

Wallace Hoff

An Interview Conducted by

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IEEE History Center

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INTERVIEWER: Sheldon Hochheiser
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Hochheiser: This is Sheldon Hochheiser of the IEEE History Center. It is the 12th of April, 2010. I'm here at the National Electronics Museum in Baltimore with Wally Hoff. Good afternoon.

Hoff: Hello there.

Hochheiser: If we could, start with a bit of background. When and where were you born?

Hoff: I was born in Madison, South Dakota. I grew up on a farm just north of there, went to school locally. A one-room schoolhouse, which seemed perfectly normal then. Then went to a local high school and ended up at South Dakota State University, got a BS EE out of there in 1960.

Hochheiser: What was what was the EE curriculum like at South Dakota State when you were there?

Hoff: Well, there was quite a bit having to do with power and power distribution and that I think historically had been their, their focus.

Hochheiser: Sure.

Hoff: They had a new instructor at that time that was getting into this new thing called solid state, and transistor devices and things like that. I got all of those that I could. And that was a lot more interesting to me than power.

Hochheiser: Backtracking just a little, were you interested in technology and science growing up?

Hoff: Yes, I think so. Not to the extent of building model airplanes and things like that. There was plenty to do, but I was always interested in how things worked and fixing things and that sort of thing.

Hochheiser: And what led you from South Dakota State to Westinghouse, rather than some other opportunity when you were finishing up your degree?

Hoff: Well, 1960 was a pretty fortunate year for those that graduated then. Things were on the upswing. I could have gone to work any number of places. Control Data Corporation was a new upstart company at that time.

Hochheiser: Right.

Hoff: I could have gone there. I could have gone to McDonnell Douglas. I could have gone to Boeing. Interviewed at IBM and ironically they withdrew their offer after they lost a program called the B70. I was most attracted to Westinghouse because of the tuition refund program. I knew I wanted to go to school and get a master's degree. And that seemed like the best vehicle for doing it. In retrospect, I think all of those people had tuition refund programs, but Westinghouse made that very clear to me as opposed to some of the others who never brought it up.

Hochheiser: So you signed on with Westinghouse.

Hoff: Signed on with Westinghouse. A week after graduating hopped in the car and drove to Pittsburgh. Westinghouse has a program called the Graduate Student Program, [or] had then. I was on the Graduate Student Program and did I think it was three weeks of indoctrination there and then received an assignment in East Pittsburgh. I was working on control circuitry for control rods in nuclear

reactors. I wasn't enthused or impressed too much about the environment there in East Pittsburgh. A lot of the engineers I worked with brown bagged and slept for the rest of their lunch hour and it didn't seem very invigorating to a 22-year-old. The next assignment I got was down here in Baltimore at the defense center. I believe I thought I was in heaven and never left.

Hochheiser: [Laughter] What was your first assignment here in Baltimore?

Hoff: I was working in a group called the solid state design in an organization called Advanced Development where some of the [unintelligible] work went on. it--I was led to believe that this group was going to do all the solid state design for everybody. We soon learned that solid state design was a way of life for just about everyone. I was designing solid state circuits almost from the time I started and using transistors and, germanium mostly 2N526s [?]. We used a lot of those at the time.

Hochheiser: were these solid state devices for specific larger projects, or were they more speculative or research oriented?

Hoff: Well, some of them were research and some were for specific applications, on maybe a development system or two. We didn't do much in that particular group where I started in designing gear for production of radars at that time. We were more in the advanced development area.

Hochheiser: About how long were you in this assignment?

Hoff: Well I was in that assignment until 1968. So I spent several years there.

Hochheiser: So you spent a fair, fair amount of time doing this.

Hoff: Yes. We started doing a lot of development work for the Army. It was during the time of the Vietnam War and they were needing clandestine kind of equipment. I got very closely identified with a program called the advanced, or the improved position locators, the dead reckoning backpack system. There was a lot of concern about in triple canopy environments our servicemen getting lost in there.

Hochheiser: Yes.

Hoff: And they needed some navigation so, we used some Hall Effect devices and made electronic compasses and it was a lot of fun. We used to run up and down the hallway testing this thing because we had to measure distance and direction. I got quite a reputation there for having this squirrely backpack device.

Hochheiser: Yes and running up and down the halls with it on your back.

Hoff: And running up and down the halls with it, that's right. In 1968 there was a reorganization in the Advanced Development organization that I worked in; it was all kind of assimilated into the engineering operation in the West Building and I ended up working for a young section manager named Dick Linder. And so I knew Dick from 1968 onward.

Hochheiser: Yeah. Who did you work with and report to before '68?

Hoff: At the department level I reported to a fellow named Kent Mack, who ironically was another South Dakota graduate, but South Dakota School of Mines, not South Dakota State. I was in his department and some of my management there was Ted Hamburger [phonetic], Reid Brainerd [phonetic]. Reid was a section manager, Ted was a supervisor.

Hochheiser: Then in '68 you start reporting to Dick.

Hoff: Yeah. And there was a supervisor working for Dick named Wolfe and I can't

say his first name right now. I'll think of it.

Hochheiser: That's okay. When you get the transcript you can fill it in.

Hoff: All right. At any rate I worked for him and then a couple of years later I became a fellow engineer and kind of an acting supervisor and I started having a group of people working with me and kind of went on from there, from a management point of view.

Hochheiser: What, what other projects did you work on besides the dead reckoning backpack in this period?

Hoff: Well, we did some satellite related work, very low power circuitry where with a collector current and maybe 30 or 40 microamps, what kind of gain could we get out of transistors. Usually they weren't used in that realm, very low voltage. And so that was an interesting project. We had a mine detector program to detect mines. We had a navigation system for a tank. We had a number of independent development programs. Then when I was working more with Dick for some period of time, I got involved in DPS 43 and SPS 58 designs.

Hochheiser: What are these?

Hoff: DPS 48 and DPS 43 ground tactical radar. The SPS 58 is a shipboard radar system. So I started getting more into radar.

Hochheiser: And this is about, is this about the time that you became a supervisory engineer?

Hoff: Yes. I was a fellow engineer as an acting supervisor. That went on for quite a while. There was a clamp on management positions I think but it didn't much matter to me. It was the same, pretty much the same thing.

Hochheiser: Just a different title.

Hoff: Yes.

Hochheiser: You had mentioned that one of the reasons that you were attracted to Westinghouse was the tuition reimbursement. So when you got to Westinghouse, did you take advantage of this?

