SMITHSONIAN INSTITUTION

LEMELSON CENTER FOR THE STUDY OF INVENTION AND INNOVATION

Robert Alan Saunders

Transcript of an interview
conducted by

Christopher Weaver

at

National Museum of American History
Washington, D.C., USA

on

29 November 2018

with subsequent additions and corrections

For additional information about rights and reproductions, please contact:

Archives Center
National Museum of American History
Smithsonian Institution
MRC 601
P.O. Box 37012
Washington, D.C. 20013-7012
Phone: 202-633-3270
TDD: 202-357-1729
Email: archivescenter@si.edu
Web: http://americanhistory.si.edu/archives/rights-and-reproductions

Preferred citation:

Robert Alan Saunders, "Interview with Robert Alan Saunders," conducted by Christopher Weaver, November 29, 2018, Video Game Pioneers Oral History Collection, Archives Center, National Museum of American History, Smithsonian Institution, Washington, DC.

Acknowledgement:

The Smithsonian's Lemelson Center for the Study of Invention and Innovation gratefully acknowledges financial support from the Entertainment Software Association and Coastal Bridge Advisors for this oral history project.

Abstract

Robert Saunders begins discussing his early family life, education, and early exposure to electrical engineering. He next recounts his time at MIT, recalling members of the Tech Model Railroad Club and his work with the TX-0 and PDP-1 computers. Saunders discusses the contributions of *Spacewar!* team members to the project and his development of the original PDP-1 game controllers. He concludes with his post-MIT career and final reflections on *Spacewar!*'s impact.

About the Interviewer

Christopher Weaver is a Distinguished Research Scholar at the Smithsonian's Lemelson Center for the Study of Invention and Innovation, Distinguished Professor of Computational Media at Wesleyan University and Director of Interactive Simulation for MIT's AIM Photonics Academy. He has contributed to over twenty-five books and publications and holds patents in telecommunications, software methods, device security, and 3D graphics. The former Director of Technology Forecasting for ABC and Chief Engineer to the Subcommittee on Communications for the US Congress, he also founded the video game company Bethesda Softworks. Weaver is co-director of the Videogame Pioneers Initiative at the National Museum of American History, recording oral histories and developing new applications for interactive media and public education.

About the Editor

Justin S. Barber provided transcript audit-editing, emendations, and supplementary footnotes to this oral history as part of his broader work into video game history and digital museology.

Table of Contents

29 November 2018

Video Game Pioneers Oral History Collection

Interviewee:	Robert Alan Saunders
Interviewer:	Christopher Weaver
Date:	29 November 2018
Location:	National Museum of American History, Washington, D.C., USA

Weaver: Good afternoon, Mr. Saunders. Would you please state for the record your full name, the date today, and where we're having this interview?

Saunders: Okay. I am Robert Alan Saunders. We are lurking at the Smithsonian Institution in Washington, D.C. Today's date is November 29, 2018.

Weaver: Very good. Thank you. Would you please tell us something about your family?

Saunders: I have been married twice. I have two children who are grown and doing professional things, two grandchildren, one of whom who is now in college, and two stepchildren and three step-grandchildren.

Weaver: Would you please tell us about your early life, your family, including brothers and sisters, where you grew up, and that sort of thing?

Saunders: Okay. The biographical details. I was born in Chicago. We lived in Chicago on the lakefront in a large apartment building, which is still there, until I was about four, at which point we moved to a suburb of Chicago called Hinsdale. My mother was expecting what turned out to be my sister, who was born when I was four. We lived at what was then nearly the last house on the south side of Hinsdale before you get to 55th Street. That's a Chicago street number.

I grew up there, and as houses were being built to the south of us, I proceeded to inspect them rather carefully to find out how it was done. I learned a good deal about building construction and also learned that cast-iron soil pipes are something which we are very good to have gotten rid of.

In 1955 or thereabouts, my father bought the vacant lot across the street from us, built a larger house there, into which we then moved. That house still exists. The house across the street where I first grew up was subsequently demolished and replaced as the town became more of a yuppieville than it was when we were living there.

I attended the Madison Elementary School, which is a three-block walk from the house. I went to the local junior high school, which was then situated in what had previously been the high school building in the downtown area of Hinsdale. They were, at the time, building the new high school down just south of 55th Street, which I attended when I got to the point of attending high school. I spent four years there and studied the usual stuff. [I] did reasonably well in academics. I had realized at an early age that I was fairly adept in mathematics and had interest in the sciences in general.

Going back a bit, during World War II, my father, who was one of the proprietors of Saunders & Company, which was the largest industrial plumbing wholesale house in Chicago at the time, had been called to the Navy to the Bureau of Supplies and Accounts to help put together the logistics to run the war. He went to Washington, D.C. in 1944 and we followed shortly thereafter. He found a townhouse which was quite new in Fairlington, Virginia, which is across Glebe Road from Parkfairfax [Condominium Association]. We lived there for, oh, probably a year and a half or so while the war finished up. He cleaned up the Navy's procurement messes, and then we moved back to Hinsdale.

While we were living in Virginia, I had learned how to read. My father bought me a couple of books which were highly influential in what I subsequently became. One was *Science for the Junior High School* and the other was the current issue of *The Radio Amateur's Handbook*. From these, I learned a lot about science, how it is done, and why it is interesting to do. It was only many years later that I was able to establish that science is, in fact, the *only* way in which we can learn anything, but that is probably beyond the scope of this discussion.

