



Oral History of Aryeh Mergi and Dov Moran

Interviewed by:
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Fairbairn: Okay. Well, welcome. This is an oral history recording of Aryeh Mergi and Dov Moran who are located in Israel. I'll let them give you specific locations. My name is Doug Fairbairn with the Computer History Museum and I'm joined by Brian Berg who is a friend of and very knowledgeable of the work that our two interviewees have done, and that we'll be talking about today. Today is September 8, 2020 and we're glad to have you both here, record your respective stories and perhaps most importantly your joint work together in the area of flash memory. So welcome and thank you for joining us.

What I would like to do is to begin is have each of you give a short, you know, five-minute-plus little history of yourselves, where you were born, when you were born, a little bit about your family life, people who might have been important in influencing you in the direction you took, university you attended and working up to the time in which you started working together. So Dov, if you could begin, please give us a little bit of your personal background.

Moran: Sure. So first, great seeing you. I'm Israeli. I was born in Israel. My parents actually were immigrants to Israel from Poland, survivors from the Holocaust. The biggest influencer in my life was probably my grandfather. There were seven brothers and sisters in my father's family, and he was the only one who actually survived and went to Israel with his son, my father. So, my grandfather left the War without six out of his seven children. He lost his wife. He lost his property including all of the factories, that he built in Poland. He was a true entrepreneur, my grandfather. And they put it all behind them, but they survived; and they came to Israel. And for many years I lived together with my grandfather, actually at the same home, same room. And until the age of 18, exactly one week before I was supposed to join the Army, he passed away. But he was an entrepreneur and I learnt a lot from him. I do believe that he gave me this entrepreneurial spirit. He taught me how to become an entrepreneur. I still have many of his words, you know, going in my mind.

And I went to Technion to study engineering because for me it was very obvious that I have to be an engineer. I studied in Technion before joining the Israeli Navy. In Israel, everybody goes to serve. Everybody needs to serve three years at the Army, Air Force or Navy but you can study before actually joining, as engineers in this case. I had a very, very interesting service at the Army. While my date of joining to the Army was October 16, 1973, and if you can take it backward, yeah, this was the middle of the Yom Kippur War. Did a very, very fast training for tanks. I was a tank driver. I was at the Syria area, which we conquered in the war for about six months. A very interesting time of my life. Left the tanks, went to study. Finished Technion. Did an artillery course. I was now an artillery officer as well, and then went into the Navy to do my service as computer engineer. My first job at the Navy was running the computer department first at the communications group of the Navy, then at the computer center of the navy. There, I became the head of the microprocessor department of the Navy. This is where we actually got to know each other, Aryeh and me. I will be happy to hear Aryeh's story of how we got to know each other.

<laughter>

Moran: When Aryeh will tell his story.... We didn't discuss it actually. I hope our stories are in sync...

Mergi: Yeah. That's the first thing in my memory. Our first meeting was when you interviewed us to join the Navy labs.

Moran: <laughs> I have a great memory... flash memory. I don't forget anything. Maybe the number of write cycles is a bit limited, but I don't forget. When I left the Navy, I served 8-1/2 years overall. Most of the people are serving 3 years, some are doing it 5 or 6 years because of their work at their specific unique job. I enjoyed very much what I was doing so I was ready to extend.

Maybe one of the most fascinating things when I was these years at the Navy microprocessor department: we had almost zero projects with microprocessors. But through the time there were more and more projects, When I finished my service, I do remember that my small department in the Navy became very large one -- 23 projects at the same time. All of them built with microprocessors, and I was like a king. You know, I was going to CDRs, Critical Design Reviews... And then decide this, this approved this, make this guy go there, this guy joining this activity, activate programmers at our center, etc. Like a big boss at the age of 26-28. So, I left the Navy I said, "Of course I'm going to establish my own company. Shall I really go to work for Tadiran, Elbit, ELTA, these Israeli companies who worked for the Navy. I can be better. And of course I was very, very stupid, yeah. I don't-- I do admit.

So established my first company without any clue about how to establish companies, any direction, no funding. In Israel these days, you could not actually raise money, and raising money seems to me it's a very strange thing. Because my father used to tell me that "Money's not growing on trees. How can you raise money? You know, you raise tomatoes. You raise flowers. But raising money? What's that?"

And then I gathered people who worked for me, and my story about Aryeh.... So anyway, I gathered around me good people and by the way, good people is really the formula for success. And I was successful in as much as I was successful only because my capabilities to go and find the right people. Not because of anything else. I wasn't smart in electronics or the smartest guy around... I, probably I'm a bit more innovative than others. Many of the products came out of my head. And I do understand what I'm doing, and I do have logic. But what stands behind my success is people. And so, I began to gather the people around me. In some stage I went to the U.S. and truly, it wasn't related to flash yet. But as a company we needed to survive. Otherwise, you know, I didn't have money to live. So we had to do projects. We began to do projects for other companies. So we developed our own products. Educat, remember that, Aryeh?. We were talking about it just before the call.

Fairbairn: This is-- Just for clarification, you're talking about M-Systems or some previous company?

Moran: Well, this is prior to M-Systems. I left the Navy about 1986 and this is three years where I was a company, Moran Systems, which I made later on M-Systems. And through this process, I didn't have-- I knew one thing. I want to run my own company. I want to do our products. I want to create value. I want to do-- to work with amazing people. And I understood that some time that in order to succeed I really have to go out of the Israeli ecosystem and live in America.

And I had the chance to go actually through a project that we have done for an Israeli company called Tadiran. Shortly about the story. This project -- I had good relations with Tadiran and I got to know these people from my service. So, one day I went to see them. I had to initiate my own project, so I couldn't just wait for projects to come. I went to them and said, "Guys, how about making a computer terminal to talk one ship to another using a regular PC?" And they said, "Mmm, no, it's a bad idea because hey, it's on the ships, it has to be rugged, but we do have an idea. How about making a rugged PC?" I said, "Of course we could do it. What's the problem?" Clearly, I had no clue how to do it.

The story is that there were two great guys I worked with in the Navy. Tadiran was ready to give me this project. So I called Aryeh and Alex, these two guys who worked for me at the Navy. And they came to see me in Ramat Gan. It's a city nearby Tel Aviv. I said, "Guys, we have this project and we have limited time to perform. Can you do it?" I learnt from them that both of them were still in the Navy or Technion, these guys. Navy?

Mergi: Yeah. Yes, still in the Navy.

Moran: At the end of their days of the Navy.

Mergi: Yeah.

Moran: I said, "it doesn't matter. Come on. Work in the evenings. We'll do something." And we did this for Tadiran and at this device actually, Aryeh came up with an amazing idea. This is a PC. It's a rugged PC. Not easy to make something like that because in those days there were no screens, not all the displays [we have today]. You had to find solution of an LCD that could be rugged and things like that and adapt them, but how do you put solid state drive into that? There is no space. The ruggedness doesn't fit. So Aryeh, and excuse me for talking for you here. So Aryeh said, "I can actually put a RAM disk into this PC." This is 1987, '86-87. "I can put a RAM into this PC and put in a battery, so this will serve like a hard disk. And whenever you turn off the power, the data will be kept because hey, there's battery! Let's do it." We did it. It works amazingly!

It worked so well that when Tadiran won a project for the U.S. Marines called HTU-- SHTU. S stands for what? HTU was Handheld Terminal Unit. They said, "Guys, can you actually take this PC and make it smaller for us?" We said, "Of course." Aryeh! <laughs> and actually Aryeh and the other guys worked on that and did an amazing job! Then we brought this project which was-- became a huge success. This was the standard, "S" stands for standard. Standard Handheld Terminal Unit. And this became a great success and that's actually the way I went to the States because they needed the support, my support for halftime at the company called Miltope at the Long Island. Miltope was the Tadiran representative. And I said, "Okay, it's a good opportunity for me to understand the U.S. market. I'll work half time at this company Miltope [to support this project], half time I'll look for other projects [for my own company]. I'll learn the market. I'll see what is this place, the United States of America... What the hell is it? [and how can I build products that would fit it needs?]

And sitting there at Miltope, these guys used to do military tapes and hard drives which actually worked very bad. So I said, "Guys, maybe you should do RAM disk. We can do for you RAM disk because and it works very well. Look at this HTU. Internally, there is a RAM disk with the battery backup." And they said, "Wow. You really can do it?" I said, "Yes." They said, "Okay. But the battery is bad." I went to the CEO. He said, "Wonderful idea. But the battery for military purposes, it's a big problem." This was actually the beginning of getting to flash, getting to M-Systems but I'm stuck here. I'll let Aryeh tell his story and then we go back to the, maybe to the story of the-- of M-Systems.

Fairbairn: Okay. Before, Aryeh, before you begin, Dov, would you just fill in a couple of details. When you were born? What year were you born?

Moran: I was born in Israel in 1955, so I am 65-years-old now.

Fairbairn: Okay. When did you enter the university, Technion?

Moran: I began at Technion when I was 18-1/2 and I finished after 3-1/2 years actually.

Fairbairn: And what years were you in the military service?

Moran: Let me see. I joined the service at 19-- just a second-- '73 I finished my high school studies, '74, I began at Technion, finished at '77. And I, yeah, '77 I began the service at the Army and I left at the end of 1985-86. I served 8-1/2 years.

Fairbairn: And that's when you started Moran Systems?

Moran: And this is when I started Moran Systems. Well, the first thing was Dikla and then it became Moran Systems which later on became M-Systems, yeah.

Fairbairn: Okay. All right, great. Thanks for filling in that reference. So Aryeh, he has turned it over to you. Tell us a little bit about your background, where you were born, when you were born and so forth. And then later on.

Mergi: Okay, great. I was born in 1961 in Morocco, actually. And my parents came to Israel together with me when I was at the age of 3. It was 1964. For the first years in Israel were very difficult. Israel was in its early days and they weren't economically strong as it is today. And they actually worked their way up and they became merchants. They have stores that they built on their own and they built actually their own business. And in time, they became financially stable. Now looking back I think that those years gave me, like, the strength, the internal strength to do things on my own and be able to cope with the uncertainties of starting a business. You know, when we started, we just didn't know if we'd have money for the next day on some of the days, right.

Moran: Yeah.

Mergi: And when I was a kid I was really attracted to electronics and then what became as computers. And in the early days I remember that my parents bought me as a present an SDK-80, which was like an Intel's first SDK for the 8080 CPUs at that time. Then I upgraded to SDK-85 and I remember spending my time like learning how to program it. It had the keypad, a 16-key keypad that you could program byte by byte in binary code. And I knew the Intel CPU assembler by heart. You know, the numbers not just instructions.

Fairbairn: You know, by hex or octal, huh?

Mergi: Exactly, yes.

<laughter>

Mergi: Yeah, yeah. And from that, I moved on to build computer games and selling them door to door where I grew up, when I was like 16-years-old or something like that. And then I joined the Army ... the Navy and I also was responsible for a computer system. Actually, it was a computer that was built in the U.K. actually for some reason. And the Israeli Navy is actually very, very small, so we were, like, in our unit we were like one person that was responsible on this system at the time. So we did everything. And one of the projects that was really relevant to what we did later without knowing that, right. And the storage of this computer was by a company called Ferranti that I think doesn't exist anymore.

Moran: No.

Mergi: It was a bubble memory with 24 kilobyte bubble memory.

<laughter>

Mergi: And the Navy had a really hard time getting the replacement parts of it at some point. So, one of the projects that we did was we built a replacement unit based on SRAM with battery that had significantly more memory. We built it and it actually worked for many years until that this computer or until this computer was replaced at some point.

In the Army as Dov said, we met actually.

Moran: How did we meet in the Army? In the Navy. Let me see if you remember.

Mergi: Yeah. So actually, I don't remember the actual meeting, so you'll remind me.

Moran: <laughs>

Mergi: But what I do remember is that we didn't serve in the same department. We served in different departments. And I was also always hearing about this Dubi, right, that--

Moran: That's my nickname.

Mergi: That's his nickname in Hebrew-- that is interested in PCs and new technologies and he's always bringing new technologies to the Army. And in a way I was the same in my department, so I was looking for him. And then when I found him, I think that we found each other, and we found many joint interests. I don't think that we did anything together in the Army, right? We just became friends.

Moran: Okay. And let me give you the story.

Mergi: <laughs>

Moran: Okay, so the story is that when Aryeh joined the Navy couple of years after I was there already and I was an officer, I left this I think I served as a captain.

Mergi: Yeah, mm-hmm.

Moran: Okay. And at some time, they gave me the job to pick the right people among the new engineers-

Mergi: Yeah--

Moran: How did they call it?

Mergi: Technicians.

Moran: Technicians, yeah. It's somewhere between technician and engineer. Actually, he spent one more year after his high school to become this kind of-- it's a level between technician and engineer. So they gave me the job to screen those people, and that's the first time we met. And I do remember I got amazing people from Ha-Reaali. It's a very good school, maybe one of the best schools these days in Israel. And I picked him, and I picked Alex and I picked another guy.

In general, the technical systems were divided among microprocessors and minicomputers. So, Aryeh was taken to the minicomputers but I did remember him and the other guy as brilliant guys. So, whenever we had a chance, we'd chat. We'd talk here and there, yeah. We didn't really work together, but it was clear to me that, you know, when this guy is going to leave the Navy, I want to work with him. And that's what actually happened.

Mergi: Yeah. In a way--

Fairbairn: So Aryeh, did you go to the university afterwards at all? Or did you go directly into work?

Mergi: Whereas Dov said, he finished the Army a few years before me and he started this early company, Dikla. We kept in contact and at some point they had this project for Tadiran to do those ...

when we were still in the Army. And he came and asked us for help there. And we helped in the evening to build this project. That continued for many other follow-on projects that we did.