Hoff: Yes. I did. In the mean time, I was married to a local gal here. We had four daughters and things were busy at times. So it was 1970 before I got my master's degree, but I did.

Hochheiser: Well, if you're doing it at night with a full time job and a life, it takes a while.

Hoff: It takes a while. That's right.

Hochheiser: And how did your studies there contribute back into your work here at Westinghouse?

Hoff: Well, from a radar point of view I think quite a bit. There was an instructor by the name of Professor Reed who had written books, at the University of Maryland and was pretty well known for propagation and propagation anomalies and that kind of thing. So, all of that helped a lot in radar, just understanding the application range equation and a lot of those things.

Hochheiser: You earned your degree '70. And then not long after that you started really working on radars.

Hoff: Yes. Yes, about that same time.

Hochheiser: You mentioned the ANTPS 43 and 63 projects. What was your role in this overall radar project?

Hoff: Well I was a design engineer, and then maybe had two or three or four people in my little group working on those systems. It would depend on what the need was at the time.

Hochheiser: In these projects, how closely did you work either with the customer or the prime contractor?

Hoff: On all of those programs we were the prime. I at first had very little exposure to the customer. We had an organization there in the West building that ran the programs per se. We were the engineering support for those. Later on I got a lot more involved with the customers.

Hochheiser: What systems were these radars designed to go into?

Hoff: Well, the TPS43 was a 3-D S-band ground based radar for air defense. The TPS43 was a shorter range 2-D radar for the Marine Corps, again, air defense. So they were ground based system, kind of standalone. Networked, and so in that sense they weren't just isolated. I mentioned also the SPS58, which was shipboard radar and tied into the combat control system aboard those ships. But I was never very involved in the design of any of that interface or the command and control pieces of it. We were more into the signal processing receivers and pulse compressors and things like that.

Hochheiser: Were you doing digital work by this time, or is this still analog?

Hoff: Well, in about 1970, I don't know the date for sure, but there was a program called Hawk down at the Army at Huntsville. Dick Linder and a couple of other people proposed a digital conversion for that analog processor. That turned out to be the first digital signal processor, up in the front end, put in A to D and do everything, all the MTI processing and everything digitally. It was probably the first real implementation and it worked very well. That was about in 1970. Very quickly all the processing went digital. It was almost paced by the A to D converters. As soon as we'd get an A to D to work with the right dynamic range and right clock speeds then we can do everything digitally.

Hochheiser: How did you come to be selected for a Lamme fellowship in '72?

Hoff: Well I worked for Dick Linder. Some of the things that we did had to do with IRAD. We had a very influential guru at the time running most of the IRAD programs in Baltimore, Dr. Paul Pan. Over time I got to know Paul Pan who was right in the middle of the selection committee for the Lamme scholarships. My name was put in and then we had to take—this was what, almost 12 years after I got B.S.— the GREs, myself, along with a number of other people. We were taking the graduate record exams and getting all those scores for them and I ended up being selected anyway. I thought I was pretty lucky and at first thought of going to Stanford. Then somehow down through Pittsburgh the notion was floated that hey, we'd like to get some international flavor for some of these people that are doing this. Three of those daughters were in school by that time, so we decided on England. Then it was more or less a choice of Imperial College or Cambridge. And so I ended up at Cambridge. It was a tremendous experience they were giving me

Hochheiser: Can you describe your experience at Cambridge and what you got out of it?

Hoff: Well, from a technical point of view I already had my master's degree.

Hochheiser: Right.

Hoff: I had almost full latitude of telling them what I'd like to work on. I wanted to work in digital signal processing. And I wanted to do course work that supported that kind of thing. Z-transforms were just coming into vogue so I wanted to take some courses there but also to work on a project. It turned out

that they had surely a genius kid about 19-years-old that was coming up with algorithms that were FFT in theory but they didn't work on points of, or linear strings of data. They worked on blocks of data, kind of a matrix version of an FFT. One of the implementations of this then was to do a digital filter bank for, say, a communication or telephone system, say, with 64 channels in it. They'd like to take that broadband channel and A to D it and given that it was analog, and convert that thing, D multiplex it without ever doing anything analog. I was able to take this theory that this young fellow had come with, and it was some kind of wild math, and conceptualize a workable system. I did that and wrote a thesis on it and got it all done in the one year that I was there, and had a great time. And they were wanting me to stay for two more years and get a PhD but the paycheck wasn't going to continue if I did that.

Hochheiser:

[Laughter]

Hoff:

So I came back. But they did award an advanced certificate in engineering for whatever that's worth, but it was great time. That's the technical side. From the family point of view we had a great time over there too and did quite a bit of traveling around and so it was a good experience.

Hochheiser:

And when you came back is when you became a fellow engineer and acting supervisor.

Hoff:

I was already a fellow engineer.

Hochheiser:

Okay.

Hoff:

I was made a supervisor shortly after that and given kind of a different group of people in this signal processing organization; that was the digital signal processing group. I ran that group for a while and then became a section manager, the job that Dick Linder had once had. He had moved on and so I became a section manager there.

Hochheiser:

As a section manager, would you have several supervisors reporting to you?

Hoff:

Yes. Yes.

Hochheiser:

About how many people in total?

Hoff:

Well I probably had 60 to 80 people and sometimes some temporaries and things. Maybe it bounced up to 100 in the middle of a big project, but direct reports, 60 to 80.

Hochheiser:

I would assume by this time your work was almost entirely of a supervisory management nature, or did you still manage to do some engineering?

Hoff:

Primarily it was management but it was pretty closely tied.

Hochheiser:

Sure.

Hoff:

And it seems like in those kind of jobs you're working on the hottest of the hot potatoes and so generally those problem areas tend to be fairly technical. So, I wasn't getting away very far from the technical.

Hochheiser:

[Laughter] Any particularly notable hot potatoes you recall after all these years?

Hoff:

In that period?

Hochheiser:

Ys.

Hoff:

We were very aggressive in bidding the processor for the TPS63.

Hochheiser:

Right.

Hoff:

That required a 12 bit A to D. We had some struggles getting that A to D to work. We had some struggles, particularly with the available budget in getting the whole processor integrated and working, but we did. But it was a struggle.