Weaver: Thank you. Do you remember, was it these books that really started you're interested in science?

Saunders: Oh, absolutely.

Weaver: And how old were you?

Saunders: Six.

Weaver: Okay. And what did your mother do?

Saunders: She was a classical housewife. At no point in my growing up was she employed in any remunerative position. She had an interest in art. [She] studied art, did painting primarily in oils, but she spent much of her time trying to keep her kids out of trouble. [Laughs.]

Weaver: If I understand correctly, you were the eldest and you had a younger sister?

Saunders: That is correct.

Weaver: What did your younger sister go into?

Saunders: She was always a horse freak but wound up getting a law degree. [She] met her then and still current husband at law school. They practiced law in New York City for a while. Then [they] moved to Vermont, where they still are, having bought a farm, which is inhabited by the usual collection of two-legged and four-legged critters: horses, dogs, cats, and the like.

Weaver: When did you first become aware of or were exposed to any sort of computer?

Saunders: Oh, boy. I don't really recall. It may well have been in 1957 when I was working during the summer between freshman and sophomore year at MIT [Massachusetts Institute of Technology]. I was employed at Argonne National Laboratory, which was then building a particle accelerator called the ZGS, Zero Gradient Synchrotron. A computer had been in use there to do some of the necessary computation to figure out how to build the thing. My task there was to build some electronics stuff which would be useful for controlling the machine.

Weaver: I want to go backwards a little bit, because we jumped from six years old to MIT.

Saunders: Yes. [Laughs.] We did, indeed.

Weaver: And I'm going to assume that you did a few things between those. The first thing I'd like to ask, and this may be out of sequence, but in his book *Hackers*—you're aware of the book?

Saunders: Oh, yes.

Weaver: Steven Levy—

Saunders: He interviewed me for the book, and we'll talk more about that presently.

Weaver: Right. Steven Levy, as you well know because you gave him the interview, says that you built a Tesla coil that ended up knocking out broadcast television all around the place.

Saunders: Indeed. This is correct. I had read about Tesla coils and figured I could build one, so I set out to do just that. I got the plastic tubing for the high-voltage transformer from Cadillac Plastics in Chicago. The power transformer to run the show came from Allied Radio, also in Chicago, along with the type 810 vacuum tube, which ran the thing. I picked the most powerful tube that I could reasonably afford, and that was it. The transformer put out 2 kilovolts, which were put directly on the plate. [That] meant you had all kinds of modulation sidebands up and down from the primary frequency at which the coil ran, which was about 790 kilohertz. This, indeed, [interfered] with the sidebands to both AM/FM radio and television for blocks around, so I didn't run it much.

Weaver: Very good. You're lucky the FCC didn't close you down.

Saunders: Yep.

Weaver: But where did you learn to do that? How old were you? Where did that electronics background come from?

Saunders: Well, as I mentioned before, I started out with *The Radio Amateur's Handbook.* By the time I was old enough to put this Tesla coil together, you know, I'd been into this stuff for ten years.

Weaver: Would that make you a teenager?

Saunders: Oh, yes. I was in high school at the time. The thing got hauled down to a science fair during my junior year, senior year. I don't recall exactly, but in that general neck of the woods.

Weaver: You mentioned that you had been working at Argonne National Laboratory, and you sort of skipped over a kind of important part, which was that you were at MIT at the time.

Saunders: Yes.

Weaver: And so, why MIT?

Saunders: Well, I had heard about it and knew a fair amount about it. I had read from the Smyth Report about the adventures in engineering going on there, and it had a

stellar reputation.[1] I decided, "This would be a good place to go if I can get in." Well, I did, and went.

Weaver: Prior to going to MIT, did you have any prior experience with electronics, with telephone systems or switching?

Saunders: Absolutely so. In particular, during the summer before I started at MIT, I worked on installing the telephone switching system in Hinsdale, which was great fun and extremely educational. I was working on the Hinsdale switch to start with. Then they decided they needed my warm body up at Elmhurst, which is about the next town north, to work on their switch. I spent the rest of that summer wiring up the switch and, during lunch hour, looking at the wiring diagrams to figure out how the damn thing worked. [Laughs.]

Weaver: With that background, when you went to MIT, do you remember early in your student career, as it were, that you became involved with any particular group that was influential to you?

Saunders: Oh, absolutely so. In particular, MIT was at the time, and, for all I know, may still be having an exhibit of various groups of interests which students might participate in. One of those, of course, was the Tech Model Railroad Club [TMRC]. I wound up going over to the place where it was ensconced, which was Building 20, which no longer exists, to see the thing. [I] discovered that I felt right at home, because the HO trains on the layout could be controlled from five control posts. In those days, the way you controlled the train was by controlling the power to the particular section of track which it was on. And the connection between the control point and the track sections was done by crossbar switches of exactly the same kind that I had spent the previous summer wiring up.

Weaver: In terms of that wiring that you were doing, how was the TMRC organized, and what did you end up doing there?