And when I finished the Army, I think Dikla got into some issues that some of the partners didn't want it to continue.

Moran: Yeah.

Mergi: And I decided that when I finish the Army, I want to go to the Technion. And Dov came to me and told me, "Why do you need to go to the Technion? You know everything."

Moran: "Join me. Come on."

Mergi: "Join-- Join me."

Moran: You're amazing!

Mergi: And my answer was, "Well, first I want to go to the Technion. And second, I want to build my own company."

<laughter>

Moran: I do remember.

Mergi: And we had some exchange around this, and Dov in his smart way, which was like I think I saw again and again through the years of our partnership, he told me, "Okay. If you want to go to Technion, okay, go to the Technion. But still you can join." <laughs>

Moran: Hey, Technion is easy! You know, you can be there two days a week and that's enough.

Mergi: Yeah. <laughs>

Moran: Yeah.

Mergi: "And if you want to build your company, you know, it's better to do it with partners and there is an opportunity. My partners just left. Join as my partner."

Moran: Yeah.

Mergi: And then we joined together and actually in the first years it was I think 1986 or 1985, something like that, in the first year we didn't do flash, we tried to invent our own products.

Moran: Yeah.

Mergi: Right. And we had, like, many ideas that some of them became really great ideas by other companies.

<laughter>

Moran: Yeah.

Fairbairn: So it wasn't clear to me, you never actually raised any venture investment money? You did everything bootstrapped, is that right?

Moran: Yeah. Actually, let me just to clarify the history here. That's important. When I left the Navy, I joined the other two guys that left even before me. One is Menachem Lasser that actually works with me until today on and off. You see, he didn't continue with me, but he came back later to M-Systems. And the late guy, amazing guy, again, great friend until he unfortunately died recently called Ronnie Konitz and both Ronnie and Menachem and me, we didn't raise money. There was no way to raise money. We had to do projects for others.

So the idea was we'll do our own products during the day, and we had all kinds of ideas, and we'll do projects-- Sorry, the opposite. We'll do projects more for others, subcontracting, during the day and we'll do our own products at night. The only problem is that you need to sleep sometime. And I think we didn't take it into consideration. So, it was very, very tough, you know, to do products for the small Israeli market ... didn't make any sense.

So that's the reason that I took a decision that I will go to the states and I'll try to understand what is the meaning of America, selling in America, distribution, whatever it is. I really lacked any sort of management experience, management and business experience. Now one thing more, what happened with Menachem and Ronnie, they actually, left. And both of them are amazing people, just we didn't have enough money to share between us. Actually, I didn't have enough money after that even more myself. And they had children, or they just got married and they wanted to feel more secured. I couldn't give them the security that they required. Aryeh, hey, he went to Technion. He had money from his parents, whatever. He could live even without security. Actually, I offered both Aryeh and Alex to join and Alex said, "Can we discuss the salary?" I said, "Salary? Hey, every month we look at how much money we have, and we divide if we have enough, you know..." I don't know what's going to be the salary. There is no defined salary. And so that's the real story. But the first time we met actually was when I was interviewing you.

Mergi: Yeah.

Moran: Do you remember it?

Mergi: I didn't. I remember-- Never mind. We'll-- <laughs>

Moran: Okay, okay.

Fairbairn: Then when the two of you became partners, then is that when you changed the name?

Moran: Yeah.

Fairbairn: Or tell me what the name was at that time.

Moran: So I'm going to New York and my name, the name of my company, is Moran Systems. And I go to visit my, uncle and aunt in the Long Island. And I tell them about my great company. We had amazing ideas, and I tell them about one of them. And then after some time, you know, they said, "Wow. That's amazing. Sounds great. What's the name of the company?" I said, "It's Moran Systems." They said, "What? You said Moron Systems? It's not a good name." <laughs> "It's not a good name."

Fairbairn: <laughs>

Moran: Hey, I already have business cards and you know and envelopes printed with Moran Systems. So I took a Tipp-Ex and I had a meeting with somebody, so I used the Tipp-Ex and erased the O-R-A-N and that's the new name, M-Systems. Anyway, it took us some time to change the name officially because there was another company called M--

Mergi: M-Something, yeah.

Moran: M-Something, yeah, whatever. We succeed to get to the name finally. But that's the story of the name, so this doesn't relate to our working together, but we actually settled on the name about 1989. This is actually the official date of establishing the company as M-Systems. Until 1989, I think January 1st in 1989, M-Systems was not a company. Everybody worked on my personal account. So I would pay my electricity at home and pay the employees their salaries from the same account. You can ask me why. Because I went to my friend the CPA and I said, "You know, I want to establish a company." He said, "You have two ways, two directions. One is to open a company official, a limited company. Or you can do it on your own account." I said, "What's the difference?" He said, "Oh, the first one would cost you 5,000 shekels as annual fees. And the second one would cost you 2,000 shekels." So, I went with the second approach, of course. Why should I waste the money?

Fairbairn: <laughs>

Moran: So I just didn't open a company until January 1, 1989. One more thing to complete the story. You may ask yourself how come Aryeh while he was in the Navy was working for others, and for me in the evenings. I was doing it as well. Because in the Navy, we actually were more developing not ourselves but we developed there were using other companies working for us. We were more monitoring or being project managers and do some programming here and there. But I wanted to work on PC. And PC came to the world, it was wow.

And so, I was working very hard in the Navy, probably every day from 8:00 till 6:00, 7:00. At 7:00, I would take off my Army shirt, change the shirt and go and work as subcontractor to do programming on actual

computers, on PCs, on a variety of projects just because I wanted to understand this media of PC. I did a lot of software and had many ideas. And actually, regarding the establishment of M-Systems, that's the story of M-Systems birth. I had amazing idea of doing a keyboard for children and the name was Edu-cat. Edu-cat stands for education, and the shape of it was the shape of a cat. So, you could actually press buttons. Buttons could be the mustache, the legs, the ears, the tail of the-- And in addition to it,-- remember that--?

Mergi: No, I forgot.

Moran: Edu-cat.

Mergi: Uh-huh. <laughs>

Moran: This was one of your most amazing ideas, Aryeh.

Mergi: Really? Okay. <laughs>

Moran: You did a project in Technion of doing, recognizing four words. You can talk to the computer and it would understand up, down, right, left.

Mergi: Awesome. <laughs>

Moran: You do. So anyway, he had this idea which I thought it's an amazing idea. Maybe he didn't think so, but I thought it's a-- And when I went to the States I was trying to raise for that money, because when I came to the States people told me that hey, you can raise money from people. They give you real money. You know, not for jobs but for equity in a company. So I went to raise money and there was a guy which was highly interested in this project in Manhattan. I lived in Long Island. And Aryeh and all the guys were working, of course, in Ramat Gan in Tel Aviv.

So, I went to the guy two or three times and he said, "Hey, this Edu-cat sounds to me like a great idea." And I had a whole idea of how do we sell software to work with that. And people buy the hardware once and then we can continue to sell them software with a variety of games and you can control things by saying "up, down, right, left" or "fast, slow, jump, walk".... So, all the operation will be verbal for children. And this wealthy guy in Mnahattan said, "Listen, it's a great idea. Sounds to me wonderful. I want to invest. But before I invest, can you bring me a business plan?" And guys, I know it sounds stupid and it was really stupid and my-- I had no clue what is a business plan.

Fairbairn: <laughs>

Moran: So my answer to him was, "Of course. No problems. I will give you a business plan within two weeks. Is that okay?" He said, "Fine. Wonderful. Come to me once again and I'll look at the business plan. I'll evaluate and I'll give you money for this company." And then before that, before that I told

Miltope, the CEO of Miltope about our RAM disk. And his response was, "It's great, but you know, battery is bad." That's the story.

Now I came back to my office at Miltope and I tried to work on this business plan asking people what is it, can you show me a sample? No internet these days. You can't see samples. There is no-- I even set up a meeting with somebody. I was told, he once a long time ago, years ago, he wrote a business plan. You have to go to him. Talk to him.

And meanwhile, I see in the papers, *Electronic Engineering Times*, this is September, 1988. September, 1988, *Electronic Engineering Times* are publishing an article about a new component, flash memory from Intel, non-volatile. You write, you turn off the power and the data will be kept there. So, I am very happy. I meet the CEO of Miltope. I became a very good friend of him. And I tell him, "Hey, Dick--" His name was Richard Pandolfi. Amazing guy. I said, "Richard-- or Dick-- take a look. There is new memory like static RAM, but you can write to it and if you turn off the power it stays there. It's non-volatile. We can make this solid-state disk, this RAM disk, without the battery." He said, "Really? Can you do that?" I said, "Of course." He said, "Okay. You know what, guys? You do that. We will be very happy to sell it for you as Miltope. So go ahead and do it." This is the a head of the-- So I listened to him.

I wrote to Aryeh and Aryeh said, "Yeah, —i will see if we can do it." And I am still running and doing my Edu-cat, which was really exciting. I had a daughter one-years-old these days and I really wanted to do it for her. Edu-cat, education. Games. Funny. PC. That's great. So, I come back from this gentleman in Manhattan, and it's the second or third day trying to find my way [to write a business plan], and this Richard Pandolfi comes to me when I'm eating my French fries at the dining room. And you know, he just puts himself in front of me and says, "Dov. What happened to-- What's going on with your project? You know, the non-volatile project?" I said, "I remember he said: "The no needing battery project." I was busy with my French fries, so I said with my mouth full of French fries, "Oh, I'm just working on the business plan for that." He said, "Wow. How much money do you want to raise?" If I was asked then if I want to do a solid-state drive, the answer would be no. I hated anything related to military. I had 8-1/2 years of military stuff. And when I quit the navy I said, "I'm not going through [doing this stuff]," and then Tadiran came with the militarized PC. I want to do PC. Games. Education. Fun." So I said, "I'll give him such a big number that he'll say, "Okay. Forget about it." And I really forced myself to give him a very, very large number. This day this was large in my, you know, in my understanding these days. How much money? Can you guess? Douglas, Brian? Give me a number. How much do you think I tell him?

Fairbairn: A million dollars. One million dollars.

Moran: \$300,000 dollars.

<laughter>

Moran: \$300,000 dollars. He said, "No, no, no. This is too-- I give you half this in equity and half as a loan which you have to bring me as product." I said, "Okay." He said, "Okay, finish your French fries. Come to my office and I'll give you a check." He wanted to give us a check. This is September. And I have a

problem. He needs to give a check to a company, there is no company. So, I had to open a company at this, you know, January 1st, 1989. This is the official date of the company establishment, actually. That's my story of M-Systems. I'm sorry to disappoint you because you probably thought we had huge of smartness and cleverness and we saw the market and the strategy and we had wonderful vision. We did have many of those, but not at the beginning. We began as practically a couple of immature guys, no idea what they are doing. By the way we added more, two more partners later on, one which was I was in the States so there was one guy running the company, Amir Friedman, and three years later, we added another very smart guy called Amir Ban, which actually was our first-- the VP of Software of the company. But this is the story and I'm sorry it's not a hilarious story and everything was smart,. No. We weren't.

Fairbairn: All right. I think it's a wonderful story. <laughs>

Berg: Yes, I do, too. And Dov, if I could ask you a couple of questions now, please.

Moran: Obviously. We've all just--

Berg: Yeah, just to back up just a little bit. First of all, I think that is a great story. You belittle it but I think it's for the reason that you are attempting to belittle it, it makes it a really great story, frankly. But anyway, to catch up on a couple of details, is it my correct interpretation of the looking at the Moran Systems as not being a good name because Moran is similar to the word "moron?" Is that--?

Moran: Yeah. That's the point. Yes.

Berg: Yes. I thought so. I thought so. Because I hadn't flashed on it until she said that and I said, "Oh. It had to have been the fact that the American word moron, <laughs> you don't want to have a name like that. Also, just for clarity, I know that both of you are at the offices of your company, Dov, Grove Ventures. Could you let us know what town in Israel you're actually located at right now?"

Moran: Yeah. This is Tel Aviv. We are now in Tel Aviv.

Berg: Okay. You're in Tel Aviv, Israel. Great. Just wanted to clear that up. Also you had mentioned earlier about the rugged PC that you folks created when you were in either the Army or the Navy. I think it was the Army.

Moran: The Navy.

Berg: The Navy. The Navy, okay. Then were you aware of Grid Systems which started in 1979 and was also making rugged computers for the military in the United States?

Moran: Which one?

Berg: Grid, G-R-I-D--

Mergi: Yes.

Moran: Yeah, of course. Of course we knew Grid.

Mergi: Of course.

Moran: Of course, yeah. There was Grid in the United States. There was another company, Kontron, in Germany that did the military computers. But of course, ours was much better and we were a PC from the first day because we said, "Hey, everything is PC. We knew-- By the way, mostly Aryeh knew, understood the architecture of the PC really from the BIOS of the software up to any component within the PC. So, we could actually do something which emulated the PC, which could be constructed from other components and things like that. Yeah.

Fairbairn: Well, were you actually familiar with the Grid systems? I mean, was it truly superior? I mean, based on your first knowledge or what are you basing that on?