Hochheiser: And were you still reporting to Dick Linder as he moved up?
Hoff: Well yes, until 1978. Then I think Dick moved to the East building to take over the electronic warfare. And then I worked for Lou Meren for about two years, and then I moved out of the job to go to the Advanced Technology Lab in 1980.
Hochheiser: Anything else on this job before we move on to the Advanced Technology Lab?
Hoff: Well one of the things I took a lot of pride in was encouraging others who worked for me to be interested and express their interest in the Lamme scholarship. I had two other guys that worked for me that ended up getting Lamme scholarships during the time, after I came back but before I left, in that same group. So we had three of us in that one little area there. Good people.
Hochheiser: What was Westinghouse Baltimore like as a place to work through this period, through the 60s and 70s?
Hoff: Well it was a lot of fun and enjoyment and challenge for me. I thought it was tremendous. In the first 10, 15 years, I didn't have much perspective of what other companies were doing and what the cultures were like in other companies. I knew I liked where I was. I began to get more and more involved with customers even late in the 60s because we were working these independent contracts. Later on with some of the more significant military contracts for the radars I was involved with some of those customers and it was always interesting and a challenge to be involved with customers across the table. They had their interest and needs and desires, we had ours and to find a compatible path through all of that is what the objective was.
Hochheiser: So in 1980 you move over to the Advanced Technology Laboratories as an engineering manager.
Hoff: Yes.
Hochheiser: And what led to this move and what did this new position involve?
Hoff: Dick Linder led to the move. It was his idea. There were some very significant programs going on at the Advanced Technology Lab and there were some devices, these were integrated circuits by that time, they made it ATL. I'll use that term now. So at ATL there was a lot of development work and new kinds of things being worked on all the time. But under that was a need for production quantities of some of these very specialized devices. Some to this day we can't talk a lot about what their application was.
Hochheiser: I understand.
Hoff: But they were, they were critically important at the system level. And so there was a need to be able to produce devices that were identical, one lot to another, and that we maintained configuration control on. There was a culture at ATL just because it is what it was, what it came out of a little development lab. So Dick felt they needed a little bit of a different culture that was more focused on cranking things out and getting things documented and things like that. So he talked me into accepting, he didn't have to talk long, but he talked me into accepting a job as engineering manager at the Advanced Technology Labs working for Gene Strull. And so I did that. In addition to some of the things that we can't talk much about, there was a program called VHSIC, very high speed integrated circuits that was rolling along, gaining momentum at that time. I was absolutely right in the middle of that. We were participating in a number- there were six primes and we were working on several of those teams. We

were cranking out data arrays and other kinds of devices for those. That was a fun and exciting time. It turned out to be that there was as much advance or maybe more, particularly with solid state memories, in the whole commercial side of the electronics world. So the philosophy of VHSIC was that DOD needs to invest hundreds of millions to take it in the direction that DOD needed. Well it turned out that the commercial world was probably investing ten times that much. And the military needed to ride that coattail or get in the wind stream anyway.

Hochheiser: So after a while there was not a need for a separate military funded VHSIC program.

Hoff: Yes. That's right.

Hochheiser: So the program ended.

Hoff: Yes. And there were people in the beginning that said there wasn't a need. But there was funding for quite some time. And there were some significant things done during that time. We worked with National Semiconductor but there were several other folks, TRW and some of the other people were working in this area and there were some significant development that was accomplished during that period of time. But in retrospect, it-probably all was pretty likely to happen anyway, particularly digital memories and things.

Hochheiser: Right. But of course you don't know that until you look back.

Hoff: That's right. So VHSIC was very experimental and it had some very positive outputs but just kind of floated away in the end.

Hochheiser: Now as engineering manager, did you similarly have a substantial group of people reporting to you, or was it like a matrix type thing?

Hoff: No. I had all the engineers, the process engineers, the design engineers. In terms of numbers it was probably 120, 140 people, something on that order, and a lot of PhDs. A number of people working on optics, most on solid state design. There was a whole group working on design of charge-coupled devices. There was just a range, little pockets of technology where we had some people that were outstanding, and were recognized in the customer community and they kind of received funding just because of the work they had done and the work that that customer thought that they could do. And so we had a number of outside contracts. We had an internal program, one in particular that we had to support big time, and had to have priority over any other development program. From a management point of view, sorting out priorities and how we were going to work in some of the smaller development programs with the big programs was all interesting and challenging. It was also interesting to me from a management perspective because I was now in an organization where the base fundamental technology going on there wasn't a tech base that I had grown up in, like in my previous job. So that was, again, in retrospect, it was an opportunity for me to learn to kind of grab a hold of what's going on and learn how to look for the long poles and the hot spots, trust the basic work to the guys that were working it and it is surprising how quickly you can kind of grab a hold of what's going and which of the critical things you need to know about and who are the people that'll go take care of the details and who do you need to check on and all of those things.

Hochheiser: So, it's very much at the same time as you're balancing the priorities for various

projects, it's managing people.

Hoff: Yes, very much so. And in that environment it was managing people that maybe at times hadn't been managed much. They were kind of freelancers working their own particular area and suddenly some of the things they were doing started to affect bigger and bigger programs, which meant success, but it meant maybe a little different MO for some of those folks too.

Hochheiser: Having to do a little bit more coordination of their work with other things.

Hoff: Yes. And not changing priorities on Monday morning after a thoughtful weekend or whatever. You've got to follow through and we've got to do what we've got to do. That all worked very well. They were a great bunch of people and a lot of fun. I always remember one PhD, fairly young, who couldn't conceive of the notion that somebody that hadn't lived their life in the technology world that he was in could possibly manage such an operation. He was frank enough to say that the first time we met, or talked. And so I was asking him to reserve judgment for six months and we'll get back together and we'll both see how it's going. And we did that, and things worked well.

Hochheiser: Then in '83 you became manager of Advanced Radar Development.

Hoff: Yes.

Hochheiser: So is this in a different part of the operations?

Hoff: It's was still in the same part of the organization that was doing advanced programs but it was more program oriented than the kind of program/technology that was going on at ATL.

Hochheiser: Right.