Saunders: Well, the particular piece of that organization was called Signals and Power, for obvious reasons, and it was a club which was organized as most clubs. You know, there was some officialdom to keep records of meetings, to worry about dispersing funds, collecting dues at hand, the other things that clubs frequently

[1] The Smyth Report (officially *Atomic Energy for Military Purposes*) is the common name of an administrative history written by American physicist Henry DeWolf Smyth about the Manhattan Project, the Allied effort to develop atomic bombs during World War II.

do. I proceeded to get myself involved in the Signals and Power operation, which I shall now describe in a bit more detail.

The switching system which I just mentioned ran off of a 48-volt power supply, 48 volts being the standard DC power level for the relay electronics of the day. In fact, it's still used as the voltage for most telephone communications throughout the world. This power was supplied by a motor generator set that was also a 24-volt power supply, which were used for some things, and 12-volt power supplies to supply the tracks, because that was the maximum voltage that the trains were intended to be used on. This gave me ample latitude to do all sorts of interesting things.

The Tech Model Railroad Club had as its faculty advisor a chap whose name I cannot now recall—it may come to me later—who had an in with AT&T [American Telephone and Telegraph Company].[2] He had secured over 1,000 relays plus some crossbar switches, as well as keys, jacks, plugs, and the other impedimenta of telephone operations, so there was plenty of stuff to play with. And if that were not enough, there was a junk dealer named Eli Heffron who had a junkyard up the road in Somerville where he sold scrap stuff, most of which he got from the naval shipyard in Boston. Some of the stuff came from there. Most of it, however, came from AT&T.

Weaver: Would it be fair to say that in terms of the TMRC, that you preferred to be under the table more than over the table?

Saunders: Yes, that would be appropriate.

Weaver: Was there a time when you actually became the head of Signals and Power?

Saunders: Yes, I was at one time in charge of that.

Weaver: I believe the year was 1958.

Saunders: That sounds good.

Weaver: I just want to read a few students whose names I believe were all in this at this timeframe. You can tell me yea or nay. Alan Kotok.

Saunders: Yeah. Alan Kotok was there.

[2] In a follow-up communication dated January 6, 2020 from Robert Saunders, Saunders indicates the MIT Tech Model Railroad Club faculty advisor was Carleton Tucker.

Weaver: Peter Samson.

Saunders: Was there.

Weaver: Robert Wagner.

Saunders: He was there.

Weaver: Steve Piner.

Saunders: He was there.

Weaver: Dave Gross.

Saunders: He was there.

Weaver: And William Mann.

Saunders: Yes. I don't remember him well, however.

Weaver: I believe that they were all members. They all joined TMRC.

Saunders: I believe that is correct.

Weaver: Is it correct that they also formed much of the core of the TX-0 [Transistorized Experimental Computer Zero]and PDP-1 [Programmable Data Processor One] hacking group?

Saunders: That is also correct. Let me elaborate on that a bit. The Model Railroad Club had a faculty advisor named Jack Dennis. Jack B. Dennis, for "Bonnell," if I remember correctly. And, of course, Jack Dennis wound up being the caretaker for the TX-0 when it showed up at MIT, Building 26, around 1958. Of course, we got to go see it, play with it, do things with it, and that is how the world began.

Weaver: Is it fair you all started on the TX-0?

Saunders: Yes, because that was the first machine to which we had easy ready access. Now, I had also done a little bit of work on the IBM [International Business Machines] computer downstairs in a project for the physics department, which was doing nuclear engineering with the MIT nuclear reactor, though most of that was a little bit later.

Weaver: You mentioned Jack Dennis, Professor Dennis. Do you remember John McKenzie?

Saunders: John McKenzie was the chief cook and bottle washer of the operation, the guy who we all looked to to keep the thing running. When something needed to be fixed, Mr. McKenzie was the one who wound up fixing it.

Weaver: Did John McKenzie also hold sway over what was attached to the computers?

Saunders: Not so much. Mostly I would say that Jack Dennis was in charge of that sort of thing.

Weaver: How did members of the TMRC, especially the members we just talked about, become involved with MIT's computers?

Saunders: Well, in various ways. Some wound up using the 704, 709, and 7090 machines downstairs for various projects, which I was only involved in to a minor extent. There were some people in the EE [Electrical Engineering] department other than the Model Railroaders who were involved in doing things on the TX-0. In particular, there was a project which was a joint effort of MIT and the Mass General Hospital to study neurology, particularly in cats. They had numerous recordings on high-fi magnetic tape of the brain signals that originated when cats could hear things Those tapes were being processed on the TX-0. One of the gals who was involved in that process was the one I eventually married. [Laughs.]

Weaver: When you were programming on the TX-0, relative to that computer, do you remember some of the challenges?

Saunders: Oh, yes. There had been an original machine language assembler which had come with the thing when it was brought in from Lincoln Laboratory, where it was first put together. The thing was built at Lincoln Laboratory as the first transistorized computer. It was basically a proof of concept. It showed up at MIT when Lincoln Laboratories decided they knew enough about it that they could build its subsequent machine, the TX-2 [Transistorized Experimental Computer Two]. MIT had it as basically an educational tool, which it turned out to be very good at. It came with an assembler. Jack Dennis decided to rework the assembler to include macro instructions in which you use a name to invoke a block of code of a length of your choice which will be inserted into the object program where you say. I thought this was interesting.

