Oral History of Gregg Zehr

Interviewed by:
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John Hollar: OK, so let's get started, then. Tell us, Gregg, a little bit about your upbringing your education.

Gregg Zehr: Sure. Well, I was born and raised in Illinois, rural Illinois, on a dairy farm kind of out in the middle of nowhere. Born into a Mennonite family. So closed community, as I said small farm, dairy with cattle and getting up every morning and watching my older brothers help my father.

And eventually it was my turn to help my father milk cows.

Hollar: OK. And how did you like that?

Zehr: Well, of course, as a kid, with older brothers you're like, oh. You just do what you're told. You learn by watching your elder siblings.

But farm life is on the one hand a lot of fun, because there's kind of a Huck Finn experience. When you want to walk down to the creek and play in the water, you walk down to the creek. But it's also very isolated, very quiet, almost lonely. Very isolated, very separate, and so kind of rough at times.

We had some hard times in the family. A tornado hit our farm when I was 8 years old and so it tore down all of our barns and kind of destroyed the family living. So that summer and fall spent kind of rebuilding the farm and everything.

So that was a good learning experience. And forced me to grow up a little bit faster than I may have had to otherwise. But it was fun if you're a little kid.

You don't realize kind of the economic, I'm sure, horrific implications of having everything destroyed like that. So I got to swing a hammer. I got to learn how to drive nails. I got to learn how to put shingles on roofs and repair things.

So that was a good precursor to long-term things to come.

Hollar: How old were you when that happened?

Zehr: That's a great question. I think that must've been in '61-- we could fact check that-- so it's 8

Hollar: Wow. What was the nearest town?

Zehr: The nearest town is a little town called Fisher, which was probably at that time 900 people, probably about 30 miles from Champaign-Urbana. So give you some perspective. Champaign's kind of the big city in the middle of Illinois.

Hollar: And talk a little bit about your education.

Zehr: Education, well of course I went to school there in Fisher Elementary, and high school. And then I went to a liberal arts school. There's a Mennonite liberal arts school in northern Indiana.

Went there for two years, seemed like a big school relative to my high school. My graduating class in high school was like 45 people or something like that. So I went to the liberal arts school for two years.

And then they didn't really have an engineering program, and I decided I really I wanted to pursue a degree in engineering. So followed in my older brother's footsteps and transferred to the University of Illinois to get both a bachelor's and a master's degree in electrical engineering.

Hollar: Was there an influential teacher along the way who maybe said engineering might be something you should think about?

Zehr: You know, I didn't have a teacher to talk about engineering, although I had a very influential teacher in high school who single-handedly taught algebra, physics, chemistry. And he had a way to communicate those abstract ideas that I could understand. So many times you work with teachers and there's just no chemistry, you don't quite get it.

But he had a way to teach things that I could understand. And so I kind of look back at him. His name was Richard Prentiss.

I look back at him and he was just so helpful in communicating those complex and abstract ideas. And I learned a lot from him. But it was all just learning.

From a social point of view, not much influence there. It was more the family. Like I said my oldest brother got a degree in electrical engineering also from the University of Illinois. And I watched him kind of go through that process, so I thought I'm pretty good at science and math.

I think I could probably get that degree. And I felt like even though there was kind of a downturn in engineering right about the time I graduated I felt like, well at least it's kind of hard. The classes are kind of hard and the concepts are kind of hard, so there's probably a job somewhere.

Even if it's just repairing televisions, I can probably do that. [LAUGHS]

Hollar: Was it natural for you to go to Illinois since he'd gone to Illinois and gotten that degree?

Zehr: It was. And it was close enough to the farm that I could avoid the expense of living on campus, so I could commute to school there. And so it was a commuter school.

Hollar: I've learned over time that often engineers like to tinker with things even as a kid. Were you a tinkerer?

Zehr: Oh, absolutely. Absolutely, and I would encourage young people to tinker with things. Two kind of large themes in my life growing up was technology and music, and so those still play a role today.

But tinkering, absolutely. If you're on the farm and something breaks down, you don't call a repair person. You fix it.

So everything from tractors to air compressors, and you learn to weld and you learn to hammer and you learn to build things. But I also had hobbies. We always have hobbies as kids, so model airplanes, model rockets, ham radio, those were all hobbies.

And so constantly building little airplanes and trying to fly them. Constantly building little rockets and launching them. I built a ham radio set.

There was a modification. You could buy Army surplus equipment at the time, so I bought an Army surplus piece of equipment and modified that for use in ham bands. And then got my novice license, so sending Morse code to other novice ham radio operators when I was in junior high.

That was a lot of fun. Kind of built a lot of things as kids, absolutely. Tinkering with everything.

Hollar: So you modified the radio yourself. That's a very cool story.

Zehr: Yeah, modified the radio myself. My older brother had pointed out in a ham radio magazine that there was a series of instructions on how to do that. So it was pretty straightforward to kind of follow those instructions, modify that radio, and fire it up and get it working.

It was my first interaction with the FCC, actually. They monitor for spurious emissions. And apparently my modifications weren't quite as perfect as they could have been, and I was reading a harmonic into a band that I shouldn't have been.

So they sent me a little postcard asking me to please modify my design to avoid that problem.

Hollar: Oh, really?

Zehr: Yep. So I had to ask my brother. I was like, oh, how do we do this? And he kind of went through and built a little low pass filter that would filter out the harmonics and put that in series with the signal. So it was like oh, OK, now I'm legal again.

Hollar: That's another incredible connection I found. So many engineers of our generation did something in the ham radio area or the wireless area.

Zehr: Wireless, ham radio, and what a great background for what was to come much later. So it was a long time between using that experience and what we're doing today with wireless, but the fundamentals are still true. The fundamentals of wavelength and radiation and how energy travels through space is still incredibly helpful.

Hollar: So how was life at the University of Illinois?

Zehr: The school at that time was really blossoming in a lot of areas. And I felt sort of overwhelmed as a farm kid, basically a farm kid coming into that environment. So many incredibly smart people and so many opportunities and things to learn.

So it was quite an experience trying to pick and choose areas that I was interested in. For example, one of the classes I took was very primitive, but they had, I think, a PDP-8 or maybe a PDP-10. And they taught a class on writing simulations for how a transistor would work.

And you could build up little circuits. And so they encouraged us in the area of physics to model these transistors using this newfangled thing called a computer. Of course, the big computer was the IBM/360, but you had to go over to a building with your box of cards and batch run your job there.

But the truly interesting thing to me that I really liked about the PDP-10 was that there was just a little teletype terminal that you could enter your program and print out your program right there. So I thought that was so much faster and so much more personal. I just loved that.

So we were constantly in the lab there. We'd take turns using the terminal. But it was a lot of fun to learn. And tons of other things going on, too.

Hollar: Did you get hooked on computing by doing that, as a pursuit?

Zehr: Absolutely. Yeah. Absolutely, just fascinated. The majority of the classes at the time, of course, were still in the analog world. But I just really enjoyed the feedback from the teletype, tell this mysterious machine to do something, it would do it.

And of course, being a science fiction fan, of course instantly fast forwarding to like, oh, I could take this, I could build a robot. It's like-- [LAUGHS] Somewhat naively, but still it captured my imagination, I guess this is the point. The point is it captured my imagination.

And the helpful thing it did for me, too, is to provide some focus, in some sense, for more complex classes. Information theory, why is information theory important? Why are all these classes in frequency domain, time domain, why are those so important?

Those are basic constructs that are still used today. How do you code information? How do you pass information across a channel? How do you deal with error correction/detection?

These are just great fundamentals that one little machine sort of got me hooked, and spun off a lot of context for why I should be studying these things.

Hollar: Were you doing music, as well?

Zehr: Absolutely. Absolutely. At the University of Illinois they had a strong program in electronic music. Of course they had a strong just musical instruments program, but of course I was drawn, fascinated by electronic music, what could be done. All the rock musicians were starting to take off and music was starting to get loud, for my generation.

And so I got involved with the electronic music classes at the University of Illinois. As often as possible I would take my electives in electronic music classes. They had some great classes.

Hollar: What were you working on, what sorts of instruments or devices?

Zehr: Well, I of course learned classical music as a kid, so anything that had a keyboard on it, I would try to bang away at it and play a few little things. Of course, my friends and I would put together little bands and play over the summer. But when I got into the electronic music classes, these guys were way out on the fringes and I was just trying to make sense of what they were doing.

One of the things that stuck in my memory was a professor there named Salvatore Martirano. He built this giant machine. He worked with engineering students and built this giant digital music machine called the SAL-MAR Construction, which is still a fascinating piece of machinery.

I understand somebody tried to revive that machine here recently. But it was the first use that I had seen of early microprocessors dedicated for use in music, and I just thought that was fascinating. It was an environment where there was just so much going on, you couldn't learn it all. It was amazing.

Hollar: Did you plan to stay on and get a graduate degree? Was that always part of your plan?

Zehr: No, it wasn't, really. I thought it was-- I wasn't even sure I was capable of getting a bachelor's degree when I started. Kind of lacking that self-confidence.

But as I sort of got towards the end of the bachelor's program, I did see some of my student friends who said they were going to try to go on and get a master's degree. So I thought I would challenge myself and give it a shot. So I talked to the school, and they said, yeah, we'll let you into the master's program.

So I thought I would go ahead and do that. And I was lucky enough to get a research assistantship at that time. And what I loved about that job was, it wasn't in the engineering school.

It was in the psychology department. They had a little craft shop, I'll call it, engineering shop, where they would build custom experiments for the research psychologists to use. So we would build gear that the research psychology researchers would use to test children.

This was at an institute where they were specifically learning about child development, how do children develop over time, what did they learn, how do they learn. And so we could build equipment that would test motor skills, cognition skills, whatever the psychologist wanted to test for.

So I really enjoyed it for two reasons. One is it was interdisciplinary, so I would get to sit down with psychologists and they'd say, well, I want to test how quickly and accurately children move at different ages. I want to test kids from four to 14 and I want to test it.

