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EDITED ORAL HISTORY 3 TRANSCRIPT

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INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is November 16th, 2006. This oral history is being conducted with Jim Jaax in Houston, Texas, as part of the NASA Johnson Space Center Oral History Project. The interviewer is Rebecca Wright, assisted by Sandra Johnson.

We thank you for coming back in again today. This is your third segment of your oral history, and we'd like to begin today with you sharing with us your participation in Space Station.

JAAX: Space Station was the reason I came here. I was told in 1969 that, "You're being brought in to work on the environmental control and life support system for the new Space Station that we're going to be building after Apollo." Of course, it took 30-some years after that before that became a reality. But when I came in, and I talked early in the first interview about a 100-man Space Station being weeded down to a 12-man, then to a 6-man; going from a element that was on the top of a Saturn V rocket, so it was a 33 foot cylinder that was quite lengthy, to little Tinkertoy elements that would stick together, much like what we have on the Space Station today, and that would fly inside of the Space Shuttle.

What they wanted me to work on, and what actually I'd been trained on in college a little bit, was on the life support systems. How do you process the air that we're breathing so that you can rebreathe it again, take the CO_2 that's breathed out and break it down and use it? We were working on regenerative process back then to do that instead of the sort of one-way systems that

we had on Apollo and Gemini, and that we actually put on the Shuttle Program. You could get away with those, or you just capture the CO_2 and just have a bottle of gas, be it oxygen or air, that you could breathe, because the missions were so short. So it didn't take large volumes, and you could put the gases in high pressure, and therefore shrink them down so that they'd fit in a rather small space, and do that. Lithium hydroxide to remove the CO_2 took up space, but not that much when you considered your mission was no longer than about 15 days or so.

But when you start talking about Space Station being up and occupied 24/7 [hours/days], 365 days a year, you have to look at a way of regenerating that gas up there. When I came here, they already had technologies under development, and my job was to do the system engineering to integrate the air recovery systems and the water recovery systems, because they can be interrelated in the process, so that you could have a system that provided those functions that would hopefully have the operating life necessary for whatever we wanted.

So we were testing those in Building 7. Most of the hardware was being built by Hamilton Standard, or AiResearch at that time. AiResearch has since pretty much gone out of the business. Hamilton Standard has been a provider of that technology forever, and it continues to do it today [as Hamilton Sundstrand].

There was another company called Life Systems, who provided some of the air and water systems in the '70s and early '80s, really led by Rick Windbean [phonetic] and a couple of other engineers who were the real smarts in the thing and did a good job. They were in Cleveland, Ohio. But when Space Station was being developed in the early '80s and the responsibility for the life support system got switched to Marshall Space Flight Center [Huntsville, Alabama], they no longer had the interest in the regenerative processes that we had, and so that company has pretty much ceased to exist as such, and I'll go into that a little bit more.

My first job as a supervisor was actually in the Environmental Control and Life Support Branch, which was providing the technologies for these regenerative processes. We had laboratories on the second floor in Building 7, where one was dedicated to water recovery systems and the other was dedicated to air revitalization systems, as we called it. In those we would take the development hardware or hardware that we were getting through technology development monies that came from [NASA] Headquarters [Washington, D.C.], and bringing in the hardware after the contractor had completed his obligation, and then trying to get some life testing or long-duration testing out of these.

Well, we had mixed success with that, but always looking forward. There were lean times there, because when Shuttle was being built, there wasn't a whole lot of interest in regenerative processes, because it wasn't going to be used for years, they knew, so we'll pick it up later at some time. So we really went down to a shoestring budget in trying to test this. We had a few contractor-engineers and our civil servant engineers. We became very wise, you might say, in the way these systems operate.

We tried different materials; had a lot of trouble with corrosion. When you're taking urine and you're trying to recover the water that's in the urine, you get a lot of solids; you got a lot of acid. You've got a lot of potential problems for the gears and various other mechanisms to be exposed to a very harsh environment continuously, and you need to find materials that will work with that. So our guys were able to come up with some material selections that I think are still being used today that were working, but our primary focus was how to get reliable working hardware.

During the two years, three years, that I was supervising the Advanced Life Support Group, we tried to put together an integrated system of taking the individual pieces. You have

one device that will collect the CO_2; you have another device that will take the collected CO_2 and break it down. It's called a Sabatier reactor. You just mix hydrogen under heat with a catalyst, usually a ruthenium-based catalyst, and from that you'll get methane and water as a product of that. The water then can immediately be electrolyzed, primarily we used here a solid polymer membrane that had been developed by GE [General Electric] that Ham Standard now has.