At this point, enter Steve Russell, who was not initially at MIT, but was working at the Smithsonian Astrophysical Observatory up at Harvard. He was also

interested in Model Railroad Club and was sort of an adjunct member thereof. He talked about a more sophisticated macro processing assembler, which caught my attention. I wrote one based upon what he had said and starting with the skeleton that we already had.

While this was going on, Jack Dennis wrote a debugging program which was an elaboration of one that had also come from Lincoln Labs. One could inspect the contents of the computer's memory using the symbolic names that one had attached to the code and variables in your original source program. This was done by having a separate program called *Symbol Punch*, which was run after the assembler had done its thing, which would basically output the symbol table on paper tape. You could then read back in with the debugging program so that the debugger would know all of your symbolic names and what they referred to. [Jack] did the original version of this thing. I thought it could be considerably improved and did so. By the time this was done, Peter Samson came up with the appropriate name for the thing. It was called *FLIT*, for Flexowriter Interrogation Tape, a debugging program, if you will. This was the immediate ancestor of the similar program which ran on the PDP-1 when that showed up. We did the over-the-weekend adaptation of the macro assembler, not mine, but Jack's original, because there wasn't room for mine. The PDP-1 only had half as much memory as the TX-0 at the time. That was the ancestor of *DDT*, the DEC Debugging Tape, which did the same thing.

Weaver: You said something about a weekend. I'm assuming a programming spurt, for want of a better term. Can you give us a little bit of the fore-story and then why that occurred and what came out of it?

Saunders: Ah, yes. The original software package that came with the PDP-1 was basically an invention of one Edward Fredkin, who I later wound up working for. It included a compiler for an algorithmic language of sorts. It wasn't terribly fast, and it produced huge amounts of output tape because it was a one-pass compiler. All the forward references had to be elaborated on the output so that his loader could put the thing together when you brought it in. We all thought that this was not as good as we could do with an adaptation of the macro assembler that was then running on the TX-0.

We proposed that we should go ahead and write a macro assembler for the PDP-1. Could we do this? Of course, we could. Could you do it in a weekend? Why not. We did. [Laughs.] There were several of us involved in the project. Each of us took a piece of code, transliterated it from the TX-0 operation code set to the PDP-1 operation code set. [We] then proceeded to cross-compile the

thing on the TX-0, having fed it a symbol table which matched the PDP-1 instruction set instead of the TX-0 instruction set. Furthermore, it translated the format of the output tape so that it would be directly readable by the PDP-1. All this was done apace, and it worked well and was the standard programming system thereafter.

Weaver: Go backwards for a second. The assembler that you wrote, did you name it?

Saunders: We just called it Macro.

Weaver: Where did the name MIDAS come from?

Saunders: Oh. That was the version of the assembler which I did which contained the better version of the macros. Of course, the idea was MIDAS is what you touch, it will turn your code into gold. It seemed like a mildly appropriate thing to call the assembler.

Weaver: In terms of the writing of the assembler, was Jack Dennis keen on creating a new assembler?

Saunders: I don't recall that he had any strong opinion on the matter. He may have been skeptical about just how quickly we could do it.

Weaver: Is it fair to try and say that doing it in a weekend was kind of a proof of concept for Jack Dennis?

Saunders: That would be a bit of a stretch. It was mostly, "Can you do this?"

[Our answer:] "Yeah, let's do it. It's fun."

Weaver: When did you first hear about or learn that the PDP-1 was coming to MIT?

Saunders: Basically, not until it showed up.

Weaver: And when it showed up, did it have all the parts that it really needed?

Saunders: Yes. The machine occupies four equipment racks which are bolted together to make one long thing. The control face is at one end and contains an array of switches and lights and a couple of push buttons which do various things. Installed behind that face was a paper tape punch and on the face was the paper tape reader. And attached to the machine is a separate typewriter put together

by an outfit called Soroban, which put their own mechanical kludge on IBM's typewriter.

Weaver: What about the CRT? Did that come with it?

Saunders: That came with. Yes, that was the Model 30 CRT [cathode ray tube] display. At that point, the computer's list price was $110,000—this was in 1961, remember, or maybe 1960—and the display was $35,000. [The] whole lash-up was about 150-grand.

Weaver: Do you remember whether or not the display came at the same time as the machine?

Saunders: It did.

Weaver: You had mentioned that you were able to create, I'm assuming, the MIDAS assembler over a weekend for the PDP-1.

Saunders: That wasn't the MIDAS assembler, as I said. There was not enough storage to run that assembler because it took more storage space than the simpler macro processer which it had replaced. It was the simpler processer which we converted over.

Weaver: Got it. Okay. With the modified processor, in terms of what you'd written, you said that you had sort of parceled it out among the members of the team. Do you remember who those members were and kind of who did what?

Saunders: I don't have a strong recollection of that. Robert Wagner was involved in the process. I think Alan Kotok was in on it too. Of course, I was in on it. There may have been one or two others, but I, at this point, don't remember.

Weaver: In a relatively short description, what were the benefits of the PDP-1 over the TX-0?

Saunders: There really weren't any. Both machines were such that you could attach useful gadgetry to do things. They were about the same speed and initially of the same memory capacity and basically computational ability, so there really was no particular advantage to having two of them, except they were somewhat different, so you could apply concepts back and forth.

