



Oral History of Peter Faulhaber

Interviewed and edited by:
Thomas Gardner

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Gardner: I'm Tom Gardner, a volunteer in the Storage Special Interest Group at the Computer History Museum, and I'm here today to talk to Peter Faulhaber, who is the President and CEO of Fujifilm, America. We're here to talk about, the storage industry from the tape perspective, given Peter's many years in the industry. Peter, please tell us a little bit about your background.

Faulhaber: Maybe my resume is not updated to the latest stage. When you get a certain age, you don't always update your resume. I'm in the storage industry more than 25 years now and really enjoy where we are going. I'm married, have two children. As you can tell, I'm from Germany, live in Germany. My family lives in Germany. I have lived for the last 16 years in New York working for Fujifilm. Before that I worked for BASF, and BASF transitioned into EMTEC, and in 2004 I joined Fujifilm as a VP of OEM, business development, and in 2012 I became the president of Fujifilm Recording Media USA.

Gardner: Where were you born?

Faulhaber: I'm born in Germany.

Gardner: Where?

Faulhaber: I'm born, let's say, in the middle of Germany in a small town called Zweibrücken.

Gardner: Okay, and your parents and grandparents?

Faulhaber: My father was born in the Palatinate area of Germany, my mother actually in a town called Gleiwitz, which now these days is part of Poland [Gliwice, Poland. (gli'viitsɛ)]. So she moved in 1945 to Wolfsburg, famous for Volkswagen. That's where my parents met eventually, and then they moved back south.

Gardner: Their parents?

Faulhaber: Their parents, again, my mother's side in Gleiwitz and my father's side all in the Palatinate area originally.

Gardner: Okay. The reason I ask is sometimes when relatives are going to listen to this oral history, they might not know that information, particularly your grandchildren. So having it recorded permanently someplace is my gift to your grandchildren.

Faulhaber: Thank you.

Gardner: Okay. Where would you like to start?

Faulhaber: Where you would like to start? History.

Gardner: Well, let's start with, how did a German person of an accounting background arrive to the level of the president of an American subsidiary of a Japanese company that's one of the two surviving companies in the magnetic-tape business? What were the seminal events that happened to you during that 25-year transition. Briefly. We can go into more detail.

Faulhaber: I have a finance background and started with BASF on the finance side, actually was an auditor for a while, did mergers, acquisitions and then transferred in 1992 to a division within BASF for the magnetic-tape business, and we then separated. BASF acquired the magnetic-tape activities from Agfa-Gevaert AG, and built a company called BASF Magnetics in 1992. I was responsible in 1992 for implementing SAP. In 1993 I became the controller of BASF Magnetics, and in 1996

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they offered me the position as the head of the business unit for data storage. So that's how I moved into the business side, and I believe that people with a finance background are able to run a business better, because they better understand numbers. They have better idea about strategy. It's not about just colors like marketing. Here is somebody who understands top-down revenue and the impact to bottom-line profitability and run this business. So that's what I did starting in 1996, so that was a time which became a little bit of a turbulence, because in 1997, BASF decided to sell the company. The core business to BASF is a chemical company, and they sold it to a Korean company called KOHAP.¹

Now, KOHAP was running this business for probably a year, and then the Korean crisis started in 1997², and the company actually was sold to an investor. It was a leveraged buyout, a number of companies, LGV [Legal and General Ventures, London], an English company, and Munich-based Apax Partners; that was, I would almost say, the start of the ending. That's how the whole business ended, because our management in that time was a marketing guy, the COO [Bernd Geisler], and the CEO [Dr. Jürgen Langeheine] was a production guy. They didn't really understand. They were happy that they got a lot of money, and it was valued very high, but the high value at the end of the day had to be paid back with projected profitability, which never came, really, and the reason why, because the market changed dramatically. Number one, the company, BASF Magnetics, was relying heavily on tape, especially VHS videocassettes and audiocassettes for the consumer, but also for duplicator tape. There was a lot of duplicators like Technicolor and Deluxe who duplicated video, and that was, I would say, the majority of the business.

Now, with the leveraged buyout and the new investor, we had to change all the brand names, and we transitioned from BASF brand name to EMTEC. What was left was always this very famous spiral BASF created, because BASF, as you might know, is and was the inventor of magnetic tape, in 1932 with the first audiotape³. The interesting part is how magnetic tape became known around the world. During World War II Hitler gave a speech in Munich, and at the same time he gave a speech in Berlin, and now the Allies-- the Americans went, "How can that happened that Hitler is at the same time in Berlin and in Munich?" But what happened is the speech was recorded, so they became aware of the audiotape, and

¹ The Korean Kohap group acquired the tapes activities on January 1, 1997.

² Asian financial crisis beginning July 1997

³ BASF developed audio tape in cooperation with AEG's (German GE) development of the audio tape drive

they took this invention and gave it to 3M. That's how this invention actually became into the hands of 3M and the Americans, like many other technologies.

But going back to the leveraged buyout with EMTEC, we could not, I think continue financially with just audio and videotape in mass-production-- we did not really foresee in the future, and the future at that time-- what was killing the videotape was optical disc. Now optical came, and people thought, "How?"-- it certainly killed the VHS business and the audio, video consumer business. Long story short, we could not pay the bills, and EMTEC had to declare Chapter 11 in January 2003.

The part of the business I was running, the data-storage business, was small but profitable, and I proposed and then did a management buyout. I found an investor, running around in Europe looking for investors. We had an investor, and I engaged Fujifilm as a strategic supplier. Fujifilm at that point in time was a supplier and a customer of ours, so I had good contacts with Fujifilm, and I engaged Fujifilm as a strategic supplier. At a certain point in our negotiation the investor said,

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"Fujifilm has to guarantee the exit strategy," which means three years later the investor wants to get out with 25 percent margin, and Fuji said, "If that's the case, we don't need the investor. We're jumping in." So that's how we engaged with Fujifilm. The management buyout eventually falls through, because Imation got the business awarded, and they bought the assets, at that time the assets were 3480 and 90 and the manufacturing of 3590. So Imation bought all these assets, and Fuji offered me a job in the United States. So I came to the United States as a VP OEM development with all my contacts, and I must have done well. They promoted me several times, and I ended up becoming in 2012 the president of the company.

Gardner: So EMTEC fundamental business was video recording. It was dying. You had this profitable, smaller computer-tape business. You tried to do a leveraged buyout, and it didn't happen?

Faulhaber: So, the leveraged buyout was for the entire company at that time, and the company more or less had three divisions. We had data storage. We had a broadcast business, and we had video, VHS.

Gardner: That was 2003?

Faulhaber: That was 2003. That was the status quo at 2003, when they filed Chapter 11.

Gardner: Okay, but I thought you said you would try to do a leveraged buyout but did not succeed.

Faulhaber: I did a management buyout, not a leveraged buyout. The management buyout went very well. We made an offer to the creditors, the administrator at that time in July 2003, and we were bidding against Imation. The creditors and the administrator at the end took the Imation offer, because it was an existing company. I had my own startup. I started my own company and bid, as you recorded, I think, an amount at around \$50 million at that time, and they took the Imation offer.

Gardner: Some of the seminal events while you were now in Fuji that led to your current success? Tell me about them.

Faulhaber: What specifically do you have in mind?

Gardner: I don't know much about what happened to you at Fuji from 2004 to present, but there must've been some things that were remarkable to you that you were involved in.

Faulhaber: I would say that in general when I came to Fujifilm, and I have to be careful how I word this, it was heavily loaded with Fuji-branded business. Fuji was very successful in DLT. Fuji as a company, and that is before my time, Fuji was involved in floppy disk and Fuji was involved in VHS. Fuji was pretty much similar structure than EMTEC or BASF before. They had the floppy-disk business, which was more or less everything they had in data storage at that time.

They developed a technology they call the ATTOM technology. It was based on metal-particle. It was the successor of chromium dioxide. Everything we did within BASF on 3480 and 90 and data storage was based on chromium dioxide, very famous. BASF was actually one of the two manufacturers of chromium dioxide. DuPont was the other manufacturer and they went out of business in 2001, So everything was based on chromium dioxide. MP was the successor of chromium dioxide, and Fujifilm developed so-called ATTOM technology with meta-particle. The success of that was that they were able to support formats like DLT and ZIP, the Iomega 100-megabyte floppy disk [introduced 1994], and DLT, DLT 4 very famous for 40 gigabyte at that time

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and very, very successful in the market. At that time, we divided the market into classic and an enterprise midrange and a consumer market. The consumer market was the floppy disk. In the midrange you had products like DLT, quarter-inch cartridges, AIT, and in the enterprise market purely 3480 and 90 and a little bit of open reel at that time.

Fuji's ATTOM technology was the enabler of DLT. The success of DLT triggered LTO. A consortium was founded between Certance, IBM and HP to start the so-called Linear-Tape Open Consortium with three companies, an open format. Everybody was able to participate. It had no limitation in terms of IPs, and so LTO became successful. LTO actually took over the DLT market faster than anybody thought. When I joined Fujifilm in 2004, DLT was declining dramatically, and LTO took over the market.