And then we'd talk about what kind of a machine could we build. What were my skills at building and what were the psychologists trying to test for? So there was this, what are you trying to build, what do I know how to build?

And I also loved the job because we had a full electrical shop, we had a paint shop, we had a sheet metal shop, and a woodworking shop. So I'd get to go and take my classes in the morning and then in the afternoon go to work and solder up little circuits and bend sheet metal and learn how to paint.

Hollar: So you were literally building your own testing equipment.

Zehr: Yeah.

Hollar: How did that work out?

Zehr: It was great. It was one of the-- for years, it was the best job I ever had. I just loved it, because it was so-- you're doing so many different things, electrical design, learning about how to bend sheet metal.

I had no idea how to bend sheet metal. Luckily there was a craftsman there who taught me how to bend sheet metal and someone to help me learn how to paint aluminum boxes or paint metal boxes and get it all working. Plus it was just--- working with kids is always fun.

They do crazy wacky things you never anticipate. You give them a pen and say move the pen from here to there, and heaven only knows what they'll do. [LAUGHS] So it was a blast. I loved that job.

Hollar: The first thing that you did out of Illinois was Magnavox?

Zehr: That's right.

Hollar: Talk a little bit about what it was like at that time to have had those experiences in engineering, and now you're thinking in a cross-disciplinary way. What were you looking for right out of school?

Zehr: Well, it's funny timing. I wanted a challenging job, but as a young person I didn't have a specific area that I wanted to work in, or knowledge of a particular industry or market share, market segment. But I sort of wanted to have placed reasonably close to home, because we had, like I said, we had a small, close-knit community there.

So I wanted something reasonably close to home, and applied several places. And Magnavox made me an offer. There was kind of a downturn.

This was in late '70s. There was kind of a downturn in the economy at the time. Inflation was a little bit starting to get out of control.

So opportunities were somewhat limited. And so I was lucky that Magnavox had a position for me. So I joined up. It was like a five hour drive from our farm, so it didn't seem too far away.

Hollar: And what were you doing?

Zehr: I was doing digital design. So the first project I worked on was a processor design. Magnavox, believe it or not, had their own instruction set.

They had worked with Ivan Flores, who was kind of the god of computer architecture at that time. They had designed these giant computers that were boards and boards are boards full of TTL logic. And there was this new integrated design technology called a bit slice, so we developed from a system this size to a system this size.

So I got to do hardware design on the bit slice machine, also microcode. So I probably spent the first two years on that job writing tons and tons of microcode, ultimately writing an extension for the instruction set to implement floating point. So sort of retroactively fitting floating point into an integer machine, using algorithms in microcode.

So it was sort of a fascinating technical challenge. Loved that. Also doing digital design in areas like DRAM. DRAM was just coming out. Previous to that, we were running programs out of magnetic core, so we had bought some DRAM parts and had to build a DRAM controller, which was a great learning experience. An old timer took me under his wing and kind of said, look, you're going to have issues on these parts, because they're notoriously finicky.

So he gave me the paper from Bell Labs that Hamming had written on error correction and detection. Luckily, I had a background at University of Illinois in code theory. So the Hamming codes were a very direct application of a very logical coding theory that I was familiar with.

So hardwired, hard-built memory subsystem that could tolerate single-bit failures and detect any double-bit failures.

Hollar: And what was the end product that these were going into?

Zehr: These were going into systems that Magnavox was building for tracking submarines. So they went into these P3s you'll see flying out of Moffett Field. They'll fly around.

Magnavox had a business dropping buoys in the water and a smaller business putting electronics into the airplanes. So the Navy had developed algorithms in FORTRAN to try to collate this information coming back from the sonobuoys. So my little computer was running those FORTRAN algorithms.

Hollar: That's amazing. What was the environment like just generally at the time?

Zehr: It was a fun environment, because the company was 99% engineers. In the group I happened to work with, there were a lot of really smart engineers working on-- they would view system design. And they were working on gnarly problems that were sort of randomly described by either an industrial application or a government application.

So these guys were working on array processing machines, SIMD array vector machines. And just bright guys. And so I had an opportunity to work, being the younger guy, kind of look up at some of these older veterans and see.

Learn the ropes a little bit. How to get things done and build these incredible machines that I thought was fascinating. I thought processing giant amounts of data was a fascinating problem. So it was fun.

Hollar: Was that the appeal of processing? Was that what made you start looking at opportunities in Silicon Valley?

Zehr: It was two things. Number one, I had been at Magnavox for a number of years and was actually getting sort of-- I don't want to say bored. It didn't seem so positive.

Government electronics didn't seem like a really positive thing to me, plus I had an Apple II that I just thought was fascinating. Fascinating machine, very personal. I loved digging down inside the Apple II to see how it worked, and I thought that was just amazing.

I was sick and tired of the cold winters. So a recruiter happened to call one time and so I talked to him about trying to find interesting work somewhere with better winters. And he said, well, I think California.

And I said, but Apple's already done the Apple II. Isn't that kind of done? What else could there possibly be? He said, well, I wouldn't write it off. I think they're still doing some interesting things at Sun and there are some start-ups. And so, again in kind of a naive move, I said, OK, I'll move to California.

Hollar: So you came to California. And you did a start up.

Hollar: Well, I worked-- when I first came to California, I worked at a company called Altos. They had done their IPO maybe six months before. They were still a tiny little company.

Then I did a couple of other companies, and eventually did a couple of start-ups. Really, at Altos, the job that brought me to California was really just to be senior engineer, doing design in what at the time we called super microcomputers. The group I was with, we would take a 68000-- or 68020 at the time-- and try to build multi-user systems.

You would hook up dumb terminals and run applications. It was sort of just, you could run maybe three terminals hooked up to one of these machines and run and automate maybe a doctor's office, something like that. We had a reasonable business in that area selling through a set of OEMs and VARS (Value Added Reseller) , multi-user UNIX systems.

My task was designing memory management for those products. So the first microprocessors didn't have the concept of virtual memory. So we sort of had to Band-Aid that on.

Then I worked closely with Motorola. We were a beta test site for Motorola as they developed the 68040. So I got a chance to build bridges with the design engineers at Motorola who were working on that, with the direction of these kind of UNIX-- what were the harder primitives that a UNIX processor would need to run UNIX. So I'd help them with that.

Hollar: Did you find the environment in California to be really different?

Zehr: Absolutely. Yeah. Much faster paced, much more commercial. You worried about quarter to quarter results. Programs had to be sort of done and shipping on time. The cost of the bill of materials was super important.

I didn't learn those skills when we were doing government work or industrial work. Sort of like the cost was what the cost was. But if you are in the commercial segment, then it's suddenly, if the guy down the street can support three terminals at half the price of my product, suddenly that became important.

Hollar: Was this your first real significant management role, too?

Zehr: My role at Altos was more technical lead, but I didn't manage anyone directly. So there'd be two or three engineers that I was sort of more senior than they were, so I'd kind of help, I'd take on kind of a leadership role for the architecture and help guide them with the design.

So it wasn't strictly a management role, more of a technical lead. Which is kind of a natural progression as you become more senior in engineering, hands on design and then maybe you would direct the efforts of several engineers, start to spend a little bit more time working cross functionally with the operations team or software team before you actually move up and do a full blown management role.

Hollar: After that, you went Apple. How did that happen?

Zehr: Well, the business at Altos suddenly stopped working. So lots of companies were happy to put a simple VT220 type terminal in somebody's office. But as the PCs became more and more powerful, suddenly a multi-user UNIX system just seemed clunky and old-fashioned. And Altos missed that transition.

So it became clear that the business was going nowhere. So business started to falter. I realized that I'd have to find something to do, as that started to happen.

So I realized that I really liked my Macintosh. I had a Macintosh and a PC. I really liked my Macintosh a whole lot more than my PC.

And I had these connections back at Motorola on the 68040 design team. So I asked that design team if they had any connections at Apple, they could hook me up with any hiring managers at Apple. And in fact, they did.

And so I had the opportunity to interview. And as luck would have it, Apple was in the process of finalizing their Macs based on the 68030 and wanting to put together a team to work on 68040 designs. So they were looking for someone and I happened to show up and I had experience, and luckily got a job.

So landed at Apple. That was in '88.

Hollar: 1988. You had a pretty broad portfolio within Apple. Could you walk through the arc of your career there?

Zehr: Sure. Well, I came in to head up the team to ship the first 68040, so a team that could work separately from the Apple team and work separately from the teams that were finishing 68030 designs. So that was my first-- that was to manage a team. And it turned out at Apple-- I didn't realize until I got there.

But it turns out at Apple that means welcome aboard. You should go find some people who want to work on your project. So kind of had to learn that cultural shift.

Then just start meeting people and saying, hey, look, this is what we're trying to do. We want to ship this new, kind of higher end, higher range Mac. What do you think?

And it sort of resonated with a lot of engineers, because they were banging away on their Sun workstations but just wishing and hoping that Apple could do a product to replace that Sun workstation with an equally powerful Mac. So built that group and shipped a line of products starting with a large system, a tower. It was the first tower Apple had done.

Lots of memory expansion, the ability to have multiple hard drives. They had not done that before. And then just took that team and we just shrunk that architecture, eventually shipping it in a small little pizza box.

So that was a great opportunity for me to build a team, great opportunity to learn about Apple's culture, about industrial design. And it's one thing to sort of ship a computer that goes into a P3 airplane, but it's another thing to ship a PC that people use and they send-- at the time, it was letters-- that they love this product or they hate the product, but they're passionate about the product. Because it's personal. It's their system.

And so got an opportunity to experience that. And then take on the broader responsibilities, eventually running the ASIC development team, including the development of desktop Macintoshes, and then an

opportunity to run the PowerBook team. So for my last two years I had the opportunity to take on broader role running all of the PowerBook development.

Hollar: And was that creating the PowerBook from scratch?

Zehr: No, the first PowerBooks were already shipping at that time. But they were looking for someone to-- there had been some attrition and some changes in that area, and they were looking for a new leader. And so they offered me the opportunity.

So I took it.