Hoff: This was also the time when a program called Advanced Tactical Fire was embryonic. And there in the avionics lab at Wright-Patterson, the lab was conceptualizing a variety of programs that would do the tech base and advanced demos for this advanced technology fighter that was coming over the horizon as a replacement for the F-15. That was all coming together in the early 80s. And so a program got defined called at first the solid state phased array program. I wasn't involved in that. It was bid here in Baltimore and we lost it to TI which was kind of an eye-opening for both Hughes and Westinghouse. The next program that got defined was the ultra reliable radar. The ultra reliable radar, sans the antennae because the rest of the radar was what the URR was and that was going to be merged with the TI solid state phased array. From a strategy point of view we couldn't possibly have anybody else winning that URR program. We wanted to be that URR winner and do the integration of that solid state phased array. So Dick Linder said...We were having an absence of the leader for that group because he unfortunately died of cancer. There was a need to get somebody to lead that group. It was just maybe four or five months before this URR proposal was due. So Dick moved me over there and said win the URR. So we went all out. There were some good people there and we wrote the URR proposal and we won it. In parallel with that, the avionics lab had conceptualized two other programs that were wound into this same batch of electronics. One of them was called a 1750A and that's sort of a flight computer and an advanced signal processor. The URR was the radar system and it was going to take the antennae, the advanced signal processor, the 1750A flight computer and put it all together with some radar algorithms and do a

demonstration. So the URR, that was a good notch for us because that was the integrator for all of this. We also bid the solid state processor. We did not win that, Hughes won that. And we also won the 1750A. So we were doing the 1750A flight computer, the URR and integrating those other two pieces. In retrospect it was great strategy to go hog wild after those programs and we won some key ones. And it led us into the next phase where we needed to hook with primes. And those primes were bidding the F-22 and the F-23. Because of all of that, we were selected as radar supplier for both the F-22 and the F-23. Those were some important and fun-filled years, going after those programs.

Hochheiser: With the URR and the related programs, those were direct contracts with the military?

Hoff: Avionics Lab. That's right.

Hochheiser: With the avionics lab at Wright-Patterson.

Hoff: Yes, that's right.

Hochheiser: Right. But then after you have those, then you are working with the aircraft companies?

Hoff: Yes. Yes.

Hochheiser: And which ones were involved with?

Hoff: Well the primes were teaming up. So there was a team for the F-23, that was a team of McDonnell Douglas, Northrop and a third that I can't recall right now.

Hochheiser: That's okay.

Hoff: And then Lockheed and Boeing were the F-22 team.

Hochheiser: Right.

Hoff: And so I guess Grumman was involved in the F-23 also.

Hochheiser: Okay.

Hoff: So those two sets of primes then became the people that we worked with as an avionics supplier. There were attempts, say from Hughes to come in and bid their own radar. We were in a favorable position. I should say too that one of the needs that came out of this whole avionics lab program was that we needed to have a better recognition and toehold of the technology for solid state apertures. We worked very hard on that. I would say that we started late. I can remember many meetings where Paul Pan used to say, if we could just come up with a good plan, we'll go to work in this solid state phased array. But, I think history might say that we got a little bit of a late start. But no matter, you are where you are. We started working extremely hard on solid state phased arrays. We began to be credible enough, but we didn't think we were so credible that we could go it all alone. There was this wildcard called TI out there. We were looking like the favorite for the radar supplier. But if we didn't pick up TI, then they could suddenly pop up with Hughes and maybe then they've got more identity for solid state apertures than, than we did. So in the end we merged with TI and that was a difficult marriage. I spent a lot of time working with TI, and trying to keep them in their box I guess, from our point of view. They came into this thinking they were the radar supplier, practically, and to gradually convince them that there is more to a radar than an aperture, a very important part but an aperture is a part. We kept our hands on the software. We kept our hands on the stay-lows[phonetic] and some of the sensitive RF stuff. So in the end then they had a role to do half of the aperture and we did the other half of

the aperture. Then we and TI arm in arm would go off and work with these primes. The fact that we did that with TI I think helped too in us being selected as a radar supplier. And it is evident, I think, that the Air Force and the avionics lab were behind the notion that if the people that they had funded to do some of this development work, -- were suddenly to fall off the edge of the table, it wouldn't look good for them either. So that's why it was important to win them in the first place and then capitalize on them in the second place.

Hochheiser: As you did.

Hoff: Yes.

Hochheiser: And then I guess since you were working with both the F-22 and the F-23 teams, you were in a good position regardless who won the fly off.

Hoff: We were. One of the other things I should mention, the avionics lab was doing EW development too. There was a program called INEWS, integrated new electronic warfare system, and we had INEWS development that we had teamed with TRW to do. So the TRW/Westinghouse team bid INEWS on both the F-22 and the F-23. They won on the F-23. So, if the F-23 won, we had the radar, we had the EW and so we would have a bigger piece of that. On the F-22, the EW went another way and we weren't playing in that EW piece. So nevertheless we had a very major role no matter who won the F-22 competition.

Hochheiser: Right.

Hoff: I mean the ATF competition.

Hochheiser: Competition, yes. But the F-22 won the competition.

Hoff: Yes, it did.

Hochheiser: Right.

Hoff: Yes. I remember those fly offs well.

Hochheiser: I bet you do. Now once the fly offs were done the contracts awarded and now Westinghouse is moving into a production phase?

Hoff: Well, it's a prototype phase. We had to step up from the demonstration hardware that had been produced via the avionics lab. We had to propose a program and quote CPFF kind of development phase to get to prototype hardware that would fly and hopefully be pre-production models. So somewhere between prototype and pre-production that's where all this was. We had a lot of work to do because there were a lot of system requirements. Stealth was a major player and when you're dealing with apertures then stealth is a big deal. We had a lot of development work that was going on. And some of that occurred during this competition F-22/F-23, but an awful lot more than on the F-22 program when that was launched and funded and underway, then we had a lot of work to do. And TI was right there always wanting to be in the middle of the tent. It was a challenging program to meet all of those requirements. We also for the F-22 and the F-23 we were proposing to use our flight test bed. But Boeing didn't want much to do with our flight test bed. We could fly the radar but then we would ship them the radar from there on and they would do the integration in their flying test labs. So had the F-23 won, we'd have played a bigger role in that phase of things too, the integrated test plan. But we did fly the F-22 here first and then transitioned it. There was a lot of skepticism about whether active apertures were ever technologically feasible in an airplane environment with vibration and G loading and things like that. There were a lot of respected and

respectable people asking questions about is it feasible or not. We were convinced that it was. We had a lot of design work to orient things and design the system so that we thought it had the best chance of surviving all of that environment. There was the whole question about thermal stability and thermal gradients and a lot of things. Some modes exercise parts of the antennae more than others and putting all those things together then we thought and worried and planned and implemented around all of that and it turned out well. They're flying today.

Hochheiser: At what stage in the history of this program did you move on to another assignment? Where was the program in '86 when you moved on?

Hoff: In '86, we had just been awarded--well, the F-22 and the F-23 had just been awarded. There was the need to carry forward with our own technology and to interface with these two primes. And that's 1986. I didn't go to ATF. There's a gap here of a year. In 1986, I went and ran the surveillance radar division.

Hochheiser: That's the part where I got a little confused because I saw there was this one position here that seems to be dealing with something else in the middle of this whole story.