Moran: I don't remember. We thought that this is, right, this is the way that we have a superior solution. But everybody thinks so. But I could tell you something which is quite-- I think it's amazing. When Tadiran came to us to do the smaller version, they said actually, we need a small hand-held terminal. This is what the Marines wanted. But it had to be something that you can hold in your hand. It cannot be a real PC it should be terminal for communication. And by the way, they said we are going on a bid and we have four months from now to present the product. And if you can't do it in four months, there is no project because we are late. We have to show a real working project. So I remember meeting Aryeh and saying, "Hey, can we do this project building a full terminal with software, with messaging, sending messages, even getting approvals on the messaging, with a list of contacts? Can we do all of it in four months?" And Aryeh said, "We can do it if we do it on a PC because we can develop the PC, the software in parallel. And if we make this terminal actually as a handheld PC, we can just make it work with-- by the way we had many, many tools to develop software quite fast. So, we practically developed a handheld PC back in 1987. This was the first handheld PC in the market, with a full system of communication, emails, approvals--

Mergi: Yeah, with all application software.

Moran: All application. We made an effort of four months. By the way, can you guess how much money we got from it from Tadiran? How much money do you think we got?

Fairbairn: For the development of the project?

Moran: The whole project.

Berg: \$75,000 dollars.

Moran: You're good. You're f**cking good. The truth, we do, we charge \$32,000 dollars and the idea was that we will get \$16,000 dollars for the project and if we succeed to bring it exactly in four months, we get

a bonus of \$16,000 dollars. And, yeah, we worked very much, we got the whole \$32,000 dollars for making the first handheld PC terminal. We were so stupid that we didn't think that we can take this market to commercial, that there will be other people that will be interested. For nothing; it didn't occur in our mind. I know it sounds to you, hey, these guys were really stupid and you are correct. We were. Business-wise, we had no clue about our capabilities, intentions, ideas and how good they are. We wanted to survive practically.

Berg: Now was this-- Was this actually an IBM PC compatible computer?

Moran: Yeah.

Berg: Or just a personal computer of your own design?

Moran: Oh, no. This was a PC compatible terminal, clearly small screen, not a full screen. Keys that you could hit. With communication capabilities. You could connect it to a radio. You could connect it so to wire. Remember?

Mergi: Mm-hmm.

Berg: So you could boot-- You could boot MS-DOS on that computer?

Moran: Yeah, of course. MS-DOS.

Mergi: It was running MS--

Berg: And here's another question because with the Grid computers, you could throw them out of a helicopter and they would survive.

Moran: That's the point. Right to the point. Yeah, these--

Berg: So you could actually throw them out of a helicopter?

Moran: Yeah. Absolutely. Yes.

Berg: Ah. Okay. Well, that's kind of the test that they had.

Mergi: <laughs>

Berg: Very good. So, did you have something you wanted to enter in there, right, Doug?

Fairbairn: Yeah. So, this was the first product that M-Systems developed, is that correct?

Mergi: It actually was pre- the M-Systems day, right?

Moran: This was pre- M-Systems. So before M-Systems was established. The idea is that we got this project from Miltope and Miltope said, "We want you to develop Solid State Devices for us. We will sell it of course as your distributor.. And it has to be actually a replacement to militarized tape that they wanted us to emulate using flash."

Berg: Wait a minute. Yeah, hold on. I think I'm a little bit mixed up. So 1987, you're working on-- with the Navy developing this compatible IBM compatible computer.

Moran: Yeah.

Berg: Now you've switched to what led up to the formation of M-Systems. So I think we just--

Moran: That's right. So until 1986 till January 1989, I'm doing projects. We are doing projects. We are developing this handheld terminal. End of 1987, I fly to New York. I meet Miltope. A year later, the CEO of Miltope says, "Take money. \$300,000 dollars. Make us a-- Bring to us this product you are talking about of the solid-state drives with--" Initially I was talking about RAM with batteries and then flash, flash memory-based product. This was, again, end of 1988 while the company practically was established on the papers officially on January 1, 1989. That's the history.

Berg: Is there anything you want-- Did you want to catch up? Go ahead, Doug.

Fairbairn: When did you develop this portable PC, this handheld PC?

Mergi: 1987 probably.

Moran: 1987. 1987, yeah.

Fairbairn: Okay.

Mergi: Well, we developed actually a PC-- a militarized PC in 19--

Moran: '86.

Mergi: I think before, even.

Moran: '85-'86.

Mergi: Yeah, '85.

Moran: '85 I just left the Navy in the middle of '85.

Mergi: Yeah. I think it was, like, in parallel to, you know, if you remember at the time Compaq started building PC compatible devices.

Fairbairn: Yes, yes.

Mergi: IBM actually published the reference book for the PC.

Berg: Right.

Mergi: Which included the circuitry and everything and companies started copying it. But in trying to do military computers with it, you couldn't use standard screens. So, we actually took a plasma screen and emulated the way that the screens worked.

Moran: Right.

Mergi: We did the same for hard disks, initially with static RAM and then with E², static RAM with the battery and then E²PROM that were at the time. So we had a lot of projects around it at the time.

Berg: Did you write any BIOS code? Did you write your own BIOS code?

Moran: Yeah.

Mergi: Oh, we actually rewrote the BIOS.

Moran: We rewrote the BIOS.

Mergi: We rewrote the BIOS—

Moran: Guys, all of it an effort of less than 10 people with unfunded company. At some time, I had a loan. I mean, I paid the salaries from my own account as I told you. And clearly, I wasn't rich. I didn't have money. So, the bank gave me loans and lucky for me, the bank, I had to put something against the loan and I put my apartment. And at some time, the size of the loan was several times larger than the value of my apartment. I was living in an apartment, not even a house. And luckily, no one at the bank paid attention to that so we could actually survive until we got this money from Miltope. Yeah. But this was the story.

Fairbairn: So once you had completed, you had the non-volatile drive. You had the portable PC or the yeah, the handheld PC, what was the next major development or product?

Berg: So the handheld was with this earlier entity and now we have switched gears to M-Systems with--

Mergi: At this time, yeah.

Moran: January 1, 1989.

Fairbairn: Yeah.

Mergi: So at that time we had some commitment to Miltope, and the initial product that they wanted was, like, a tape emulation type of SSD and SSD that would replace tape devices that they had many customers in the U.S. Army for. And we told them, we will do that, but we feel that there is an advantage doing something similar with SCSI interface because this will give us a broader market. And with the serial interface that they also had some need for that. So that like was our initial commitment to them.

Moran: Three projects.

Mergi: Three projects and we had this \$300,000 dollars that Dov talked about. By the way, a few years after I read that SanDisk raised in their initial days, \$50 million dollars. Yeah.

Moran: Five-zero.

Mergi: Five-zero million, yeah.

Moran: Oh, \$25, I think.

Mergi: \$25 million dollars, okay.

Moran: Yeah.

Mergi: So \$25 was after.

Moran: <laughs>

Berg: So the fact that it was initially a tape emulation, that actually made it much, much simpler than a disk emulation because you could write serially.

Mergi: That's right.

Moran: Yes and no....

Berg: And not have to worry about the flash wearing out.

Mergi: You're right.

Berg: Right. So that's actually-- It's actually a great start because that allowed you to get that working before you entered into the complexities of emulating a disk drive.

Mergi: That's right. That's right and that's--

Moran: Right. But we developed all these projects, actually in parallel.

Mergi: Yeah. We had to be seeking--

Moran: We did all the tape and then we were struggling with all these three at the same time.

Mergi: Yeah. But I think that Brian is right in regard to when we arrived to delivering the SCSI drive.

Fairbairn: Yeah.

Mergi: We saw that our algorithms are not perfect, are not optimal. And we tried to find a solution and we couldn't find a solution, actually. And at that point, Dov told me that he has this friend from the Technion, this genius friend that has, like, grades of A-plus. He really, really was a genius and we should bring him. And I said okay and we brought him. And actually, Amir was the one that came up with the TrueFFS solution which eventually became FTL that is the basis of flash management even today. <laughs>

Moran: Even today, funny. I must tell you a story. So we are talking about Intel components and we are developing our hard disk based on-- or disk emulation based on flash from Intel. And there's a story that Eli Harari, which I love and adore and he's an amazing person and an amazing friend. Eli these days established his company, and Eli came from silicon. As a silicon guy, he said, "I want to develop the flash. And, yeah, I'll take flash components and I'll make out of them a full hard disk." And Eli because he knew how to make flash, we didn't know how to make flash, Eli said, "I am going to make a hard disk where every sector of the disk.... A disk works on sectors. So, I'll make a flash where every block will be one sector." Now a sector is small, 512 bytes. So, the meaning is having very, very small blocks, many of them. Now clearly, every block has overhead. You go there, you create, you need a huge extra of hardware and there are many, many other issues related to that.

And the funny story of Eli is that about this time he is negotiating getting a nice check from Sequoia and Intel comes with the announcement of "we have flash." So Eli goes to a meeting at Sequoia and Sequoia are telling him, "Hey, why do you have to develop flash? There is flash from Intel." But his heart is with silicon, with developing the flash. The system is something else. He wants to develop flash memory. So he goes, he tells them, "Listen, it's impossible to make a hard drive emulation using the regular Intel flash." And they say, "Go and check it." He goes home. He writes a document of 20 pages, goes back to Sequoia and in his document that he presents to them, it says it is impossible to make a solid-state drive using Intel flash. Very, very good arguments, whatever. And they are convinced. He convinced them. He's an amazing convincer, Eli. And they give him a check.

And he begins his company. And per his story, a few months later he hears about these stupid guys from Israel that are actually buying regular flash component from Intel and create from them flash memory-- sorry, solid state drive. So Eli's story was, you know: "when I saw, when I learned about you and what you are doing, I was very concerned that my board, my investors would come to me with this paper that I proved that it's impossible and say, "Hey, what's that? What this company's doing?""", He said, "Luckily you were so quiet no one heard about you for several years and when they heard about you it was already too late, yeah. And we were on our way and we did fine."

But yeah, we were, we came with the idea, we used regular flash to do solid state drives, and we were very, very quiet and very, very, you know, we truly were very bad in publishing, in marketing, raising money, whatever.

Berg: Yeah. I think a key differentiator that we should bring up indeed between what Intel had and what Eli Harari was developing at SanDisk was the fact that he put metadata on board his flash memory and that metadata would allow for the management of the flash to know how many times it's been erased and to allow the remapping so that when the flash wears out, it's easy based on the on-board metadata to manage it. What you did it--

Moran: I have a big smile on my face.

Mergi: Okay.

Berg: Yeah. What you did is--

Berg: Right. Is you were aware of indeed, the shortcomings of the Intel flash. Because it was basically meant to be a code storage medium.

Moran: That's right. Yeah.

Berg: They were so in bed with the idea of the EPROM that had been so successful with, Dov, Frohman's invention of 1971, that they had this mindset of code storage. But Eli had the mindset of data storage like you did. But he was able to get the money to develop new flash to perform that most easily. What you had to do is you had to write a "kludge" to allow the Intel flash to be able to do the same functionality by way of your flash file system, which was additional software to manage the flash.

Mergi: Interestingly enough, I don't know if this was intentional or not, but Intel flash was really efficient in the cell size, because it had large blocks and it had, it didn't have a lot of overhead. And SanDisk or Eli when they developed their flash, they tried to build this to very small blocks and to actually emulate the way that hard disks worked.

Moran: Physical.

Mergi: Yeah, the physical structure of a hard disk. So they had an area for metadata the same way that hard disk had, right. And this made their flash less efficient. And they thought that the Intel flash couldn't have been made to work as an SSD. And I think that the TrueFFS proved differently and that was, you know, the algorithms that Amir Ban developed.

Berg: Right. So you're kind of the happy medium between the two. You were able to take advantage of the efficiency of the large block size, with the additional overhead of the software to manage it. And he had to end up rearchitecting his system to increase the block size for efficiency at a later time.

Moran: And at some time he did a very, very smart thing.

Mergi: Yeah, he moved--

Moran: He moved to Toshiba component. Which by the way, it's part of his greatness. And really, I'm talking about greatness because he put so much money into developing his own flash, NOR flash. And, you know, he did something which very, very few people that I know would do. He said, "Okay. There is a good solution for me from Toshiba. I'll throw away my development or part of it, the flash part of it, and I'll move to actually partnership with Toshiba to make-- to use the Toshiba NAND component and make out of them a SSD--" And this was several years after we did this move from NOR flash from Intel into the NAND flash of Toshiba/Samsung.

I still accuse myself; I do remember one time I went to California and I met Eli and he took-- I remember he took me in his car to meet somewhere and on the way he says, "Hey, Dov. How are you doing?" And I said, "Hey, we are doing great. You know, we use actually these components from Toshiba. Unbelievable! Fifty times faster than Intel in write. Maybe a bit slow in read, but it doesn't matter. It's still very, very fast in read." And he said, "Yeah, but, you know, how is working with Toshiba?" I said, "Great. Wonderful guys." I really loved the guys. And I accuse myself as one of the guys that really pushed him to move into Toshiba. I'm joking, yeah. But yeah, Eli did the shift from their NOR flash into NAND-- We just didn't have the choice. We could not build our own flash. We didn't have the money. We didn't have the knowledge to do that.

Mergi: Yeah.

Moran: And by the way, one more thing. If you look at the names of the companies, SanDisk, SanDisk came from sand-- sand. Silicon components. We were the M-Systems. We were the systems guys. We truly understood very, very well the systems. Well, this is the PC in the first days of M-Systems dealing with disk emulations or later on when we talk about mobile with our mobile DiskOnChip, which created huge success at this market. So we were the system guys and SanDisk were more at the silicon side.

Fairbairn: So, given these two paths to a similar solution, is it the case that either one could replace the other or one was strong in one area and the other was strong in the other area?