Hollar: What was the biggest challenge with the further development of the PowerBook? Because that was pretty early in the whole life cycle of portables.

Zehr: Yeah, absolutely. Well, the biggest challenge started right away, when I landed. You may remember at Apple at the time, there was a sabbatical. You could work five years and then you could take a few months off. So I just taken my sabbatical and come back. And they said, hey, we got this new opportunity in PowerBooks. Would you like to take it?

So I said, sure. So I land in the job there. And I hadn't been paying any attention, but apparently Apple had been experiencing some trouble with one of their new models. They just launched a model, I think they called it the 5300. And they had experienced what was a new phenomenon, which was the use of lithium ion batteries. And they had a couple of batteries that had caught on fire.

And this was kind of a new phenomenon. It hadn't occurred to me such a thing was even possible. Coming from the desktop world, I'd never heard of such a thing. So I landed in that. And that was the case. They had just launched this product, and it was having problems. So it was quite a test and quite a challenge. 5300 eventually wound up developing additional problems with reliability. Plastics were failing in the field.

Eventually, long term, we had to recall that product. So that was a sobering day. I remember the product was in the field getting all kinds of reports of issues, and getting a call from the editor of one of the Macintosh magazines, saying, hey, I'm going to write a review for the 5300. It's the worst review I've ever written in my entire life. I just want you to know. [LAUGHS]

Hollar: What went through your mind?

Zehr: Why did I take this job? That was the first thing that went through my mind. And also, I was like, there are important questions you should ask before you take a new job.

Hollar: Was it known within Apple that the issues rose to this level?

Zehr: No. We had heard reports, but they were hard to straighten out and anecdotal. There wasn't a lot of accurate information. But seriously, when someone calls you with that, an editor of magazine that's going to go out, about all I could think to say was, hey, well, look, if work to fix the problems, would you review the fixes for the product? He said, absolutely.

So set up a team, put together kind of a tag team to say, OK, we've got to fix this. It's a mess. So started just methodically working with the engineering teams, working with the manufacturing teams, working with the legal teams, to work through how do we get this product straightened out.

And so kind of quarantined that team, a get well plan for the current product, but also how do we start to influence the replacement products? Because there's always a pipeline of products that you're working on. And we of course had products in the pipeline and clearly didn't want to re-ship those problems.

So we had to get to root cause for hardware issues. Why were the plastics failing, why were the batteries exploding, and why was the software unstable? So we had to work through all those. And that was just a grind.

Hollar: That was everything. That is software, that was hardware, that was the OS.

Zehr: Yep. It was a grind to work through all those problems. Eventually, we released the more stable version of the software, got that going. That seemed to take care of most of the problems.

Like I said, eventually we had to recall the product because of the problems with the plastics. So it was with a lot of trepidation that we launched the new products, then, the year after that. And I remember talking with that same editor later, and he's like, well, the new products aren't the sexiest products, but they're like the Volvo. I can't break them. They're rock solid. They're stable. And I thought, OK, Volvo I'll take.

Hollar: What was the environment like within Apple as you were working through all these issues?

Zehr: Well, you know, I was there for nine years, and so the environment changed quite a bit during those nine years. When I first came, it was just months after Steve had left. I happened to pick the time period when Steve was never there as actually CEO.

It was an odd, peculiar time. When I first got there, though, he had just left, and so there was still a lot of momentum for things that he had worked on and had been driving. And, you know, John Sculley was the CEO.

And a very upbeat guy. And I thought he was fun to work with, so I thought he was a good guy. Industrial design of course was important, so that industrial design mystique was something that I wanted to learn about. So got to know the industrial design team.

Hollar: So you got some direct exposure to that team?

Zehr: Absolutely. Yeah, I had a great opportunity. The first product I worked on was a new tower form factor. We had never done that before.

Hollar: I remember that. It was very exciting when that came out.

Zehr: Yeah, so we developed that, and we had to figure out. So I had to work with industrial design on what should it look like? How do you take something that's kind of big and make it nice?

And at the same time, how do you manufacture such a thing? Because Apple wasn't an environment where we're just going to bend some sheet metal and ship that. So it had to look nice and beautiful.

And how do you build those nice, beautiful curves and those walls so they're reliable? So that was a great learning. So that environment seemed very positive, is still Steve-like.

It was edgy. Inside the engineering teams, the hardware engineering teams, it was a lot of sharp elbows, a lot of pride, I want to be the team to ship the next Mac. I want to get my name associated with shipping a Mac.

Hollar: Sorry, let me turn this off. [PHONE RINGS] I thought I had. That'll give you a chance to take a drink of water, too.

Zehr: Then, like I say, my early years at Apple I thought were very exciting and it was fun to watch the company overall, because no one was sure. Could keep you keep producing Mac forever? We had just sort of finished up Apple II and Mac was kind of the replacement.

And there was some part of the company that felt like there were other things that would replace Mac, so that's when the Newton team spun up. And there were several other teams working on things that were not Mac, but sort of supposed to be the next thing. But I kind of had a sense that Mac was still kind of the heartbeat of the company, and I wanted to work close to that most important product. Plus I just loved the product. I thought it was great. It was fun to work on it.

But as years went by and as the company kind of changed, the company fell on some hard times. As the company kind of changed, towards the end it got to be pretty chaotic. A lot of churn at CEO level, a lot of churn down below that. And not a lot of strong technical direction. It was a lot of I think this, I think that. And to be honest, it was really struggling.

So when they made a decision to-- they were looking at how to get the next generation of operating system. They looked at Be operating system and looked at the NeXT operating system and wound up choosing NeXT. And so it was sort of the triumphant return of the founder.

So that was super exciting to hear about, but sort of chaotic if you were inside. I was vice president of one of the major products and came in to work one day, and like everybody above my level had been let go. The executives from NeXT sort of came in and took those roles, really streamlining the org chart, really providing focus for the group, which I actually thought was a good move.

Painful, painful to watch-- a lot of good people got let go-- but it was for the better. And Steve was in the parking lot, but still kind of in a consulting role. About that time I decided to leave and try my hand at a start-up. Less than six months later, Steve was back and Gil was gone.

Hollar: What did you take away from Apple, from that experience?

Zehr: Oh, I just learned so many things. Learned so many things. And I can't even list them all.

The obvious one are the importance of industrial design. That's just a great learning and at least dipping my toe in the water of what's the vocabulary for industrial design. Why is industrial design so important?

So I learned a lot there. But more important in my trade is engineering and development of hardware, is what happens in high volume production. So I had the opportunity to spend a lot of time at various Apple factories.

We had factories in Ireland as well as in China, so you could imagine going to China in 1989, 1990. It wasn't like today where you just show up and walk in. It was drama just getting into the country.

But what a great learning experience. What a great opportunity to learn about high volume production. So the ins and outs and just the discipline of getting a design so it's ready for high volume production was a great learning.

And, of course, how do you manage a team super creative, super brilliant engineers that sort of want to be managed, but maybe sort of don't want to be managed.

Hollar: How big was your team?

Zehr: Well, when I started out, it was really only about five people. But as you sort of demonstrated capability, other engineers as their projects wound down sort of said, well, what other projects are interesting. So I started to attract people to my team.

So when we launched the first towers, when we launched the first 68040 products, we were probably up to 20, 25 people. Then when I left, by the time the PowerBook position got going and got working, we were up to 180 people.

Hollar: How did you feel managing a team that large at that point?

Zehr: I thought there must have made some sort of mistake, because it was like how could I possibly have those skills. But I kept reminding myself that I really always wanted a manager who understood technology. And so I tried to think of the role models I'd had earlier in my career that were strong managers that I appreciated.

And what could I learn from them, what could I emulate from them. That was the biggest test for that position, because like I say, above me my managers were constantly changing. So I sort of had to take on an independent role a little bit.

Hollar: Then you leave Apple and you do the start-up at VA Linux.

Zehr: I left the start-up off there. I did a start-up called Ridge Technologies that lasted about nine months, so I don't even bother putting that on my resume. We had the vision to do RAID storage solutions for NT servers.

We thought Windows NT would give Sun workstations a run for their money. But the CEO got cold feet and sold the thing off. Like I say, we didn't even last nine months.

And so that was a failed start-up, but at the same time I learned that I really liked a start-up. I really like building small teams, scrappy teams.

Hollar: This was the era of the hot start-ups, wasn't it. This was the late '90s.

Zehr: In retrospect, although at the time it seemed confusing and chaotic. But it was, in retrospect, a real time for start-ups. Companies, they were going crazy. Companies like Brocade. They just launched and they were just going gangbusters, as were a number of others, in new areas that I hadn't heard-- even familiar with those technologies. So it was great. Those were great models to say, well, I'd like to do something like that. So I knew that I liked start-up. And bumped into the guys doing VA Linux.

So VA Linux was a Linux company, kind of self-funded. Shipping a little bit. They had kind of a business that was sort of working and not working. But they start to attract interest from venture capitalists and Intel. So they were finishing a round to take some money and try to grow that business. So I had the opportunity to go and meet with them.

And I was fascinated by two things that really caught my attention there. The first was, they had-- it was funky, but they had a 2U server that they could-- with some poor engineering-- but they had proof of concept that you could cram two Pentium processors into a 2U server. And I thought there was opportunity in small servers, especially serving up-- people were just starting to serve up web pages in serious high volume.

And I thought, well, web pages would be perfect for very small servers. You could do a network of very small servers and serve up a lot of web pages. And it would distribute nicely across these machines.

And so I thought that was fascinating. And then the other thing that I thought was fascinating was open source, just the idea that you could have an operating system that was sort of available to anyone. I thought that was fascinating, because it was such a pain to try to have a hardware company.

And still, how do I have a hardware company and work with Windows? I can't change Windows. How do I have a hardware company and work with Mac OS? I can't really change it. There were a few companies trying to sell operating systems, but nothing as dramatic as open source. And because I had that experience with UNIX years and years earlier, there was still kind of a warm spot my heart for UNIX.