Weaver: Why would MIT allow a group of students to play with their newest, expensive toy?

Saunders: Well, I am not entirely sure, except that apparently Jack Dennis was of the opinion that it would be a good thing to do, and it turned out that it was.

Weaver: I noticed you said computationally there really wasn't any difference between the TX-0 and the PDP-1, but in terms of the graphical interface and in terms of the display mechanisms, would you consider there was a difference?

Saunders: Again, not really, because the TX-0 also had a CRT display not noticeably different in function from that that came with the PDP-1. Quite a lot was done with that graphic display on each machine.

Weaver: Then let me jump to something. When did you first hear about the concept for a *Spacewar!* hack?

Saunders: Probably from Steve Russell, and it was probably not long after the PDP-1 showed up in 1960 or 1961. I do not recall the exact date.

Weaver: If the two computers were basically computationally the same, why didn't Steve just make a recommendation that you play around with the TX-0? Why program the PDP-1?

Saunders: A fair question, and I am not entirely sure. One reason would be that the TX-0 was in heavy use for research applications, while the PDP-1 was basically bare bolts. Nobody had any idea what to do with it, except to do experimental programming of various kinds, so machine time on the PDP-1 was a lot easier to get than on the TX-0.

Weaver: Was Professor Dennis open to this in terms of allowing you to use it?

Saunders: Oh, absolutely. [Laughs.] In fact, it was his idea.

Weaver: Tell me something about it in terms of the evolvement of *Spacewar!* from that period. You said you were told it by Steve Russell.

Saunders: Yeah, he had mentioned the idea of a *Spacewar!* game, and a number of us, not including me, were actually involved in programming the thing. In the fullness of time, it came up and it worked. People added various things over a period of time to the original design. The star in the middle of the screen was an afterthought, and the starry background was an after-afterthought. But the original implementation was how are we going to control this thing? Well, there's sense switches on the computer's control panel which can be used to tell the thing to turn left, turn right, accelerate, and whatnot. This impressed me as being

obviously unsatisfactory. It was at that point that I decided, "Let's build some control boxes. The thing has got all kinds of IO capability. It can read the boxes without any problem. We simply have to change one instruction in the program, so it reads the boxes instead of the sense switches, and we're good to go."

I put together the control boxes, pictures of which I have. The original boxes wore out years [later] and were evidently discarded. I built replicas for use on a subsequent machine in 1972, which I still have and have brought some pictures of. Anyway, I put together these control boxes. [Uses hand gestures] They're about so-by-so and so high with two lever switches and two push buttons all attached to cables which were then attached to the computer.[3] A pair of these I put together one evening and took them over to the computer. We hooked them up, they worked fine, and we were off and running.

Weaver: Two things. First of all, I want to go back to the boxes in a moment, but did anybody help you build the controllers?

Saunders: No. Nope. I designed them. I built them using telephone gear scrounged from AT&T's castoffs.

Weaver: Now, I'm going to make an assumption here. Tell me if I'm wrong. By the time that you were making a controller box, *Spacewar!* or some piece of *Spacewar!* had to be running.

Saunders: Correct.

Weaver: Okay. Go backwards to the programmatic side for a moment prior to the things being added, such as the star field, etc.

Saunders: Yes.

Weaver: In your earliest recollection of *Spacewar!*, who were the programmers? What did they do?

Saunders: I don't really recall because I wasn't paying a lot of attention to it at the time, so I can't really help you much on that.

Weaver: Okay. You know that Steve Russell was one of them. Correct?

[3] In a follow up communication dated January 6, 2020, Robert Saunders describes the original controller size as around 4" deep and 6" wide.

Saunders: Well, yeah. He was basically one of the ones who came up with the idea. I do not now recall how much of the code he actually wrote, if any. I presume that you'll be interviewing him in the due course, and you can ask him.

Weaver: Does Steve Russell have a nickname?

Saunders: Yeah. He was called "Slug."

Weaver: To the best of your recollection, what does that connote? What does it mean?

Saunders: Nothing. I have no indication of how he came by it. And many of us have nicknames, including me, one which I don't publicize anymore, because I always used it as a kid.

Weaver: When Russell was coming up with the idea for the code, do you remember as part of this group that he was reluctant to sort of make good on his idea?

Saunders: I have no such recollection at all. In fact, I would suspect that he was more encouraging than reluctant to proceed with it.

Weaver: What about somebody like Peter Samson?

Saunders: I believe that he was also involved in it. Again, I do not recall the extent to which that was true. He did, as I recall, eventually do the star background based on the actual positions of a number of the brighter stars.

Weaver: What about the central star, the gravity that you were talking about? Do you remember who implemented that?

Saunders: I do not. It required some mathematical trickery. One of the bits of mathematical trickery that was supposed to be necessary for the thing to be implemented was to have sine and cosine routines which would calculate these. Eventually somebody wrote some and they were, in fact, used. However, it turned out that you don't actually need the sine and cosine routines to do *Spacewar!*. I wrote a version which does not have them.

Weaver: Do you remember, by any chance, what Alan Kotok did on the project?

Saunders: No, I do not.

Weaver: Was there any resistance? You were building some custom hardware in order to play the game. Was it something that you just were able to physically connect to the PDP-1?

Saunders: Absolutely.

Weaver: Well, I don't mean mechanically.