Moran: Yes, of course. PCMCIA cards! That's a PCMCIA card! [Holds Flash cards up to camera] And then this one has the TrueFFS in it. We actually at some time moved to do PCMCIA cards. Now this is another story related to flash and standards. So we came up with TrueFFS. Why is it TrueFFS? FFS stands for flash file system. Now practically, we didn't do a flash file system, we did a disk emulation, not at the file level but at the sector level.

But in these days, Intel and Microsoft came together to bring software to enable the emulation. And they called the software FFS1 then came second generation which was FFS2. And this was actually emulation at the file level. I'm not talking about sector or record, I'm talking file. You could actually write a file, erase a file. You could not open a file of contacts and just change the contact. You could erase the previous file

and write a new one, but that's the level of emulation they have done which we thought this is very, very bad.

We did a true emulation of a hard disk at the sector level. So first we gave our software a name, which was a terrible name, TrueFFS, means they have FFS, hey, we have a true one. Very stupid, I do admit as well. But clearly, we had a much, much better solution compared to Intel Microsoft, and we began to promote actually what we offered, this new standard to the PCMCIA Committee. And one of the things which I think was done very well by us, I sent Aryeh to California for one year to establish our TrueFFS or FTL [Flash Translation Layer, the official name of the PCMCIA committee] as the standard versus the flash file system. By the way, if we hadn't done that, I do believe that the whole industry of flash emulation using flash as a disk or storage would go-- would be very different because if Intel Microsoft solution would become a standard, this would be bad. It's like the 64 kilobytes of the PC that if you remember, we suffered many, many years from the fact that DOS recognized only 64 kilobytes [and SW requiring more than 64K needed virtualization and swapping and many other limitations].

So Aryeh went to California and he did a I would say a miracle of-- And can I say it? It's okay? It's a miracle of convincing the committee, the PCMCIA Committee, the IEEE Committee or PCMCIA Committee, to actually not to adopt the Intel Microsoft solution but to adopt ours. Hey, we were small guys, small company, non-funded company from Tel Aviv fighting, yes, Intel Microsoft and we are winning. You have no idea how big it was. It's like some stupid company would come today with solution against Facebook and Google and win it. And because WinTel, the Microsoft Intel combination was so strong these days you can't imagine winning against. We won. Almost won. But then came the extra counter that SanDisk had in their flash memory. What we have done in TrueFFS, we actually had a counter that every time we erased a block, we erased the counter, for leveling purposing.

And the night before we had to actually get the support of the Committee, the voting to support our standard, SanDisk, which by the way, it's not an accusation. I do think that they have done what they had to do business-wise and that's fine. They sent a letter to all the members of the Committee stating that this algorithm, the TrueFFS, is infringing their patent on a counter. Now it seems very, very strange. How can you file a patent on a counter? Hey, you didn't invent a counter—No! They claimed that they have a "patented counter". And by the way, it never went to court. I think that if they would go to court they may lose, but what happened in this suit then is that the Committee members said, "We're not going to vote. Guys, you solve the problem between you." We went back to SanDisk and said, "Guys, it's a counter. Everybody knows about counters. Why do you think you have a patent on a counter?" "Because we think so. That's good enough for us." This was their answer.

What we have done, we actually made a change in the algorithm and instead of doing a counter, we did something related to randomizing stuff so we'll get, wear leveling, maybe not optimize wear leveling but good enough to actually pass and we passed the standard.

Berg: Yeah.

Moran: But this took a year. And in this year, the PCMCIA cards of SanDisk with the IDE interface-- IDE?

Berg: Yeah.

Mergi: ATA.

Moran: Actually, became very common, so they became with their solution THE standard and we, when we came and made this solution, full solution. We had the software without a need in a controller -- just memory, this was a solution with no CPU... no controller, just memory, the software is in the PC. Great solution but this was too late and SanDisk became, like, a standard in this market so they won this market of cards. And that's part of life.

Berg: So what years are we talking about here? You've identified some--

Moran: 1994.

Mergi: 1993-4.

Moran: Yeah, I think end of '93, maybe 1994. Maybe beginning of '95, even.

Mergi: Yeah.

Moran: That's-- And by the way, there is something in business, you know, sometimes you lose something, you gain out of the loss. Because the fact that we lost, so we lost the card race. We lost because SanDisk did an amazing job establishing themselves as standard. Then they went into smaller versions of their PCMCIA cards, they switched, and then they had the CompactFlash, and then they went to MMC together with Hitachi and Panasonic, I think. And then they went to SD together with-- Oh, no. This was Panasonic and Toshiba and then of course miniSD and the microSD and all the rest. And we lost this race. But sometimes losing in one place enforce you to become the winner at another place.

We worked with Intel. Intel guys, reality and, yeah, I'll say it, you know, if you ask for honesty. Intel was, these days, of course, was very full of themselves. They looked at us as "who are these guys?", you know-- Initially when we came with the idea of the solid-state drive based on flash, I do remember going to meet Intel guys, even Dov Frohman, and they said, "Guys, totally mistake. Forget about it. Our flash is good. It's not data. Forget it. We have a solution for data we can't tell you about." Yeah. And then, you know, PCMCIA cards, we were their partners because of our SW support, they had cards. We bought components from them. We built our own cards. The bastards-- excuse me for the word-- sold us the components for a higher price than the price of the PCMCIA cards. We said, "How come?" They said, "That's another division and they buy in large quantities."

So it was very difficult for us to team with Intel. And I think that Intel made a huge mistake not really working with us helping us. And, yeah, at some time we had some closer cooperation when they tried to make the smaller cards-- what was the name? Miniature Card?

Mergi: Yeah. Miniature Card or MiniCard or something like that.

Moran: Miniature Card. MiniCard. Miniature Card for the officially named, they called it. They only said, "Hey, guys, you do software. You do amazing software. Let's work together." But even working together then, we clearly want to work together, this took us about four years to do that. It was too late. We lost the card business. Said, okay, we are not good in cards. Let's move ahead. Where can we go? We can do embedded. We have a solution that actually for embedded can be very, very good. And that's going to--

Berg: If I could interrupt for a second here. You've covered a lot of ground. And I actually want to help answer the question that Doug asked a few minutes ago. So which was better, the Intel approach or the SanDisk approach? And I think actually you came up with a really good example of that difference and how the SanDisk approach ended up being superior. And that was by virtue of the fact that you had developed this software that would allow the PCMCIA card to operate, but it required software that would be loaded first in the computer to make it work. But what SanDisk did is they developed their version that was able to use this metadata embedded in the flash so that they could plug their card in without needing an extra driver in the host. So I think that the bottom line showing the superiority of the SanDisk approach and what it took to make the Intel approach work. But we also covered a whole lot of ground there. So I think what it came down to is PCMCIA cards that are disk emulation devices, the ones that were not officially sanctioned by the PCMCIA organization, maybe you can correct me on this, but they didn't require extra software so they became at least the de facto standard because you could just plug them in and they'd work.

Mergi: Well, our solution actually because many of the systems had their own software. It wasn't like standard PC that you just buy at the store. The software issue wasn't such a big issue. It was, but every customer that we had, and we had many customers at the time, could install our software because it was systems that they were selling and they in any way installed their software inside. It wasn't like standard general-purpose devices. And the whole intention of the PCMCIA Committee was to standardize on it and then to have the TrueFFS driver or the FFS driver shipped together with the Microsoft Operating Systems. And when Microsoft and Intel actually lost to us in the standard battle, then they came to us and said, "Okay, let's do a partnership and let's work together with you." And then our partnership started and we did I think it I think was a few years of partnership together with Intel. But as Dov said, I think that Intel was not fully--

Moran: Committed.

Mergi: Committed to this partnership. And I think that this caused both Intel and us to lose the first wave of cards in the market. I think the main design there was, like, for the camera of the future and I think that SanDisk won Kodak and Canon, I think it was. And when they won Kodak and Canon, we came back and we said, "Okay, we have revenues, but we are not succeeding in cards." We had Maxtor as a partner to distribute our cards and so on, but it wasn't enough. And then we decided to focus on the embedded market. That was very different. It was a smaller market, less flashy in a way, but it was really a good market and this is the market that took us to the next step in a way.

Fairbairn: Tell me about the products and the applications that you describe in the embedded market. What exactly are you referring to?

Mergi: Well, at the time Dov had a meeting I think with a customer and he came back with the idea because this customer didn't have a PCMCIA slot, but they did have the BIOS in their system. It was, what's the name of the company? Amper... or something like this.

Moran: Ample--?

Mergi: Ampro, right.

Berg: Ampro, yes.

Moran: Great guys, yeah.

Mergi: And he came, and he said, "What if we'll do like an SSD that will replace the BIOS, we'll combine the BIOS and the SSD." And we said, "Yeah, we can do that. That's a great idea." And we said, "Yeah and we can call this the DiskOnChip."

Moran: Somebody came to me and he asked me, "can you do it." I said, "Of course we can do it." You know, and then I went to Aryeh because I knew Aryeh can do everything, yes. This was very simple. I said, "yes, we can do it," DiskOnChip.

Fairbairn: It contained BIOS and data storage?

Moran: Yeah.

Mergi: Yeah.

Moran: The same chip.

Berg: Right. And of course, when you're in an embedded environment you have the luxury of being able to define everything you need. Integrate capabilities that you needed right into the BIOS of an embedded system and that would allow everybody else who is developing on top of that platform to not worry about other drivers or other things. So, you know, they could be more easily integrated. So, it's interesting to go back to the Miltope days because that was a military application, and so could you describe how much the military applications helped you over the years?

Moran: Well, initially we began doing this SCSI hard disk because that's what the customer, the partner wanted us to do. Clearly, we learned a lot by doing the devices. We even had a great project with-- By the way, the first product we sold was to submarines, cartridges of how much was it?

Mergi: I think 640K bytes, like.

Moran: 600 and how much? 640 kilobytes, yeah.

Mergi: Right, yeah.

Moran: 640 kilobytes. And it was, wow, an amazing project. And we had later on a project, a military project supplying SCSI hard drives, hard drives to a project for helicopters.

Mergi: Yeah.

Moran: Remember? What was the name?

Mergi: I forget.

Moran: But, yeah, we learned. This was our way to learn. We did all these projects. We did that-- We went deeply into the flash, the capabilities, what can be done system-wise, and practically played many, many games and clearly understood whatever we had to understand. Until one day, we got to see, there was an announcement of the NAND flash by Samsung and Toshiba, and this was a breakthrough. We tested these components. They were wow. So much faster. So more density. And by the way, this was from people who wanted to sell and not by people giving us, making us a favor if they allocate for us 10,000 components, which was the Intel treatment these days. By the way, if you want to hear one of the great stories about how the history could be changed, shall I tell you the history of flash?

Fairbairn: Yes.

Moran: I think it's the biggest story of flash ever and I take the blame of the-- of me, of this for not to happen. So, the story is that actually Toshiba was the one who invented flash in general and they were working on NAND flash and Samsung actually did a license from them, and came to the market. And what happened is that they bought, they went to the States and there was a player in the States, SanDisk. And SanDisk claimed that Samsung with their components are infringing their patent.

Berg: What year was this now?

Moran: I'm talking 1995.

Mergi: 1996, I think. '95?

Moran: 1995. Yeah. 1995. I know. And okay, by the way, you should ask yourself which kind of patents? Because remember, SanDisk is developing NOR flash, okay. Controller in the-- By the way, we didn't have controller here, only flash. Software is controlling everything. And SanDisk it's a NOR flash, very complex, as NOR is, small blocks and Samsung comes with NAND and SanDisk comes with the claim.

And the ITC in the States actually is ruling against Samsung and telling Samsung that they cannot actually sell their components in the States. Now these days Toshiba was not really still, not active yet selling. I tried to go to Toshiba, too early for them. We converted our products to NAND from Samsung. And I built very good relations with Samsung. And one day they tell us, "Guys, we can't sell you any more

of the flash because you cannot sell anything in the States based on our flash. We are not allowed to sell in the States. You are not allowed as well." Hey. We just moved all of our product line, the DiskOnChip and, you know, PC/SSD.

Mergi: Yeah.

Moran: We had a board sitting on a PC that functioned like a hard disk based on flash [This was the PC/SSD]. We moved everything to NAND. We are very eager to get it to the market. Amazing performance. Everything is great. I go to Korea to meet with Samsung. Now if you remember, in 1995, Samsung went through a very, very severe business issue. They almost went bankruptcy. Go back to the days of 1995, Samsung as a whole company goes through-- except for electronics-- goes almost to bankruptcy. And I go to meet the guys there and I say, "Guys, what can I do?" They say, "Listen, you should try buy fro Toshiba" but I know they're not selling, and they won't be able to sell as well. I said, "Maybe you can sell us components. We'll put them with no name, you know" They said, "No, no, no. This is cheating." We are not cheating. Of course, we are not cheating. They are not cheating. We can't do that.

So, then I had an idea and these days, Intel and SanDisk had cross-license. That's the reason that the Intel that SanDisk never sued Intel and vice versa. So, I said, "Listen, I have an idea. Your parts are much, much better than the Intel NOR flash. How about Intel buys the flash division of Samsung and then they don't have any restriction because they have cross-licensed with SanDisk. So, then they can sell NAND flash easily in the States anywhere." They said it's a good idea. I said, "Okay. I know the guy running Intel Flash, Bill Howe, and I can talk to him." They said, "Okay." "So, in order to go and talk to him, I need to hear how much would you like to charge for that?" And they said, "Oh, we need some time. Anyway, wait for us here few hours. We'll go to a discussion. We'll come back to you with a number of selling the Flash Division, Samsung Flash Division. All of it, yes, all business. Sell it to Intel." I wait. I wait a few hours, they came back to me.

Hey, Brian, you are great in guessing numbers. How much money did they want for the NAND flash?