Hoff: Well, the reason for that was that I was department manager level, then there was an opening in the surveillance radar division for the level of general manager.

Hochheiser: Right.

Hoff: And Dick asked me if I wanted to be a general manager, I said sure.

Hochheiser: Yes, did you want a promotion?

Hoff: Yes. Right. Do I want one? And it wasn't in the area that I would most like to have worked

Hochheiser: Right.

Hoff: But it was a promotion to a general manager and I took it. So for a year I was working in really kind of the, the systems that I grew up with, TPS 43-and 63 and some of those. By then they had gotten a lot more involved in communication systems adjunct to those radars and networking command and control systems and things like that. So I got involved I that. I was there for about a year and things were getting hot and heavy then the ATF program was getting underway. And for whatever set of reasons Dick wanted me back over there working with those primes. And so after one year I went back and worked the F-22/F-23.

Hochheiser: Some of these things that you already have spoken about.

Hoff: Yes. And I was very familiar with the people and the programs and the objectives.

Hochheiser: Right. You were going back into that ongoing program one level higher up.

Hoff: Yes. That's right.

Hochheiser: So did you have additional responsibilities when you came back now that you were a general manager?

Hoff: Yes. There was still some ongoing work to try to sell INEWS. I had EW responsibility. I had EO. We weren't in the middle of the EO activities and it turns out that there wasn't going to be an EO sensor on the F-22 at that stage anyway. At a concept level we were trying to incorporate the notion of EO so that we could be compatible with it as time went on. So we were working EO

and I had those areas as well. Some space kind of development work as well. That was a good job, a big challenge and a lot of very good people. There was also a category of programs that I'd call special. In that timeframe there was quite a lot of that stuff going on.

Hochheiser: So you had a lot more under you besides the F-22/F-23 program at that point?

Hoff: Yes, yes.

Hochheiser: Any of those of particular note that you can talk about?

Hoff: Well one of them turned out to be the Apache Longbow. That is fundamentally a radar program but it had some very unique and clever target classification modes that can now be talked about. That program started in 1979. That was a very interesting program with the Army. A lot of the labs around the country got involved in that. I'm trying to think of others. None come to mind right now.

Hochheiser: And that's fine. What stage was the F-22 program by 1990 when you moved on?

Hoff: We were through flight test and we were bidding the next phase of the program. That was going to be pre-production. I went to the division where that program was going to transition to. I was involved in the bidding, quoting for that program. It was very appropriate because then I was the one that was going to have to live with that quote because it transitioned. That's the way our system worked. We developed in one organization and transitioned to production divisions, so-called.

Hochheiser: Was it common for a manager to move over with that transition as you did?

Hoff: Maybe at some levels of management, but probably not at the general manager level, but this was a pretty significant program too. And it kind of fit my career; I won't say needs, but it fit in with a career plan for me because I spent almost my whole time up until then on the development side of the work. And I needed to get some production experience.

Hochheiser: Okay, so in your next position you followed this big project into the production phase?

Hoff: Yes. And I also had responsibility for ongoing production like F-16s. That was the major program in those years going on in that division. There were probably about four different incarnations of the F-16 radars. One of them was the APG-66, which transitioned into an APG-68. There were various configurations of each of those, and for different customers, a lot of them international, and a lot of work with then General Dynamics who was the prime on the F-16.

Hochheiser: And, I guess you were in that position, what, for a year or two?

Hoff: I was in that position for maybe a year and a half. Then Aris Melissaratos was moving. He was offered a job to run the research labs in Pittsburgh. Aris had the engineering and manufacturing organizations. So after that year and a half then I moved over and took over engineering and manufacturing, probably on the order of 5,000 people, thereabouts, and we operated in a matrix organization. So those people worked for me but supported all the programs around them.

Hochheiser: That must have led to a whole different set of management issues and concerns if you're now managing 5,000 people in a matrix setting.

Hoff: Yes. It certainly is. I had a good flavor for the matrix from some of the other programs you know. But on the other side.

Hochheiser: Right.

Hoff: Back in the 60s and 70s, or back in the 70s anyway, when I was doing some signal processing, that was a matrix organization as well. So it wasn't totally new, but it creates a lot of--your focus has to be significantly on the programs and trying to bridge and merge all the requirements; it's sometimes an impossible task. And then you got to cajole and say in a couple of weeks we can do this or something, but I'm absolutely convinced matrix management is the way to run the kind of businesses that this was then and is now.

Hochheiser: It worked.

Hoff: It worked. Yes.

Hochheiser: What were the things that occupied the biggest chunks of your time in your five years in this position?

Hoff: Well personnel development to make sure that we were doing the right kind of training and union interfaces.

Hochheiser: Because now you have manufacturing under you...

Hoff: Yes, right. Lots of or periodic union negotiations and things, not much from an external point of view. I was almost not working with customers then. It was all internal. My customers were program managers. And so it did change a lot of the day-to-day activities for sure. I still had to be involved and know what was going on in some of the major programs, because if we were causing problems there was no shortage of visibility on any of those, so, we tried not to create problems wherever we could. In addition to training, career development and moving people around like 15 or 20 years earlier I had been moved around. It's good for people's careers to move them around. And picking the folks and picking where to move them, that's all an important part of that job.

Hochheiser: And who did you report to in turn?

Hoff: I reported at that time to Dick Linder. It was probably another year or so later that job was expanded because Noel Longuemare accepted the job working for Bill Perry down at the Pentagon. Then, in addition to engineering and manufacturing, I picked up the development organization that I used to work in. I was back into sometimes having to worry about the development programs and the matrix operation. I had that whole piece and that was pretty broad kind of job.

Hochheiser: Were there any programs that ended up requiring a chunk of your attention or at this time were you too far removed from them?

Hoff: Well, you know I had people working for me that were focusing on specific programs a lot more than I was, but depending on what was going on, a particular phase, a particular circumstance or whatever, then I would get pretty involved. And there were some very significant things going on in AWACS. So at times I spent quite a bit of time on AWACS helping to strategize and interface with customers on some of those things, some of the special programs going on. They continued in that timeframe. But typically there wasn't a program that would tend to consume you in that position for months at a time, but maybe a week at a time or a weekend at a time or something. But it all works when you have good people that you delegate things to and they carry the ball and let you know what's going on. And so I did have those good people and it worked.

Hochheiser: Did you have much contact with the people back in Pittsburgh in this position?