Saunders: I understand where you're coming from on this, and the answer is, nobody really cared. [Laughs.] "You want to attach this gadgetry? Well, there's the panel, which is what it's for. Go for it."

Weaver: Where did that philosophy come from?

Saunders: I don't know that it actually came from anywhere. We just sort of inherited the way things were done.

Weaver: Would you say that Jack Dennis aided or fought with that concept?

Saunders: Oh, I would say that he was all in favor, you know. By the time this was all going down, Jack Dennis had been exposed to our efforts on the TX-0 for quite some time. He could see what we were doing and how we were doing it and thought, "This is a good thing. These people are learning stuff." He would hardly have been loath to encourage the same sort of business to go on on the PDP-1.

Weaver: You were talking about making controllers, and I believe you said—and if not, correct me—that the controllers were made because you felt that it was a better way to control the ships on the screen of *Spacewar!*.

Saunders: Yes, that's correct.

Weaver: Was that something that you just came up with independently? You decided that, "Hey, I don't like the way the movement is going, the controls are going. I'm going to build something to do it"?

Saunders: Yep.

Weaver: Why did you do it?

Saunders: Why not? [Laughs.] This is the mother of invention. You see a better way of doing something, you say, "Can we implement this?" The answer, in this case, was, "Trivially." So, I went ahead and did it.

Weaver: My understanding was that you were a pretty fair player of the game.

Saunders: Yes. In fact, I could beat almost anybody pretty reliably. And it's ironic that *Spacewar!* is the *only* computer game which I ever spent any time actually playing.

Weaver: Is it true that there was a particular maneuver that you either invented or became well known for?

Saunders: Once the star was installed, it became pretty much necessary to start out by applying acceleration so that you didn't fall into it, and once you had an adequate amount of momentum established, then you could take the trouble to turn the craft, shoot at your opponent.

Weaver: Was any of this strategic maneuvering called the CBS [Columbia Broadcasting System] maneuver?[4]

Saunders: I don't recall any such—that it ever had a name.

Weaver: Regardless of it not having a name, were you the expert at that maneuver?

Saunders: I don't think anybody was overly expert at it. It was just something that you learned to do because it was obviously necessary. It was just part of the deal.

Weaver: This many years later, if I was to tell you that we were going to have a couple of emulators out on the floor, would you take on all comers from your group?

Saunders: Well, I could give it a try, but from what I am told, it involves using typewriter keys to tell the machinery what to do. I can claim no expertise at that, having never done it before. [Laughs.]

Weaver: Were you at the open house when *Spacewar!* was shown?[5]

Saunders: Yes, I was there.

Weaver: Can you tell something about that story, how it came about, what your experience was?

---

[4] The "CBS maneuver" describes an in-game strategy that resulted the spaceship avatars maintaining a consistent, stable orbit around the heavy star. The resulting visual trailing effect on the PDP-1 monitor would create the illusion of the open eye icon of the Columbia Broadcasting Network.

[5] The MIT Science Open House event in May 1962 is considered, for all intents and purposes, the offical release date of *Spacewar!* as the complete version's public debute.

Saunders: It was a popular exhibit. We had acquired another video display which could be run in tandem with the display which came with the machine, which made it possible for more people to see what was going on. That proved to be helpful. Aside from that, it was basically an exhibition of "This is what this does, and if anybody wants to give it a try, sign up."

Weaver: Just out of curiosity, how did you know, as part of the group, whether it was a group decision or an individual decision, how did you know when to bring it to the public? How did you know when the game was fun enough?

Saunders: Oh. I didn't have any part in it. It was obviously a fun game. You know, all of us spent a fair amount of time playing at it. When the open house was pending, it was an obvious thing to attract people who would be interested in seeing it. That was pretty much, "It's there. We should do it."

Weaver: At the open house, did it end up being people of similar ages playing or were there kids playing against adults?

Saunders: Oh, everybody did, kids, parents, little kids, you know. It was a pretty good attraction throughout.

Weaver: Did you have any inkling of how truly attractive that game would be to the larger public?

Saunders: Yes. However, at a cost of $150,000 for the hardware, it was clear that it wasn't going to be popular anytime real soon.

Weaver: Well, did you help to sort of increase the visibility or expand the visibility of *Spacewar!* either while you were still at MIT or when you left MIT?

Saunders: Not to any significant extent. In the early 1970s, I wound up working for Hewlett-Packard. They had, at that point, the 2114, 15, and 16 series of minicomputers which were basically intended for instrumentation and sold primarily for that purpose. There was a display which could be attached on which a *Spacewar!* could have been run, and I wrote one to do so. Not having the original boxes at hand, I constructed reproductions, which I still have and which I have brought photographs of, which were substantially identical. The only visible difference is that the new ones had aluminum panels while the original ones were Masonite.

Weaver: Do you remember what the relationship was between *Spacewar!* and DEC, the Digital Equipment Corporation, who created the PDP-1?

Saunders: All of the stuff which we produced at the Institute we made available to DEC for them to do anything with it that they wanted, because we figured, "Turnabout is fair play. They gave us this fun box. We might as well give them anything we do with it which they might be interested in doing."

Weaver: And do you remember what they did with it?

Saunders: No. I was not party to that decision or knowledgeable about its impact.