At that time there was hardly any OEM business. OEM business means private label to the original equipment manufacturers. It was mainly the branded products from the manufacturers, the media manufacturers, and Fuji was the major player. We had a market share with Fuji brand about 50 percent overall in DLT, if not even more. We were successful in the LTO business with our branded products, major and significant market share in LTO as well, but then I remember very well HP changed the market and changed the business behavior, because HP came in, and with their strong brand name, they bought from three different manufacturers, from Maxell, TDK and from Sony, and they had a huge bargaining power, as you can imagine, a strong brand name, huge penetration in the market, and they had a pretty significant bargaining power, and they still have. But what happened is they leveraged this, and they

drove the market, especially the price, down, and suddenly HP became a major player in the media business, even though they were not a manufacturer. They were purely an OEM. But they achieved market shares in Europe up to 40 percent and even higher, and they have pretty significant market share even in the U.S. these days, very attractive, of course, for media manufacturers to supply to HP.

Now, it's not profitable, because if you don't support your own brand, you're not in control of your own destiny. You cannot maintain this business. That's not a sustainable business model. So when I came to Fujifilm, we hardly had any OEM business. We were relying purely, I would say, on Fuji brand. We did not really have a strategy. The OEM business just got the leftovers, so when I came in and was supposed to be the VP of business development and shortly after became also the VP of the OEM business, and I questioned the strategy. I purely just questioned the strategy, I didn't say what is right or wrong. I said we need to develop a strategy, and we all have to support the same strategy and can't just go out of the room and one goes right, and the other goes left.

Gardner: That's a very Japanese way of business management, isn't it, consensus as opposed to a more autocratic decision making.

Faulhaber: I totally agree with that. The Japanese are very consensus-driven, and as a German, I'm not that patient. That's certainly a challenge working for a Japanese company, but I always said I'm coming here and support the business as long as they accept that I'm vocal and raise my voice and question the way we're doing business, and they accepted this, and we were pretty successful, and suddenly we turned this around technically.

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The OEM business became equal to the Fuji-brand business, and we suddenly had a strategy, and the strategy was that we clearly maintain our Fuji brand, because we are in control of our own destiny, but we also support OEM business, and the way we support OEM business is by selling a value proposition. It's not purely on price and I'm very vocal on this. The value proposition, the service, the quality, the support, was always very important to us, and that's how we are successful, because we are reliable. We have capacity. We always can support our OEMs. We never let them down. They get great quality, and they get good service.

One significant advantage we have is, we have U.S.-based manufacturing in Boston, Massachusetts, so we can react quickly to the needs and the upsides in terms of demand and without even forecasting, and we are clearly the leader, Fujifilm, the leader in research and development. We are investing heavily in technology. We are committed to invest in technology, and we were always committed to invest in technology, and so that's part of our story-- we are selling a value proposition. It's not short-term optimization, short-term selling. It's about the future.

Gardner: Now, back in 2003, about the time you moved into Fuji, I think there were seven tape manufacturers.

Faulhaber: There were, I would say, six or seven manufacturers. There were even more brands out in the market, but in 2003 it was EMTEC, Imation, Sony, TDK, Maxell and Fujifilm, so six tape

manufacturers at that time, yes? But several more brands, as you can imagine, came up with-- just from a TPC [Technology Provider Companies]⁴ side, you had Quantum, who actually bought Certance. There was Certance they bought in 2005. There was IBM, HP, Verbatim, Tandberg, and several more brands out in the market competing for market shares.

Gardner: Yes. In my notes, I have that by 2013 it was five manufacturers, and today there are two.

Faulhaber: That is true, and it's very unfortunate, to some extent, but it's all about investing into the future. So selling at the lowest price and not making money, you cannot invest. I think the business model-- and that's where I'm coming with my finance background, understanding what it takes, you have to earn money. You have to have a bottom line, a profitable bottom line to be able to reinvest in the business, and that's part of the value proposition I tell my customers, too-- if you want the lowest price, you don't have a healthy environment. You need a healthy environment and to support a healthy environment, an environment which is able to support in the future, development.

That's another story we can talk a little later, but think about where we came in the '90s from megabytes, and open reel tape had 200 megabytes, and where we are today. We have the highest cartridge capacity. We have 20,000 megabytes on a single cartridge. We couldn't handle the exponential data growth without R&D and investment in this future technology, and that's where Fuji is clearly the leader, and we were always able to invest in the future, and I always say-- HP was more or less killing this business model, because companies like TDK and Maxell and even Sony didn't really support their own brand. Especially Maxell and TDK gave up their own brand, more or less, and supported HP, not competing against HP.

Now, if you always compete for the last market share and when trying to utilize your production--
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because the market was also driven by overcapacity. Overcapacity brings price down, very competitive. That's not a long-term business model you can survive. You need to enjoy the business. You have to make some money and be able to reinvest, and that was Fuji's business model all along. We are not the cheapest. We sell a value proposition, but we reinvest, and we provide a roadmap for the future technologies. That's why I would say EMTEC went out of business. Imation eventually went out of business. They could not keep up with technologies. They could not keep up with the investment it takes to develop new, high-density tapes. Maxell eventually couldn't keep up. TDK couldn't keep up. Sony stayed in business, because they do have a strong broadcast business, especially hardware, which they have to support with the media. So they had to stay in business to support their broadcast business from the hardware and media perspective. The Betacam system on the broadcast side, including HDCAM SR business. That's what they had to support and why they had to stay in business.

Gardner: So as the market evolved from 2003, as new generations of drives emerged, you had to qualify new generations of tape, and by investing in the technology, Fuji was able to be on the leading edge and

⁴ The LTO Consortium licenses technologies provided to it by the three "Technology Provider Companies," currently IBM, HP and Quantum. See: <https://www.lto.org/licensing/>

therefore capture the leading-edge, higher-margin tapes than the rest of the guys who were probably cash-cowing their existing production.

Faulhaber: I couldn't say it better.

Gardner: I'd like to hear your perspective on that.

Faulhaber: I think there is a significant difference the way we do business and when I came to Fujifilm, and the reason why we went very strong for OEM business, we went specifically very strong with IBM and actually Quantum, because we had good relations with Quantum from the DLT, SDLT side when they actually acquired the Certance portion for the TPC, became a TPC member, because we worked very closely in developing the next generation of tape with the next generation of drive.

So LTO had a roadmap out, and I remember when in 1998 the TPCs announced the roadmap for LTO-1 through LTO-4, and it went from 100 gigabyte to 800 gigabyte, and I said we are killing ourselves, because technically we were selling 3480 and 3490 with 200 and 800 megabytes, respectively. There are a couple of cartridges for the demand for 800 gigabytes, so for some companies the demand was just 800 gigabyte on an annual base, so I thought we are killing ourselves.

I didn't consider really the exponential data growth, but what happened is, and was quite different, at one time, talking about the old 3480 and the 3490 technologies, you more or less independently developed your tape while IBM and the hardware manufacturer developed their drives in parallel. It became more a joint development, where all the specifications need to be developed together and see what is possible from a drive and a media perspective at a given time. So it was very important that you work closely with the drive manufacturer and working closely with IBM, so it gave us an advantage. I think we had a great technology with ATTOM technology in early 2000, which actually enabled LTO-1. We were out first to market with LTO-1. Fuji was out first with LTO-2, LTO-3, LTO-4 based on our tape development, and we were developing closely with IBM. Being out to the market early means there is no after-market, because the hardware gets sold bundled with media. That was our strategy, sell the hardware together bundled with media, less of a price pressure, early out in the market. That's when you make some money before the market shifts into the after-market, where it's far more competitive and hardly any margin left. We were able to be successful and be able to invest into the future, and that was our business model:

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Be early to market, being early where the price still is high. You made some margin, and are able to invest.

Gardner: There are a couple of things you just said, which strikes my curiosity. First of all, you talked about the LTO being open, but it's really not. You have to be licensed. You're not in the consortium. DLT was also not open then, but Quantum would license and did, in fact. Fuji was licensed in both technologies.

Faulhaber: You raise a good point. Even LTO is not open, because you need a license, and the other thing why it's not open is because the media manufacturer has no input into their specification and

capacity per se. So, yes, you were able to license, but you could not input to the specification. So it's not per se open, because you had to license, but anybody who wants and has the capability to manufacture was able to license. Even you could license without having the technology, just getting the specification. DLT was different. DLT was more a closed format. It was controlled by Quantum, and Quantum at one point only gave, that's my understanding, the license to Fujifilm and later to Maxell, so Maxell and Fuji were the major manufacturer for DLT. Little later, Sony came in, and Imation actually tried to get in and was never really successful going to the DLT business as a manufacturer.

Gardner: This is your observation, then, that by controlling the entrance, Quantum actually committed a business error because their prices then in the aftermarket were higher compared to LTO, is that part of the reason why LTO ultimately pervaded over DLT?

Faulhaber: I wouldn't say that. In general, there were different times and different markets and different formats. DLT was very successful in the late '90s, early 2000s, very successful. What they did is they kept the price artificially high, because there was no competition. It was a single source. Quantum was the only provider. They could control the market, which was eventually an antitrust issue actually, what they did, the way they controlled the market and controlled pricing and dictated pricing. Nobody really was able to get in. Everybody was, I think I remember the dealers got rich, by just being part of the distribution of DLT. Mainly distributors and dealers really got rich at that time. Fuji was very successful. I believe that Maxell was just as successful as Fuji was and we were able to develop next technologies. Before there was no DLT. DLT then came more or less in the late '90s, early 2000s, and from my perspective what killed DLT, was because of what Quantum did as the answer to the LTO roadmap which went up to 800 GB.-- It was 100 GB for LTO-1, LTO-2 was 200, LTO-3 was 400, and LTO-4 was 800 gigabyte per cartridge. Quantum announced the so called SDLT, Super DLT, and the roadmap was SDLT-1, 160 gigabyte per cartridge and SDLT-2 was 320. Now, the problem Quantum faced mainly was that they were not able to deliver to their promise. You lose credibility in the market. Now suddenly you have a consortium of three companies, Certance, HP, and IBM, well known in the industry, whereas Quantum couldn't deliver to their promise. They were not able to deliver really 260 gigabyte. They could never really deliver the 320 in time. So you lose credibility, and here is a consortium providing with several manufacturers of LTO. So that became I would say, almost the de facto standard, but I have to say just de facto. It wasn't standard. It was a de facto standard. It became LTO, and DLT was not successful.