The ability, just the idea that multi-threaded operating system, multitasking operating system, was pretty straightforward to hook up multiple terminals to UNIX. I just thought it was fascinating. So I loved the idea of convolving those two things, open source and physically small servers built on the Intel platform.

I just thought it was a kind of an industry standard. Felt like a very safe and a cool opportunity. And it turned out it was a cool opportunity.

Hollar: Was there mass take up of LINUX at that time already?

Zehr: I had never heard of it, but it was in the trenches of developers. If you looked at the younger developers, the young kids coming up through school, it was sort of like the do it yourself. I don't remember, but there was a book written by a guy, called MINIX, which was a little operating system.

You could just buy this book. It sort of had the source code for a really small, lightweight version of UNIX. And so that MINIX book created a lot of interest among what I would call hobbyists or developers that would have a day job, but then come home at night and build little machines on their own.

And so that evolved and developed. And I think Linus did a great job of pulling together a group and saying, well let's take this, but let's build on it and make it better and better and better. And that was happening and I didn't know it. So when I talked to the people at VA Linux, I thought it was fascinating. So I wanted to learn more about it, and so I had the opportunity.

Hollar: Did it simplify your life as a head of engineering to be able to focus mostly on the hardware and kind of have this operating system being developed in parallel?

[INTERPOSING VOICES]

Hollar: I can see it working both ways.

Zehr: There was an element of both ways about it. There was an element of both ways about it.

Hollar: Especially at that point, with Linux being so new.

Zehr: It was so new and our concept was we would have these small servers and pre-load Linux and ship it. So it was sort of copying Sun a little bit. Sun was shipping their servers.

And it was also a little bit of the model of Dell, where you could call up and say, well I want two processors, this much memory, this hard drive. Could you build that for me? Sort of configure to order.

So we sort of from a commercial point of combining those two things. What became obvious-- sounds obvious now, but became obvious-- was it's super important to version stabilize Linux, because you could snapshot the Linux sort of code tree any day of the week and get a slightly different version of Linux. So we had engineering teams that sort of would look at that code, do some analysis, and do some testing to find out which packages could we combine to be stable enough to ship to a commercial customer.

So that was one half of the organization, was doing the hardware, the version stabilization. The other half of the engineering organization was just to hire as many Linux developers as we could find. So we had a lot of Linux developers who were just young kids.

But a lot of them never had a job before. Like, oh, yahoo, I got a job. Sit and work on Linux all day, so they loved that. So there was kind of those two groups inside the engineering group.

Hollar: Interesting to manage.

Zehr: It was a challenge to manage.

Hollar: And that must've been a really intense three-year period, then, wasn't it?

Zehr: It was.

Hollar: Birth, growth, this was a classic to the right era.

Zehr: Classic up and to the right era, followed by the internet bubble burst. Our goal was to get our servers on every web buildout, every internet web buildout that was going on. So Toys.com, Pets.com, all these companies were great customers. And we were building that architecture out. And we'd get calls. We were amazed. We'd get calls, we want to buy 200 servers. So it was just classic. But of course, they were all venture funded, and when the internet bubble burst, as near as I could tell it was just a code word

for venture didn't want to put any more money into content or internet sites anymore. So huge percentage of our customer base just went away overnight. It was a classic start-up rocket ride to the top and then crash to the ground.

Hollar: And what did you do at that point?

Zehr: Well, I went home and started riding my bike. [LAUGHS] Luckily, I'd gone through the IPO, and so I had little cushion and could take a little time off and kind of get some perspective. So that's what I did. Got on my bike. Got out. Started to think things through, what I want to do from here.

As luck would have it, things are changing at Palm, also. So I got a call from Palm. They were looking to kind of re-craft their engineering team. A friend of mine had just taken the position to run all of engineering. And he called up saying, hey, I know you're out riding your bike. Why don't you come over here and help me for a while.

So I went over and talked with them, and it kind of looked like fun. I told them, look, I want to do another start-up as soon as I can, but I'll come and help you for six months. And help you get this thing going and hire my replacement. But as luck had it, as things worked out, I was having fun. I never got around to finding my replacement or leaving. So I wound up staying there for two, almost three years.

Hollar: What was happening in the Palm product cycle and life cycle as a company at that point?

Zehr: Well, they were shipping, they had just shipped the first kind of Palm. I think it was called Palm V, which is pretty cool. It had a really cool industrial design, very slim, very trim. But they were sort of trying to figure out what next. And there was a fair amount of upheaval. The founders had gone off to do Handspring. And there was a lot of-- the company couldn't quite figure out, do we monetize internet traffic? Do we do we proxy internet serving? How do we deal with the internet things? The original Palms were very nice little standalone device. You hook it up your PC and move information back and forth.

Hollar: Not designed to be mobile.

Zehr: No, not designed to be mobile, but designed to be very small, very lightweight, long battery life. So these two things, the internet and the Palm PDA, were kind of crashing together. And when I got there they really hadn't figured out how to resolve that.

They were the process of replacing all their management. Tom Bradley had just come in to be the CEO, and like I said, Steve Manser had come in to take engineering. And Handspring guys were gone.

So they were just trying to figure all that out. I thought there were some good ideas. They had teams working on mobile.

We had a wireless team in Chicago and a wireless team in Seattle. I thought wireless could be something. The technology of the basic Palm wasn't all that complicated, so I spent a lot of time getting to know about wireless and handsets and--

Hollar: Was is your first exposure to wireless as an element of engineering?

Zehr: It was, yeah. It was a great learning. All the way back to ham radio days, it's like, OK, here's the antenna chambers. OK, how do they work? So I had some of the vocabulary but none of the industry insider information. So I had great leaders in Chicago and Seattle who helped train me on how shipping a wireless handset worked.

Hollar: And then strategically, how clear was is it that mobile connectivity was really going to be very important?

Zehr: I think it kind of depended on who you asked So the core DNA of the company, there was not much of a concept of wireless. So the old timers, the people who had been there for a long time, were sort of like, I don't know.

Maybe we should be driving costs out and make a Palm device available to a lot of people. Maybe that's more important. Because adding WAN and voice, it's expensive. The device is expensive. We don't really know how to sell it. At the time there wasn't much digital, wasn't clear how you would move digital information around. So I think it was kind of an awkward, it was definitely an awkward time. On the one hand, we developed a $99 Palm device that was kind of a breakthrough. And that little device sold like crazy. And part of my team also developed a super nice, higher resolution, larger screen Tungsten line. So that device did fine. But we had done enough work to sort of craft on Bluetooth.

So that turned out to be a lot more work than you would expect, because the operating system didn't really have a COM stack. So it was really complicated to craft how do you graft on a wireless stack onto an operating system that's really all about go to sleep as often as possible, reduce battery life as much as possible.

Later, on top of that, the fact that they had split the company into a hardware company a software company, so I could write the firmware to boot the system and I could write the little drivers for Bluetooth, but I didn't have access to the core operating system. That was owned by a different company.

Hollar: Why was that done? I'd forgotten about that, actually, until you mentioned it.

Zehr: I don't know why it was done. I think part of the reason it was done was to try to get the operating system onto more companies shipping hardware based on the Palm OS. I think the Palm Source team really wanted to get their operating system running on as many different devices as possible and felt like they were sort of captive to the Palm hardware team. So I think I think that's probably why it was done. But that happened before I got there.

Hollar: Well, I was a Palm addict. I had practically every Palm ever made. I think the Tungsten was my last Palm.

And it was about this time-- it was the early 2000s that you're talking about-- that I made the switch to a BlackBerry, because I just had to have all those features. And it broke my heart to do that. In fact, I think I still have a shrink-wrapped last version of a Palm in my house somewhere, because I had just bought it and then it was clear I had to do something else.

Zehr: Yep. We did launch some handsets with the Palm brand, but they didn't achieve any commercial success, really. And we were really missing fundamentals, like we didn't have a really strong email solution, which is totally missing the boat. I was personally really interested in media, so we had built a prototype.

Just before I left, we demonstrated a prototype that could stream movies across Wi-Fi or capture movies onto an SD card. We had built a little box, kind of a set-top box, that would record television shows onto an SD card, so if you were getting ready to jump on the plane, the idea was you'd pop out your SD card and you could watch a television show.

Hollar: That was all software solution, that--

Zehr: That was all software solution. The founders had returned to Palm when Palm acquired Handspring. And we demoed that watching video on a little screen.

There was no interest in that.

Hollar: No interest. So even though you didn't have access to the OS, you were still developing a lot of futuristic, cool software.

Zehr: Absolutely.

Hollar: And was this a search for a transition model, the sort of larger vision of a product that was going to be more contemporary?

Zehr: Well, it felt to me and to other people on the hardware team that we had to. It felt like the four-function PDA was struggling to find out what's next, and so we had written a little music player so you could listen to MP3s. And it seemed like video was the next logical media type that people would like to have a richer environment on their little device. So we prototyped that. We had a good-- it was a small software team, but a very ambitious software team. We had prototyped, like I say, streaming across Wi-Fi.

We had built the Wi-Fi into these little prototypes. Like I say, the returning founders had no interest in the media. They were, of course, all about handsets. And they were right, in that handsets were super important. BlackBerry was taking that model and running away with it, and we were behind.

Hollar: So here you are. You're thinking about all this, the media, the portability, this sort of next function device. Were you restless at that point? Is that what led you eventually to the thing I really want to talk about, which is the development of the Kindle?

Zehr: Absolutely. When they put the two groups together and I realized there was just no interest in media, no interest in a richer environment on that little small device, plus my friend who was running the engineering group had left and there were lots of changes in the company. So I just I just left at that point. And blew the dust off my bicycle and started riding again as kind of a form of mental therapy.

Hollar: At what point, by the way, did you and Jon Rubinstein meet?

Zehr: Oh. Well, that was--

Hollar: We skipped over that.

Zehr: Yeah, we skipped over that. Yeah, no problem. Yeah, no.

When I was at Apple, the last year I was at Apple they did the NeXT acquisition. They said, OK, we're going to buy NeXT. And as I said, I came into work one day and they had decided to kind of scrape off all the executives kind of just right above my layer of the organization, and kind of said, OK, here's a new boss, Jon Rubinstein.

