later developed the first dedicated spellchecking program. Gorin began documenting the PDP-6/10 code from summer 1971 to summer 1972, modifying the game to allow up to five players simultaneously on six displays and adding such features as mines[12] and partial damage (Gorin, 2014). Players could also easily change variables through a text-based menu. It was these features that made the Spacewar Olympics possible and helped bring the game to public consciousness.

Stanford's versions of *Spacewar!* also inspired the first arcade videogames, *Galaxy Game* by Bill Pitts and Hugh Tuck and *Computer Space* by Nolan Bushnell and Ted Dabney. Pitts first saw *Spacewar!* on Stanford's PDP-1 while a student there and later on the PDP-6/10,

12 Baumgart (2014) reports that Gorin produced a bug displaying dozens of mines at once, making the game resemble *Asteroids*. Gorin could not recall this event.

introducing his friend Tuck to it in 1970. Although Tuck saw the possibility of turning *Spacewar!* into a commercial product, it was not until the PDP-11 was released for $10,000 that they decided the project could be economically viable. In June 1971, Pitts and Tuck purchased a PDP-11 with an HP 1310 Electrostatic Display and ported *Spacewar!*, which they renamed *Galaxy Game.* In September, *Galaxy Game* was installed at the Tresidder Union at Stanford, where they charged ten cents per game or three for a quarter. Although it was popular and ran at Tresidder for many years, it was not until May 1979 that the hardware finally paid for itself and *Galaxy Game* was disconnected (Smith, 2013).

Bushnell, on the other hand, took a more practical approach with *Computer Space.* He saw *Spacewar!* on the PDP-6/10 in fall 1969 and was inspired to create a coin-op version, sharing his idea with his friend Dabney (Goldberg and Vendel, 2012, p. 25).[13] Working together, the two built custom hardware to run the game at low cost, Bushnell building the cabinet and Dabney the display (Edwards, 2011). The result was the first arcade videogame, location-tested at the Dutch Goose in August 1971 and released commercially in November (Smith, 2013). Thus, although *Spacewar!* originated at MIT, it was Stanford's version on the PDP-6/10 that directly influenced the arcade videogame industry.

Minnesota Spacewar!

Minnesota Spacewar! was another famous version, programmed by Albert Kuhfeld for Control Data Corporation's CDC 3100 with 8K of memory at the University of Minnesota Williams Laboratory for Nuclear Physics. Kuhfeld did the bulk of the programming in 1967, finishing in 1968. Kuhfeld was a graduate of MIT in 1963, where he played *Spacewar!* In the fall, he took a position at the University of Minnesota Department of Physics and Astronomy, which at the time was constructing a new particle accelerator. Work was completed in 1965, and a CDC 3100 was installed. However, it took some time for the computer to get up and running. Kuhfeld (2014b) recalled:

13 Bushnell claims to have played *Spacewar!* first at the University of Utah while a student there from 1965-1968. In 1966, the University had a UNIVAC Type 1108 connected to a PDP-8 with vector display. However, this system was still being developed by February 1968 and would have been reserved for computer graphics experiments by David Evans, making a *Spacewar!* adaptation unlikely (Goldberg, 2014). Bushnell's account has not been confirmed at this time.

A new laboratory needs, of course, a lot of tweaking, tuning, and adjusting, so I didn't even get a chance to lay hands on the computer (except to say hello) well into 1966. Then I was writing particle-tracking software for awhile. 1967 is the first year I really had the time and equipment to work on the game. When the accelerator is working well, there are long data-collection runs during which the RAs sit by the computer twiddling their thumbs. Gotta find something useful for those thumbs to do, not to mention the other eight fingers. And there was that keypunch...

Kuhfeld missed playing *Spacewar!* at MIT and began programming his own version for the CDC 3100. The game went through three iterations:

The first was rough-and-ready, to get things working. That, among other things, was where I learned integer sine and cosine routines were a bit tricky. The second version was for playing, while we gained experience. And the third version added bells, whistles, options, and polish (Kuhfeld, 2014a).