Gardner: Which has died.

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Faulhaber: Died. Correct, and then the other thing is, Quantum, very smart, they recognized that SDLT wasn't successful. They took an opportunity which everybody said, "Oh, I would have done this," but they did it. They bought Certance, and with Certance, they became a TPC member. Now Quantum suddenly was a TCP member of the LTO Consortium and they had DLT/SDLT. So they were playing both. I am not sure whether HP and IBM really liked it, but Quantum suddenly became a player in the industry for LTO and understanding where LTO is going and where DLT/SDLT is going, they put their money on the LTO horse.

Gardner: Now you mentioned that you have had and still have a close relationship with IBM who is in the Consortium. The other Consortium companies have, as near as I know, no research going on in tape technology. IBM I believe, still has some prototype lines where they can do development, but how does that work that you, who have the production, are working closely with the company who is a TCP and you're not? How does that work out from an intellectual property issue? Is that a problem?

Faulhaber: No. No, it's not a problem at all. I think we are working technically closely with all TPC members these days, and the market dramatically shifted, as you said. I think IBM today is the main drive manufacturer. I would say Fuji is the main media manufacturer and it makes complete sense that the two major manufacturers in media and hardware are working closely together for next generations.

Gardner: But the Consortium gets the royalty which you're not a part of.

Faulhaber: Yes, but whether I like it or not, that's a different story. But that's the way it's set up. You have to ask IBM whether they are happy in sharing the royalties with the other TPC members, Quantum and HPE now. Why IBM is doing the major development, that's a different story. The question is, why is Quantum and why did Quantum and HPE stop developing hardware, drives, per se.

Gardner: And presumably investing in media technology also. As you pointed out, they do go together. There has to be a dialogue. IBM still does media work in the laboratory level.

Faulhaber: Not really.

Gardner: Really?

Faulhaber: No. I don't think so -- No, IBM does not. Even in a laboratory scale, you need a coater. They do test a lot and know where the direction's going, but they rely on samples from the media manufacturer, and they do testing with our samples.

Gardner: Really?

Faulhaber: I'm pretty sure they do testing with Sony samples as well to look where the future generation is going, and we do demonstrations. We do media demonstrations so you know what is capable based on I would say, areal density. We are commercializing 20 terabyte and today is 2019. We demonstrated more than 220 terabyte already together with IBM in a single cartridge. So based on our technology, we support any roadmap for the near future, any published roadmap out, we can support.

Gardner: So the Consortium produces the roadmap which, based upon their analysis, is a reasonable projection of in two years or three years we ought to be able to double or increase the capacity. You guys have input to that. You tell them whether it's practical or not, but then you're doing your research to stay ahead of that. Is that what I'm hearing?

Faulhaber: That is it in a nutshell, yes, but I think it's a little bit more than that. I would say the LTO idea always was to double capacity every two to three years. So I don't think there is more into that than just let's say, double. Why? Because the projection for the exponential data growth, and we see a compound average growth of 30-35 percent growth year by year.

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So to support the exponential data growth, you technically have to double every two to three years, capacity, just to handle the data growth. Now, the next question is, how to manage this and how to supply and support the roadmap. I would say LTO-1, LTO-2, 3 were pretty simple. In fact, when LTO-3 came out the roadmap was extended to LTO-8, now the roadmap is extended to LTO-12 which goes up to a native 192 terabyte on a single cartridge. The question is the development now goes along to say how can we support the next generation? We are now at LTO-8, 12 terabytes. We are working now on LTO-9 together with IBM and see what we have to do to achieve LTO-9 and up to 24 terabytes. The question is, will it be 24 terabyte or not, it's the question of hardware and media and that is always a challenge, but it's always the job to overcome the challenges. Fuji, as I said earlier, is committed to tape. Fuji is committed to tape technology. We are committed in R&D, investing into the future. We started, as I pointed out earlier, we started ATTOM Technology in the early 2000s, late 1990s, with ATTOM technology based on metal particle. We then developed Nanocubic technology. Nanocubic is still on metal particle, but what it is, it's smaller particles. It's nanotechnology, because you need smaller particles in order to achieve higher density. Higher density means higher signal to noise ratio, which means higher capacity. In 2006 we came and developed, which we started to develop much earlier, but we commercialized and started commercializing in 2006, barium ferrite. So we replaced metal particles with barium ferrite particles. Why did we do this? The main reason is smaller particles with barium ferrite — if you get metal particles too small, they lose their magnetic signal strength. That's what you need for write and read, you need the magnetic signal strength. Particles get too small, they lose their magnetic strength, you can't store the capacity. So you need smaller particles to achieve a higher density. Barium ferrite, perfect example, is how we can get smaller particles with higher density and accomplish higher capacity, and that's not the end what we're doing. We are currently developing a new particle to replace eventually barium ferrite with so called strontium ferrite particles. Again, same magnetic property, smaller particles. You can have strontium ferrite even smaller than barium ferrite particles to achieve, again, higher capacity. So that's what Fujifilm is working on. That's not history, that's future.

Gardner: As you described it, Fuji went through a transition just prior to your joining it when the business went from a consumer retail business mainly to an enterprise computer tape business. Transitions like that are generally very difficult for companies. They mostly fail, Kodak being a great example, and you guys survived. As an observer not there, can you tell me something about that transition, key decisions, key players, key events?

Faulhaber: Let's start with product and technology. So the way Fuji was structured in the '90s, before my arrival actually, they had a strong consumer business which mainly was floppy disks. In fact, an interesting story how to connect the dots again. In 1993, BASF had a facility in Bedford, Massachusetts, very close to Boston, where we actually created together with Fujifilm a joint venture called B&F

Microdisk, manufacturing floppy disks⁵. That was in the early '90s, '93 still a major business, especially in the data storage industry. Besides that, Fuji had a tape business for the broadcast business

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supporting Sony's Betacam business, and eventually Panasonic's DVC business, and the retail business was floppies. Around 1994 Fuji took over the BASF part of the B&F Microdisk in Bedford and took over the entire facility, manufacturing floppy disks. Now, Fuji always had coating, based on their history, it's all about coating. It's 80 years and more of coating technology. So what they did is coating is their bread and butter and that's where they have their technology. Magnetic tape is nothing other than coating. So we have a history of coating. We have experience in coating, and we are committed in technology, which was driving the next generation of tape. Now, Fujifilm developed metal particle, which was a successor of chromium dioxide, smaller particles, higher density, higher capacity. This technology was applied in ZIP technology for floppy disk and in DLT. That's how Fuji actually transitioned into the data storage industry, out of a pure consumer business which was purely floppy disks, into a tape business with DLT. They actually also supplied tape to IBM, to EMTEC and to Imation at that time, for the 3590 technology which was a successor of 3480 and 90 technology, 10 gigabyte, a huge jump from 800 megabytes based on chromium dioxide, to 3590, 10 gigabyte based on metal particle. They did not manufacture the cartridge. They supplied purely the tape to Imation and to EMTEC.

EMTEC then started development of their own MP technology, I was part of EMTEC at that time, we developed a so called chloride free tape, a 10 gigabyte tape for 3590, and then it became 3590 with 20 gigabyte. Fuji was not the manufacturer of this cartridge. EMTEC was supplying cartridges, 3480, 3490, 3590 to Fujifilm. Imation was the main competitor. At that time actually, going back in history there were two other competitors for 3480 and 90 which purely went out of business based on technology, Graham and Anacom. They both were manufacturing 3480 and 90 technology, but they could not keep up with technology and especially the investment of the technology when 3590 came alive and became, more or less, replaced 3480 and 90. Now, with Fuji's technology, metal particle technology enabled ZIP technology on the consumer side and supporting DLT was then very successful supporting 3590 from a tape perspective, but then it was a transition when IBM started developing and come up with a new format, so called 3592 technology, 3592 replaced quickly the other formats, per se. 3590, 3480 and 3490 were almost dead at that time.

Fuji decided to become a player in this field and not just supplying the tape, but they also became the manufacturer of the entire cartridges, and the only supplier to IBM for the 3592 based on IPs (intellectual properties) and our technology, Fujifilm's technology for 3592. That was the new value proposition. Now, with DLT, Fuji made a major step from the consumer business, floppies, ZIP cartridges, into DLT which became the mid-range project at B2B product, supplying mainly to the aftermarket thru the retail channel. When I say retail, I mean resellers and distributor channel, and were very successful in this channel,

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because technically, there was no competition. It was Maxell and it was Fuji as a manufacturer, and we had Quantum as another brand, and there were a couple of brands out, but Quantum was controlling the market price, which was questionable in terms of antitrust issues, but I don't want to go into that debate.