That's probably a prime candidate for what they would use on going to Mars or something in the future. It's also being flown, I believe, now on space Station to help solve the problems that the Russians have continually had with getting a system that provides oxygen on there that reliably works and that. Hopefully this system—I haven't heard whether it's been turned on yet, but will get some—it needs zero-G test time. That's the biggest problem that we couldn't do here on the ground.

As we were testing this stuff in the '70s or in the early '80s, the push for a Space Station became very strong. So the Space Station Freedom was that first one that we did, and I want to talk a little bit about the life support system, then I went on to a thermal control system as a real effort. But we had strong hopes that when Space Station Freedom was finally awarded, that Johnson Space Center would be responsible for the environmental control and life support system as well as many other systems. But at the very last minute, literally, a midnight deal was cooked where they wanted a balance of dollars that was coming to Marshall versus JSC, and the dollars were weighed in how much it took to build these different technology, or subsystems, as you have there.

So JSC got the data management system, or avionics as such, and in order to make that equal, they needed something to go to Marshall, and they decided to send environmental control and life support to Marshall Space Flight Center, which was, to us in the division, a complete

shock, because there was nobody over at Marshall that had worked long-term type stuff. The only experience they had with it was really on the Skylab module, which was just an extension of our Apollo Program, for a short period, and then yes, it was a manned space station as such, but it was manned for forty-five days or a rather short duration as such, and they had used systems in which they literally collected the CO_2 and then dumped it to space.

We in the Apollo had collected CO_2, but it was contained inside of a lithium hydroxide canister. It was really not a good process to heat it up and boil it to space or something, but with their process, that's what they did. They didn't have all these canisters sitting inside the spacecraft, because once you get beyond about 15, 18 days, why, that's a lot of lithium hydroxide. So their process was good for the application they had there.

So they were awarded the technology, and immediately we were directed to give them all the help, all of the resources that we could. They started out with us giving them a huge data dump of all the technology effort that we'd had, all the contracts that we were working on water and oxygen recovery, and we briefed them, literally, on each of the systems, how they worked, what to do, and tried to get them familiar with them enough that they would be comfortable enough to select them to put in the Space Station Freedom, because we were still working on the technical design with McDonnell Douglas or, in their case, they had Boeing. When they stoked up the work package, they ended up with Boeing being their contractor for the manned module that was in there, the habitation module, I guess they called it at the time.

They fairly looked at what we had presented to them, but because they didn't grow up with it, whereas from the beginning of my career, I got used to seeing this stuff work, recognizing there are still some difficulties, but nothing that we didn't feel we couldn't resolve, given a little more money and a little more time.

They backed all the way away. They just literally dropped all of that kind of technology and went back to what they used on Skylab, and that's what they use on Space Station. That's their design, a molecular sieve type device for collecting the CO_2. It took the technology and just dumped it, you might say, as far as any progress to where we could say today that we could have something that's really matured. That's why you didn't see it on the Space Station, on the International Space Station.

What happened later then was that as Space Station Freedom got into big money problems and schedule problems, and this is where we had a problem with the Congress where we gave an estimate on how much it would cost to build, the complete estimate to complete the thing. I may have said before that we knew it was going to be close to $20 billion to do this, 17 [billion], 18 [billion], somewhere in that range, but we were told that wouldn't sell, that it had to be 8.3 [billion] as a number. We said, "Well, we can't do the content for that."

"You'll do the content, and you'll make it work for 8 [billion]," and, of course, we didn't. The program never was able to recover, because we just couldn't do all that that design would require with the resources available. So Mr. [Daniel S.] Goldin came in as Administrator, and we started redesigning or looking at alternatives, and they finally put together some—well, let me go back to Space Station Freedom and that part.

The technical job I had on that was—in Crew and Thermal Systems Division, we normally did the environmental control and life support system; in other words, the things that you usually associate with a human inside the spacecraft, which also we collected the heat and got rid of it. If you have a box that's got electricity going through it, there's waste heat that's being generated. If you've got a human being, your body is giving off heat. You've also got

sweating, so we've got to condense that so that we can keep the place warm, or we've got to heat it up, in case you're losing heat to space or whatever and you don't want it to get too cold.