These included a scoring system, timers on the torpedoes, and faster code. The most famous addition was the “Minnesota Panic Button,” a cloaking device that made the player's ship invisible and served as an alternative to hyperspace. Skilled players could project their ship's trajectory and sneak up on their opponents – however, their position would be given away once they fired their rockets. *Minnesota Spacewar!* also added retrorockets for easier deceleration. The sun and explosions were created with semi-random number generators in x/y pairs, which were then reflected into the four quadrants (Landsteiner, 2014). Taking a cue from MIT, Kuhfeld also built two custom control boxes.

Minnesota Spacewar! was played primarily during the day: like at Harvard, research was conducted at night, and the game could only be played when the accelerator was periodically shut down for maintenance. However, with the arrival of a CDC 6600 and PDP-8, there was considerably more time to play *Spacewar!* and the game became increasingly popular. Kuhfeld published an account of *Minnesota Spacewar* in the July 1971 issue of *Analog*, where it excited popular consciousness. The article was picked up by Goodavage (1972), who

visited MIT, but borrowed extensively from Kuhfeld's article, and also by Brand (1972) in *Rolling Stone*.

Spacewar! at University of Cambridge, England

The University of Cambridge is already notable in game history for A.S. Douglas's *Noughts and Crosses*, created on the EDSAC in 1952 as part of his PhD dissertation in human-computer interaction. The game was displayed on a 35x16 pixel screen and has enjoyed some notoriety as the first graphical computer game (Winter, 2013).[14] In the 1960s, Cambridge was still a leader in computer science. The university owned a Ferranti Atlas computer, dubbed "Titan," and purchased a PDP-7A in 1966 (Soemtron, 2014) to run the Type 340 CRT display connected to the machine (Cutler, 2014). It was used primarily for vector graphics research.

Sometime around 1968, two graduate students, M.S. Peterson and John C. Viner, created the *Spacewar!* adaptation *DUEL*.[15] The game used console switches rather than joysticks, with five switches per player. This version introduced "viscous space," which allowed the spaceships to decelerate over time – hardly scientifically accurate, but a feature later found in many arcade games. There were also no explosion effects or hyperspace – once a spaceship was hit by a "bullet," the screen would go blank (Digital Equipment Corporation, 1968). *DUEL* appears to have been simply a demonstration of the PDP-7's graphical capabilities and wasn't taken very seriously: no copies survive at Cambridge.

Spacewar! on the PDP-8

Starting in 1965, DEC released the popular PDP-8 line of minicomputers. At a base price of $18,000, these affordable machines quickly spread to computer labs across the country. *Spacewar!* followed, with different versions for various models of PDP-8.

14 The EDSAC 1 was shut down in 1958.
15 DECUS catalog number 7-40.

The earliest dated example is *SPCWAR* for the LINC-8,[16] published on August 12, 1968 by Edwin G. Duffin of the University of Pennsylvania.[17] This version was modified from an original source and appears to play identically to MIT's PDP-1 version, sans hyperspace. The University of Pennsylvania also had a LINC in the Biology building in 1964 (Johnson, 2014). At the end of a round, the game displayed text describing its outcome:

- COLLISION
- SNOOPY PREVAILS
- ANOTHER NOTCH FOR THE RED BARON

More often than not, labs used whatever interface the computer came with. *SPCWAR* used a set of knobs on each side of the LINC-8's control panel to operate the horizontal and vertical movements of each spaceship. Sense switches 0 and 5 were used to fire. In the case of University of Michigan's DDP-224, the joysticks were originally used along with a light pen to scan bubble chamber film, but had been repurposed for gameplay (Jones, 2014). The use of knobs and joysticks illustrates an important point about *Spacewar!* adaptations: programmers typically used whatever controls were readily available for the computer rather than built their own.

Next came *Space War*, programmed by Evan Suits of DEC in January 11, 1971 and published in *DECUS* March 22.[18] The game ran on a LAB-8 display and was programmed in PAL8. It retains hyperspace, but with a constant 3:4 chance of survival rather than the original 1:8. The ships here also have retrorockets, allowing the player to decelerate. Torpedoes cannot be fired in volleys, but only once every few seconds. The game code also has a section where programmers can load in special victory messages.