Hoff: In that position a fair amount because at the time when I picked up the development organization then I had engineering and development. and that was almost the full spectrum of interface for the research labs in Pittsburgh. It was the full spectrum of their interface down here in Baltimore. So, various of our technology development, ATL kind of people and maybe some of the next level of technology, those folks up there were all interfacing in the organization that I had. I interfaced with some of the management up there at the research labs a good bit. At the bigger management level, I was aware and I became involved in meetings and things with our corporate management people. That was more Dick Linder's role than mine by far, but I would support it. And so I got to know a number of corporate people in Pittsburgh and also some of our peers in other parts of the company.

Hochheiser: Anything else on this position? I know the one thing you mentioned specifically here in the notes you prepared for me was the F-35.

Hoff: F-35, yes. It started out as the joint strike fighter. Our strategy early on was to couple that, make it a next generation of the F-22 technology. We did that. When I moved to be the general manager of Air Force avionics division, that joint strike fighter stayed back in the development world. So there was a period of time I didn't have much responsibility for that. But then I came back into this matrix job and also the advanced development work. And so I got back involved in the joint strike fighter. That went on and we worked with a number of people, built prototypes and that ended up then being the F-35. We had some of the same folks involved in the joint strike fighter. Boeing was more or less going alone, competing against Lockheed. By then a lot of the airframe consolidation had taken place. And Northrop, then Northrop Grumman had decided to team with Lockheed I guess. So my timing is a little bit unclear right now. At a point in time, McDonnell Douglas was acquired by Boeing.

Hochheiser: That's right.

Hoff: Well I'll have to get that straight and I can take care of that and then--

Hochheiser: Yes, when you have the transcript there's ample opportunity then to get that straightened out.

Hoff: Right.

Hochheiser: Can you give me your recollections of the sale of the division to Northrop Grumman?

Hoff: Yes. There was kind of a confluence of events going on in 1995. Completely apart from Northrop Grumman Dick Linder was going to be 65 in July of 1996. So at the corporate level they were beginning to think of succession planning and all and had decided that Fran Harvey would come down and be the next president of the Westinghouse Defense Center. That actually occurred about August or September of 1995. And Dick then was going to work until July of 1996 when he had to retire.

Hochheiser: Right.

Hoff: He was going to work with Fran during that period of time. So in the fall then after Fran was down here, but not long after, there was the decision at corporate that having bought CBS they had to figure out how to pay for it at Westinghouse. Not a very bright crowd up there at that time. My opinion. So they decided about the only saleable asset they had was the defense center. So

they put it on the block and this was all going on in late 1995. And Fran was sort of the spearhead from here, along with Dick Linder. Another thing that was going on, there was a meeting of corporations that Dick Linder and I had historically been going to. And so he and I were down in Phoenix and there were a group of primes and defense contractors there. And it was interesting because the wives were there too. My wife and I walked in for dinner and the protocol was that you reach in this fishbowl and pick out your table. So we reached in the fishbowl and picked out a table and just ironically we ended up sitting next to Jim and Diane Roach, the first time I had met Jim Roach, the fall of 1995, and he was saying they were already--Jim Roach was Northrop. Northrop headquarters, Northrop Grumman. They were already eyeing this defense center thing. We were talking a little about things, and the fact that we were kind of getting ready to be on the block and those sorts of things., Then he said, you know, I'd like to meet Dick Linder. And I said I can take care of that when we finish dinner. And so I took him over and we talked to Dick for a while. Then it was a matter of a few weeks, kind of right between Christmas and New Years as a matter of fact, they came in here, or maybe it was the week before Christmas. They came in here and we were to give them a major presentation of the whole operation. I was presenting the aerospace. Fran had decided to move me over to run the aerospace operation because Emmett Wheeler was going to be retiring. This was occurring so I was presenting the aerospace piece of this thing anyway. Jim Roach was there and I knew him. he was there with Kent Crussa [phonetic] and all that. So we presented and then over Christmas they--I guess they took Christmas Day off, but they decided to blitz this thing, make a preemptive offer to Westinghouse and kind of short circuit the whole exhaustive auction process that might otherwise had happened. So they made their preemptive offer and Westinghouse accepted it. It all happened very quickly relatively speaking, and for 3.6 billion. I was in the middle of presenting what we were and what our programs were and they were probably more interested in people that were presenting than programs. They could find out about the programs and have an appreciation independent of having these presentations per se. But they were very interested in sizing up the people and so forth. It didn't hurt me at all that I already knew Jim Roach, I think. Then things happened pretty quickly and I think it was the 16th of March or something in 1996 that the sale was consummated. And I continued in that job that Fran had put me in a few months earlier.

Hochheiser: To what extent did things change here or not change once Northrop Grumman because the owner of the operation?

Hoff: I would say more things didn't change than did. My view then of Westinghouse corporate was extremely low. And to have somebody in a headquarters organization that knew what AWACS did, and it wasn't quite that bad maybe but it was almost. So it was very refreshing to have a CEO of a company in the same business we were. And that certainly wasn't the case before. As far as changes are concerned, Jim brought his own tight inner circle, to no surprise I don't think. Fran Harvey ended up not staying because Jim Roach had lobbied hard with Kent Crussa to get this president's job here, and he got it. He brought his own financial guy, and he should have. He brought an implementer sort of

fellow, Bill Brackney [phonetic]. He brought along a couple of other people, but basically he said this is a good organization; I'm not going to throw any sand in the gears here. We're going to keep doing what we're doing and I'm going to catch up to what's going on and we're going to succeed. So it was a good move, a good strategy. The other thing that helped in the longer run was that there wasn't a like kind of organization in Northrop Grumman. There wasn't anybody else building radars and EWs and EOs and processors and all the stuff we did, so there wasn't the prospect of merging organizations. There wasn't the prospect of or problem of overlap. There were a lot of fortuitous situations that all helped us along through this whole process. We continued to make money as we had been and they were extremely pleased I think overall.

Hochheiser: And you continued on in the position that Fran Harvey had moved you to just as all of these things were starting to unfold.

Hoff: Yes. Right. And it was running the aerospace organization. So it included F-22s and space divisions and AWACS and Longbow radars and lots of things. Subsequently we bought, no we had bought Norden. That brought along with it a significant role on Joint Stars and Joint Stars prime was Northrop Grumman. So that all kind of fit conveniently. We were then the radar supplier for Joint Stars and so I had all that, and the Norden Organization.

Hochheiser: So roughly how many people did you have in this organization?