So Jon had been running hardware development at NeXT and came in and took over hardware development at Apple. So I worked for Jon for that last year.

Hollar: Ah. And you guys developed a really good collaborative relationship.

Zehr: He was a great guy, crazy smart, and also knew how to work with Steve really well. None of us had any experience. None of us even knew Steve. I'd never met Steve, to be really clear about that. But Jon would push us in the areas where we pushing made sense. There's a little bit of a clutching action, because he had come up through the ranks of the smaller companies and NeXT, and here was Apple, where it's this great big giant company.

So there were times when it was like he wanted to do things a certain way and I would just be like, well, Jon, I don't know. It was like tons and tons of-- it's big huge company back here. It's a big giant army. So we can't just like turn everything upside down on one day. He and I developed a relationship where he'd kind of like, OK, Jon, you want to do this, but I think I can get this done. What you think about that? Well, could you do this. And we sort of worked through that relationship. Plus, like I say, we had launched the replacement PowerBooks that were seen as sturdy and they weren't failing in the field. We were past that.

And there were kind of other, bigger problems at Apple. Jon said, look, it seems like your space is doing fine. Why don't you just keep that. I've got to spend a lot more time over in these other areas. He spent a lot more time there. We'd get together once a week and see how things are going. Yeah, he's a good guy.

Hollar: Let's go back to you. Here you are, you're on your bike. You've left Palm, you go back to your bike. Things are changing. What happens then?

Zehr: Yeah, trying to think about what to do next and what's possible. You know, the valley's small enough that people start saying, hey, there's somebody looking for something to do. It turns out that unbeknownst to me, Jeff at Amazon, Jeff Bezos at Amazon, was thinking about digital media.

And you have to realize at the time, physical goods probably accounted for-- well, if you take books, CDs, and DVDs, just those three categories-- that was probably 70% of Amazon's revenue right there. Jeff's a smart enough guy to look at just those three things and kind of go, those could be digital downloads any day now. And if we're not part of that transformation, somebody will.

And I'd rather transform my own company and turn my own business upside down than have somebody else turn it upside down. So he reached down into his management group, selected a lieutenant, and said, I want you to come over here and get us into the digital business. So they got started.

Hollar: And was the digital business defined at that point?

Zehr: The thinking was books, movies, and music-- or video and music. So those were the three areas that they knew on the one hand were incredibly important to the business, the physical, and they knew were ripe for being converted to digital. It was just clear.

You could do a digital download on any of those. Apple was starting to make some headway on MP3. The iTunes store was starting to make some headway.

So Jeff could see, uh oh, CDs could eventually become a download. And he thought more broadly and said, well, we've got to consider video and books, also. So they started that process. They realized on some of these they would probably have to start a hardware business.

Hollar: Who was the person he tapped?

Zehr: That was Steve Kessel. Steve Kessel. I think he had been running the mainstream books business in the United States at that time, which was obviously the single biggest business at Amazon. He came over and they realized they would probably have to get into the hardware business.

So they had to figure out how to do that.

Hollar: Now, that's an interesting leap to be in the core business that Amazon is in and then decide, wow, we're going to have to have a device.

Zehr: Yeah. That was a smart move, in retrospect, especially at a company who was already selling hardware. You could buy almost any gadget you wanted. So I thought that was kind of good thinking.

Hollar: Was that how it was presented to you the first time you had a conversation with them?

Zehr: Yeah. Yeah, they had already thought through that, especially in the area of books-- there were already MP3 players on the market, and there were already at least set-top boxes or VHS systems on the market. But they really weren't any devices optimized for reading. And so that was the area where Jeff, I think, had kind of realized we're kind of exposed.

We will probably need to get into the hardware business if we're going to do that. Knowing Jeff now for almost 10 years, I think he's a big thinker, not afraid of really hard problems.

Hollar: Right. And how did he find you?

Zehr: Well, that's a fun question. I don't know the whole story, but I know they had interviewed a number of people. I know that they realized industrial design was important.

They really respected the great industrial design and the way that it resonated with customers, sort of that passion around industrial design. So Steve came down to the Silicon Valley and talked to a number of industrial design firms. Lucky for me, he also talked to the guy who ran industrial design for Palm, because they liked the little Palm devices, too.

The Zire was a very beautiful little device. And so they talked to Rich, who was running the industrial design group at Palm, and said, hey, I've got this idea. What do you think? And Rich was like, well, I think it's a great idea, but I'm an industrial designer.

I'm not an engineer. I do industrial design, great models. I can help you understand customers, but I'm not an engineer.

So Steve asked, do you know anybody in engineering? And he kind of said, well, there's this one guy who just left. Because Rich and I got along well.

So Rich Gioscia gave my name to Steve during that meeting. And so Steve had a recruiter give me a call. So that's how we got started.

That's how I got introduced.

Hollar: The introduction was made through your friend Rich at Palm, and then what was the next step?

Zehr: Yeah, so a recruiter called me. Kind of said, hey, Amazon's looking for someone to get this business going, would like to talk to you. Would that be OK?

So kind of went through kind of the initial ideas with the recruiter, but then Steve called me. And I had several conversations with Steve about that what Amazon was trying to do, the general outline for what they were trying to do. I remember when he was first talking to me I remember thinking, like, oh, please not a digital book, please not a digital book.

Because in my mind, the digital book had been tried. Several little start-ups had tried it a few years earlier. And when he said, yeah, we're thinking like maybe figured out how to do digital text. And I was like, oof. That could be hard.

Hollar: That didn't appeal to you.

Zehr: It felt like it had been done and failed. So we had a series of conversations. Eventually he said, why don't you to come up to Seattle and meet Jeff.

Well, let's back up a little bit. Why don't you come up to Seattle and meet some other people. So I came up to Seattle. And Amazon, of course, has a very thorough interviewing process. So a chance to meet several other senior executives in the company and then, since that seemed to go well, a second trip up then to meet Jeff. He's very hands-on in the project and wanted to meet whoever they were going to hire.

So I had the opportunity to meet Jeff. And somewhere along the line, it occurred to me that it was a great opportunity. And here was kind of my thinking. My original thinking was that it was a kind of a failed idea, but the more I thought about it, the more I liked it. I always tell people it's kind of an upside down start-up. Classic Silicon Valley start-up, two people in a garage, they've got some cool little gadget, but they don't have a brand. No one's ever heard of them. They don't have a channel. They have no idea how to sell it. And they don't have any content. It's like, well what do you do with this thing? And it occurred to me during the conversations with Amazon is that Amazon is a brand everyone trusts. We all have our credit cards on Amazon. It is a channel. They sell stuff. And they have access to content, publishers. It's an important channel for publishers. So they had access to content. But they didn't have a gadget. So I thought, well, I know how to do a gadget, so great. Let's get going. So I thought it was an opportunity to really slingshot ahead. Palm had failed because I showed them the streaming media and they said, no, we're not interested in that. But here was a company that said, that's exactly what we want. We want content on a device. We have the content. We have the business relationship. We know how to sell it. We just don't know how to invent it. I'm your guy. I know how to invent stuff. So that made a lot of sense to me, then.

Hollar: And did you feel, too, that they had the will to invent a device-- a really hard thing to do-- and to see it all the way through?

Zehr: That was one of the first questions I asked Jeff. I said, why on earth would Amazon want to get into the hardware business? It's razor thin margins.

It's a tough business. To get your first product out the door, it might cost 50 million bucks. It might be a flop. You never know with hardware. And he convinced me that he was determined, patient. He knows hard problems take a while.

But most important, that the strategy was right. That people would want to buy digital media from Amazon. We have to work on that strategy. If that means we have to be in the hardware business, so be it. We'll do that. So we talked about that a lot. And he said, well, eventually in talking with Steve, it was like, well, we'd love to have you come and head up this program. And I said, well, I'd love to. I just don't want to move to Seattle. And he said, that's no problem. Why don't you stay down in the Bay Area? It's probably more hardware talent, more hardware experience down in the Bay Area anyway. And so we decided to set up a group here in California, Silicon Valley.

Hollar: What was the genesis of the name, Lab 126?

Zehr: Yeah, great. So the group had incorporated with a name something like A to Z Development, California, Incorporated. And had sort of gotten going that way. But I was trying to imagine business cards or t-shirts or try to attract talent from other companies with a name like that, A to Z Development, California, Incorporated. That's a terrible name. So I had some people help me and just said, look, we need to pick new names. And so worked with some people at Amazon in their group who works on brand.

And so we just started working through list of names. There is there still is a sort of corporate culture around the phrase A to Z. If you look at the logo, the little arrow goes from A to A in the word Amazon. And the online guarantee is A to Z guarantee. So that idea of A to Z is in the culture. So we talked about would we include A to Z in the name.

I told the naming consultant I really would like to get a name that was some combination of a skateboard shop and X-Files. Just something that young engineers, creative engineers would think was like, this is kind of cool. So played with a bunch of ideas and somehow I landed on the idea of lab, like area 51 or lab, something like that. And then 126 is just one for A and 26 for Z, so 126.

Hollar: Oh, that's great. So you've got a marketing gene in you, as well.

Zehr: I did want to find a name that if Amazon wanted to, could use as a brand ingredient. And what I mean by that is, when you go to buy a new stereo, if it says it has Dolby, you sort of go, like, yeah, I want Dolby. The reality is I don't have any idea what Dolby means.

But if there's two side by side and one has Dolby and one doesn't, I want the one with Dolby. So I wanted to pick some kind of a brand, also, that if Amazon would want to they could use as a brand ingredient. So that was just all the different things that were going through my mind. But the main thing was a recruiting aspect to it. I knew we'd have to grow. I knew we'd have to add talent.

We'd have to convince people to leave jobs that were maybe with more well-known brands. And at the time, when we were starting Lab 126, we didn't want to advertise the fact that it was Amazon. So I couldn't say, hey, why don't you come on over. Amazon is starting this new initiative in Silicon Valley. Really, it was like, look. We're funded to go and start. We're doing this start-up. We're funded. We have this concept for a new product. We're very secretive about what it is, but it's great. I'd like you to meet some of the people. Why don't you come on board.