Weaver: You were talking about the HP [Hewlett-Packard] 2100 series. Was what you wrote placed in their HP program library?

Saunders: I don't recall that it was. For one thing, the display system which it used was not a popular accessory at the time, so they would not have shown much interest in it. Still, there are enough dirty fingerprints on the control boxes to remind me that more people played it than just me.

Weaver: Looking back, what influence do you think *Spacewar!* had on the early programming community?

Saunders: On the programming community per se, not all that much, but as a prototype gaming system, of course, it was pretty much fundamental. The idea was, here is an entertaining thing that you can do with a computer. If you can get the computation hardware at an acceptable price, people are going to use it to play games. We see Atari coming along with the original *Pong* and all of the subsequent games that have happened since, which all are basically branches of this tree.

Weaver: When you were working with these computers in the 1960s, especially given your experience, could you have foreseen sort of the computer ecosystem and development of today?

Saunders: No, not a chance, because remember that the TX-0 and TX-2 were built using single transistors. The integrated circuit had not yet come to bloom. The notion that you could get 10 million transistors on a chip the size of a fingernail, you know, would not have been even conceivable at the time.

Weaver: Let's go back to *Spacewar!* for a minute. I know you said that you didn't think that it had a material effect on programmers. Do you think that it had a material effect on the development of the computer game community?

Saunders: Oh, yes, of course. You know, it's "Monkey see, monkey do" situation, and it's just a question of, "Now that we know we can do this sort of thing, what can we come up with that will be interesting and salable?"

Weaver: I know that you spoke to Steve Levy when he was working on the book *Hackers*. What more can you tell us about both what was on the page and what was not on the page?

Saunders: Well, let's see. Steven Levy's book is reasonably, but not entirely, accurate. I subsequently wrote a critique which I eventually gave to him. It would have been useful to include if he had done a second edition of the thing. But in general, the approach is reasonably sound. Now, he spoke of what he called the hacker ethic, which I think is a bad term for a basically nonexistent concept. What he meant by it was that this intellectual property should be shareable by anybody who was interested in doing so without having to pay for it. But this supposes an environment in which the tools are supplied by an institution such as MIT which would expect to derive the benefits and profits from the use of such thing, to the extent that there were any. In other words, there was no place in what is basically a research environment for proprietary interests. For Levy to try to expand this to situations which were potentially proprietary was, in my judgment, not a good thing.

Weaver: When you left MIT, briefly, what did you do? In other words, if you were breaking it up into decades to follow, did you stay in computers?

Saunders: Okay. So, some history. Edward Fredkin, who I had mentioned, decided he needed some help doing his thing, which was to do computer activities with a PDP-1 mostly for the Department of Defense. He offered me a generous salary to come and do them at his facility, which was in the same complex of buildings that Digital Equipment Corporation was also occupying at the time. This was a moderately long commute because I was living in Cambridge, but I did it, and we did some interesting projects with that.

The first one involved reading films taken of oscilloscope traces from radars that were tracking missiles. They wanted to get accurate and extensive data on what the missiles were actually doing. They had taken basically a movie film of the computer screen upon which the radar traces were being shown. I worked on that for quite a while, and we sold some stuff in that regard to an Air Force base in New Mexico. Just basically as a gag, we shipped the machine there with *Spacewar!* installed on it so they could play with it if they wanted to. Recall that these machines had core memories which would remember what they had been

told after the power was turned off, unlike the dynamic RAM memories of today. That was fun.

Then we got involved in doing a LISP system for a computer that the Air Force had originally made four of. They bought them from IBM, and the machines were basically ancestors of what IBM called the 7030 STRETCH system. They had 64,000 words of 48 bits of memory, all cores. There's an interesting story about that which I'll get to. There were four of these scattered around the country, which they were originally built with the idea that they would be part of the DEW [Distant Early Warning] Line network, which would look for Russian bombers coming over the North Pole from Canada. And technology being what it is, they presently decided that the whole concept was obsolete before it had even been fully implemented. So, they had these big computers. What are they going to do with them?

Well, the one at System Development Corporation in Santa Monica, California, was adapted as a timesharing system, basically a proof of concept. One of the things they decided would be fun to have on it would be a LISP system. And having been involved in LISP to some degree at MIT—I had taken John McCarthy's artificial intelligence course where one of the things you did was to learn it. It was called "Uncle John's Mystery Hour"—I was engaged to work on this.

I decided that the first thing we're going to do is we're going to have a compiled system rather than an interpretive LISP system because it'll run faster. A LISP compiler had been developed at MIT and Stanford when McCarthy went there from MIT, which he did in the early 1960s. It looked to me to be a fairly easy task to adapt the existing compiler to spit out code for the 48-bit machine at Santa Monica. I spent some months at Stanford in, oh, god, about 1965 working on this. By the time I was done, we had a magnetic tape with the LISP system on it, which I then took down to Santa Monica and we installed it on the machine in March of 1966.

The only part of that system which required machine language coding which I had not incorporated in the compiler was the garbage collector. One of the features about LISP is that it produces a lot of intermediate results which are later discarded and need to be cleaned up. During the month of March 1966, I wrote the garbage collector. I didn't get it quite to the point of being fully debugged, but, subsequently, they tasked me to do that and I did. The thing worked and people used it for the sorts of things which LISP is useful for, which is not a very long list, as it turns out. But it's fun and it's an interesting take on

what you can do with a computer where most of the information is in the linkage between things as opposed to the things themselves.