⁵ Joint venture was announced in 1989. Computer Business Review, March 8, 1989

But Fuji transitioned clearly from purely from retail, based on technology. So the vision was not who had the vision to move into the next generation, it was our R&D, our strong commitment to research and development and our capabilities in research and development to deliver a tape technology which would be the enabler for future generations, and that was, I think, clearly our vision. Our vision goes back to R&D, to technology, investing in technology.

Gardner: Do you recall any or know any of the key engineers or scientists who were involved in the development of ATTOM and its application first in ZIP and then in later product?

Faulhaber: I don't recall the names, especially that were in Fuji Odawara or that were in their facility, R&D facility. That was far before my time. I remember the next generation going from metal particle to barium ferrite and here I know it's Mr. Higuchi. We call him Hunter, his American nick name, but I gave him the name Barry, because he was behind the invention of barium ferrite, so his American name is for me, Barry. He is clearly behind barium ferrite technology, but there are many persons. It's not one per se, there's one head but there is a huge team behind the development of tape technology. Fuji was always committed to invest in technology. We are spending a pretty significant amount of money. I always give presentations of this, we are spending over 1.5 billion dollars per year in R&D. We are committed to the future. We are today, as Fujifilm, as the classic photo film business disappeared, we're doing less than one percent of our revenue in film these days while around the year 2000 was the peak, was over 50 percent of our revenue, and think about it, we are a 24-25 billion dollar company these days. We are investing in different technologies and we are achieving 80 percent of our revenue with products which we haven't had 10 years ago. That tells you about diversification and we have a vision investing into the future.

Gardner: And being in the right investments. ATTOM was the right investment at the right time, as was later, metal particle. There are examples of investments in technology that go no place, and you guys were either very lucky or very good or some combination, to be through a couple generations now, at the right place. Is it that you do a number of alternatives, the old IBM method, you try three or four things and kill off the three that don't work and go with one or some other way, how does that work?

Faulhaber: You know, you can call it lucky or visionary. Based on our coating technology and recognizing that chromium dioxide had a limitation, Fuji came up with the technology, and that started much earlier than the commercialization of metal particle in the '90s, which then brought in 1996, ZIP and DLT-4 was based on metal particle. The development starts far earlier, recognizing the limitation of chromium dioxide. You can call it lucky, but it's also having a technology, providing a technology to hardware manufacturers. That's what we did, working closely at that time with IBM, working with StorageTek closely, to provide a solution. Worked closely definitely with Quantum with DLT providing a solution to support the roadmap and what they wanted to grow in capacity, supporting the exponential data growth. But what is even more important, you don't stop. You don't stop with metal particle. You look further out and see what is the next generation, and that's what Fuji did very well where they looked into this,

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looking at all perhaps, and said, how far can metal particle support the roadmap, because now you have

a published roadmap which goes, at that time in the '90s when LTO was announced, up to 800 gigabyte, and when LTO-3 was announced, they extended it to LTO-8 with 12 terabyte. The question always is, what does it take to achieve 12 terabyte on a single cartridge? What technology can be applied, and it's particle technology, it's R&D, but also process technology.

I'll give you an example. You know, we talk about LTO-8 now with a perpendicular orientation to get higher density, but it's this vision of, in working on this, what can be applied to support it, what is announced in terms of roadmaps to support next generation of technology, and I believe that Fuji has a vision. I know that Fuji has a vision in supporting this. It's driven by management, by R&D, by the capability, and the commitment to invest into this technology, and that's our value-- that's part of our value proposition. We are committed to future generations of tape. We are committed to invest heavily to support any roadmap published out in the industry, and we know what it takes to support it. We knew there is a limitation to metal particle based on the magnetic properties. When you make the metal particles too small they lose the magnetic signal strength. So what is the next generation particle, and Fuji came up with barium ferrite. We patented barium ferrite as it is now applied and even specified in generations from LTO 7 onwards. But we all know that even barium ferrite eventually has a limitation with the magnetic properties. So what is the next generation, and we are already developing, and we believe probably LTO-10 will be strontium ferrite. So it's about the vision of where to go and what does it take to support this roadmap.

Gardner: And without revealing trade secrets, I presume beyond particulate recording layers, you're looking at metal film recording layers as the ultimate areal density like the hard drive guys are doing today.

Faulhaber: You know, we look at different technologies, but I can tell you it's all about, at the end of the day, you have to be competitive in terms of other technologies, not about you, or other media manufacturers. There are other technologies and you have to provide a storage medium which is cost competitive to other media. We are open to look at all the different technologies. We at Fujifilm do not believe in sputtering, and it's mainly due to cost reasons. It can be done, but it's not cost effective, and we are looking at exponential data growth. We have to store in the future zettabytes of data! When we started we looked at megabytes, we then looked at gigabytes. Today, we're looking at zettabytes. A zettabyte is 1,000 exabyte, and 1,000 exabyte is 1,000 petabyte. So it's a million petabytes, is a zettabyte. So we are looking beyond what does it take to store the exponential data, exponential data growth into the zettabytes, and you have to be cost effective, especially from a manufacturing perspective, and we at Fujifilm do not believe that sputtered tape is the future, and we don't believe, I'll tell you, we don't believe in holographics. Holographics, as somebody famous said, "Holographics is and will always be the technology of the future, so it will never come to life." We are interested in looking at what today is DNA or 5D glass. There are different developments out, but they are still, I would say, probably 15 to 20 years from commercialization, and then the question, at what cost can it be commercialized?

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So we have a solution out which enables companies to preserve their data and to support their exponential data growth.

Gardner: Let's talk a bit about the dynamics of the cartridge market. You mentioned earlier that initially it starts as an OEM. The tape drive manufacturer sells a bunch of cartridges with the drive, and then maybe sells the first few cartridges to the buyer of the drive, but ultimately it moves from an OEM sale on your part to a retail market seller or at least a distributor/integrator resale. Back when I was in the cartridge business, I did some analysis of ZIP, for example, and sort of concluded over the life of a ZIP drive it would absorb something on the order of 12 to 15 cartridges.

Faulhaber: You know, we did this sort of analysis years ago where we said how many cartridges per drive for a drive cartridge ratio to determine what the market size is. But this is not really reliable because of different applications where they have it nearline or offline and how you use it and also on the capacity. That's not the way we're looking at it these days anymore. I remember very well that we looked at this 10 years ago, the attach rate. That's not really reliable anymore. At one time it was, we thought 40 to even 100 cartridges per drive, but it's all about even including migration now.

But I want to answer this question slightly differently and I come up with one example, and we talk about the hardware manufacturers attaching media versus the aftermarket and the retail channel. Think about the tire manufacturer for a car. So a car manufacturer, say a good German car manufacturer like Mercedes, BMW, Audi, Volkswagen. They, and even the Americans, they sell the car with the tires, correct? So that's where you deliver the tires to the car manufacturer and they deliver the car to you as a consumer with the tires. So that's what we like to do with the hardware. Get the first tape library out, with the cartridges. That's a market which is not accessible for a media manufacturer, because this is supplied by the hardware. The tire manufacturer can't sell a tire without a car, so the car needs to be supplied first. Now, if you drive your car and you get a good mileage on your tires, you're very happy to go back to the same tires you had and buy the same tires through the store. The Mavis Tire store or wherever you buy your tires. That's the same idea we have in our industry. If the customer is happy with the cartridge, with the performance, the quality, then they go and buy the same cartridge again, because it's like a reliability factor. So you go out and say, "Hey, I had an IBM cartridge or even a Fujifilm cartridge in my library when it was supplied first. Where can I buy this?"

So, now the market is shifting to the aftermarket, but what we try to do is we try to make sure that we supply a good quality cartridge with a good service to the hardware manufacturers. They bundle it with the hardware, sell it to the customer, the end user. Now the end users, they either go back to the hardware manufacturer, or they go to the aftermarket. In the aftermarket now, it's far more crowded in the market because now you have all the media manufacturers, all the different brands in the market, competing for their share. This market force, driven for many, many years, starting with LTO-1, are won by overcapacity, significant overcapacity, which drives the price down. There's a bargaining power, you know, you want to utilize your capacity so aftermarket was very crowded. It's all about the last five cents. And the price comes down dramatically. But before the market moves to the aftermarket where it's very competitive and hard to make any money,

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it stays for typically a year in the hardware channel before actually the customer re-buys and goes to the aftermarket to get a better price. So, that's where we try to take advantage, where we try to leverage. And then I remember I went, when I became responsible for the entire business, I went to a distributor, and

the distributor told me and said, "I sell what the customer wants or where I have the highest margin." So, they are not actively promoting a brand or a quality or a certain value proposition because they don't have the time and the knowledge to promote it. They are purely selling what they have the highest margin on or what the customer asks.

So, that's why we changed at Fujifilm, we changed our strategy, and we sell a value proposition now to our customers. We do tape evangelism, and we talk about the advantage of tape. We're talking about our value proposition so that the end user, the customer, actually eventually goes to the reseller or the distributor and specifically asks for Fuji branded cartridges. Why? Because we sell a value proposition. We tell the end user where the value is, where the value proposition is. That's how we try to stimulate the business, especially trying to make sure that there's a value in buying Fuji branded or actually Fuji manufactured tape.

Gardner: The analogy, of course, is I buy Michelin tires for my car regardless of what I get when I buy the new car. The first time the tires wear out, I buy Michelin because they have a great value proposition. But see, that goes to share more than total market, right? The aftermarket for tires is dependent upon the number of miles driven per year per car and retirement of cars.

Faulhaber: And how many cars are sold.