Hollar: So you had to be stealth just like any start-up had to be stealth.

Zehr: Just like any start-up had to be stealth. So I wanted a nice brand that people would say, well, at least these guys thought about the brand. So that was kind of the little logo. And if you check out our website, it's always been all about the creativity of the environment. It's a great place to come and work.

Hollar: So what are the first things you had to set out to do to begin architecting the Kindle?

Zehr: Yeah, well, first things we had to work through was what business did we want to go after? So we talked about music, video, and text, and kind of figure out which one would we want to go after. So we had a lot of conversations about those three areas, what would make the most sense to go and focus on first.

We had hired a few people from ReplayTV, and of course they were passionate about video and watching video. The largest business, though, was text. And my background with PowerBooks and with Palm, I had seen early prototypes of electronic paper displays.

And I just somehow felt like if we could combine sort of the battery life of a Palm, use some of this new technology around electronic paper displays, and with the reputation for Amazon around books, it would be a very natural thing in the consumer's mind to say, sure, Amazon, books. Yeah, I'll buy books from Amazon. I thought the other areas would be a little harder, music or video.

And so anyway, during those conversations we talked about all that it. And it wasn't just me, it was a group of people. But eventually agreed that why don't we get started with a reader device.

And so we started architecting that. All the hardware architecture you'd expect around what kind of a processor, what kind of memory requirements. We started to explore are these electronic paper displays real, so we went and talked to the various vendors that were making them.

And what we soon discovered was they were all R&D. Nothing was shipping in any kind of volume. But it seemed like the brand E Ink was ahead of other people. They were sort of a spin-out from Phillips. And they seemed to have a leg up. They were start-up out of-- a spin-out of MIT. I should be very careful. A spin-out from MIT, but they Phillips had made some investments and gotten the technology pretty far along. So it was almost ready for volume manufacturing.

The other displays we had looked at were still very much R&D one-off products.

Hollar: So E Ink was far along, but not yet commercial.

Zehr: That's right. They had launched one product in Japan. Sony had launched a reader product in Japan, the Librie.

But that wasn't a very high volume product. There was a proof point that Phillips could manufacture it, at least in some kind of volume, which was ahead of the other guys. So sort of latched onto that. Did a sanity check. Could you guys support us on this? Trust us, we've got access to content. [LAUGHS]

Can't tell you who, can't tell you how, but we have access to content. And got going.

Hollar: It's interesting that the decision was to build a reader with E Ink, which was an as yet somewhat unproven-- or maybe you'll tell me it wasn't-- but somewhat unproven technology, when music and media would've have been at that point, wouldn't it? That was another big leap. First, to start with hardware. Second, to go in a direction that had to be proven.

Zehr: Yeah, it's a good point. And there was competition. There were already MP3 players in the marketplace, so it felt like a natural to go and work on music.

But it just seemed to me-- and everyone else agreed-- that really, the opportunity with the Amazon brand, the first thing people think about was books. And they looked to me like, can you really ship this thing? It's like, well, I think so.

We did look at other displays. But of course, TFT displays, they're just so power hungry. And that requires a bigger battery, and pretty soon the experience is just not that great. So we decided to roll the dice. We did do an analysis. People do talk about other readers that were there.

Rocketbook was an early attempt. Great idea, probably just too soon. But it was LCD-based, with backlight, with large batteries, with ethernet. And they didn't have any content. It's classic start-up. They didn't have access to very much content.

And people would ask us, what are you going to do different for the Lab 126 reader? It was like, well, we're going to start with a better display. We're going to include wireless.

We're going to do some things that are different. And we're going to hook up with a giant company that has tons of content. That was the most important thing, hook up to a company that has tons of content.

Hollar: Was wireless baked into this from the very beginning?

Zehr: No, it was not, at least not in my mind. In my mind, I was more than happy to sort of fast follow MP3 players, where the shopping experience is on your PC. You just hook up a cable to your device, download the content, and you're off to the races.

I had been thinking that way because it's low power and low cost. But I still remember a series of meetings with Jeff, kind of reviewing the progress and some of the prototypes we had built, or we were thinking about building.

We hadn't built anything yet. One of the meetings, he started to come up with, well, I think maybe we should have wireless on the device. It was like, well, wireless is hard. Tell you the horror stories, it's like a million things. It's expensive. It uses battery life. It's hard.

But we sort of developed a little rule. If you had three meetings with Jeff and he kept bringing up the same issue, it was like, better pay attention. He's really serious. So I said, OK, we'll do wireless. We'll do Wi-Fi. It doesn't add a whole bunch of expense and the power consumption is not terrible.

And Jeff was like, I don't know. I really like my BlackBerry. He was using a BlackBerry at the time. I really like my BlackBerry. When I want to check my email, I can check my email wherever I am. I kind of think we should do that.

That was like, oh, I was having flashbacks to the Palm days with wide area networks and the complexities of that interconnect. So I hired a guy smarter than me on wireless and he joined us. And we started just pursuing what were the options around wide area networking.

BlackBerry at the time was using this weird network call MobiText, but they were just moving very lightweight packets around. It seemed to me like that was a messaging, pager. That was an old pager network, very low bandwidth, and really not built out all that well.

So I encouraged Jeff to look at 3G. 3G was just coming on board for moving digital information around. And so we built up a little-- well, not little, this giant honking prototype where we had bought a third party 3G modem, lashed that into our prototype, and demonstrated 3G connectivity into the network.

And so that was really what-- that was Jeff's vision. Jeff's vision was even bigger than that, though. His point was when you buy the device, should be able just turn it on and you have connectivity.

Hollar: Immediately. You didn't have to sign up for anything.

Zehr: Which was genius, but also meant it was like, oh. We got a lot of hard work to do.

Hollar: Well, and at that point there's no other device anywhere that works that way.

Zehr: Yeah. Well, that's the fun of being the engineering at a company who's full of visionaries but not stuck in a box of what can be done. They're not biased by what can be done or what's hard or what's easier. The famous phrase, when you say, like, this is going to be hard, the famous retort is usually, well, you get you better get started, because that's what we want to do.

After fighting it for a while, I thought, why am I fighting this? It's actually a really good idea. Let's go start working on the problems.

So multiple problems come up, of course. We wanted to buy wholesale time. We wanted to work with a carrier to buy wholesale time so the customer doesn't get a bill, Amazon gets the bill.

Going to try to work that business relationship with carriers when you're working in the stealth mode is a bit of a challenge. As well as the technical challenge, how do you integrate a modem, a data modem, into a consumer electronic device, and not kill the battery?

And then finally, how do you shop on that device? Because the idea, of course, is you can have a little store experience on the device. And to my knowledge, at least at the time, I didn't know of any device that had solved all of those problems.

Hollar: That's a long list of problems for the head of engineering to solve.

Zehr: That's right. That's exactly right. And famously, you'll hear of talk about it took us three years to do the first product.

You start to realize, like, oh, yeah, there's a lot of infrastructure we had to go and build out-- those business relationships, those technical connectivity issues, the wireless, the hardware, battery life issues, the software issue of on-store commerce or on-device commerce, straight from the device without any intermediary. Plus, another part of the vision was if you ordered the device, when it comes to you, it already comes pre-configured knowing your Amazon credentials, so you can just turn it on. It wakes up, it provisions out to the network, it goes and presents your credentials to the Amazon store in a secure way.

And you're able to, within just a few minutes of turning the device on, you're connected and able to download content. And our first piece of content we always download is a little note saying thanks. Thanks for buying.

Thanks, Gregg. It puts your name. It says, thanks, Gregg, for buying a Kindle. Many thanks, Jeff.

With a little signature on the bottom. That provisioning experience, knowing that it was you and getting your credentials safely securely onto the device once it's delivered to you was another level of complexity that went into that first product.

Hollar: How long was the development cycle?

Zehr: It was almost three years to the day from my hire date to shipping the first product. Now, following products had much shorter and more normal development cycles. But getting through that first system, getting through a V1 is hard. Shipping a V1 into a commercial space takes longer than you think.

Hollar: Let me talk about some of the component parts. Let's go a little deeper into a couple things you talked about. First of all, the two I'm really interested in are E Ink.

And then the second was the relationship with the carriers to provision this whole private network that Amazon came to run and still runs now. Can you talk first about E Ink and its development, and how you gained confidence in it and then began to ready to deploy it on a large basis?

Zehr: Sure. We had heard about the Sony Librie. We did a bunch of research. We got every device we could find that was anywhere near e-book-like.

And there were some that had shipped and kind of gone obsolete. We found some of those to look at and play with. But the most interesting to me was-- like I said, at Palm I had seen early prototypes of that type of display from E Ink.

And I had heard that Sony was shipping this device. So we went and looked at all those devices. But then, of course more importantly, as you go and visit E Ink and get to know the engineers there, get to know the founders, try to understand the technology, and then dive down into their supply chain.

Where are the points of risk at each of their supply points as they provide the technology? They displays use peculiar chemistry, peculiar pigments, and processing for putting a charge on each one of these little displays. There's a little white ball and a little black ball, and you put a charge on each of those.

And then you can control those electronically. So we needed to understand, how real was that? Were we willing to place a bet on that display?

Likewise, how do you control that display? Because all of the processors that you could buy at the time controlled LCD displays or LED displays, but none of them of course controlled these E Ink displays. So we had to then find out was anyone making a controller chip, and establish a relationship with them.

So we spent a ton of time evaluating that supply chain to understand the risks involved. And after looking at it, it just seemed to me worth placing the bet. We could have done another TFT display.

We talked about it. We did a paper analysis of what that would look like. But if you did that, battery life would be measured in hours.

Hollar: What was your goal for battery life?

Zehr: Well, we wanted it to-- as long as possible. We had no real idea what the right number was, but once we saw the potential for a display, there's a display you can basically put an image on that display and then take power off of it, and the image stays put. We realized that reading was the perfect application, because you can turn a page and then you can quiesce the power.