Weaver: Did you ever do anything with the video game industry?

Saunders: No.

Weaver: Have you ever made any money from the video game industry?

Saunders: Not a penny.

Weaver: Do you think that it's been influential to programmers of today?

Saunders: A good question, and the answer is I'm not entirely sure. There are nowadays many flavors of programming. You do operating systems, which is what I was primarily doing in my career at Hewlett-Packard. You do game systems. You do application software, of which there are now a blizzard of applications, you know, accounting packages, personal management packages. Benioff made a mint off of one of those. And on and on and on. As the prices have come down and the uses have increased, any number of people have made a fortune off the little boxes.

Weaver: What would be your comment to the youth of today who are interested in STEM [Science, Technology, Engineering, Mathematics], but they're not sure yet to the degree that they would be interested in STEM? In other words, what would you say to someone to get them interested in, for instance, the sciences?

Saunders: Well, let me think a moment. It depends, I think, so much on one's personality and one's personal interests that it is probably impossible to give a recipe which is of any general validity or use. Some people are interested in sciences. Some people don't really care. My daughter, for example, was interested in horses and not much of anything else. She became a veterinarian and is still doing it. The only science she cares about is basically veterinary medications. If you're interested in sciences in general and electronics in particular, then computers offer a variety of possibilities for you to stick your spoon in and stir the pot.

Weaver: What about digital art?

Saunders: There has been a fair amount of that going on. I think that in this day and age, the principal users of digital art are the people who are doing video games, of which are excellent examples of the sort of artistry that you can do. Now, this, of course, has a long history, starting with a computer display called the Minskytron,

which is displayed on MIT's video about the PDP-1, which also includes, of course, shots of *Spacewar!* and people playing it. But, again, this is a field which has been made possible by the vast expansion of computing capabilities. It's not something which could have been done with any great facility back in the 1960s or even the 1970s or even the 1980s. It needed a lot more horsepower. Now the horsepower is available from sources such as Nvidia and people have used it to good advantage.

Ross-Weaver[6]: You mentioned your daughter. I think you have another child. What does that child do?

Saunders: My son is now working for SAP in Mountain View doing computer stuff.[7] He spent much of his career working at eBay and their operation down in San Jose.

Weaver: While *Spacewar!* may be your most celebrated work in terms of public awareness, what is the work of which you are personally most proud?

Saunders: That is something which has nothing to do with computers whatsoever. I will tell you about it. First off, you need some background about *Hackers*. The publication of Steven Levy's book led some people to have the idea that people involved in these black arts should get together from time to time and meet and trade ideas. This is the germ of what is called the Hackers Conference, which has been held annually. I have attended most [them] of ever since the book came out decades ago. Interestingly, none of the people who were involved in the *Spacewar!* project wound up attending this except me. But one of my cohorts at Hewlett-Packard and her husband were participants on a fairly regular basis, although they haven't attended the last few.

At one of these meetings, we were talking about the philosophy of science. I remarked at that time that you could, by experiment, prove that a theory was wrong, but you could not ever prove that a theory was right. You could only show that it appeared to work in the particular circumstance to which you tried it. Somebody in the audience said this sounds like a thesis that had been put forth back in the 1920s, and had I ever heard of the guy who did it. And I had not. The chap wrote two important books on the subject: *Conjectures and Refutations* and *The Logic of Scientific Discovery*. His name was Karl Popper and he was a member of the Vienna Circle when it finally decided that logical

[6] Nanci Ross-Weaver is a media consultant and executive producer, having held executive and senior producer positions at Post-Newsweek Stations, CNN, and CBS News.
[7] SAP SE is a European multinational software corporation that makes enterprise software to manage business operations and customer relations.

positivism was a basically flawed system. Popper came up with the idea of refutability as being the keystone of how you actually do science. Popper's conjecture about refutability was something which was exactly in line with what I was saying. I presently was able to get a hold of Popper's books and see what he said about it, and this impressed me as being of fairly significant importance.

Now, the question which then arose: was he right? Popper did not have the necessary mathematics available at the time to show that his claim was true. The mathematics has subsequently developed, and I have used it to prove that he is, in fact, right. In particular, the information content of any thesis is limited by its refutability, for which you can immediately conclude that a thesis which cannot be refuted can convey no information. And I think this is of overpowering importance, because one of the things which it does is to show that every modern religion which posits the existence of God is wrong. You cannot know anything about a god because there is no way you can refute any claim about a god.

Robinson[8]: I've got one more. How would you describe *Spacewar!* to someone watching 100 years from now?

Saunders: Oh, boy. I would say it's a video game. There's a screen of which two spaceships are displayed. They can be controlled with control boxes. They can maneuver and shoot at each other, and when you hit one, it goes "bang!" [Laughter.]

Robinson: Anything more about it in a more general sense beyond actually the gameplay?

Saunders: Nope. That's basically it. That's all there is to it. [Laughs.]

Weaver: Excellent. Thank you, Bob.

[End of interview]

[8] Matt Robertson is producing and directing the documentary component of the Video Game Pioneers Initiative and runs a New York based film production company.