Gardner: Well, the first set of tires comes with the car sold, but two, three, four, five years later, the next set of tires is sold on that car depending on how many miles. So, the total market is, in fact, dependent upon new sales and retirements of cars. And that sort of gets to the same total market analysis for tape-- or maybe not. Maybe it's really driven by data growth and affordability of data. And your market growth is not so related to the tape drive business. Interesting dynamic question.

Faulhaber: Not at all. I think it's a very good question. In fact, I think there are a couple of components here that's driving this. Data cost is one component, clearly, but it's all about what we call, tape evangelism. We try to educate our customers in what is the best way of storing data. And I make it always very clear. We're not competing against HDD. That's based on an application. There is a natural way of tiering. Famous people like Fred Moore, whom you know as well, started with a pyramid. It's a tiering pyramid where we talk about the different tiers. It depends on how hot or how cold your data are, how often/frequently you access data.

That's all about the application. Disk has an advantage over tape. And tape has an advantage over disk. It depends on the time and the lifecycle of the data and how often you access data. Cold data which you never access, it doesn't make sense to keep it on disk, which uses power and spins for 24/7. You want to put it on another tier. It's all about optimization in your storage environment, and tape plays an important role in your storage environment. And now, it's all about educating your customer what the best practice is. Fred Moore, and not just Fred Moore, everybody says about 60 percent of existing data are cold data, cold data never accessed after 30, 60, or 90 days. What are you doing? Where do you store your data? What is best practice? And that's where we try to educate customers. And that's part of how we try to increase the market beside the exponential data growth in general.

Gardner: I'd like to back up a little bit now to your BASF and EMTEC experiences, and particularly the time in which you became the business manager. And I guess it spun out as a separate entity.

Faulhaber: In 1992 BASF bought from Agfa its magnetic tape activities

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which they combined into a BASF subsidiary called BASF Magnetics GmbH. I was part of BASF for many years on the financial side. I joined in July 1992 BASF Magnetics GmbH when they spun off. I was responsible for SAP implementation before. In 1993, I became the controller of the entire company. The company, BASF Magnetics together with the Agfa activities were very strong in VHS video tape. We manufactured millions of VHS cartridges for the consumer. We manufactured a significant amount of what we called duplicator tape for duplicators like Technicolor or Deluxe. We put video on VHS tape. That was a significant business. Another business was broadcast business. We did and were strong in audio and video broadcast. We were strong on the audio side. Major competitors at that time were Ampex, which then became a famous name, especially in the Valley, which then eventually became Quantegy, so it was BASF and Ampex and Quantegy who were on the audio side. BASF also was supporting the Sony formats like the Betacam. And then we had a relatively small business on the data storage side, which I was running, became the head of the data storage business unit in 1996. At that time, on the consumer side, we had our floppy disk. And we were, I would say, the major supplier, the market leader, in what we call the cookies, the disk inside of the floppy envelope. We supplied this around the world to all the Chinese companies, the Taiwanese companies, the Indian companies like Moser Baer and CMC in Taiwan. Many companies in China started up. There was no barrier of entry to manufacture a floppy disk. We supplied the cookies, with the metal particle technology.

Gardner: Before you continue the evolution, I'd just thought I'd remark that sounds remarkably like Fujifilm's situation 10 or so years later, big, retail consumer business, a small computer business, but BASF didn't make the transition. I'd also note, in my research when BASF set up the Willstatt plant in 1966. And they projected computer tape would be 30 percent of their business going forward. It sounds like they never got the 30 percent of the business by the time you got there.

Faulhaber: I probably missed the heyday in that business, clearly. At one time, I think Willstatt was manufacturing 3480 and 3490 cartridges. Everything was fully automated. I think it was a state-of-the-art facility. We did about 18 million 3480 and 90 cartridges per year. We had a market share of over 30 percent, but it was relatively small. I think the BASF business was dominated by clearly VHS. And VHS was not the technology of the future. It was retail. I don't think that in retail, in the consumer business, you make enough margin to be able to invest in future technologies.

Gardner: I mean that's interesting because it began that way, right? All of this industry started in consumer businesses. The fundamental technologies did not come out of non-computer technologies. It was audio and video media that then led to computer products, and now computers can't support them because audio/video media has been replaced by other technologies and new computers no longer read them.

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Faulhaber: I would say that it all depends on the barrier of entry, and VHS was a technology which was even manufactured by Korean companies. So, it's all about capacity or I would say overcapacity. It's consumer driven. If you go back, and I remember in the early '80s there were several competing formats for videotape. It was Betacam. It was Video 2000, which was a Philips format, and it was the VHS format. The VHS succeeded. It was not necessarily the best format. But the way it was promoted was why it eventually succeeded. A VHS cartridge in early 1980s worth about, converted into dollars, was worth about 20 to 25 dollars. At the end, you were able to buy a VHS cartridge for less than a dollar. So, tell me where you make money on this. It was driven by the Koreans. They dump the tape into the market. They only have one vision, and this is being the market leader, whether you make money or not. The Koreans were driven by capacity and market share at the time. They haven't really had a good brand.

The Korean brands at that time in the '80s and '90s were cheap, but they were not just cheap in terms of price - they had no brand recognition and they were very, very inexpensive the way they're supplied. And they destroyed the market. There were hardly any margins left in this business, in the consumer business. So, the question is it was it a business which drove millions of VHS cassettes, per year. But can you survive just by supplying quantities? Then it becomes a management topic where what is the next technology. And what came out in the mid-'90s, 1995-1996, was optical. It was CDR replacing audio, and it was a massive growth. But I remember the EMTEC top management that time, didn't believe because it cannot be what they don't want it to be. It's always a bad strategy. I think denying where the future is because this is not supporting what we are doing. So, if you close your eyes and not investing into where the future goes, then you're out of business. The last man standing is not a good business model. So, that is what drove EMTEC technically out of business beside some management, I would say mistakes within the leveraged buyout - by not understanding that you have to pay your bills quarterly to the banks. That is, how do you pay it? You pay it from your profit. If you don't have bottom line profit, you can't pay your bills. If you can't pay your bills, what is the conclusion? You're out of business eventually.

Gardner: To your point, I think the first floppy disk was priced at five dollars a disk, and by the 1980s, you got them free in the mail.

Faulhaber: You know what killed us, some companies started the rebate system, the mail-in rebate. I remember that actually technically killed the industry. You bought the floppy disk, and you had a mail-in rebate system, where technically you got the price back by mailing it back and getting the rebate. You can't sell for free. I remember, it's a funny story. Optical disc came, and at the beginning there was a significant shortage of CDRs. So, you couldn't supply the market. The price was very high. One CDR was sold for ten dollars at the beginning. Suddenly, the market came down because capacity suddenly ramped up. And with capacity, the price dropped faster than you could believe. I remember a time when the inventor of optical disc said at one time, "You cannot manufacture an optical CD for less than a dollar."

Gardner: How many dollars?

Faulhaber: One dollar, that was the bottom line for manufacturing, at one time. That's what they said. They were sold for pennies at the end.

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But with the market, there was a shortage. Suddenly, we had products. But with products in our warehouse, the market price came down. The market price came down faster to even below what our cost we purchase it for. I went to Staples, and Staples made me an offer -- they quoted opportunity inventory. They gave me a deal - they'd buy a ten pack from me for thirty dollars, but I have to provide a thirty-dollar mail-in rebate. Now, the question is can you now calculate how much is coming back in mail-in rebates. But I also had to buy out the existing brand in their shelf, and I went out of this without having the deal. I refused the deal, and somebody said when you sit in the Staples parking lot, the people who come out and cheering, these are the people who didn't get the deal. The people who are sweating and crying, these are the people who got the deal because they don't know how to finance it. So, this is retail. Retail can be a very poor business, and optical quickly took over clearly the floppy disk business, very successful, but it also took over the VHS business. DVD came in and killed, killed really from one day to the other, overnight, the VHS business. All the management said it can never happen because of all the VHS recorders in the homes. But it happened. It happened quickly, very, very quickly, and it killed the VHS business, the retail business but also the duplicator business. And with that, you can't pay your bills. That's why EMTEC eventually went bankrupt.

Gardner: That is the story of the industry. By my count, there were thirty tape drive companies at its peak around 1985, thereabouts, and it's, you know, down to one.

Faulhaber: It repeats. It's all about capacity. It's all about technology and staying in the market, being able to invest into the future, making money. It's not just making money to become rich, making money to be able to invest in the technology.

Gardner: Well it appears to me your experience in the tape media business is that the transition in technology was rather straightforward. You didn't go into making optics, for example. It was different technology. You were able to continue to invest in your technology, and the products evolved from the retail VHS floppy with a small computer business to a very large computer business, maybe not very large. The revenues today -- how do they stand compared to when you were a more retail vendor than you are a computer vendor?

Faulhaber: You know I would say our revenue is growing. When I came to Fuji technically, we had a consumer division. We had a broadcast division, and we had the computer division. The consumer division, we divested quickly because we couldn't make money. It was mainly selling CDs, CDRs, DVDs. You buy and sell. It's not a business model you want to be in, especially not in the U.S. retail channel with all the rebates and all the chargebacks especially.