The responsibility that I picked up was working on the cooling system there, active thermal control system. I got to work with that on the very beginning, you might say, and that was where I talked about on the Shuttle Program, we had a device there, the flash evaporator, that nobody had ever seen. Well, on Space Station we were very much interested in two-phase fluids technology, in which we could use heat pipes. I think I've described these heat pipes before, but you collect the heat through a thermal bus system that has a closed-loop liquid vapor system in it, in the heat pipe. Then you transfer that through a mechanical linkage to a heat exchanger that is, in effect, a heat pipe. That's got a long handle out there, and you use the coldness of space to radiate that heat away.

So they put me in charge of the development of such a system, and we had a couple of technology programs going on to work that. McDonnell Douglas, being our contractor here for the International Space Station, was willing to go ahead with our design and to put it in. So my job was to make sure that technically it worked in the environment that it was going into. The real problem with two-phase systems, as I described before in experiments we flew on the Shuttle, is you can get a gas bubble inside this tube you've got here, and it can stop everything, just a little bitty gas bubble as such.

So we did a lot of testing. We flew flight experiments, and we had the thing pretty much a proven design that we felt comfortable with. We were in the process of testing it. The Space Station, though, was really a mixture of four different work packages. We had a solution that was based on two-phase technology. Marshall had a water system that they were collecting the water, or cooling, to give us the heat, just on a single water loop just like we used in Apollo; we

had glycol and water there. The Glenn folks, folks at Glenn Research Center [Cleveland, Ohio], were doing the cooling for the solar arrays, because when you bring the energy off of the solar array, you bring them into converters, and you have a lot of mechanical devices there that get very hot. You also have to store the energy in batteries, and a battery, of course, as you're drawing energy from it, gives off waste heat, and so you have to cool them, and they were using a different technology.

It became obvious that if you've got three out of the four work packages doing totally different things here, then you're not getting any synergism. Once Space Station is built, you've got to keep a supplier going for each one of these technologies. You've got to keep up resources that are going to have to feed all of these at the same time. So can't we do something that will at least get maybe the heat exchangers to be a common design, even though they're interfacing? Because that's possible. Or can we maybe combine fluids so we're using the same fluids, so that the ground servicing that you do at the Cape [Canaveral, Florida], if you have to take spare parts or whatever you have to, you can minimize the inventory.

So I was made the first Architectural Control [and Design] Agent, an ACD Agent is what they called it, Architectural Control and Design. That title was put on to about six or seven of us that were in different technical areas as such. There would be one for environmental control. There'd be one for guidance and navigation; another one for structures, perhaps, or mechanical systems. Our job was to look at all of the work packages and see if we couldn't bring together some commonality and synergism.

I chaired a large group there, in which we finally wrestled with all three of us Centers and came to a common solution for the thermal collection, how we would collect and transfer the heat. If we picked up heat from a box, the heat exchanger would be of a common design so that

I could use it here at JSC, or you could use it at Marshall in their design, or you could use it at Glenn in their design. That worked out pretty well. People really did see the thrust we had.

Of course, we were getting sizable monetary problems in the whole program then, so carrying your flag as the only flag that could solve and fighting everybody else was not going to be a real winner. So it turned out to be a good experience for me, because you also had to convince the contractors that they've got to work together on doing this thing, and it turned out, I think we had a reasonable solution for it. But it came very late in the program, like a lot of other things. We were moving along, and it was becoming obvious that the Station had a problem.

It was about this time that I got tapped from the Director of Engineering to be part of about a four-person group that were to assess Work Package 2 and what's the probability of success or failure in being able to complete this thing. This was leading it, and Aaron Cohen was the Center Director at the time, and Henry [O.] Pohl.

We went to McDonnell Douglas and interviewed different parts of their organization and management and their technical teams to just see, get a value judgment, you might say, of just what progress was being made, what challenges lay ahead, and were we going to be able to meet schedule, cost projections, and other—and just how much of a change order problem we really had. It was supposed to be an independent look from the program, because the program, that's their responsibility, but we were to come from the outside.

We determined collectively that there was no way they could meet the schedule that was committed there. It was going to have to delay some to allow things to mature. To make those things mature, you had to have more money. There just wasn't enough there to do that. I had seen—in this ACD Agent role, I was the one who presented the final design to the Space Station

management team at Reston [Virginia], and I had seen there where our work package would be told, "You will do this," whatever this change was.

Then we'd ask, "And what about the funding that goes with that?"

Then we'd be told, "There is no funding. You've got enough funding already in your—the way you guys manage things down there, you surely have got enough money to handle this. Next subject."