Fairbairn: No idea.

Berg: \$40 million?

Moran: No. This was too low.

Berg: No. \$550 million?

Moran: \$200 million. This was the number. Okay, I said, "Guys, next week I'm going to the States. I'm going to ask to meet Bill Howe. I'll ask for a meeting and I'll--" I went to the States. I went to meet Bill Howe. By the way, he is a very nice person, but it was maybe the culture of Intel these days and not Bill Howe per se. But I went to meet him, and I did a terrible job because I think that if I would know then what

I know today, I would prepare him ahead of time. I would make a presentation. I would come with data that showed that the NAND from Samsung is so much better than the NOR flash.

But I came very, very —immature, this was 1995. And I went to meet him, and I told him, "I have this opportunity for you really, it's amazing opportunity for Intel." And he said, "Hey. Why do you think it's so good?" I said, "Hey. Performance, 50 times faster in write." He said, "No, no, no, no. Listen. Most of the times flash is written once. It is used for read. Writing is rare. So what's really matter is the read speed. And we are faster by 10 percent." I said, "Hey. The price, much, much lower than your price per megabyte." He said, "Hey. You don't understand. Price is something we dictate. We are Intel. And if we want to lower the price, the next time we take it on to a lower geometry, our price is going to be lower or worst case equal to their price. That's not an issue."

But what he forgot is that when he takes it to the next geometry generation of a fab, then Samsung and Toshiba will do it as well. They always were in a very low price compared at cost per megabyte. So, I said what I said, and then he said, "Dov, go back to Israel. If you want a recommendation from me, go convert all your product back to NOR flash, and you do business in buying the Intel amazing flash components". Which, of course, it didn't happen. I could change history. I was stupid enough not to do that. But clearly, the whole-- if you see, today, what would happen if you-- 1995, Intel would buy the Flash business from Samsung, the whole history of Flash, mobile-- many industries could be very, very different. Didn't happen.

Fairbairn: Great story, thank you very much.

Berg: So, just to be clear, this came from an International Trade Commission exclusion order?

Moran: Yeah, after a year-- after less than a year, Samsung and SanDisk got into agreement, and Samsung actually--

Mergi: Paid SanDisk--

Moran: Paid a lot of money over the years as a licensee. And that resolved the whole issue.

Berg: Wait, so that situation was only existing for about a year, you're saying.

Mergi: Oh yeah, even less than a year, yes.

Berg: Got you. And so, what happened with your design for using the NAND flash? Did it just get delayed for your ability to sell it?

Moran: It was delayed, yeah, this was delayed. Unfortunately, yes. It was very painful, but it was delayed. We continued to sell products with NOR flash, but finally, they resolved it, and we could go to the market with our NAND-based solutions.

Berg: And how good was that NAND flash, initially? Was it reliable?

Moran: Amazing.

Mergi: It was significantly better. It was significantly better. And, you know, you asked, what did the army and the army militarized project gave us. I think, at the time, it gave us the sense of the reliability that is needed from those components. And the only problem that NAND flash had, at the time, it was less reliable on the device level than NOR component. So this is where we got in with our technology, we solved the reliability problems of NAND both in software and the error detection and correction codes, and some other technologies there. And we implemented-- I think the first project was on a PCMCIA-- was on the DiskOnChip?

Moran: DiskOnChip, yeah, DiskOnChip was the first one. Yeah.

Berg: So the first one was, can you repeat that again?

Mergi: Was the DiskOnChip.

Berg: The DiskOnChip.

Mergi: The first product that we converted from NOR to NAND -- we had already few generations of NOR, DiskOnChip. And then, at some point, we converted to NAND, and gave us huge advantages. It was significantly faster, significantly higher densities at a lower price than the NOR. So we just didn't look back. And once it worked in the first product, we converted all the other products to that one.

Berg: I remember seeing those devices at trade shows in the late-90s, early 2000s. I remember seeing a booth for M-Systems. No, actually, I think-- was it Miltope? [No, this was M-Systems]

Fairbairn: Let's move on. So, what was the next-- you talked about the DiskOnChip. Was the DiskOnKey the next product, or was that similar timeframe?

Moran: No, no, DiskOnKey came much later. DiskOnKey is an idea that came into my mind in 1998, and took us too much time to file a patent. We finally filed the patents at April of 1999. So, April of 1999. We brought the product to the market in 2000. So, the idea was, we have a DiskOnChip, which is the embedded solution, we have the DiskOnKey, which is the pluggable solution. No cards. Card is for-- is for SanDisk.

Fairbairn: And the DiskOnKey, is that similar to, or the same as, the USB product?

Mergi: Yeah. We gave it the name DiskOnKey. By the way this is one of our first-- those boxes... You can see DiskOnKey. [Holds it up to camera]

Fairbairn: Right, so out of focus there.

Moran: Right, I'll try it later on. So, anyway, this was the name we gave it in Israel, but in a very short time, we took a decision that selling it in retail is not the right solution for us. And what we have done, we decided to be the brand behind the brands. That's it-- that's the strategy we adopted. We gave it a name. And actually, what happened in a very short time, we began to sell it to IBM, Dell, HP, Memorex, Verbatim, Fuji Film, I-O DATA, Buffalo, even sometimes Best Buy had their own brands, Squad Team, and many, many others. The idea was that when you came to the Best Buy store and stood in front of the shelf with the many, many USB flash drives: Sony, HP, Verbatim, you would pick a product, they were all from us. This was the issue, yeah? Kingston, by the way. A basic partner, great guys. Love these guys. David Sun, great man that we actually convinced to enter the flash business.

Berg: So, to be clear, this was your device but being rebranded by all these different companies, is that correct?

Mergi: Yeah, exactly.

Moran: Yeah, we sell them the device that we built for them with their name. We made the design for them. Actually, one of the reasons there is no name-- and everybody calls it a different name -- Thumbdrive, memory drive, USB stick, USB flash drive, it's because we tried to let everybody have a differentiation. Different packages. Different structure, you know? Different sizes. For Kingston, for example, it always looked more rugged. It was always more ruggedized. Kingston's focus was selling to industry. And therefore, if you want a name, you want to call it memory stick, memory drive, call it whatever, that's fine. And so we are the guys to be blamed for the fact that there is no one, single name for USB flash drive in the market. We call it, generally, a USB flash drive. That's a general name.

Fairbairn: Did you-- SanDisk, of course, also has that product. Did you have a patent on it, or was there any restriction, or how did that happen, or what?

Moran: So, until 2000, or something like that--

Mergi: Right, took the--

Moran: The first few years of the company, we were so stupid. We filed very few patents. We began to file patents relatively late. We understood the patents are very, very important. I think not until 2000, overall, we had less than 20 patents. From 2000 to 2006, in six years, we filed over 200 patents, yeah? And yeah, we had a very, very strong patent for the USB flash drive, which went through courts and won.

And by the way, how do you file-- how do you really measure the strength of a patent? Only in one place. In the court. So we went through the courts several times, and we won in all of the courts except one place. We lost one case of the USB flash drive in a court taking place in Singapore with a company in Singapore-- doesn't matter the name. And they filed a patent four months after us. Their patent talks about the need for software in the computer. So, with the software they can read or write the content. We say no software, it's disk emulation. No one wants to install software. And they won in Singapore. But that's part of life. So, worldwide, I'm defined as the inventor of the USB flash drive. In Singapore, guys-- if

you go to Singapore, don't say that Dov Moran is the inventor. They say, no, no, no. Mr. XYZ, he's the inventor. And they are correct, by the way, because officially, in court, he won in Singapore. He's the inventor in Singapore. I took the rest of the world.

Fairbairn: So did SanDisk and others have to license that from you? Is that what happened?

Moran: Well, clearly, I spoke with Eli a lot about that. They didn't license from us. But Eli said, listen. We do have-- we have so many patents, that I am sure that, if we go over your products, you infringe several of them. So, let's play this game that I don't sue you, you don't sue us. We didn't sign any license agreement. I think that we didn't sign officially.

Mergi: We didn't sign the license agreement, but we went on to do joint partnership--

Moran: Cross-license, yeah.

Mergi: Yeah, on development. And around this, we signed--

Moran: Yeah, at some time-- and sometimes we did it for a joint development of something called-- we tried to file it for something called U3. It would enable actually booting from the device and having specific applications, U3. But before signing this agreement, practically, we never sued them, they never sued us.

Fairbairn: Okay. Before we move on to the next product, then, can you tell me-- can you size the size of the company M-Systems? From the beginning of '89, you had a small investment until 2000. How large did the company grow, and--

Moran: So, we were-- we actually went public before SanDisk. We went public back in 1993. I ordered this-- this is the prospectus, yeah? Prospectus. I'm trying to put it here.

Fairbairn: Yeah, it just isn't focusing. I think it's focused on Aryeh.

Moran: You know, prospectus, yeah. You know how prospectus look, generally?

Fairbairn: Yeah.

Moran: So, we went public in 1993, and raised huge amount of money. \$4 million. Nice. \$4 million on a valuation of \$11 million, pre-money.

Fairbairn: And this was in the United States, on NASDAQ?

Moran: Yeah, in NASDAQ, in NASDAQ, yeah. Crazy? Yeah, that's what we have done. Very, very immature but we got money to survive. We got money that allows us to really go and develop. And then raise money once again, this is 1996, we raised, I think, \$6 million, \$12 million-- and then, raised money in 2000. And all these years, we grew up the revenues. We grew from zero 'til 2000, our revenues were

\$90 million. And then came 2001. Boom. Everybody was crashing. We got our hit as well. \$45 million. But I think that, by then-- it took me a long time, but by then, we understood business. We understood how to raise money. We understood how to grow business. We understood B2B, and B2C, and B2B2C. And offices worldwide. And we grew the business from revenues of \$45 million in 2001-- this is 2001. It dropped from \$90 million to \$45 million. From \$45 million to over \$1 billion in the year 2006, when the company was acquired. If we would complete the full year of 2006-- as a company, we were acquired before the end of the year, we were reaching, according to the numbers we saw at the end, the level of \$1.08 billion. You know, who counts the 0.08? It's \$1 billion plus \$80 million, yeah? Which is an amazing growth, much higher, actually than SanDisk at this stage.

Fairbairn: So tell us about the major drivers in that period, 2000 to 2006. I believe you entered the cell phone market?

Moran: Yeah. So this counts-- we had the DiskOnChip, remember? Now, at some time, Aryeh and me looked at the market requirements. Now, in 1999, 2000, everybody was talking about Internet appliances. And I said that, I turned to Aryeh and say, I don't believe in this market. There is a lot of hype. And many are doing, you know, part of demos, and in small quantities, and some customers don't pay us. I hate it. And I don't really believe that Internet appliances is going to grow. We need to shift to mobile. And it wasn't easy, but I convinced Aryeh. And Aryeh, once he was convinced, said, okay, I'll take it upon myself. And he did an amazing job to actually find the first customer. Because we said, if you want to be there, we had to go with--

Mergi: Or before going-- okay, I want to really tell a story that is still coming from the DiskOnKey, the main two drivers that we had, during this amazing growth that Dov told about, was the DiskOnKey and the mobile DiskOnChip which was like our mobile product. But one of the stories that we had like in the early days. And I think that in every product, we had similar stories, is when we went and we tried to sell the DiskOnKey, the USB flash drive concept to the biggest PC vendors. And, initially, we had many hesitations, where some of them really liked the product, and some of them signed with us. The first one that signed was IBM, actually. We have a device from IBM on this. And-- but the story that I remember is pitching to one of the largest vendors in this market about the DiskOnKey, and seeing that he likes the product, and he likes us, and he's going to sign with us. And I was like pitching and saying-- you know, I was like getting away with myself, and saying, and this is going to replace the floppy drive, right? And if you remember that period, the floppy drive was like in every PC and every Notebook. And in Notebook, it was one of the biggest problems of Notebooks on reliability, on size, power consumptions. The density was very limited. So, for me, it was like an obvious statement. And it was like with the CEO of this company in the room. He stood up, and he came to me and tapped me on the shoulder, you know, you have a great product, and you are really nice people. But this will never replace the floppy disk drive. And I don't think that Apple was the first one to replace to the floppy drive-- and I think that two years after, this same company decided to remove floppy drives from all of their PCs. So it didn't take a long time for this to happen.

Moran: By the way, Doug, do you remember the name of the company who was the leading company in floppy drives?

Fairbairn: MiniScribe?

Moran: No, hey, I'm testing you now, guys.

Berg: Was it NEC?

Moran: TEAC, TEAC, T-E-A-C. Number one. The majority of the market was TEAC. Now-- TEAC. T-E-A-C. It's a Japanese company, nearby Tokyo somewhere. I tried to-- actually, since we were the floppy killers, I tried to go and have some cooperation with them. And I did go, actually, to meet the guy who was the CEO of the company. And we came, we sat about three hours, and everything they said went back to floppies. Okay, let's have a floppy with USB. Said, hey, it doesn't help. Let's have a-- okay, let's have a USB but a big connection to floppies. And after two-and-a-half hours where we couldn't find anything that we can do together.

I do remember it was in the evening, I went to the lobby with the CEO, and while we were waiting for the taxi to take us from there I spoke with him. He was very nice person, he looked at my eyes and said, "actually, Mr. Moran, Moran-san, I'm supposed to hate you, because my father established this company 70 years ago, and you are killing my company". I said, I was-- you know, I was suffering, because hey, I didn't come to kill anybody. I don't want to kill TEAC, and I do have amazing respect to these guys and to their technology and to their tradition. And I said, "Mr. CEO-San, I truly have no intention to kill your company, but you have to understand something. This is technology. And if you don't move forward with technology, you will find yourself with an obsolete product. And that's the situation". We didn't keep relations, but I see that they recovered. They still exist, by the way. I checked, not a long time ago. And I do hope that they are succeeding, or will succeed, finding their way.