Customers, like a warm heart, they don't even pay you in full They always have some chargebacks. And managing the chargebacks, it's a totally different, another story. But one thing, we always look at different technologies. We looked at optical. Fuji had development and research in optical. We developed a die, which we supplied to major manufacturers of optical, but we were never really in the optical business because the barrier of entry is too low. If the barrier of entry is too low, everybody can make it. If everybody can make it, you face overcapacity. And it was very clear, look at the companies who did floppy disk in the early '90s became the companies in the late '90s

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who did CDs, CDRs, and DVDs. The CMCs, the Ritek in Taiwan, the Moser Baer in India, all driven by overcapacity, low, low cost. And eventually the retail price was too low -- you were able to buy a CDR for pennies, far less than one dollar, what Taiyo Yuden projected as the bottom manufacturing cost. The price came down because the Chinese, Taiwanese, Indian companies went in just massive, and there was no barrier to entry from a technology perspective. So, Fuji did not enter -- and that is I think the smart part. You take a strategic bet, but we're not investing in the technologies which has no barrier because that's not an area where you make money eventually.

Gardner: So, the three divisions, the consumer division was basically a reseller buying blanks and relabeling it and selling it. And that's a very low margin business, but there's also no technology investment. Your video business technology investment probably was much bigger than the computer business in that time period?

Faulhaber: So, Fuji was clearly in the VHS business. But as the market came down and optical took over, we divested in this business again. I think, yes, it's this coating technology, but Fuji at that time already invested in, clearly supported MP and was in the data storage business with DLT. So, we divested the retail business. We completely went out of retail after I came in 2004. We made a decision to, in 2008, to completely get out of the retail business.

Gardner: So, how much did your revenues go down when you divested? How big, more or less? I'm not looking for detailed numbers, but was your business cut in half?

Faulhaber: No, it wasn't cut in half. It was I would think maybe 25 percent when we cut that business. But we became more profitable because the 25 percent as a percent of top line revenue, contributed a huge loss to the bottom line. So, you have to look at it from a business model, and again it becomes handy that you understand numbers and know how to improve numbers. So, we looked at this and did a restructuring. We divested the retail business, which was not profitable. We had a significant amount of chargebacks, which we had to clear. I think it was the best decision we were able to make at that time.

I'll give you an example. Just the opposite, Imation who was spun-off from 3M from 1996, was not able to invest in tape technology, in coating technology. They weren't able to keep up in terms of R&D but also process technology. What they did is they suddenly invested into the retail business. They bought Memorex brand ⁶. They bought a couple of other optical brands. They became the major supplier of optical. But what killed optical? It was flash. The iPod-- the iPod in 2003 changed completely the market. And now, you're sitting on a business, which is dying, like optical business. What is your future? I know that Imation then went into a marketing and distribution company, brand marketing, and distribution company. They wanted to support this, so they distributed IBM. They distributed for StorageTek. But that's when you're not in control of your own destiny. If one of these companies decides to go a different route, you're out of business. So, eventually the problem is the market is changing, and if you're not prepared as it changes, then you're always running behind.

⁶ [Ed. Note] In January 2006 Imation purchased the Memorex consumer business and brand from Handy Holdings. This did not include the Memorex computer tape business.

Gardner: My recollection is-- now correct the numbers if I'm wrong, that Imation paid something close to a hundred million dollars for the Memorex brand and ultimately sold it for much less.

Faulhaber: I think your recollection is wrong. In 2006 Imation acquired the Memorex consumer business for three hundred thirty million dollars.⁷

Gardner: You are correct, and then Imation re-sold it in 2016 for \$9.4 million. It was not a great business deal.

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Faulhaber: They had a couple of strategic bets that didn't pay out. They invested in technologies like they wanted to compete against Iomega ZIP. They came up with the LS-120, which never took off. So, they did a couple of strategic bets, which it's fine to take a strategic bet. But eventually some have to pay off, and nothing paid off there really. So, I think they went out of business eventually as a result. I think there are many examples. If you're not able to make money and to invest, you're out of business.

Gardner: So, to me what is really unique about the Fujifilm story is that you guys made it. Most everybody in the coating business didn't - counting maybe a dozen or two dozen companies at its peak. And the vision that enabled you to get through it sounds like is the continuous investment in technology and with the right technology at the right time perhaps being the luck part of that story.

Faulhaber: It is enjoyable working and being with the market leader, especially when it comes to technology, clearly. It's enjoyable. I tell you it's much easier being with a company who has a leading technology and is committed to the future technology. It makes life easier.

Gardner: And the key event was ATOMM.

Faulhaber: Metal particle ATOMM technology.

Gardner: But if it wasn't for ATOMM, there might not have been an MP. I mean it sounds like in listening to your history of the industry, the really key transitions-- there was chromium dioxide transition. We saw it with iron oxide, right?

Faulhaber: Yes.

Gardner: Rust.

Faulhaber: Correct.

Gardner: Chrome dioxide.

Faulhaber: But even MP is an oxide.

⁷ "Imation To Acquire Memorex For \$330 Million," Jan 20, 2006, W. D. Gardner, TechWeb News <http://informationweek.com/hardware/showArticle.jhtml?articleID=177102292&subSection=>

Gardner: Oh yes, to me, that's always been the strength of media. You're recording medium is already rusted - turned into a stable particle. As a metal particle, it may not be so stable, but certainly the oxides are, and ceramics are much more stable than pure metal?

Faulhaber: Yes, in general, you're right, and I would say to your other comment, ATOMM MP-- ATOMM was based on metal particle. I think you have to look at these together. ATOMM is MP technology based on Fujifilm's technology and was clearly the game changer. I don't know how many years it was in the making. Typically, I think probably ten years before it commercialized, we developed on metal particle with some experience in other areas. But it was, for storage industry, clearly a game changer. And I remember sitting on the other end of that table at that time with EMTEC. I know that Fuji had the best tape solution. IBM recognized this. IBM only worked based on the history of the 3480 and 3590, and even 3590, with Imation or and EMTEC. But they recognized that Fuji has a superior tape technology.

Gardner: But that was chromium dioxide.

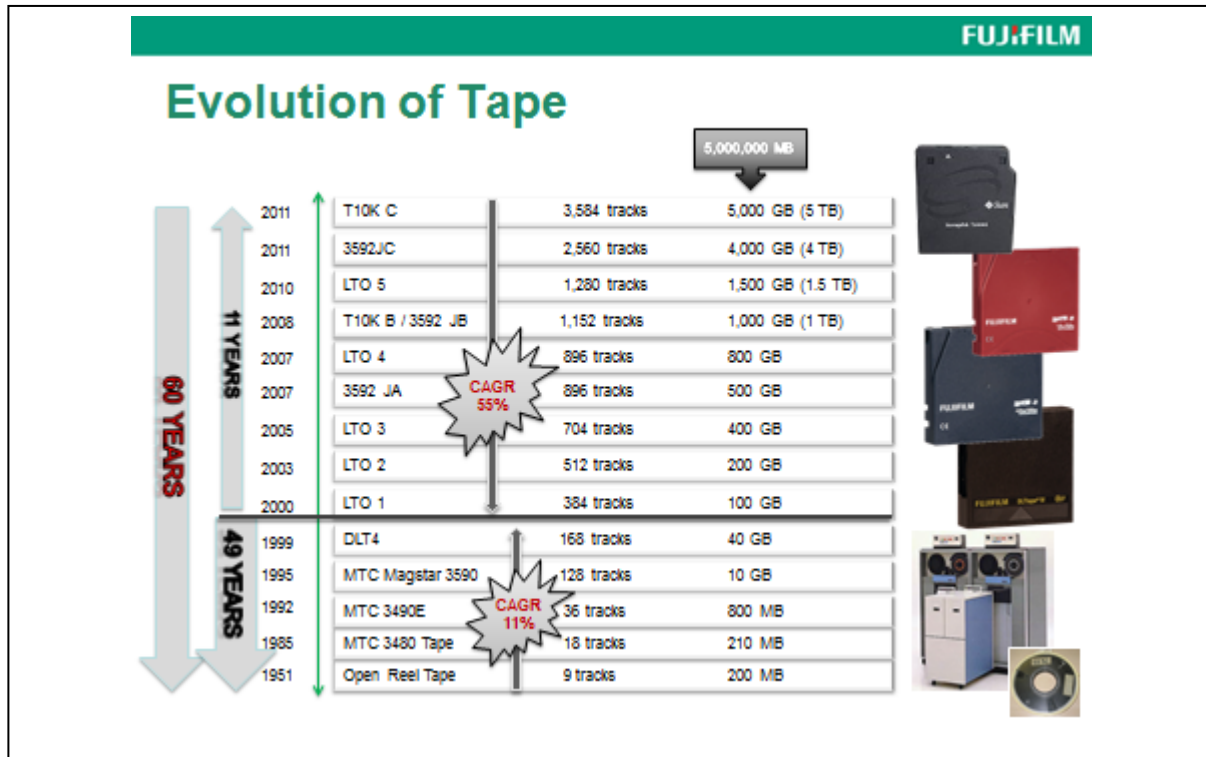
Faulhaber: 3480 and 90 were. 3590 was MP already but, in the early stage, supplied as a tape from Fujifilm. So, every 3590 in the first years supplied by Imation or EMTEC was supplied from a tape perspective, from Fujifilm. So, Fujifilm was the tape manufacturer. EMTEC put Fujifilm tape in the cartridge, and we started actually interestingly enough was, with 3590, that's where servo track writing started, which was not used in the 3480 and 3490. The track density became far more precise.