I saw that happen repeatedly, and it really was disappointing, because you'd lay out a good technical argument, and you'd say what the pluses and minuses were. Usually we had to build up, "Here's where we'd decrease or delete," to offset this thing, because we were trying to stay within a zero game or zero-budget game, or a zero-net gain game, so that you didn't impact the overall program with whatever change you were making there.

But then we had been told, "You can't get rid of this. You've got to continue doing this, and you've got to add this to it." So, to me, it was sort of like a bus to Abilene [Texas] that we had.

We presented those results to Aaron Cohen, and I was surprised at something. I mean, he listened to us, but, boy, he challenged, and he just literally told the group of us that, "You guys, if this gets out, this is going to kill the program. We're not going to have a Space Station. We're not going to have a manned spaceflight program. We're not going to have any of this stuff."

Of course, we're just carrying the message as this thing. Each time we'd bring up something, I'd explain, "Here is what we saw," and then he'd come back with this, and we'd explain, "No, it's not that bad. This is what they could do, and this is how they could handle that, but this is what the reality it." And, of course, you're getting beat back and forth here, and

I'm looking at the Director of Engineering, because at that time I guess I was Deputy in the division as such, and so he's two levels, and this is my boss, my boss' boss, who is doing all this.

So this meeting lasts probably for about an hour, and I walked out of the meeting and I asked Henry, "What just happened in here? I mean, we thought we were just giving this report."

He said, "Don't worry about it. It was all just a game." I'm going to say game; it was real. He said, "What he was doing was trying to hear your answers to his ranting and raving, because that's what he's going to get, and he just wants to know what you guys would say in those situations so that he can formulate his thoughts on how he will respond to hearing this question from whoever it might be, be it congressional, be it his management and Headquarters, or for whatever."

I said, "Well, it would have been nice if you'd have told us before we walked in, because I thought my job was going to be on the line, the way it was there." So it was a different management style than I'd been exposed to. I never used that when I was senior management, but certainly I will say that the four of us, the three or four of us, didn't lose our cool, although we sweated a lot in there. But the idea was we kept trying to reassure him that, "Hey, there's a possibility. There's ways to do this." So, in effect, it worked exactly the way he wanted it to work, at least from my viewpoint. I don't know if he'd say the same thing. But I just wish that Henry would have shared his knowledge real-time, because it would have been a little more self-assuring that I'm not stepping on something I don't want to step on when you do this.

Well, it wasn't too long after that that [it was] obvious that the current Space Station design wasn't going to work. They needed to have something different. The climate in Headquarters and at the Congress was something we had to change, so they started looking for new ways to design this Space Station so that it had a chance to solve its problems.

They put three teams together, one at Johnson Space Center, one at Marshall Space Flight Center, and one at Langley [Research Center, Hampton, Virginia]. Langley did Option B. Marshall was Option A, and we were Option C. Each of us was to have sort of a clean sheet and come up with a whole new design. John [W.] Aaron led the group here. He had been the Space Station Manager for Work Package 2. He was put there with Henry Pohl, the Director of Engineering, and with Don [Donald C.] Wade, who was a Structures Division Chief in engineering.

They selected people they wanted to have work on this, so I was selected to do integration, the SE&I [systems engineering and integration] work. I don't know how large the team was; it was probably about 50 or 60 of us that worked on it, but there were about 5 or 6 of us, maybe 8. Bill [William C.] Schneider did a lot on the design stuff and did a very good job.

But we thought about it for a while, and what do we know best at this Center? Well, we know the Shuttle better than anything, and the Station, we certainly know the human aspects of flying human spacecraft. So the idea was conceived that we would base it off of the assets that exist in the Shuttle Program, and we would put together what we thought would be a satisfactory spacecraft, but it was dependent upon much of what already existed in the inventory of the Shuttle Program and the facilities and services and ground servicing capabilities at the Centers and at the Cape for the Shuttle Program.

So we came up with this design that we started in early March that was done by mid-June.

WRIGHT: What year was this?

JAAX: In 1993. This design, I think, was an outstanding effort. The neatness of it was that—I've been on a lot of conceptual design things here, and many times your knowledge is not too thick. It's pretty thin. It's broad. You've got different ideas, but you don't have a lot of depth in it. This thing here, we had all the depth in the world. We knew what was flying on the Shuttle. Most all of us had worked in the design of it; not just flying it, but had been there in the development stage and seen the testing and seen the product and had worked with the flight problems, so we were very familiar with that.