Mergi: I think, getting back to Nokia and to the mobile DiskOnChip. As Dov said, we were focusing before on the Internet devices market. After the embedded market that we took over and actually led this market - but the embedded market was limited in size. It was like-- I think that we reached a revenue level of about \$50 million, \$60 million there with headwind of the bubble, in that period of time. And we said, okay, we need to go to a bigger market. And there was like the bubble then, at the time, and Internet devices looked like there's an extension of embedded devices. But when the bubble collapsed, we saw that there is no market in internet devices. And we looked at the flash market, and mobile phones started to become a very big market for NOR flash, mainly for code execution. And we thought that it can be-- that it can be a great application for SSDs. We saw that mobile are starting to get cameras inside, music. We thought that it can get to videos and of course apps, and we thought that it can be like a huge market for-- next market for SSDs. And the SSD market grew by markets. SanDisk took the camera market, and it--

Moran: They did an amazing job.

Mergi: Yeah, and it let them grow significantly. We lost it. And we thought, okay, this is like-- it's in infancy, and we can win this market. And we established the mobile division, and our guys tried to get to customers there, but it was really difficult for a company like us, that had tens of millions of dollars of revenues, to go to companies that are really in the-- I don't remember the exact numbers, but--

Moran: Many, many billions--

Mergi: Many, many billions of dollars of revenue, and make them their products, that they have to ship every quarter, dependent on an Israeli company that is so small. And then, we looked, and I took upon myself to go to Nokia, which was the largest player in this market. And it was a really long, difficult process. I think it took us more than a year to really convince us-- to really convince them to move to us. And we had like really many challenges there, similar stories, you know, some senior managers are telling us, you know, why do you need hundreds of megabytes in a mobile phone, right? Today you have 512 gigabytes, and probably going to higher numbers in the coming years.

But at the time, some really senior people were telling us, why do you need so much memory in a phone? And they had like those cost formulas, and they didn't believe that we can bring something that is lower cost than Intel. They actually believed more to Intel, of course, we can understand this. But we succeeded to convince Nokia to choose us for the first product. And it required a few significant innovations. One of them was a business innovation, where we allowed Toshiba and Samsung to also-- for Samsung, we didn't exactly allow it. It was like-- it was Toshiba, but Samsung, we closed our eyes and later did a partnership, and they paid us for this. And I think that this was like the entrance of SSDs and NAND into mobile phones.

And there was another, very big fight that was between us and SanDisk, actually. And this was whether the flash need to be a card or embedded. SanDisk came with the MMC card, and later with the SD card-- and that they tried to push to mobile phones. The SD card was too big, so they came with the micro SD. And then, in the early days, there was really a big debate, you know? Some companies had the slot, and some companies had the embedded flash. And in time, the companies that had the embedded flash grew more. And I think that it-- this was the right approach, you know? If you look at the future, at where we are now, things are developed-- there is no mobile phone that is shipping with a slot for memory cards.

Moran: They're shipping, but no one is putting any memory cards into them.

Mergi: Yeah, you know, the main one, Apple-- there is no slot.

Moran: But one more thing that I think was very, very important, you didn't mention, if I can--

Mergi: Yeah, sure.

Moran: One of the biggest advantages that we had in the DiskOnChip—actually. Intel was selling NOR flash. And the claim was, you need NOR flash, because you need to boot the phone. Otherwise, from where will you boot the system? And we came with, I believe, a very, very smart idea. By the way, very smart idea, which is not from me. This is Aryeh and these other guys, the other guys at M-Systems, really very smart guys, that actually say, we can do boot. We can boot from NAND. And how can we boot from NAND? We'll actually add into the flash, a little static RAM. And when the system goes on, we'll put the "Ready" signal down, so the CPU won't begin to boot, and then we'll copy very, very fast one block into

this RAM, and then, we'll release the Ready signal, so then the system, the CPU, will actually look at this RAM as if this is a NOR flash, or whatever, and we boot from that.

And this was what enabled, actually, us to provide a component which could be, at the same time, the same component for the code and the data. You could eliminate NOR flash. I believe that we caused Intel, with this solution, a damage-- annual damage of many, many, many billions of dollars a year, because if Intel would continue to sell NOR flash into the phone industry... You know, it's a billion units a year, whatever number, multiplied by \$5, \$6, \$8 per chip. And with what we have done, actually, we showed that, hey, you can take NAND flash, DiskOnChip, in this case, and practically do a boot from this component. Hey, guys, yeah, I do feel-- Intel are very, very close friends. I have many, many friends at Intel, then and now. And it's an amazing company, which I truly adore for what they've done, but I'm very proud of the fact that we actually enabled every phone-- even the one that you're holding until now in your hands, to have a better solution. Eliminating excess of cost that is not really required, having much more flexibility, and many other benefits.

Berg: Wait, so a key point we can make here is the fact that NAND flash does not allow execute in place, while NOR flash does. So that was a key differentiator. So that was certainly Intel's argument for needing the NOR flash. But what you just described was pulling the first few sectors out of the NAND flash and executing it in RAM, is the key differentiator. An important thing to mention and put on the record here is I believe that the first Nokia phones that had your NAND flash in it was shipped in 2002? Is that accurate, time-wise?

Mergi: Yes.

Moran: Nokia 9000, no?

Mergi: Yes. 9000 series. I think it was--

Moran: 9000. This was the high end of Nokia phones, that you could open, actually, like a small notebook, yeah.

Berg: A flip phone?

Mergi: Yeah, yeah.

Berg: Flip phone. Right. But indeed, 2002 was the year?

Mergi: Yeah.

Fairbairn: So, it was this DiskOnChip application in the phone, and your DiskOnKey products, that really drove your revenue from \$45 million to \$1 billion in that 2000, 2006 timeframe? Is that correct?

Moran: Yeah.

Mergi: That's correct.

Moran: But what happened in the company, at least there is-- I did begin to understand much better how to run companies. I divided the company into four divisions. So we had four divisions. And every couple of years, I merged two divisions and I opened a new one. There was always, always a change. There was the thing we used to say that the only constant thing at M-Systems is the change. And when the company was acquired, there were four divisions. One dealing with the mobile market, DiskOnChip, mobile DiskOnChip, second one dealing with the USB flash drives. There was a third one which was dealing, actually, with, I believe, amazing idea that didn't really happen, but dealing with security. We said, hey, storage will require security. We opened, actually, a department that dealt with security. And these guys actually got into the idea that they can put flash into SIM card. And then, using the SIM, this would be a secured flash. And practically, this will eliminate the usage-- the need in cards, whatsoever, and even its memory inside.

So you can take the SIM card and move it from one phone to another. And then you move, actually, all the applications with you. Unfortunately, this didn't happen, because SanDisk acquired the company before we got the-- before the product was in the market. We did have agreement with a company called Gemalto, which is the leading company in SIM cards. But SanDisk was not interested to pursue it, because the claim was, hey, this is against our memory cards. They were right. We said it-- this was counter to memory cards of SanDisk. And they actually stopped this project, that actually died.

There was a fourth division. Both Aryeh and me were very high believers in solid-state drives. And we said, this is from the beginning, one day, solid-state drive will be there. Everything will be solid-state drive. Maybe, you know, very high capacities, servers, will use conventional disks, but solid-state drives are going to take the market of Notebooks and whatever. And this division, actually, when we were acquired in 2006, we weren't just the largest supplier of solid-state drives in the market. We were the majority of the market suppliers of solid-state drives, selling to Dell, IBM, HP. They were buying only from us, solid-state drives.

Unofficially-- SanDisk was not a great believer of solid-state drives. SanDisk began with solid-state drives, and they had their own bad experience of selling solid-state drives. And when the company was acquired, Eli told me "I don't think SSDs are going to be really a large business". And I said, "Eli, this is a large-- it's not a large business yet. It's only about \$100 million today, but this is going to grow". I do understand why Eli was thinking so. You buy a company, and there is a lot of complexity in the merger, and many activities, and mobile - which they were not in mobile; we were in mobile - the whole issue of the solid-state drives at SanDisk was pushed down. Pushed down in a way that they didn't really pay enough attention to that. And basically, the combination of M-Systems, SanDisk lost the leadership to other companies. Then when SanDisk tried to get back into the market of solid-state drives, it cost them a fortune, and they-- up to now, I'm not sure that they do have a leadership position in this market, while it could be theirs.

Fairbairn: So, tell us about how the acquisition came about. How did the conversation start, and what were the driving forces in leading up to 2006?

Moran: So, over the years, the first time Eli and me met was the summer of 1993, around this time, yeah, when we tried to bring the PCMCIA standard, before Aryeh went to the States. We used to meet from time to time. Most of the time, when I went to the States, whenever he came to Israel-- he used to come to Israel quite often. We always used to meet when he came Israel, at the same place, Dan Hotel in Tel Aviv. We always ordered cheesecake, because he liked cheesecake, their cheesecake and I like it too. And from time to time, the issue of, how about we acquire you, came up from him, from Eli, which I said NO again and again. He's an amazing person. Until today, I see him as a great innovator, entrepreneur and mensch. And Eli said, Dov, you know, we are competing. How about merging? And I said, you know, Eli, I think that-- I truly believe in the potential of our company, and we're not really competing head to head. If you understand, over the years, they went to cards, we went to embedded. They went to micro SDs, we went to USB flash drive. They went to cameras, we believed in the mobile market. It wasn't really head to head. We didn't hate each other. We were competing. I think the competition was, most of the time, quite fair. Is that a good definition, Aryeh?

Mergi: Possibly [laughing].

Moran: Yeah. They were larger. They used their power. They used the fact that they are in Silicon Valley. That's a fair treatment. And it's a fair business, by the way. And I said, no, one time after the other. In 2006, I took a decision to-- I wasn't happy with the board. It's a long story, which I won't go into all of it, but Eli that met me months before, understood that I'm not in a-- I'm not happy. And one day, he gave me a call and said, Dov, maybe that's the right time. And I said, okay, let's do it. And we had short negotiation about the price, and I sold the company to SanDisk for \$1.6 billion. And that's reality.

And you can ask what would happen if I won't sell-- I don't know. You never know. Could do amazingly, could do terribly. 2008 came with all the difficulties, don't forget that. We-- I could go and team with Hynix or-- which actually wanted, very much, our partnership, as another supplier of flash. Could happen, could not, maybe not. So, I don't know. But I think it was a fair merger, acquisition, in a way. Whether it's the finest merger-- because it was stock only. And I was very happy to continue and support SanDisk and assist SanDisk over the years, working with Sanjay, of course, after Eli left. And then seeing how SanDisk is acquired by Western Digital, and becoming what it is today.

I just met the head of Western Digital activity in Israel, that quit last week. And he came to-- first thing he did, I think, he came to see me, which is a big honor for me. It's a guy that I hired for M-Systems. I hired him 15 years ago. And he said, "Dov, do you remember, when you sold the company, we had-- we were about 1000 employees in Israel. We are now even more than 1000". I acquired a small company, actually I was very happy on that, in a place in Israel called Omer, for the security division, because I really believed that security would go together with flash. I totally believe, until now, that SanDisk, Western Digital, they somehow missed it, this combination which is so important. And there are other companies established to do things in this area, which I was supporting. But we acquired a small company in Omer to do security and to actually become our basic ASIC center, the center for silicon design. And they're still there. And they-- when we acquired them, they were 10 people. They grew to about 120 people in 2006. They are now 170 people under Western Digital. And I was so happy to hear that, hey, we did do

something in the field. It's still there, it's still running, it's still working, it still does great stuff. I'm very proud for that. Omer is nearby Beer Sheva. Having there a hi-tech facility is so important for my country.

Fairbairn: So, Aryeh, we haven't given you much chance to talk a lot here. Tell me how-- what roles you played in the very beginning. It sounded like you did a lot of the early innovation, but then it sounds like you switched more to like strategic planning, business development, that kind of thing. Tell me, if that's not right, tell me how your role evolved in the company, from 1990 to 2006.

Mergi: I think that after 1993, after that we did the IPO--

Moran: Oh, initially, you were the VP of Technology.

Mergi: Yeah, initially, I ran technology in the company. And handled all the technology side of the company. And then, in 1993, I moved to the US to do the PCMCIA effort, and in a way, it was also our kick-off for the partnership with Maxtor and our selling of products in the US. And then, when I came back to Israel, we didn't have good sales organization. That wasn't successful enough. And then, Dov told me, you know, you understand the product best. Take sales on your responsibility. Sales and marketing. And this is what I did until about 2001, when we moved to a division structure as Dov described. And at that time, I took on the role of business development, and did things like Nokia and the acquisition of this company that we did, and so on.

Fairbairn: What year did you return from the US? You had been there, working on the PCMCIA and other things, but when did you return?

Mergi: It was '93 and '94. Between '93 and '94.

Fairbairn: So you were in the US for a year or so?

Mergi: Yeah, I think more than a year, yeah.