Hochheiser: Yeah, it's hard to do numbers--

Hoff: Well, because we're a matrix. But we weren't matrix to the extent of Norden and we also had a plant in Huntsville. I probably had 700 or 800 people at that time. We supported a lot more than that with our programs. Sales wise, we started out at about 800 million. I think my last year we did about 1.4 billion. So, sales volume wise, it was a pretty substantial piece. And it was pretty profitable

Hochheiser: Any particular challenges you faced in this position?

Hoff: Well, we had several AWACS challenges along the way. We were coming up with some new and advanced technology for AWACS. We worked that very hard. We were also coming up with I guess what I'd call a poor man's AWACS. It's now called wedge tail. And we were doing the development for that. It mounts on a 737 instead of 707 like AWACS, and so it was a more available airplane and cheaper to operate. So those were some challenges. From time to time we had Longbow challenges because there were always some questions about how that thing is working and do they need it; the system does certain things, but the application was changing or the need for a battlefield kind of penetrator like that. We were getting into urban warfare; what all different things could this thing do. There were some of those kind of challenges but those are pretty normal for any kind of major aerospace system.

Hochheiser: In your previous position your attention was pretty much internally focused.

Hoff: Yes.

Hochheiser: In this did you have more of an external focus?

Hoff: Almost total, external.

Hochheiser: That's what it sounded like.

Hoff: Yes.

Hochheiser: So here you're spending most of your time interfacing with customers.

Hoff: Yes

Hochheiser: And with primes

Hoff: With primes, yes, so very external focused. And also with government people where we're prime to government. Most of that aerospace work was through primes. But you still get involved in supporting joint meetings with the prime and their customer. On a policy level, like exports and things you get involved with a different set of customers. I was interfacing with quite a spectrum of external people.

Hochheiser: So I would assume that involved a fair amount of travel to where the customers were.

Hoff: Yes. A lot of travel, international as well, and so there was quite a bit of travel in that job.

Hochheiser: So, you're selling these systems to American allies around the world.

Hoff: Yes. And supporting, often supporting, say for instance Ft. Worth, by then it was Lockheed Martin, but we were selling into the United Arab Emirates. They were trying to sell AD airplanes and they wanted active aperture radars. There was issues of what level of technology could be exported. That's a government interface. The government wants to talk to us, not Lockheed. Lockheed doesn't like not being involved. You know, all these little subtleties. Then it's time for negotiation and our piece of that pie was big enough that I ended up being in Abu Dhabi during the negotiations over there and so it's a broad range of things. Could I take a quick break?

Hochheiser: Absolutely.
[Tape stops, and then resumes]

Hochheiser: Okay. so you were talking about some of the challenges of dealing with government exports and level of technology and customers such as those in the United Arab Emirates.

Hoff: We exported configurations of our radar to Israel. That's kind of a unique scenario as well.

Hochheiser: What made that a unique scenario?

Hoff: They A), are very good from a technology point of view. They know what they're buying. And B)l they're tough negotiators. So you have to be very careful or you get over committed and it's their objective I think. They regard defense contractors in the U.S. as deep pockets and maybe they get a medal of honor or something if they--I've had them even talk about that. So the whole point is nothing devious or anything, they're just very capable and very aggressive. So you've got to be careful, that's all. Another of the programs that required quite a bit of attention during that time was SBIRS, space based infrared system. We were in the development phases at that time. That's a pretty advanced and sophisticated system involving a lot of primes. We ended up being in quite a few major meetings with all different parts of the Air Force involved, and different primes. In fact, after I retired there were continually escalating issues, not related to our system so much as other parts of it. But Kent Crussa ended up having to participate in some of those sessions.

Hochheiser: Anything else from this position you can think of?

Hoff: Well at that kind of a level you again get into personnel development and moving people and I had seven vice presidents I guess working for me during

this phase. So trying to grow them and have them be capable and productive and able to take on additional challenges. All of those are kind of still personnel things that exist and need to be given consideration.

Hochheiser: Then your final position, late 2001, was as a senior vice president. Was this a designed transitional position before retirement?

Hoff: Yes.

Hochheiser: It sounds like it.

Hoff: It was a twilight assignment or whatever it is. Jim Pitts was taking over my job at that time. And Bob Arizzo [phonetic] had taken over for Jim Roach because Jim Roach went to be Secretary of the Air Force. So then Bob Arizzo took on Jim Roach's job and Jim Pitts, who had been running engineer and manufacturing--Jim followed me on a number of assignments. So he was kind of trailing along behind me on some of those and he took over the aerospace operations when I left. So it seemed appropriate to Bob, to me, to, to any rational person I think that you don't want to saddle somebody with a responsibility like that in the middle of the year. I was slated to retire by May, or June. I guess I could have stayed until June. So we decided that October, November, I forget when the date was, but we gave him that responsibility and I kind of went over and worked with Bob and planned my retirement and maybe on some days kind of took it easy.

Hochheiser: And what led to your retiring at that point?

Hoff: I was 65 and had to retire. We continued with most of the infrastructure that we inherited and operated under from Westinghouse like retirement plans and things. And at if you were incentive grade in management then you have to retire at 65. So I think it's a good rule. And it was time. I had 42 years in by then.

Hochheiser: In what ways have you remained active since your retirement?

Hoff: Well, when I retired, Jim Roach was Secretary of the Air Force.

Hochheiser: Right.

Hoff: So all of the sudden Jim Roach is saying to me, I want you on the Air Force Scientific Advisory Board. Normally there's a nomination and a vetting process. I think some of that was short circuited because Jim was nudging it along. At any rate I ended up on the Air Force Scientific Advisory Board. That's a four year slot and then you have to leave. It's a way to prevent long-term cronyism. And again, the timing was fine with me.

Hochheiser: Sure.

Hoff: That can be a consuming job. I ended up running a study on urban operations for the Air Force Scientific Advisory Board. I did a number of reviews of the technology laboratories in the Air Force, including the avionics division I had seen from many other perspectives, but that was a different one; judging their effectiveness and cohesiveness and coherence and all of those things. That was a good assignment. I also had a consulting contract with the Northrop Grumman organization here in Baltimore. I did some proposal reviews and a few things with them, but never got very involved. It's a little bit hard to go back into organizations you've run and to be kind of an advisor or. But where it seemed appropriate, and proposal reviews was one area, to have somebody kind of separate review an RFP and judge the response and what might have been