When you want to make a design that makes use of the rear part of the Shuttle vehicle, they knew what loads it could take. They knew what structure it could have. If you want to use the cockpit area or the strong back, you might say, of the underbelly of the Orbiter, where you've got a cargo bay there, how you could design that activity. We knew what support systems were necessary to support the Shuttle, and therefore you could easily put it into this design. We knew what resources were planned to be available for Shuttle for the next 20 years and which ones weren't, so you have all of that there.

So instantly we could put together a credible design. It didn't look like a Space Station as such, as they had, but it would support the six men or whatever the design requirement for this. It would be able to go the duration, you know, 365 days a year. It just would look different from what you had before, but it would have a lot of credibility as far as could you actually build it. We went to Washington two, three times to present it, primarily here's what we're thinking about, here's how it's maturing, and here's the final design for this thing.

We would meet in Building 17, and all of us were sort of housed there as a team. I could tell how the structural work was going by listening to Bill Schneider whistle, as he would. He is a very good whistler. In fact, he'd take some classical pieces by [Wolfgang Amadeus] Mozart or

[Pyotr Ilyich] Tchaikovsky or whatever, and if he's feeling good about the subject, down the hall you're going to hear this [imitates whistle], and it's beautiful. I mean, it's not very long that he's doing that, but he's content. And that's the way the feeling got to be inside there, that, hey, we've got something here that we feel very comfortable with that is pulling itself together.

My job on the thing was to take all the systems that you have in a spacecraft and to try to get them to a same level of maturity as to what the requirements were for them, what the basic design was going to be, what was the makeup of the design as far as the piece parts that you had to have, because you had to have a weight for these things. You had to have a power estimate for them. You had to have a cost estimate. Since we had built most of these things for Shuttle, we knew pretty much where it was, what it was, or how it was.

I knew the thermal system, so I used it as my template, because I had done this same kind of thing for Shuttle for a bit, and also we had worked it on Space Station for my division. I was trying to remember if we had EVA [Extravehicular Activity] capability; I had that already down, because I worked—that with my division then. So I had two or three systems already sandboxed, you might say, that I could do this.

I then open it up to the rest of the systems. There are 17—16 or 17 other systems in it. I made a book that had all of this design material in it, made them all the same. The requirements page was one or two pages, whatever it was. Then they'd cartoon and add the schematic on the thing, and then what the piece parts were for it, and then what the design challenges were, what the technology needs were, and what the costs were as we went through it.

Of course, many of these other systems really didn't think of things quite like that, so it took a little while to bring them in there. I recruited a couple computer resources, because I wasn't computer literate at the time, but I had a young lady who had worked with me on the

budget stuff for my division, who knew the [Microsoft] Excel spreadsheet, and really, a lot of this stuff was done on an Excel spreadsheet and [Microsoft] Word. She later told me that she was thankful that I never took the time to learn, because she'd lose a job as soon as I learned how to use the computer, and she's probably right. Because later in my career, why, then I would sit there at the console and just type out what I needed.

So we were able to produce the book, and this was also done within about two months. That was a part of our final product was that here's a design that has all the words and the nice prose that go with a proposal like that, because that's what we gave them was a proposal. But not only that, but we've got a design data book that goes behind it that tells you what this thing really consists of. You can look at the piece parts; you can see actual cartoons or photographs of the piece of hardware, because it's existing stuff. We tried to use as much existing as we possibly could.

It went to Washington. They evaluated it, commended us on our boldness for whatever we did, thanked us for our effort in there, but it probably was too different, too different for the world to say, "What is this thing?" Of course, now you look at the Orion and you look at Apollo, and it's sort of the same thing, and they say, "Hmm."

Anyway, so Headquarters chose Option A, which was done by Marshall, and it was an offshoot of the previous Space Station design. It wasn't that much more different than what they had. But they pulled together a team, and some of the people that are leading the current Space Station Program are the ones that are still there, were there at that early beginning, and put them in Crystal City, Virginia.

I'm still a Deputy Division Chief in EC [mail code for Crew and Thermal Systems Division], and I'm sitting on a telecon [teleconference] on about July 18th or 17th, and this is July

after the June finish of the Option C. The Director of Engineering says, "And by the way, I want these three people to go to Washington for the duration, because they're going to be part of the redesign of the Space Station," and he lists my name and two others. I had no idea that I was supposed to be going there or anything.