Fairbairn: And then you came back, and Dov asked you to take on-- develop the sales organization to a much more--

Mergi: Yeah, yeah. And of course, you know, both Dov and me were very involved in the product, and all major product initiatives were areas that we were very involved on and worked on. And, you know, one key one that we didn't discuss yet was like the X4 technology, which was like the first QLC flash in the market. And you asked about, you know, SanDisk and what drove the acquisition, and I think that, as Dov said, there was like discussion from time to time, again and again, but I think that what happened in 2006 is that Eli started feeling really threatened on a few things that we came out with. One of them was this X4 technology, the QLC technology that was able to store four bits per cell, and was really revolutionary in flash. And the other one is the product that Dov described, the mega SIM that was a big threat to the SD cards in mobile phones. And I think that acquiring us, for Eli, was beyond getting the system knowledge,

which was like really complementary to what he did in getting, you know, revenues of \$1 billion. I think it was also getting the technology that we had, that was really threatening for the next cycle. And Dov--

Moran: Eliminating competition.

Mergi: Yeah, eliminating competition, in a way. And Dov says, you know, he doesn't know what would have happened, but you know, between us, we both think that we were-- we could become like significantly bigger. Who knows.

Fairbairn: You said that you had come up with a four bit per cell idea. You were not a component developer, but you came up with the fundamental architecture for developing that? Is that correct?

Mergi: Yeah, that's a really good question, and I think that you are touching exactly the right point. Because a few years before, Intel, in parallel, I think, to SanDisk and Toshiba, came with the MLC technology, which stored two bits per cell. And the implementation of two bits were done inside the device. Two bits is actually four levels. And they succeeded to do four levels with the device technology, we call this. And when we looked-- and we said, okay, what can you do more on the systems side? And we said, well, we can do more. And we tried to look, okay, what will be the right goal? And we said that the goal will be like to do 16 levels, which is four bits. And actually, Dov brought, I think Amir Ban initially, and then Menachem, and that he mentioned, to run this activity. And Menachem, which is really a really good manager, with his feet on the ground, said, you know, you cannot do this, right? It's impossible. But Dov and I think, told him, yes, but try this direction and this direction and this direction. And he's really a good manager and a good engineer. And he worked with different teams, developed really the key system technologies that enabled moving to 16 levels, which is four bits.

Moran: We actually worked with Toshiba. So the idea was, hey, we are not flash guys, but we are system guys. And truly, to do a four bit per cell, you need to understand the system, you know? You need to understand not just the error correction and detection, but how to really manage the silicon, yeah, many, many issues addressed, you know, number of write cycles, and number of read cycles and spares. We did actually build the system around to enable the X4. X4, as it exists-- then it became the X3 of SanDisk, actually. They use it to--

Mergi: Today, the market is in QLC, which means--

Moran: QLC, actually, yeah, that's--

Mergi: That's four bits.

Moran: One of the dominating technologies in flash.

Berg: Could you talk a little bit more about that systems side of it? Because I don't think there's a lot of understanding in the marketplace about that. So, what is it about the systems side that was sort of key for the development of QLC?

Mergi: Well, first, you needed significantly more advanced error detection and correction codes. You know, the error detection and correction code that were used until that time were very basic error detection and correction code. And we developed, together with the scientist from the university, an error detection and correction code that were tailored to the error patterns that 16 levels of flash imposed on the system. And then, there was a drift in the voltage that was different in different blocks of the flash. So we developed the technology to do on a block level type of referencing. And it was dynamic in real time, that you needed. And we had many different such technologies that some of them were done in the controller, and some of them were developed together with Toshiba, inside the device.

Moran: The biggest breakthrough was understanding that you should not just implement a regular, strong, let's say, error detection and correction code. Because there are codes in the market, but actually, the nature of the mistakes are going to be very different. They might be very similar to-- so you have to actually look at the specific characteristic of the flash, and to develop a specific code, error detection code, that fits what's really happening in reality in the flash. This was a big breakthrough on doing this four-bits per cell.

Fairbairn: So how long did that process take, to develop the four-level capability?

Mergi: More than three years, right?

Moran: More than five years. We practically began the development some time in 2001. And when we actually sold the company, we had samples working in 2006. And SanDisk, for their-- whatever directions and reasons, they said, let's not do X4, let's go and do X3. And they implemented it, actually, implemented the technology on the X3. And several years later, that became the X4. QLC.

Berg: So was this dynamic per block? So it would be a different scheme, basically, per block, within the NAND flash?

Mergi: Yeah.

Moran: Yeah, you can-- it's even-- not just it's block-- or it's actually blocks in-- yeah. The nature of the errors-- you have-- if the level, let's say, is 7 out of 16 levels, 7 will go to 8 or will go to 6, it will not go from 7 to 10. But if you look at it on the analog way and not on the digital way, zero ones, then the nature of the error detection correction would be very, very different, much more suitable. If you take anything on the digital level, then it's, you know, random bits that are changing their situations, but not if you look at it at the analog levels. I'm trying to give you insights into the code, but it's-- clearly, this is very complicated.

Berg: So how many patents were built up on this technology that SanDisk ended up acquiring?

Moran: I really don't know, because I don't remember-- don't forget, I left the company before-- we both left the company before it became a product. But we filed for many patents. We filed-- I would estimate that for X4 by itself--

Mergi: Maybe 20.

Moran: 10 to 20, I would figure out, that's the number, yeah.

Berg: It was quite aggressive, to go for four bits when the world was only working on two bits per cell.

Moran: We were aggressive. We were so stupid. We were aggressive -- sometimes it worked well, sometimes it didn't work well.

Fairbairn: So, have we missed any major developments, products, with M-Systems? Or can we move on to the post-M-System period?

Moran: We can move, yeah, go ahead.

Fairbairn: Let me start with Aryeh. So, the acquisition is arranged. Tell me what direction you took, and did you stay with the company, and if not, what were your next steps?

Mergi: Yeah. Well, I left immediately after the acquisition, and I took a year off to rest, you know, after close to 20 years working around the clock on the company. And then, about a year after, I met a guy from a different company that came to me and wanted to consult about building a flash for data centers. And this is a project that we started looking at the M-Systems, but we didn't arrive to doing it, because it was too early for flash, and because of many other reasons.

But I liked the guy, and we decided to cofound, together, a company around this. The company was called XtremIO. And the concept for XtremIO was to develop a flash for data centers as the main flash array, not just the cache-ing layer for data storage, which is what they did until then. We call this all flash array, and actually generated a whole market for this. The company ended up being acquired by EMC and becoming most of EMC flash-based data center's development. And it was very successful story. There are a few thousands of employees in this division now in Israel, and it is still running EMC, now Dell EMC, data center flash.

Berg: What year was that acquisition?

Mergi: It was in 2012, I think, something like that.

Fairbairn: So, what is the current size of those products now? What units do they sell them in?

Mergi: What the density is?

Fairbairn: Yeah.

Mergi: It's hundreds of terabytes. There are some-- in some cases, you can stack a few units and get to petabytes.

Fairbairn: A single unit, what is the smallest unit, so to speak?

Mergi: I think in a single unit, you can get one petabyte, or something like that.

Fairbairn: Okay.

Berg: So that would be like in a 1U, or up to 3U--

Mergi: Yeah, normally 3U.

Berg: 3U? Yeah, yeah. So, I'm sure a lot of the cloud infrastructure that we all use, unbeknownst to us, is based on this technology.

Mergi: I think, major area of it. I think the flash in data center developed in two directions. One is the centralized storage, big storage systems like the ones that EMC did. And the other one is distributed, which was, you know, maybe pioneered by Google, and then more advanced by Amazon and by other players. So, there are like two directions that it took, and this is maybe half of the market. But many of the technologies that were implemented inside are of course relevant to the whole market.

Fairbairn: What was the major breakthrough or insight or technology that allowed you to capture that market?

Mergi: Well, we went first with an application that stored a lot of virtual machine, which is what-- The infrastructure of data centers is built on this, and Amazon and others. And if you look internally on those virtual machine, there is a lot of duplication inside. So we developed a very strong and unique deduplication technology that was tailored to work with flash. So this was one part of this that made a big difference for us.

Another part was that we did a significant parallelism of SSDs, in order to significantly increase their performance. Write performance was an issue. But we had significantly better performance than hard disks at the time, and we had significantly better reliability. So we could get to cost that was very similar to hard disks in many, many applications. So, very, very fast, I think, in two years after the acquisition, the company got close to \$1 billion of revenues, just from this one product. And today, flash is, I think, more than hard disks in data centers in revenue numbers.

Fairbairn: So, how large was the company when you sold it to EMC?

Mergi: We were at the prototype stage. We weren't selling, actually. So we had zero sales. But all the big players at the time, IBM, NetApp, Dell, were competing on buying the company, because we had like these ten prototype units that we gave to customers. And all the customers came to them-- came back to them, and told them, that's what we want. EMC was an investor in the company, and they told us that if what we do works, then this is really changes all their business. So, this actually caused them to acquire

the company. It was really a large amount to a company that does-- that has no revenues. It was, I think, about \$450 million, with zero revenues, practically.

Fairbairn: Well, it's always nice when you have people competing, that makes all the difference in the world.

Mergi: I agree, I agree.

Berg: I assume there was a big patent collection that went along with that acquisition?

Mergi: Yeah, definitely. Definitely.

Fairbairn: So that took you to 2012, is that correct?

Mergi: That's right, that's right.

Fairbairn: So, fill in the 2012 to 2020 period.

Mergi: Okay, so as you probably heard, you know, we are computer people. So, I went on and founded companies in different areas, still following what's happening in storage, and looking at-- looking for the next big thing. And actually, I didn't see anything until about 2017, where I met two guys that ran Samsung flash activities in Israel. Samsung has an advanced flash technology center here in Israel. And they came with the idea that-- from the perspective of time-- I can phrase it in perspective, when you look at the demand in flash and on densities and on performance, they grew so much that you couldn't deliver this with the way the flash works together today. And that worked until now. And actually, if you look how flash worked until now, it actually emulated disk drives.

But flash now is much bigger than disk drive. Why emulate disk drive? So they came with the idea of developing-- restructuring the storage stack in a way that will fit better the applications, and will work better with flash. And this was around the key value data store concept idea, which is the way that modern file system and databases already work. When you look at the storage stack, it has many redundancies that are built just because of this block interface.

And we are actually developing, in the company, what we call a data processing unit, DPU, which actually take this whole storage stack that is built on-- with files and blocks below, and FTL below. Any of them are doing the same things in a redundant way and collapsing this to one layer that just does really, really fast key value store, currently getting performance numbers that are 50 to 100 times better than what you can get with current flash devices with the current storage stack. And our belief is that this is the way that flash will be used in the future, and this will enable significantly faster and lower-cost storage systems for data centers and beyond.

Berg: And that company of course is Pliops P-I-I-O-P-S.

Mergi: And the company is called Pliops, right. Thanks.

Berg: Yeah, you bet. And you folks are going to be a major—have a major place in our upcoming Virtual Flash Memory Summit in October. So, I see you on the program, and we'll be very happy to have you as part of the program this coming October.

Mergi: We too, we are looking forward to this.

Fairbairn: Okay. Dov? The sale happened in 2006. Take us from here to there.

Moran: Okay, so, first, I was requested by SanDisk to stay six months and help as the manager, and I actually helped to reorganize the whole combined company, which they took half of the-- halfway-- they went halfway my recommendation. But still I worked very hard to help reorganize and went to all the customers, helped to do the transition from M-Systems to SanDisk. Six months.

After six months, the last day of my contract. I called my guys, I said, at noon, I said, guys, I'm allowing myself to leave today early, because I didn't leave even one day earlier until now, at these six months. I worked really like crazy in Santa Clara, in Israel, in Tokyo, in Seoul, in Taipei, Hong Kong. I traveled almost every second week. So I said, this is the first time I'm allowing myself to actually leave at noontime. And I brought with me wine, we drank wine and said, cheers, "If you have any problem, I'm always available for you". I am available to them - this is till today. And I left the company. I went about-- I crossed the street, I went about 100 meters to the right, entered the building-- this was my new company that I established this day, Modu, with the concept of doing modular phones, which was a great concept but it didn't actually succeed. So, I established Modu. Modular phones concept. And, at the same time, Eli asked me to become the chairman of Tower Semiconductor. Modu, I had this idea of modular phones-- iPhone came to the market, 2008, it was very difficult to raise money. I raised money from the wrong investors, made many mistakes on the way. And finally, at the end of 2010, I actually had to terminate the company. I sold the patents and the technology to Google, not for a lot. We could actually do much better job in selling. But this was the first time in my life that I sold company assets. And on the other side, was the Tower side. I came to Tower while Tower was in-- I would say even deeply, into bankruptcy, with a loan of \$400 million they could not return, negative gross margin. You know, everything was bad there. And then-- with the management, of course, with the CEO, Russell, he's an amazing CEO, I succeeded to do a turnaround.

So, when I left the company, after two-and-a-half years as a chairman, Tower was back on its feet and working well and actually moving to profitability. We did an acquisition of Jazz, which was an amazing acquisition. You know, while-- on one side, I say-- I remember going to the banks. They had to approve everything, because we had a huge loan to debt. And there was a bank Vice President that said, I'm not approving you to buy or acquire Jazz. Because, guys, you are the guys without a leg. And these guys, they don't have both hands. They are in terrible situation as well. Combining you and them will never create a good marathon runner. Forget about it. I had to bypass him

Mergi: To go to the CEO of the bank.

Moran: I had to actually find my way to the CEO of the bank to get the approval to finalize this deal and did it and was an important part of saving Tower. I'm very proud that we succeeded, and the company, Tower, is a great place. Still working, value of several billions of dollars. Later, I established a few other companies. I began to invest in companies. And some of my companies still exist, doing okay. One way or not, some of them failed. That's part of life. Every success comes with failures.