Suits graduated from the University of Michigan in 1968 (Class Notes, 1970) and would have seen *Spacewar!* on the PDP-1, PDP-4, or DDP-224 there. He was obviously an avid Spacewarrior, since his first comment line in the code is “Interplanetary Death and

16 The LINC-8 was manufactured between 1966 and 1968 and was a combination of the PDP-8 and LINC (Laboratory INstrument Computer). The popular LINC was manufactured from 1962 to the end of 1969, and ran on emulation through the LINC-8.
17 DECUS catalog number L-39.
18 DECUS catalog number 8-395.

Destruction on your LAB-8," and the game's goal is to become "Supreme Ruler of the Universe." The code is full of similar descriptors: when the Delta ship is destroyed, for instance, the notes state, "DRINK LEADEN DEATH, NUMBER ONE!" Ironically, *Spacewar!* had traveled full circle from DEC to Michigan and back.

At least one other PDP-8 version was programmed in 1974 by Doug E. Wrege and Don Harmer of D.E. Wrege & Associates, a computer software company in Atlanta, GA with ties to Georgia Tech.[19] The ships use retrorockets, but rocket exhaust is not displayed while in hyperspace. The spaceship designs were changed to the Klingon Battle Cruiser from *Star Trek* and the classic *Flash Gordon* rocket, and there are also flying saucers.

PLATO

Spacewar! found its way to the University of Illinois through PLATO, an early experiment in adapting computers to education that allowed students and faculty to both use and program interactive lessons. The game was adapted around 1969 by Richard Blomme, one of the heads of PLATO. Blomme used custom ASCII graphics to represent spaceships instead of drawn images, a common technique on PLATO. *Spacewar!* also made use of an innovative big board style matchmaking system, similar to those found on modern online multiplayer games. The big board displayed a list of user nicknames, allowing players to challenge anyone to a duel.

Unlike in other labs, PLATO users could spend lots of time not only playing games, but also programming new ones – provided other students weren't doing classwork. As a result, games quickly became more sophisticated, and *Spacewar!* eventually lost its popularity. However, it was still requested and played sporadically until PLATO went on the ARPANET in 1974, at which time many big board style games became incompatible. To solve this problem, Silas Warner, creator of *Castle Wolfenstein*, programmed a networked version called *Orbit War*.

19 The two published a paper, "SPACEWAR--A Tool for Teaching Assembler Programming, Operating Systems, and Real-Time Programming" in *DECUS Conference Proceedings,* 1974.

Spacewar!'s influence can be seen on other PLATO games, including *Dogfight* (1973 or 1974), a 2D airplane fighting game, and Brand Fortner's 3D simulation *Airfight* (1975), which later lead to *Microsoft Flight Simulator*. Both demonstrated a fascination with one-on-one duels, a trend also found in arcade games such as *Tank* (1974). However, the greatest influence can be seen in *Empire*, John Daleske's epic game of strategy and tactics. The first version, finished in May 1973, involved managing a planet's resources. It was replaced in September by *Empire Version II,* which featured large battles between different spacefaring races inspired by *Star Trek*. Gameplay was similar to *Spacewar!*, with acceleration, torpedoes, and gravity mechanics, but on a larger scale with fleets of ships. Subsequent versions of *Empire* continued to emphasize tactical space combat, and by the early 1980s, large player communities emerged, staging mock wars between guilds. This concept of including *Spacewar!* style gameplay as part of a larger simulation is an enduring legacy that can arguably be traced through games like *Star Control* (1990).

Observations

The above examples indicate *Spacewar!* spread much more slowly than previously thought. Furthermore, the large, active player communities celebrated at MIT and Stanford are exceptions and should not be used as examples of every computer lab in North America. There is, however, clear evidence of *Spacewar!*'s dissemination from lab to lab, as with the cases of MIT to the University of Minnesota, but notably, the game's spread was not immediate: when Spacewarriors transferred to other labs, they first had to build the software libraries they were hired for before they could start hacking their own programs.