You can turn the power off. And that page stays. And so if you're a slow reader and it takes you fine minutes to read that page, you don't use any power during that period of time.

So we saw the opportunity to make the battery life, measured in at least weeks, if not longer. So we saw that. And we thought that was incredibly valuable, but we also saw the opportunity to make the battery lighter.

So we felt like lightweight, this was a different use pattern than a PDA or a laptop or even a cellphone. This was a device that people might get immersed in reading and read for an hour and a half. So you might be sitting there holding that same device in more or less the same position for an hour and a half.

So ergonomics, lightweight were important. We felt like those were super important. We had to try to take all that into consideration, too, as we considered the display technology.

So it was a roll of the dice. It was a real bet. But we got to know the supply chain. We get to know the supplier.

We got to know people at E Ink and developed a confidence that that was the right direction to go. We of course had no idea what the volumes would be, how many we would sell, how many they would need to make. We had no idea.

Hollar: Were you confident if the volumes really ramped that they were going to be able to go with you?

Zehr: No. [LAUGHS] As a matter of fact, we learned that on day one.

Hollar: Ah, OK. All right, we'll come back to that. But now, let's talk about the network and how you build this very sophisticated wireless capability into it.

Zehr: Well, luckily we hired some smart people who knew about networking. And that's on the device end of it. And also in Seattle, of course they understand networking.

They build these giant server farms all the time. So they understand networking there. So we built a team to go off and go work on this.

So engineering team with expertise in wireless, engineering team with expertise in networking, and a business person start going to the carriers, meeting with whoever will meet with us, again under this sort of mysterious auspices of, who are you guys now? What exactly are you doing? And of course we--

Hollar: And even when they know you, they're not the most generous group to do business with.

Zehr: No. And their business is handsets. And they're under a lot of pressure to ship new and better handsets each quarter. And so when we show up with this weird R&D thing, and this kind of funky looking thing, they're like, OK.

I've got 60 handsets. And then if I get all that work done, maybe we'll talk to you. And then we say well, we don't want the customer to get a new phone number.

We don't want the customer to have a minutes plan. They're not going to pay you month by month. We'll just pay the bill.

That was a very different business model for most of them. Luckily, we met up with a team at Sprint. Sprint had a business model, a small little team that was trying to break into the business of selling wholesale minutes, and so there was an alignment there that fit in better.

And they were willing to kind of roll the dice and help support us in setting up that first product. Wound up talking to all the guys and eventually found the group inside of Sprint to say, oh, yeah, we'll give it a shot. So that's how we launched in a version of wireless.

Hollar: One more technical question about the touchscreen. So you're in an era at that point where there is an iPod and it has a touchscreen, but it's not yet a tablet era where there are larger form factors. How did you go about designing in and understanding exactly what you wanted in touch?

Zehr: Well, the e-paper display, the ink is very, very close to the surface. And it's also true that on those first generations of E Ink products, all of the light is reflected light that's coming over your shoulder. So we were reluctant to put any sort of a touch surface in front of that display.

Just to back up a little bit, the way most touch interfaces work is you have a display and you layer a clear touch surface on top of it. So when you touch on this, then you can measure the touch. But that touch surface is not perfectly transparent.

It's not perfectly optically clear. It does degrade the light somewhat. And in our application, the display itself was already-- it didn't have any backlight.

On a laptop or on a tablet, on staged tablets and smartphones, you can just make the light behind the display a little brighter and you don't notice the touch surface. But on e-paper displays, all of the light is reflected light. It's just whatever light is reflected. So when you put another surface in there, you lose a lot of the light as it goes through it, hits the surface, and comes back.

And so you lose a lot more light when the light is reflected back. So the first product, we didn't have touch. We had to come up with a little control mechanism of the first product that we could control purchasing and reading without a graphical user interface. So those first, if you go back to the first products that shipped, it took a lot of work in the development of the user experience to work with a display whose update rates are pretty slow.

If you think about a tablet, frame rates, you can update the image 30 times a second, no problem. But all these little first generations of e-paper, each time you update the page, it takes about 3/4 of a second.

Hollar: And it's very visible to you when it's happening.

Zehr: It's very visible when it changes. So we had to do a whole bunch of work on that display, on that user interface and on that experience, to make it usable so that people wouldn't get frustrated when they tried to use it. So you notice on the first product, we put a little helper display, a little high speed display beside the main slow display, that you could use a little scroll wheel and go up and down and select an item and push select and go from there.

And we had mechanical physical page turn buttons, too. So you never actually touched the screen. You were always working with a virtual user interface to draw things on the screen, but you have buttons to make selections.

Hollar: And then the final piece would be the content. So how did Amazon go about convincing publishers this was a good thing to support?

Zehr: That work was handled by a whole separate group, which I didn't know all that well at the time. But Jeff reassures me that the actual hardest part of the Kindle development team was to get the content owners comfortable with going to digital, transforming to digital. So that was a huge, huge effort, to get those owners comfortable with that.

I'm sure, if I was in their shoes, they had just watched-- music had just taken a huge transformation once people could exchange digital music files. It was a scary time, I'm sure, for those content owners. But we worked through a set of DRMs to help them feel comfortable.

And, of course, we have a reputation. We want to be reputable in the marketplace. We want to respect the rights owners' rights.

So that was a very careful dance. And luckily, we got some publishers to agree to give it a shot. So we launched. We had set a goal to lunch with a good selection of content.

Hollar: When did you know that you were getting this right?

Zehr: [LAUGHS] Well, there were milestones along the way. The first milestone for me personally was the first time when we had a prototype that-- when I saw the first, in the engineering lab, I saw the first book come down across the network. And the text was just right there and it looked really nice on that display.

I felt like, wow. We've accomplished something. We could search the books on Amazon and select a book and have it come down onto the display.

For me personally, it was like, wow. That's amazing. Because that at that point, I'd used PCs and used MP3 players, but to see a new type of content showing up on a personal device, that was awesome.

But I think the real breakthrough moment was, we got everything stabilized enough to do what we called a beta cycle. And we sent units to-- I think we built, I want to say 100 units, maybe, maybe it was 50, maybe it was 100-- out to people to let them read on the device before we launched. So we sent those units out, get feedback from them, what they liked, what they didn't like, fix a lot of bugs.

They'd do things we didn't expect and turn up a new bug. So when we got done with that period and we said, OK. Now we want to collect up the devices.

You'd be surprised how many people said, there is no way I'm giving this back. So for me, at that point, it was like, OK. If you really care passionately enough to tell Amazon that you're not going to give you this thing back, to me that indicated that there was something there. This weren't people who worked on the project, these were people independent.

So that felt like a real turning point in my mind that yeah, there's something there.

Hollar: Other than the E Ink, were there components of the first version of Kindle that were really breakthrough, or were you able to work with things that were mostly around?

Zehr: Well, we had that little helper display over on the side, and that was a unique display. That was PNLCD, which just means it worked off the same principles as the E Ink, which is reflected light. Most displays depend on a backlight, but I didn't want to waste the power to light this little helper display.

And I also felt it would be sort of bizarre to have a glowing display here and a reflective display here. That just felt like a odd user experience. So we developed this little low power, reflective LCD.

So that was unique. And then of course, the industrial design, the shape, that was unique. And we talked about the system software, so how all those systems piped together.

We plumb out through a carrier network, out back across a wide area network, back into a Amazon secure network, and all the payment transactions. So at a system level, those things were all unique. But to be honest, the microprocessor inside was pretty standard little ARM processor, pretty standard memory, pretty standard battery technology.

Those things were pretty much off the shelf.

Hollar: And when did it ship?

Zehr: November 2007.

Hollar: What were the initial sales like?

Zehr: We had built so many units before we launched, and we launched, and we sold out in something like three hours. We just sold them all. We had an event in New York.

Jeff demonstrated in front of the press there. It got a lot of coverage. People went online and we sold out by noon. We had a little party to celebrate in the morning, and then before noon I was getting calls from people in Seattle. It's like, OK, we need to build some more. And it's like, [LAUGHS] we have to order some more parts. That's when we learned about lead time. And that's what we learned about when you call up a small vendor and say, oh, wow, we need to order a lot more. And they sort of go, oof.

We don't know how to build that many. It's a high quality problem to have, but we learned a lot about how to select a supply base that can support a rapidly growing business, what kind of protections to put in place in next generations. So we sold out quickly on that first day.

We had some material in the pipeline. We built those. Those were on back order. We had taken back orders. We sold all of those. And then we went dry for about the lead time, about three months while we ordered the long lead time material, had those transformed, and then we were able to start taking orders again.

And so we sold through, then, that next summer. And then in the fall of that summer-- we stayed in stock. In the fall of that year, Oprah Winfrey demonstrated a Kindle on her show and we instantly went out of stock again, and we lost sales through that holiday selling season.

So that was incredibly painful and an incredible missed opportunity for us. But it just goes to show that we believed in the product. We believe that it was important to the Amazon business.

But we didn't anticipate how quickly people would switch over to adopt a new technology. I think that's often the case. If you have a great idea, people are ready for it. People are ready for good ideas. It was just a great reminder. I think we were surprised, though. I think we never expected that rapid of adoption, that rapid of a switchover.

Hollar: When did you start to think about evolving the Kindle platform into a device that would do so much more than just be an e-reader?

Zehr: Well, on the readers themselves, we've tried to stay pretty much dedicated to reading. We've experimented with a few other ideas. Most people don't remember, but for a little while we shipped an MP3. You could listen to MP3s, because some people like to-- I like to listen to music when I read.

We built in a little MP3 player. But that didn't really catch on. We tried a web browser, but because of the slow update rates on the displays, that was kind of for emergency use only.

So we've morphed those additional capabilities into the product, more with a focus on the reading experience. I'll give you an example. On the latest version of the product, if you're reading a book and there's a word, maybe there's a word in Spanish.