So I began to invest, and I find that I enjoy very much the investment side. And about five years ago, I took a decision to move to the other side. From the entrepreneurship into the investment. It is a Grove Ventures, a very unique fund. Israeli companies only, early stage, deep technology. Deep technology is semiconductor, its cloud infrastructure, core AI, Science. We do not shy away from highly complicated stuff. And the concept in the fund is that we are not just investing, but we are truly putting our efforts and knowledge and know-how in. When I invest in a company, I tell the CEO, "listen, I'm your business development guy. Use me. I am here for you."

And I'll travel with them, wherever required, and help them make contracts. By the way, with some of them, with Tower as a Fab partner-- so back to my relations with Tower. And we are doing at the fund very, very well. I'm very happy with what I'm doing. I am a very lucky guy. I really do, for a living, what really I enjoy to do more than anything else in my life, seeing amazing entrepreneurs, seeing amazing technology, you know, it's wonderful. Couldn't be better than that.

Fairbairn: So, we're not only interested in the technology story, but we're also interested in the ecosystems story of startups and entrepreneurs and venture capitalists. And so, you've had this opportunity to start a company in Israel when it sounds like there was very little in terms of ecosystem investors, whatever. And so, tell me not how your companies have changed, but how the investment entrepreneurial ecosystem has evolved in Israel. And right now, you have your own venture firm. What other venture firms are there? Tell me about that ecosystem story.

Moran: So, I'll tell my belief about the Israeli ecosystem. I believe that there is a lot of amazing entrepreneurship in Israel. By the way, let me fix something which is important to understand. It's not that in Israel there are smarter people. Actually, I can give you the proof that this is incorrect. But there are-- the proportion of entrepreneurs in Israel is much larger than anywhere else in the world. And there is explanation to that, as well. So, many entrepreneurs. But actually, until 1993, there were almost no VCs in the country. There was one VC, very small, great guys, Dan Tolkowsky, still alive at the age of 99, I believe. He was the first one. But there —were no others, no culture of investing in startups. The high tech in Israel until 1993 was mostly military stuff, one large company called Scitex that failed, actually. In '93, the government actually, by establishing a program called Initiative that was sort of a safety net for VCs, gave a very positive-- a very important push to the industry of VCs.

And then, about ten VCs were established in 1993. And this was the beginning of the bloom-- blooming period of the Israeli high tech, because hey, here comes money. You can actually get money from investors, come with ideas, and in very short time, Israel became number one in the world until today in number of entrepreneurs and initiatives, startups, in high tech in proportion to the population, of course, of the country.

So, it's amazing place, a lot of innovation, a lot of entrepreneurs, bold moves. We are doing well, because we're not just Americans. We look at the American market, we look at the Chinese market, European market. We are not good in building large companies, so companies are acquired. And when I established M-Systems, if someone would tell me that I will be acquired for \$10 million, I would say, no, come on. You're fulling of it. Impossible. When I went public, and people would tell me, hey, you should reach \$100 million, there were no Israeli companies at the value of \$100 million. We crossed it quite fast. Then, we were acquired for \$1.6 billion, and people said, wow. This was, I believe, the third or fourth largest acquisition of any company in Israel, ever. \$1.6 billion. Today, you see Mellanox, last year, \$7.8 billion. Mobileye-- I was, by the way, coincidentally the mentor of the Mobileye guys. In a way, they claim I was the mentor. I was-- my job was much less significant, they are very smart by themselves. I helped them somehow. But this was \$15 billion acquisition. So, we do see the ecosystems growing. With many more initiatives, amazing guys, amazing technologies. And I do hope that the government of the country won't succeed to spoil this inherent strength.

Mergi: Harm--

Moran: To harm this, and in Israel, we continue to be a great country for technology and entrepreneurship.

Fairbairn: Now, for the venture firms, are they mainly homegrown? Or are there US venture firms that established offices there?

Moran: There are many VCs in the country. Almost all of them are Israelis. There are some, you know, branches of American VCs. We do have here-- we used to have Sequoia here, we do have Benchmark--

Mergi: Lightspeed, Bessemer--

Moran: Lightspeed, Bessemer, that's right, these are the largest. But almost all of the VCs are Israelis, and you have to be Israeli to invest in Israel. Otherwise, you won't really understand Israelis-- the nature of guys-- you need to really talk with the people face to face, be very active in what's going on in the army, intelligence, navy, who works with who. So, I think that to invest in Israel you have to be Israeli.

Mergi: Yeah, but, in a way, the ecosystems was developed that together with the significant growth with Israeli funds, there is a big entrance of the bigger US venture firms and corporate VCs from all over the world, you know, from Germany and from Japan and from China.

Moran: Great activity. Intel is here, Microsoft are here, Qualcomm CVC, which is very active in Israel, great guys as well. I can mention Norwest Partners, by the way, it's amazing partners of us in Israel. Yeah, it's amazing place. It's amazing place. Again, we just hope that stupid governments won't actually kill the world and damaging the countries.

Fairbairn: Let me ask one other dimension of that. In Silicon Valley, one of the reasons people give for its success is the idea that failure is not a red mark but rather, but rather one step on the path to success.

And even, just culturally, around town, you know, everybody understands that failure is part of the process. Is that same culture alive and well in Israel?

Moran: Absolutely, yes.

Mergi: In a way, no. Now, yes. But you know, in the beginning--

Moran: Yeah, not in the beginning.

Mergi: We were not like-- we couldn't--

Moran: By the way, even--

Mergi: Meet on failure.

Moran: Even now, some people say-- by the way, I did see, five years ago, when I went to raise money for the fund-- and by the way, Aryeh is invested in the fund. I mentioned Roni Kornitz, he invested in the fund, many other friends are. But when I went to raise money for Grove, I still met stupid money managers in Israel that said, "hey, you failed at Modu. We're not going to invest in your fund".

Mergi: That's the Israeli investors.

Moran: Israeli, yeah, that's right. But there are some like that and some that begin to understand entrepreneurship. But they-- clearly, in Israel, you know that if you want to succeed, you have to face disappointment, you have to face failures. My claim, when I talk about myself, I did an overview in front of my investors, in our latest LP meeting. And I said, guys, I did everything you can dream. I had a very long list of things I've done in high tech and business. Establishing companies, raising money privately, publicly, converts, B2B, B2C, IP claims, suits-- I was sued, I sued others, and I said, that's the list. Actually, such a long list that if you find anything that could be done in high tech that I haven't done, I'll give you \$100 bill at lunch time. No one could come and take this \$100 bills.

And then I said, from all this long list, do you know what's really is the most important one? You know what's the most important one that allows me to stand here, handle you money wisely, do whatever I'm doing as investor successfully? Failures. I failed so many times. You look at my back, it's full of scars. I failed many, many times. Even at M-Systems, we did have many failures. We lost this battle of the cards. We learned. Okay, this didn't work for us. Let's do embedded. Let's push there. We find our advantages, doing the mobile DiskOnChip or the USB flash drive, later on. So, failures are important. Failures are part of the way to succeed. And, by the way, if I take it back to Eli's story, which I just watched, few days ago, clearly, he had failures. Maybe he is talking less about them, but the fact is that Eli understood his failures, and every time he failed he fixed things, he improved, he found the right ways in order to create his amazing success story. Failures are a part of the story.

Fairbairn: Absolutely, absolutely. So, Aryeh, did Dov invest in any of your new ventures, after 2006?

Mergi: No, but-- oh, yeah.

Moran: We do have one joint investment, yeah.

Mergi: We have one joint investment, that's right.

Moran: We did okay. Went public.

Mergi: Went public, right.

Fairbairn: So, Dov, you have a number of artifacts in front of you. Have we seen them all? Have you told the story of each one?

Moran: I-- believe me, but I think that the Zoom is-- let me see, great camera, but it's not actually allowing Zoom. So I do have a-- this is the first--

Fairbairn: Yeah, it doesn't show up, it just-- yeah, that-- back farther, farther.

Moran: If I go back, maybe this will do it.

Fairbairn: It keeps focused on Aryeh.

Moran: Aryeh, you are too nice. But it's a DiskOnChip-- I brought these components. Here, these are the mobile DiskOnChip. It's small components.

Fairbairn: Oh, yeah.

Moran: Take them out-- if I take them out, hey, take a look, this is-- I think this is eight megabyte, eight megabyte DiskOnChip. The component that we put into the Nokia 9000. I wrote my entire book about failures. This is \$1,000, this was best failure-- so talking about entrepreneurship, this is the DiskOnKey, the first DiskOnKey, which I sold-- yeah. I'm not great in keeping all this history, whatever, combined what we have here.

Fairbairn: Brian, do you have some questions before we wrap up?

Berg: Yeah, I do have a couple things. One comment about one of the companies that was purchased earlier this year in Israel, Mellanox, it was purchased by NVIDIA. And that's really, that's a very interesting acquisition, because Mellanox, which, by the way, has been a regular participant in our Flash Memory Summit for a number of years. They provide basically the infrastructure for tying together a backplane as well as, you know-- it's used a lot of data centers. So, it's very high-speed communication scheme that they've got. And so that was the reason that NVIDIA bought Mellanox. And, in fact, instead of Mellanox, this year, we're going to have them under the name of NVIDIA as a big part of our Flash Memory Summit. But one of the things that's interesting-- in fact, it's Jensen Huang, the CEO of NVIDIA, he gave a kitchen

talk, literally from his kitchen, because of the fact that the NVIDIA conference had to go virtual this year. One of the things he talked about was what's happening with the data center. He's calling the data center a single storage device. And the reason for that is by virtue of the Mellanox technology that they've now purchased. So, the NVIDIA GPUs need so much memory, and can do processing so quickly, they need lots and lots of memory, and they want it to look like it's all directly accessible memory, as opposed to a storage device. So I just want to underscore the importance of that Mellanox purchase for the future of NVIDIA, which of course is one of our biggest success stories in Silicon Valley.

Moran: I think, generally, in Israel-- Israel is small country. And if you look at my history, M-Systems-- navy, great guys, M-Systems, Tower, Modu, Comigo, all the companies I invest in now. I think there is no one in Israel which I don't-- which doesn't know me or that I don't know him or know somebody who knows him. Now, from M-Systems, many, many-- or Modu, many, many guys went and opened their own companies or became part of managements. For example, if you talk about Mellanox, the CIO of Mellanox, which is quite an important guy to the organization, he's the guy who worked for me at M-Systems and was the CIO of M-Systems. Udi Weinstein, Great guy. So almost every Israeli company that you will talk about, I know the guys. I know people who work there, I'm related, in a way, to them. That's great. And, of course, the CEO of Mellanox by the way, which is about 500 meters from here, from this place, is a friend. We talk a lot. I try to help him. He tries to help me.

Berg: A couple other points I wanted to raise. The similarities, Dov, in your background and Eli's background. You, fortunately, made it out of the Holocaust. Eli was fortunate enough to have his family emigrate to Palestine from Poland, although he did lose some family members. But he emigrated to Palestine in 1933. So you both have that similarity of the background in Poland, and the horrors of the Holocaust and impact at that time. So, I'm sure that there is a very deep relationship you established just implicit in that fact. So, I just wanted to bring that up. Also, the whole reason that we're having this conversation today in this oral history is the fact that the two of you were the Lifetime Achievement Award winners in 2018 at our Flash Memory Summit. And so, I'm very happy that-- working with Jim Handy. He's the one who brought up that we should recognize M-Systems. And the more we looked into it, the more we realized that of all the innovations that you've done over the years, basically made Intel flash usable for data before Intel itself did. You brought the USB flash drive, embedded flash systems, flash for the cell phone, and QLC flash before anybody was really, realistically thinking about even three-level cells. So, those are the things that we recognized you for, and I'm so happy we did, because as this conversation has shown today, there are so many fascinating things in your guys' background that a lot of people in the world really don't know. But fortunately, a lot have been informed by way of that recognition in 2018, and I hope they'll listen to this oral history, as well.

Fairbairn: Okay. Dov and Aryeh, is there anything that you feel that we've missed? Any important milestones or products or developments that we should have touched on?

Moran: I'm fine. You did much more than-- you actually got from us much more than what I planned to tell. And generally, I'm very happy to have this opportunity.

Mergi: Yeah, it was really a pleasure, and interesting. I think that we didn't do such a conversation, so it was an opportunity for both of us to look back at the history as well.

Moran: That's right.

Fairbairn: Yes, we sometimes find that two people that have known each other for quite some time learn new things by being brought together in this oral history format. Just for your interest, we had such a conversation between Gordon Moore and Arthur Rock, you know, the founder and funder of Intel. In the process of that conversation, Gordon discovered some things about-- oh, you, Arthur Rock, wrote the business plan. I thought Bob Noyce had written the business plan. So, yes, we enjoy bringing entrepreneurs together to have a little self-discovery along the path. So, thank you very much. We very much appreciate your time and devotion to this.

Moran: One question. You're going probably to edit it, because this was very, very long. So you probably squeeze it to an hour, or something like that?

Fairbairn: No, no, we will transcribe the whole thing in text form, and we will do the preliminary edit and then share with you, ask you to do any final corrections or whatever, but it will be published in its full format. No editing or whatever.

Moran: I don't think that anybody's going to look for something which took how much time? How much is it?

Fairbairn: Three hours.

Moran: Three hours.

Fairbairn: But that's okay. The story is the story, and if it takes three hours, it takes three hours. I think it's a very worthwhile investment on all parts.

Moran: I do have to say, one day, one day, my grandchild, you know, will ask himself, oh, I heard about this grandfather. Let me learn about him. Hey, this will be great.

Fairbairn: Exactly.

Moran: Thank you very, very much. Really, pleasure.

Berg: Thank you.

Moran: A lot. Bye-bye, bye-bye--

Mergi: Thank you, Doug, thank you, Brian. Bye-bye.

END OF THE INTERVIEW