Think about the history of open reel tape. It was all half inch, and first it was seven tracks on half-inch tape. It became a nine-track tape with two hundred megabyte. That was in 1952. When you go back now and look at this from

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1952 to 1985 when IBM replaced the open reel with a cartridge, 3480 magnetic tape cartridge. Still two hundred megabyte, it was eighteen tracks, a huge jump from nine tracks. We doubled from nine tracks within thirty-five years. We doubled the tracks, great improvement. Now, if you look at the jump-- from 1984, to 1986, 1987 when the 3490 was developed, it had jumped to 800 megabytes and 36 tracks. So again, we doubled from 18 tracks to 36 tracks. That was based on chromium dioxide.

Gardner: I'll hand you a foil from one of your presentations⁸ that might help you walk through your track density discussion.d



Faulhaber: Yes, thank you. Yes , so it's a 3490, 36 tracks, it had 800 megabyte. In 1995 the tape cartridge Magstar 3590 came out at 128 tracks and 10 gigabyte, but what was the enabler? What enabled the jump from 800 megabyte to 10 gigabyte? It was metal particle. We changed from chromium dioxide to metal particle, and technology wise, we started servo writing. The track density became much denser, and we changed from 36 to 128 tracks. Now, LTO-1 started with 100 gigabyte. When you look at the Magstar 3590 with 10 gigabyte or eventually 20 gigabyte, the LTO-1 was 100 gigabyte and 384 tracks. Now I'll just make a long story short, today, we are at 8,704 tracks on a 20 terabyte IBM 3592 JE medium which, just to put that into perspective, that's equivalent to 79 tracks on a single string of human hair. That's how technology is evolving.

Gardner: And where is it going? It's still a half inch.

Faulhaber: Thank you for this. This is a great leeway. When you think 79 tracks on a human's hair or 8,704 tracks on a half inch tape is a lot, and you're coming from the HD business. HDDs have about 250,000 tracks on a half inch, comparable. They have 500,000 on a square inch, 500,000 tracks on a square inch which, just make it simple, is about 250,000 a half inch. This relates to over 1,000 tracks on a single human's hair. Compared to 79, that's pretty damn good. Now put that in perspective. This gives

⁸ Slide 7 from "FUJIFILM Recording Media, U.S.A.," Peter Faulhaber, 2010 ca.

us, and shows you the opportunity tape has in terms of density, higher areal density and track density. That's a long way to go to grow.

Gardner: So Peter, we've talked about track density and where we've been and where we're going. Can you expand, talk a little further about where you think the tape industry is going, particularly in the context of flat revenue, declining unit volume, and an industry with two media suppliers and one drive supplier? Are you going to be around 30 years from now?

Faulhaber: Yes. A very clear statement, that's the way I look at it, and that's my prediction, and the prediction could be wrong.

Gardner: Of course.

Faulhaber: But my prediction clearly is that we'll be around and in general I would say there are a couple of reasons why. When we talked about track density and we talked about HDD, currently over 250,000 tracks on a half inch, while tape is still at just 8,700, which is still a huge number, but at 8,704 tracks to be precise, there is huge room for improvement, and I would say there is, on tape, no technology limits, per se.

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So we have a long way to go in terms of areal density and track density compared to other technologies. Now, the other question is, you asked me about declining numbers of cartridges. We don't necessarily see a significant growth in terms of units shipped, but what we see is a significant growth in capacity shipped. So that underlines what we are all talking about, the exponential data growth, and we believe that the exponential data growth, IDC is predicting that we are growing to 175 zettabytes in 2025. Now, this is all data created. When we talk about persistent data, we're talking about we are roughly at all data currently stored, different formats, roughly one zettabyte. IDC predicts that we are at 7.5 zettabytes, and all the analysts support the 7.5 zettabytes in 2025. So within the next six years, that is a compound average growth rate of 35 percent. Very significant. To support this, you need to grow capacity per cartridge. Otherwise, you won't be able to handle the capacity and manage this, the capacity and the data overall, and tape has no technology limits in terms of density and track density, meaning areal density, so it's a great format to store. That's why I believe that tape will be around for a long time. There is currently no other technology on the horizon.

Gardner: I know you're a finance and CEO type, and maybe it's unfair to throw a technical question at you, but there may be no immediate limits on the size of a recorded spot, but can you get the head close enough reliably enough and long enough to those spots to be viable at those much higher densities?

Faulhaber: You are right. I am not that deep into technology, but I would say from what I know and hear from our experts and what I understand, yes we can. The interesting part, it's not just the tape technology. It is the interface with head technology. So it's not just tape can grow and yes, tape has room to grow in areal density, especially when compared to HDD, but it grows along with other technologies, especially the head technology. So as head technology is moving from MR heads to GMR heads and now to TMR heads, we have shown that there are solutions to this and opportunities lay ahead of us.

Gardner: Well, I don't want to be argumentative, but the same head is already in the hard disk drive, reading that spot or writing that spot. But in the disk drives, they have a very controlled head and head disk spacing, and in tape, which is essentially a noodle as opposed to a disk, the spacing may not be as well controlled, which leads to issues of, can you read or write the spot and not wear. So the issue is tape may not have a magnetic reading or writing technical barrier, but maybe, and I honestly don't know, there is possibly a mechanical barrier coming that may limit you from going as far as the magnetics could go.

Faulhaber: You are completely right. I think that is a challenge and can be a challenge, but that's what our experts are working on. The interesting part is, as you just said, the TMR heads, the disk industry is working on this technology for almost 10 years now, but with the expertise they have, moving that into the tape technology I think it's even an advantage for us. We know what it takes. Yes, there is a spacing issue. I think the heads are flying and it's not touching, while on the tape, there is some interface. So there is clearly a spacing issue and could be a spacing issue, but again, the interface between tape technology, so make the tape smoother. What does it take, smaller particles, finer particles to make the tape smoother, and this solves eventually the spacing issue.

Gardner: So you don't see any issues in the near future that your technologists are worrying you about?
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Faulhaber: It's interesting. I don't see necessarily in the near future an issue, and I especially don't see an issue or a problem which can't be solved. At the end of the day it's more, is there a way to combining to some extent the tape and disk technology in terms of when we talk about head technology? How to apply the head technology from a disk on a tape technology?

Gardner: Well, I hope we're both here 30 years from now to see how your predictions come out.

Faulhaber: I'm very curious to see that.

Gardner: And I'm curious to know what you think about whether the data will still be around 30 years from now.

Faulhaber: You know, if you would have asked me that question 30 years ago, who would have thought about the worldwide web, what that even is? You know, I remember when the worldwide web was introduced and somebody said, "You can go into the Library of Congress and more or less get access to every single book," which was unbelievable. This is an event which changed the entire world. The email changed the world. It's what and how the world is changing, what events occur in the next 30 years, 50 years? Who would have thought that we are moving from paper, completely from paper, to emails, from punch cards to tape? I think if you would have always known, and we know we have seen where the future is going we would have been much better in our strategic bets and have been prepared.

Gardner: I think you've referred to something you call the digital dark age as, we're in it, and 30 years from now we may be deeper in it. What is the digital dark age?

Faulhaber: So the digital dark age is clearly here. Some experts refer to the digital dark age because now we know about the 21st century less than what we know about the 20th century, and the main reason is in the 20th century, everything was born analog, was on paper. Let's take pictures as an example. Today in the 21st century, everything is born digital, lives digital, and eventually dies digital, and I'll give you a great example. When you come home at Christmas, and the family sits around the Christmas tree and you open your photobook and you look through the pictures you got from the last vacation, —who opens a smartphone? Whether it's the iPhone or the Samsung smartphone, and show all the pictures they have taken during the year? So everything stays on your computer. You don't archive your pictures. You don't go and sort your pictures anymore, so content is born digital, lives digital and it dies eventually digital, and that is a challenge, and that's a phenomenon which we have to deal with, and we have to make sure that we save our data. I would say to close this loop, tape is a perfect solution to solve the problem of the phenomenon of the digital dark age, because you need a reliable, safe, cost-efficient solution which also you have to migrate. You talked about migration. They have roadmap on tape, which you can migrate, and tape is the perfect solution to prevent the digital dark age because I think very importantly, we have a social responsibility to preserve the digital content. The sum of our knowledge for future generations.

Gardner: Interesting perspective. It does require you and I to make use of the cloud, because we're not going to have a tape drive in our house.

Faulhaber: You have a hybrid solution. I think as a consumer, you don't have a tape drive at home, but you have your disks at home, and yes, you have your cloud at home. That's for the consumer like you and me. How do we store our digital content these days? I think if you store it on one format only you take the risk that it dies. You back it up and archive in different areas, not just everything at home. You might have two solutions, but do you keep everything at home? No. But now look at companies with their responsibility,

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and they yes, companies move into the cloud and more and more gets stored in the cloud, but they have a hybrid solution, and interesting enough, I remember somebody asked me and said, "Doesn't the cloud kill the tape business?" No, it creates tape business. There are so many data backup or archive in the cloud on tape. You believe, we had this conversation, you said, "You are not using the cloud." Everybody's using the Cloud one way or the other. You don't even know when you're using the cloud, and I think the best example is your emails. Your Gmail it's Google email in the cloud.

Gardner: Well, I think earlier on you mentioned total data generation as some number of zettabytes, only a small percentage of which is actually reduced to digital or stored as digital.

Faulhaber: Stored.

Gardner: Stored as digital, yes.

Faulhaber: Stored. So I think the sum of data we are creating is predicted to be growing in 2025 up to 175 zettabytes. The persistent data, data we're really storing is projected at about 7.5 zettabytes, so a small portion of the data we are really creating..