This helps explain the delay between when the platform was manufactured and installed to when *Spacewar!* was programmed for it. Programming *Spacewar!* was a massive undertaking, consuming hundreds of hours at a time when most computers were dedicated to practical research. Games could only be programmed during downtime, excepting unique cases where *Spacewar!* was specifically programmed to demonstrate the capabilities of new hardware, as with the IBM System/360, Data General NOVA, and Imlac PDS-1. Additionally, in some instances there was no need to regulate the game's use simply because most available computing time was already reserved for research purposes and programmers

were interested in other things; laboratories at places like University of Michigan and Harvard were essentially self-regulating. The atmosphere of each computer lab was unique – there was no "national" culture of computing until the proliferation of microcomputers.

However, a shift occurred around 1968, as indicated by the large number of documented *Spacewar!* versions after this period. This can be attributed to the growing number of computers available as well as an increase in the number of graphical displays.[20] The most popular graphics terminal of the period was the IBM 2250, introduced in 1965 for the IBM 1130 and 360 series of computers. The displays were developed in response to the growing need for computer graphics in such areas as aerospace and drafting. The market, dominated by IBM, included new models from DEC, HP, and Control Data Corporation in 1967 and 1968. By 1971, it was estimated there were approximately 1000 interactive graphic displays throughout the United States (Da Cruz, 2008).

Larger numbers of computers with greater processing power meant more available computing time as well as more computer programmers. Although games were not officially sanctioned, more computer resources meant games were more likely to appear in a given lab or programmed on a certain machine. Ultimately, *Spacewar!* spread with the market for interactive displays, and as the size of that market grew, so did its audience, until eventually the game achieved mainstream notice.

On January 26, 1969, Walter Cronkite demonstrated *Spacewar!* with physicist John Mott-Smith at the Air Force Cambridge Research Laboratory in Everly, Massachusetts on the TV show *The 21st Century.*[21] The computer was described as "only for relaxation for the programmers," suggesting it was dedicated to non-critical research, such as computer graphics – Mott-Smith was also a recognized digital artist, with work featured in the London Institute of Contemporary Arts and *LIFE* magazine ("The Luminous Art of the Computer," 1969). In an era of heightened Cold War tensions and the looming threat of an actual "Space War" with the Soviets, Cronkite was quick to dismiss any military application: "No, the

20 The 1970 issue of *Computer Display Review* lists 43 different models. Some of these, such as DEC displays, the IBM 2250, and Imlac PDS-1, are known to have run *Spacewar!*

21 The episode, "Tomorrow…Today!," broadcast January 26 and featured training simulations by NASA for Apollo astronauts. A film copy has not been located at this time, but a transcript is available from the Dolph Briscoe Center for American History, Box No. 98-331/30.

Pentagon is not designing interplanetary warships. This 'space war' is an exercise programmers use to relax and to learn what their computer can do" ("Cronkite Flips," 1969).[22]

Despite this recognition, it is important to remember that throughout the 1960s, *Spacewar!* was only available at computer labs in universities and research facilities to students, teachers, and employees, and only occasionally made available to family, friends, and visitors. While the general public was made aware of the game through *The 21st Century*, *Analog*, and *Rolling Stone*, it would not be until 1977 when Larry Rosenthal released the arcade adaptation *Space Wars* that Russell's game finally enjoyed a mass audience. Rosenthal in turn influenced other designers, such as Ed Logg and Lyle Rains (*Asteroids*, 1979) and Eugene Jarvis (*Defender*, 1981), who, like many other designers, also played *Spacewar!* while in college.

Conclusion

There are many dangers of making broad conclusions on areas of history where little information is readily available, particularly when having individual examples represent wider trends. This underscores the value of historical research for game studies rather than continued reliance on a small number of primary sources.

The lack of information regarding *Spacewar!* in the 1960s is troubling, though unsurprising. Documentation from this period is scanty at best, and many versions, such as *DUEL*, have so far been impossible to locate. While source code periodically appears thanks to the efforts of projects such as Bitsavers, as well as museums, archives, and individual collectors, the historical record will remain scarce, and we are forced to accept that many early computer games are simply lost forever. For this reason, oral histories are our only chance of recording the history of this lost era of computer games.

22 Conspiracy theorists were unconvinced. Goodavage (1972) suggested *Spacewar!* was a classified simulation used to train pilots to fight aliens.