missed in their response. Those are productive things to do. I also knew Ralph Crosby who worked for Northrop Grumman for quite a few years and had left. He was president of EADS North America. EADS North America was wanting to bid the tanker program back in the early 2000s. This was pretty much a bottoms up organization that Ralph was building down in Washington, D.C. There was a need for infrastructure and establishing management style and maybe even culture in that organization. He wanted me to run the military, the DOD part of EADS North America. I turned that down. I said, you know, I've done enough of that stuff working day and night. He said well, you can do it part time because it isn't that big and I said, well, I've not heard of a part time CEO of anything. And I'm afflicted, I would get involved and buried in it. So I didn't take that job. But I said I'll help as a consultant. So I did. About that time they were trying to decide whether to bid the tanker prime or go with Northrop Grumman. They ended up going with Northrop Grumman with Melbourne [phonetic] as the lead who also happens to build the Joint Stars. I knew a lot of people down there. So I helped them get into the right places and offered them some suggestions as they were going along on this program. I don't know how familiar you are with the tanker program but that's been through a lot of lumps. Jim Roach was still Secretary of the Air Force. There was a point in time they were going to go sole source to Boeing and John McCain got involved, the whole thing died. Then they competed it and then Northrop Grumman won. I was gone by then from EADS. Northrop Grumman won and then Boeing protested and now it's re-competed and Northrop Grumman isn't going to bid and so there it is. That's current.

Hochheiser:

Yes.

Hoff:

Very awkward program and very needed by the Air Force, that's the sad thing about that program. Other things I did after I retired— I was already on two or three boards. I continued to do that. I'm still on the board down at the University of Maryland Baltimore, laws, nursing, medicine, that sort of thing. I'm the token engineer on their board. I've been on the board of Baltimore Museum of Industry. I'm not now. I'm on the board here. I've been on the board in the past, gotten off, I'm back on the board here at the Electronics Museum. And so I have plenty to keep me busy.

Hochheiser:

To switch topics a bit since you know I'm from the IEEE, I'd like to ask you about your involvement in the IEEE. I know you're a life member.

Hoff:

I am.

Hochheiser:

When did you first join IEEE?

Hoff:

When I was a senior in college.

Hochheiser:

What led you to join at that point? Do you recall?

Hoff:

Well it was free. [Laughter]

Hochheiser:

That's a good reason.

Hoff:

I signed up with the notion that after I became a working member of society I would pay, but as a student I didn't. As I recall I didn't. I think that's maybe still the case. I don't know. That was 50 years ago. But I've always been interested in IEEE. I've gotten the proceedings. I haven't participated in much of the local. I was very interested at one point in my career in the signal processing section. They did a lot of really trailblazing work I think, or

chronicled a lot of trailblazing work in digital signal processing. And so it's a good organization. That's for sure.

Hochheiser: Looking back, in what ways did this operation here in Baltimore evolve over your many years here?

Hoff: Well, I think it kind of matured from, I won't say device, but standalone subsystem to an integrated system level. That's certainly a step in the hierarchy I think and it wasn't just this organization. The whole community was doing this. It's not building a black box radar and bolting it onto an airframe in the last second. It's a lot different than that. And it's not just building a standalone tactical radar on a truck and hauling it out and climbing in and looking at the PPI. It needs to be integrated, it needs to operate with other things. We were a lot more in the standalone status when I started here. Over a period of time we started getting more integrated and participating in this natural evolution I think. And it's made the place a lot different, a lot more need for system engineering. Circuit design is 10% of the challenge these days. It was probably 80% when I started. But instead system engineering and defining interfaces and software is massive. That's what's come to be the dog as opposed to the tail. That's good. I won't say that we were leading the pack. In some respects, we've always gone head on competition with Hughes. And I think Hughes in the avionics areas was ahead of us. I'm not sure they are now. And it's Raytheon now. But they were probably a little more leaning that way. We were probably a little sticking to our guns on the technical side of things. I don't know that there's a right or wrong there. It's just that probably Hughes got on the bandwagon a little more than we did early on in, in this stuff. But we have, in my view. We brushed up on this culture in other companies thing a little but didn't talk about it, I believe that cultures in companies are a major driving force, often unrecognized. And I've seen a lot of them.

Hochheiser: Right.

Hoff: And in my humble opinion, this organization here in Baltimore has as near optimum as I've seen. I've seen very dominant organizations where all the decisions are top level. The technicrats are told what to think and do and say, not so in this organization. Our technical people have for a long time been the power behind this organization. I think it's very highly regarded. The people are highly regarded. Technical people are listened to and the management here gives them a lot of room. I think then that kind of room, that feeling of being able to impact contributes to innovation, and positive feelings about I can make a difference, through the whole technical rank. And I think that's powerful. And this organization does that.

Hochheiser: Looking back, how would you characterize your career as a whole?

Hoff: Simultaneously fun interesting, challenging, sometimes frustrating but then if you're going to deal with things that aren't simple, frustration is a natural element of all of this, but very, very satisfying. If I had an opportunity to start all over again, I can't even think of anything I'd change. I was extremely lucky it seemed like, felt like I was always in the right place at the right time. There are other people that'll say, well, that's the way it looks if you're doing the right things and other people are aware of it. I never tried to do anything consciously just to be seen. Just keep your nose to the grindstone I think is the way to do it

and be able to grab a hold of things and finish them. Not let up, let back on your effort just because nobody's watching. Things have to be finished. I just saw one of our real senior fellows, 15 years older than me, John Stuntz [phonetic], who you've probably interviewed, I assume. I bumped into him last Friday or Thursday or something at a funeral home, and he said, I remember the first time I got to know you. It was one of these very things. We had the Air Force looking down our throat because they guessed that we were mixing money between fixed price and CPFF contracts over at ATL. We did have both of those kind of contracts in there building the same kind of devices. And so John said to Dick Linder, hey we've got a problem here, the Air Force is doing this. Dick Linder said to me get this sorted out. And that's the end of the direction. Being able to go in there and figure out what the problem is, I had a whole team of people I met with every day and in the end we produced a book this thick with all kinds of data on where all those devices were made and what charge numbers they were made on. And it, one, I think answered the question and two, it kind of swamped them. I guess I believe in overdoing on some of these kind of things. But, I had no clue that that had much of any visible impact to John Stuntz from where I was in the organization.

Hochheiser: But he saw and remembered.

Hoff: And it all had to do with following through and taking it to the end.

Hochheiser: Well my cards are face down. I've asked you everything that I thought to ask you. If you have anything you would like to add, you are welcome to do so.

Hoff: Well I can't think of anything right now.

Hochheiser: Okay.

Hoff: It's been interesting and you've been on point with a lot of these things.

Hochheiser: Well and you've been on point with your answers. Well, thank you, in that case, I think we're done.

Hoff: Okay.

Hochheiser: Thank you very much for your time.

Hoff: You're welcome.