You don't know what the word is. You can press on that word and hold on it, and a little menu will come up and offer you the opportunity to translate that word from Spanish into English. It'll give you the definition in English.

It'll give you the opportunity to look that up on Wikipedia. So those are all things you could do in a general purpose browser. But what we've done is dedicated it to the reader and tuned it and refined it, that says it's not a general purpose web browser, but when you need to translate a word, we know how to do that.

When you want to look up more information on Wikipedia, we know how to do that. That's on the reader itself. And then of course, now ship tablets.

And those have fast displays. So those allow us to bring across more full service, full function web browsers. So you'll find those on the tablets.

We've also ported the Kindle reader application to other platforms. So if you're using iOS or Android or other platforms, you can read a Kindle book. So you don't feel like you're in a closed system.

So you can read Kindle books and never ever buy a Kindle. We think that's fine.

Hollar: Oh, yeah. I mean, that's miraculous. I love that.

Zehr: I think that's a smart business play. And we think it's also longer term. If you look at the short term, you could argue that having people locked into a platform is important.

But if you look at it longer term, keeping the customer happy is more important. Jeff has a phrase, start with the customer and work backwards. And if you think about the customer concern, you know, you're paying for a book. You want to feel like, well, I'm not locked into any one platform.

Hollar: Let me talk for just a minute about the development environment that you've created at Lab 126. This was not, obviously, your first chance to develop a whole environment and do it your way, sort of the way that you had always dreamed you could do it, but maybe pretty darn close. What are the things that you brought to the whole arc, through the whole arc of your career that you really implemented in making this lab work?

Zehr: Yeah. Great question. I mean, I try to both on the technical side, on the people side, try to be reflective and thoughtful about all the experience I've had in the past, and bring those forward. The reader, I learned so much in PowerBooks, I learned so much at Palm, I learned so much in these other experiences, and bring those forward to implement Kindle.

But likewise on the development environment, there was sort of the fun, crazy parts of start-ups that I wanted to bring. But I also realized that a company like Amazon, it's a real business. It's a big business.

We can't bet the farm on everything. So we have to sort of pick and choose. But I always think of it as, you know, when I'm doing hands-on engineering, I want to work in an environment that respects creativity, respects meritocracy.

It looks at design for the quality of the design. I want to create an environment where we put the data on the table and we look at the data. And we can debate the data.

It might be a messy process and it might take a while. But we look at the data but we respect each other. We respect the people around the table.

Because if I build a work environment where the brightest and the most creative and smartest people enjoy working, then I know they'll pick up the phone and they'll tell their friends, hey, this is a great place to work. Why don't you come on over? And when we're in the process of growing as rapidly as Lab 126 has grown, it's super important-- especially a small place like Silicon Valley where everybody knows everybody-- it's super important that we try to have a very positive work environment.

But I really want creative people. I really want the smart people. I want an environment where people who have some self confidence can bring forward ideas and we can look at those ideas, put them on the table, thoughtfully consider those ideas. I call it cocoon those ideas.

It's a friendly environment where it's always OK to bring up new ideas. And senior people often have the reaction to say, oh, I could think of 10 reasons why your idea won't work. But I try to have a culture where it's like, let's wait a few days before we list out the 10 problems with this person's idea.

Let's find out what the idea was. Let's let that idea sort of germinate for a little while, and see. If we come back to it a day or two later, maybe there's elements of it that we hadn't thought of before.

I really want that. I'm trying to-- you can talk to people who work there-- but I'm trying to create an environment where it's creative, smart, pleasant, and we nurture new ideas. If I could have a legacy, I'd love it 10 years for people to say, Lab 126 was the most innovative consumer electronics company ever. So that's my goal. I don't know if we'll get there or not.

Hollar: That's a great goal. How big is your team now?

Zehr: We don't talk about that.

Hollar: Ah. OK. I found one question that I couldn't get you to answer. So to the extent that you can talk about it, what's next?

Zehr: Well, what's next. The obvious thing is-- maybe not obvious. I have 101 ideas to how to make the Kindle reader even better, tons of ideas that we've learned and refined and tested little tiny bits and pieces of it. So we have ideas to combine, to make the basic reader better and better and better for many generations.

So I'm personally excited to be heavily involved with that. And the fundamentals are all still true. Amazon is a great brand.

It's a great channel. It has access to a lot of content. And I think people love to have access to that content.

So I think there's, I think we still have an opportunity to come up with new ideas. We've just launched Fire TV set-top box, classic set-top box. But we think we've brought some innovation to that.

And we have a bunch of other ideas that are in the lab. We'll see if they ever make the light of day or not, but we do have a benefit at Lab 126. And the benefit is the following.

Amazon already has a healthy retail business in consumer electronics. We already sell, let's just pick one thing. We already sell MP3 players.

So if you're want to buy an MP3 player, that's great. You go to Amazon website and you can buy an MP3 player and Amazon's happy. We sell it.

There's some margin in that product. So there's no pressure on me at Lab 126 to invent an MP3 player that competes with the ones we already sell, because we already sell it. So I have the opportunity at Lab 126 to, I always have the challenge that it has to be something significantly different than Amazon already sells, because it would sort of be pointless to sell a me, too product.

There's no benefit to just-- maybe if I invented an MP3 player we'd get a little bit better margin, because we'd own the supplier, but that's not terribly interesting. So that's why I say the point about innovation at Lab 126 is the most exciting part. And the business model frees me to take on those harder challenges.

You just read the shareholder notes that Jeff sends out every year. And he said he's willing to place big bets. And if they take a long time to develop, he's patient with those ideas, which I think is also brilliant from a business model idea.

We have tons of ideas. I think as an industry, the sky is still the limit. Even though I thought when I first moved to Silicon Valley it was kind of the end of innovation, I've changed my tune.

I think we're really just getting started in other ideas that are well beyond the scope of anything that's happening today.

Hollar: What are your reflections on this change?

Zehr: Well, it's been just a blast to be involved in it and watch it. I still think, though, that there's a lot of new things that we can do. I still think that a lot of these little-- let's just look at smartphones.

I love smartphones. And I remember talking with people when I first saw the first devices came out. It's like, these things are going to just replace laptops. 80% of what I do on my laptop is email and casual browsing.

I can do that just fine now on a little thing that I carry in my pocket. And that's just gotten better in terms of capability. So suddenly, sort of the definition of what we thought of as a computer is suddenly morphing because the fact is I can carry it with me.

And that has had the interesting side effect of spawning a bunch of new ideas. Who would've ever thought about Twitter, or who would've ever thought about the cool new messaging apps that allow of groups and sharing of photos and things? So I think just the fact that things are smaller, more mobile, wirelessly connected, has created a whole new way we interact with information.

And I think we're just getting started. The devices are still too hard to use. They're still too complicated, still incredibly expensive for most people.

We're sort of spoiled here in Silicon Valley, but for a lot of people it's beyond their means to have that kind of connectivity all the time. So I think if we can drive costs down, I think there's a whole bunch of innovation we need to do around how we interface with these devices.

I'm excited to think of ways that new sensor technology and new interfaces, new ways to control, will continue this movement. The computer, you sat down and typed, and then there was a laptop. You could carry it around, kind of a pain.

Now you've got a little, it may be a little mobile smartphone or a tablet, that kind of moves one direction. But I think directionally it's going to continue along that vector. And I think the ease of use, even more personal, even more directly connected to myself and my environment.

I think there's a long ways to go yet on that.

Hollar: Let's talk about the question if you were going to give advice to a young engineer. What advice would you give?

Zehr: Well, I think I would tell young engineers to take a little time early in your career to learn your trade. We're kind of in this go, go, go. And people take AP classes and they sort of come out of college.

And sometimes I feel like they don't give themselves the time to really learn their trade, learn their tools. Try to get some mentoring from someone who's a little bit of a seasoned veteran and learn the ropes a little bit. And really hone that craft.

It's really a craft that you should take some time and really get good at it. When I look at the people that I think are the most successful, though, they're smart, but they bring creativity to it, to the problem. So I might encourage young engineers to be creative in their solutions, encourage you to be self confident.

It's so easy to think, well, I'm not sure I've got any good ideas here. But you probably do have ideas. Bring those ideas forward.

Find an environment where it's safe to bring those ideas forward and share those ideas with other people. So I think those are super important on the technology side. And then I think as you start to build those technical skills, then I think be aware of soft skills.

Working with people, how can you work with people? How can you lead your ideas? Can you write?

Can you just write a nice description of your idea that someone outside the industry could read that description? So pick up on those soft skills, too. They're incredibly important long term in your career.

And they're just as learnable as calculus. You did a lot of work in school to learn calculus and differential equations. Now refine those tools as you get into the workplace, but then also refine those soft skills.

That would be my advice.

Hollar: It's good advice. Did you feel like you got some good advice when you were starting out as a young engineer?

Zehr: I did. I felt like some of those old, seasoned engineers at Magnavox took me aside and said, well. Rather than say, here's what you should do, or here's how everybody else does it, the guy gives me the Bell Labs paper written by Hamming and says, I think there's something in there that you should know about.

He knew full well what was going on, but he really wanted to encourage me to read it and learn it for myself. Likewise, I had sort of mentored or really appreciated a senior executive at Altos. He had come from IBM and cut his teeth at IBM.

And he was the guy who started to talk-- I had the technical skills, but he was the guy who started talking about the business, putting those technical skills into a business context. Well, OK, you've got that great idea, but how are we going to sell it? You've got that great idea, but there seems to be a market over here that's taking off.

Did you notice that this is taking off? Of course, I'm not. I'm an engineer. This is the little world of things I'm excited about.

And then like I say, at Apple with the industrial design, and then various managers, as business has boomed I've learned a lot of things, and as things have collapsed in maybe more painful times, you also learn soft skills that help even during the downturns.

Hollar: Through those times, yeah. This has been great. Thank you.

Zehr: Thanks, John.

Hollar: Yeah. Thanks very much. I'm looking forward to reading back on this.

Zehr: Yeah. Well, we'll see.

Hollar: And getting even more out of it. But this has been wonderful.

END OF INTERVIEW