However, collecting oral histories has its own obstacles. Programmers who were active during the 1960s are now in their 70s and 80s, and memories from half a century ago are often hazy or unreliable and must be verified from period records. Many surviving artifacts are owned by private collectors, few of which are members of organized networks. Some might be interested in recording oral histories of computer games of the era, but if they are unaware of such an effort, how can we record them? Others are difficult, if not impossible to track down. Many of these individuals may also have artifacts from the period, including photographs, code, paper tape, controllers, and other materials that would greatly illuminate our understanding of early computer games.

These difficulties are not insurmountable. We hope to continue documenting the oral history of *Spacewar!* and other early computer games. There are still many more examples of game software that need to be investigated, and many oral histories waiting to be recorded. We hope other historians will continue to follow this method of collecting oral histories and that more people will be willing to come forward and share their stories for future generations.

References

AUSLANDER, M. (2014), Questionnaire, (June 2, 2014).

BAUMGART, B. (2014), Personal interview, (May 4, 2014).

BELL, G. (2014), Personal correspondence, (May 7, 2014).

BRAND, S. (1972), “Spacewar: Fanatic Life and Symbolic Death Among the Computer Bums”, *Rolling Stone*, (December 7), <http://www.wheels.org/spacewar/stone/rolling_stone.html>.

“CLASS NOTES”, (1970), *Michigan Alumnus*, vol. 76, no. 10, (June), p. 33, <http://books.google.com/books?id=eh1YAAAAMAAJ>.

“THE COMPUTER DISPLAY REVIEW” (1970), p. 1961-1982, (March),

<http://bitsavers.trailing-edge.com/topic/graphics/ComputerDisplayReview_Mar70.pdf>.

COSSELL, B. (1995), "Computer Game Pioneers ? ? ?", Forum post, *alt.folklore.computers*, (April 3, 1995), <https://groups.google.com/forum/#!topic/alt.folklore.computers/Rd3F_7BXZ7U>.

"CRONKITE FLIPS DURING SIMULATED WALK ON MOON" (1969), EXPRESS and NEWS (January 4), p. 4.

CRONKITE, W. (1969), "Tomorrow...Today!", *The 21st Century*, CBS Films, (January 26).

CUTLER, N. (2014), Personal correspondence (June 6).

DA CRUZ, F. (2008), "IBM 2250 Display Unit", *Columbia University Computing History,* (May 13), <http://www.columbia.edu/cu/computinghistory/2250.html>.

DATA GENERAL CORPORATION (1969a), "We have this slightly used computer", *Control Engineering*, Vol. 16, No. 1, (January), advertisement.

DATA GENERAL CORPORATION (1969b), "How to Play Spacewar on the NOVA," (November), pamphlet.

DIGITAL EQUIPMENT CORPORATION (1963), "PDP-1 Computer and Spacewar", Brochure, <http://www.masswerk.at/spacewar/pdp-1-computer-and-spacewar.html>.

DIGITAL EQUIPMENT CORPORATION (1968), *DECUS Program Library Catalog June 1968*, <https://ia601601.us.archive.org/12/items/bitsavers_decdecuspratalogJun68_4474090/DECUS_Catalog_Jun68.pdf>.

EDWARDS, B. (2011), "Computer Space and the Dawn of the Arcade Video Game", *Technologizer,* (December 11), <http://www.technologizer.com/2011/12/11/computer-space-

and-the-dawn-of-the-arcade-video-game/>.

ERNEST, L. (2009), “A hummingbird with range,” <http://www.stanford.edu/~learnest/sail/umunhum.htm>.

FINCH, G.P. (1965), Letter to W.S. Elliott, Cambridge University Mathematical Laboratory, January 8 (Cambridge Computer Laboratory Library).

GOLDBERG, M. & VENDEL, C. (2012), *Atari Inc.: Business is Fun*, Carmel, NY, Syzygy Company Press.

GOLDBERG, M. (2014), “Nolan Bushnell and digging up *Spacewar!*”, (January 11, 2014), <http://ataribook.com/book/nolan-digging-spacewar/>.

GOODAVAGE, J. (1972), “Space War! A Computer Game Today, Reality Tomorrow?”, *SAGA*, (November), p. 34-37, 92-94, <http://www.masswerk.at/spacewar/SpacewarSaga.html>.

GORIN, R. (2014), Personal interview, (December 24, 2014).