Gardner: So most data is ephemeral anyhow. It goes away.

Faulhaber: Many data are not stored and go away, but even 7.5 zettabytes or 7 to 8 zettabytes, put it this way, I think it's just a prediction, that's a significant growth in data, and what is driving it, who would have thought when the iPhone came out. I remember Steve Ballmer made a prediction in 2007 that the iPhone will never have a success story. How wrong was he, and he's a great name in the industry. So there are predictions. I remember the founder of 3Com made a prediction that the worldwide web will go quickly supernova in 1996. We don't know where the world is going and it's changing rapidly and fast, but we can be sure of one thing, that change is persistent. Consistent change, we will always look at changes.

Gardner: I'd also note that you may be able to at least store the data on persistent memory like tape, but if the application doesn't exist when you read it back, it will be gibberish unless you have a lot of money to rewrite the application or there's some sort of translator, You need a Rosetta stone to read Word 1.0 documents today.

Faulhaber: You know I would say migration is key, and that's why the roadmap is so important, and that's the other advantage of tape technology per se, because we have a roadmap which supports the data growth, and yes, you have to migrate eventually.

Gardner: So that may preserve the digital information, but I recently tried to read a Word 1.0 document in Microsoft Word 2010 and it was there, but it was a bit of a resurrection task to find the data amidst all of the other symbols.

Faulhaber: But again, it's about migration. It's technology migration in general. It's not just the tape migration. Technology migration, per se.

Gardner: I think some of the more modern formats for the storage of information are so ubiquitous that they will be readable 30 years from now, formats like PDF. PDF may be at version 100, but you'll still be able to read version 8. There will be a translator. But who knows? We're just predicting. Anything else you want to talk about the future?

Faulhaber: I think in general the future is bright. We talked about digital transformation which is unlimited, and I think tape in general has a renaissance and it's going through a renaissance. Tape was supposedly dead for many years. I know that EMC at one time came out and said, "Tape is dead." I would say tape is going through a renaissance. There are applications. I think it's not about tape versus disk and other technology. It's about complimentary, and it's all about storage optimization.

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Gardner: We talked about three divisions existing when you joined Fujifilm. I believe a broadcast division and a consumer vision, and then a data storage division. You hived off the consumer division. Very early it was losing money. At that time I thought I asked you the question of, what was the ratio between broadcast and computer, and I thought you said, 25 percent was broadcast, but maybe you meant 25 percent was consumer.

Faulhaber: So I'll just give you a little bit of a breakdown. When we're talking about the three divisions within recording media, especially here in the United States, when we had about 25 percent consumer business in terms of topline revenue, 25 percent for broadcast, and 50 percent was data storage, and that mainly consists of LTO, DLT, and enterprise. At that time it was IBM enterprise 3592 and StorageTek, Sun, and Oracle T10K were our technology.

Now we divested the consumer business. Topline revenue is one thing, but there was no profit. It was technically generating more a loss to our bottom line and overall P&L. So we didn't invest in this business. We didn't see the future, especially not in optical. We also sold some USB which are now giveaways more or less, and that flash technology is very difficult if you're just kind of a reseller and not a manufacturer, because capacity is growing fast and then the price comes down, you can't sell old technologies.

But then on the broadcast side, the market changed completely, and the main trigger for this, the broadcast business was always dominated by Sony. Sony has the formats like the Betacam, the Betacam SX, the HDCAM, HDCAM was our business. Sony had some propriety formats like HDCAM-SR, and so Sony was very dominant on the hardware side, and clearly on the broadcast media side. There were two other manufacturers, EMTEC was at one time a manufacturer, but it was mainly Sony and Fujifilm with relatively small market shares. It was still a very nice, sizable business for us, very profitable as well, but both Fuji and BASF and Maxell, with rather small market shares. You might remember in 2011, March 9th, 2011 a major earthquake followed by a tsunami hit Japan, and Sony's facility was in Sendai, north of Tokyo, close to Fukushima. The tsunami completely I would say, destroyed their production facility, flooded it and destroyed the coating lines, and Sony was out of the business for probably roughly nine months. They had proprietary products such as HDCAM-SR, and they had market shares of 80 percent on HDCAM, and significant market and manufacturing shares on Betacam and they couldn't supply. So companies were desperate for product which they couldn't get. So they had to find different solutions, and when companies or consumer are under pressure they find solutions, and there was a solution, especially on the broadcast side. Cameras starting using flash. They backed it up on the server and eventually, instead of having the archive on videotape like Betacam where everything was actually archived on videotape, was suddenly archived on data tape. So there was a transformation in terms of the tsunami triggered a quick transformation and technically, videotape is completely dead and we stopped manufacturing videotape and here we are, since I would say since 2017, we stopped manufacturing broadcast tape and selling broadcast tape because the market more or less disappeared, which was a nice profitable business unit within one of our segments, but you can only imagine how Sony was hit by this change in the market. So from a propriety product now going back to data tape is LTO or 3592.

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Gardner: As a finance guy, I'm sure you understand the fixed cost allocations issues. When you lose half your business, even though that half of your business may not have been profitable, it still was absorbing a fixed cost. Now that fixed cost has got to be absorbed by half the business. Somehow, you managed through that.

Faulhaber: Yes. You're right, as a finance guy you look at this and you take actions and you take actions early enough. We have a German saying. It's more or less, "You fix the roof before the rain starts." When the rain starts, it's too late. You have a hole in our roof, you get wet, so you try to fix it before the rain starts. So what you do is, you fix your organization before people start scrambling here with a business change. You have to do the predictions. Just before I became the president, we actually did a spin off. When I joined in 2004, the recording media was a division of Fujifilm North America and was spun off into Fujifilm Recording Media, USA. We did a major restructuring, and we looked at the business from a different angle, to make sure that we were able to serve the market. We are selling today more cartridges and we're generating more revenue than in 2008, and we are shipping far more capacity than we did in 2008 with less people. So it will be a far more efficient in what we are doing, but that's what it takes to support the market in the business. You have to act early enough.

Gardner: It must have been a challenging period.

Faulhaber: It was a challenging period, when in 2008 the financial crisis hit, everybody was struggling, and everybody tried to reorganize because businesses lost revenue and you had to restructure. There is a pain point, and you suddenly start quickly restructuring, and, by the way you stop as soon as the pain is over. We had done our homework, and I believe that it's my responsibility. It's management's responsibility to make always adjustments to the change, and you have to predict the change and you have to make immediate and constant changes, that the market is constantly changing, you have to make constant changes, and adapt to the changes.

Gardner: Any particularly interesting change you made at that time that you'd like to share with us, or just a difficult time period?

Faulhaber: It was a difficult time period, but we looked at this carefully, because, you know what? I would say, when Fuji was very successful in the DLT days, I would always say, and I wasn't part of this, so it's easy for me to say, I think we were almost like, we were very, very successful. It didn't matter how fat we were. The organization became fat and fatter. I think we gained more and more people. It doesn't matter really if you get more people. But as the market is changing, you have to make sure that you adapt to the changes and make necessary adjustments. It is challenging, but it's part of our responsibility to make sure that you stay competitive in the market environment.

Gardner: And you did.

Faulhaber: And we did, yes. It's not me alone.

Gardner: Anybody in the team that was particularly important contributing to that?

Faulhaber: No, it's always a team effort. It's not me alone. I think I would say I only can be as good as the team is, and it's not just me.

Gardner: So Peter, you are here contributing to the record of history at the Computer History Museum. What does it feel like to be at the Computer History Museum?

Faulhaber: To be honest, I'm honored. I'm very pleased and very happy to be here. I'm part of just a few years of computer history. Twenty-five years is a small part of history in general, but I'm very happy that something like this museum exists where we preserve the history for future generations to come, because we are in the tape industry. I'm focused on media,

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and I would say the kids today don't know anything about this. I'll give you an example. Whenever I come through immigration and the immigration officer asks, "What are you doing for a living," and I say, "I'm selling tape," and they say, "What? Tape is still around, tape's alive?" and I say, "Yes, tape is, you know, we're still selling tape." The interesting part is that the younger generations never really touched tape. We all, I think the older generations, one or the other way, we touched tape. We had our audio recorder, audio tape, consumer tape. We had our VHS tape. We talked about this. So we all touched tape one or the other ways. But the generations today, they don't even know anything about tape. They don't even know that tape is around. So we actually try to educate. One of our friends and colleagues from IBM, Dr. Rice Bradshaw, a good friend of mine, we hired him to go to universities to educate the students about tape, because that's a technology they have never touched and they're not aware of. So it is interesting to see how we need to educate what the technology is and deal with the technology. So this museum here is focusing many years just on hardware, and has warehouses full of old hardware; all different.

But now it's about digital transformation and it's now not just the media. I'm happy to be here and talk about tape technology which is part of the history but it's also part of the future. But it's interesting to see and understand how this actually helps to preserve and do the digital transformation and I go back to what we said before, the digital dark age. Here, this history museum prevents the digital dark age of the history in storage.

Gardner: That is a great way to sum it up. Thank you very much for your time with us today, and I really enjoyed this conversation.

Faulhaber: Tom, I thank you for having me, and I'm really honored to be part of this, and I hope that my grandkids, as you said earlier in the introduction, can come back here and see what we are talking about. I'm very, very happy to be here. Thank you.

END OF THE INTERVIEW