GRAETZ, J. (1962), “PDP-1 Plays at Spacewar”, *DECUSCOPE*, vol. 1, no. 1, p. 2, 4, <http://bitsavers.informatik.uni-stuttgart.de/pdf/dec/decus/decuscope/Decuscope_Vol01_No1_Apr62.pdf>.

GRAETZ, J. (1981), “The Origins of Spacewar!”, *Creative Computing*, vol. 7, no. 8, <http://www.masswerk.at/spacewar/SpacewarOrigin.html>.

HENDRICKS, E. (2014a), Personal correspondence, (June 16, 2014).

HENDRICKS, E. (2014b), Personal correspondence, (August 25, 2014).

JOHNSON, H. (2014), “LINC tape drive,” *Retrotechnology,* (April 14),

<http://www.retrotechnology.com/restore/linc.html>.

JONES, D. (1999), “History of Joysticks,” Forum post, *alt.folklore.computers*, (January 22, 1999), < http://neil.franklin.ch/Usenet/alt.folklore.computers/19990122_history_of_joysticks>.

JONES, L. (2011), *It's Cool to be Clever,* Victoria, BC Canada, Agio Publishing House.

KOSSOW, A. (2008), “Oral History of Steve Russell”, *Computer History Museum*, (August 9, 2008), <http://archive.computerhistory.org/resources/access/text/2012/08/102746453-05-01-acc.pdf>.

KUHFELD, A. (1970), “Spacewar,” *Analog*, (July), p. 67-79.

KUHFELD (2014a), Personal correspondence, May 7.

KUHFELD (2014b), Personal correspondence, June 7.

KUNIAVSKY, M. (1996), “Info on Spacewar (Space Wars?) and PDP-1”, Forum post, *alt.folklore.computers*, (August 10, 1996), <https://groups.google.com/forum/#!topic/alt.folklore.computers/lZMm-uIrX8w>.

LANDSTEINER, N. (2014), Personal correspondence, April 7.

LEVY, S. (1994), *Hackers: Heroes of the Computer Revolution* [1984], New York, NY, Delta.

“THE LUMINOUS ART OF THE COMPUTER” (1968), *LIFE*, vol. 65, no. 19, (November 8), p. 52-58.

MARKOFF, J. (2005), *What the Dormouse Said*, New York, NY, Viking.

MORRIS, J. (1993), “Classic Space War for PC?”, Forum post, *alt.folklore.computers*,

(March 10, 1993), <https://groups.google.com/forum/#!topic/alt.folklore.computers/FumCeSapsPs>.

PALMER, H. (2014), Personal communication, (August 17).

"PDP-1 SERIAL NUMBERS VER 20060819" (2006) <http://bitsavers.trailing-edge.com/pdf/dec/pdp1/PDP-1_SerialNumbers.pdf>.

SMITH, K. (2013), "Galaxy Game", *The Golden Age Arcade Historian*, (March 13), <http://allincolorforaquarter.blogspot.com/2013/03/galaxy-game.html>.

SOEMTRON (2014), "Digital Equipment Corporation PDP-7", *Soemtron*, (June 9), <http://www.soemtron.org/pdp7.html>.

SWARTZ, F. (2014a), Questionnaire, (May 13, 2014).

SWARTZ, F. (2014b), Personal correspondence, (May 13, 2014).

UNIVERSITY OF MICHIGAN (1966), "Survey of University Computing Resources", *Research News*, vol. 16, no. 12 (June), p. 18-38.

WEXELBLAT, P. (1996), "Info on Spacewar (Space Wars?) and PDP-1", Forum post, *alt.folklore.computers*, (November 10, 1996), <https://groups.google.com/forum/#!topic/alt.folklore.computers/lZMm-uIrX8w>.

WINTER, D. (2013), "Noughts and Crosses - The oldest graphical computer game," *PONG-Story,* <http://www.pong-story.com/1952.htm>.

YASAKI, E. (1963), "Computing at Stanford," *Datamation*, (November), p. 43-45.

ZITO, T. (1983), "Vintage Video Whiz: Long Ago, Steve Russel [sic] Invented Spacewar!", *Washington Post*, (May 25, 1983).

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