The next day or next weekend—I guess that was on a Friday, and so on the Monday I was on a plane to Washington to participate in the Space Station redesign. We went in there, and of course, we didn't know how they were organized, and they didn't tell me what my job was or anything like that. So I created the job, saying, "Well, whatever their system is, we're going to hand this over to a contractor, whatever our baseline is." Of course, they were trying to decide whether it was going to be Boeing, McDonnell Douglas, or whoever was going to be the lead, and they ended up later choosing Boeing to do the work.

They're going to need a systems data book, and it was hinted that, "The reason you're selected is because you did this outstanding job on this system data book. Nobody had anything like it, and that's what they're going to need."

So I said, "Okay, I can do that. I'll just tell them, 'If that's what you really need, I will then build one for this new design,' and I'll set up now."

During Option C, I was talking to guys in Building 17 or Building 13—on site here. I'm now talking to Marshall or I'm talking to Goddard or someplace else. And it worked, but the real question was, or the difficulty was, that they didn't have the maturity of design that we had here on the Shuttle Program. Much of theirs was based on what was evolving out of the Space Station Freedom Program.

So again, I pulled this young woman up to Washington to help me with this. Kornel Nagy was there with us. He was the second person. He was working the meteoroid debris

problem and some of the structures, but mostly meteoroid debris was where I saw him go most. The third one was Laurie [N.] Hansen, who replaced me when I retired, as the Deputy Director of Engineering. Laurie was supposed to follow system integration stuff, but she was never there. She had vacations, she had other things, and I don't think she really wanted to be there, but that didn't—career-wise, it didn't seem to be a problem, but I think the real difficulty was that they didn't have a job identified. "This is what we expect from you to do this."

It was just sort of you get there, and you go in this room, and, "We're here. What can we do to help? We don't quite know yet."

Well, I'm there about three weeks into it, and I was up there from mid-July to the end of October, or September, end of September, and four weeks. I'm now knowing the Marshall folks some, some of their senior folks in there, because I'm constantly asking questions about the systems they're thinking about and what they're doing. I discover during these negotiations we [might be working with] the Russians. "What do you mean, Russians? What are they involved in this for?"

There's a delegation over here, and there's talk about them being involved. I would see this guy going across. I stayed in the Doubletree [Inn], and he stayed over there, too, and we'd walk to work. Crystal City is very close. Daily he'd go, "You wouldn't believe what we're talking about now." Of course, I need it, because I'm designing the system—not designing it. I'm trying to consolidate all the information on the systems, and I'm trying to figure out what kind of spacecraft or Station are we putting together here. And he'd say, "Well, they're talking about being intimately involved in this."

"How intimately?"

"Well, they may fly the first module."

"What do you mean, they're going to fly the first—what's going to be in the first module?"

"Well, probably the guidance system."

I said, "What do you mean, the guidance?"

So they would have these meetings in another building over here, and we'd wait to hear what was being decided as they went through it. Meantime, we're off over here trying to make a U.S.-only type spacecraft, knowing full well that over there, there's negotiations going over for a Russian involvement to some degree, not knowing what it is that we might be giving to them or taking from that. So they made it difficult to get a consensus, and it wasn't until late August, I think, that we finally figured out what they thought would work.

Of course, you've got to get this through Congress, and you've got to get this through all the other things, so there were lots of side meetings going on. We'd work Saturdays, and several Saturdays I'd see Dan Goldin, the Administrator, would be on the same elevator with us, going up to meet with the senior people working this, and the rest of us are working on the piece parts that make it up, and not knowing what or where or how this thing was going. So it was a very unusual environment that we were working in. Friendly.

We had "Buzz" [Edwin E.] Aldrin [Jr.] show up on July 20th. I guess that was a couple of days after I got up there, and he just walks in. July 20th is a special day, because that's the anniversary of the Apollo 11 Moon landing. He walks in there, and he says, "You guys have got an important job to do here."

Of course, we point, there's Buzz. "Hear, hear."

He gave us a pep talk about this is something, and he walked out and left, and we're sort of saying, "Okay. I don't understand, but he certainly gave us his opinion."

We did not have a whole lot of other visitors as such. We were pretty much left alone, but you would get people from different Centers come up every once in a while. Saw Gene [Eugene F.] Kranz come up a few times and talk to people. We'd sort of look at each other, and of course, he's trying to figure out why I'm there and what we're doing for that. I knew Gene a little bit through the engineering stuff I did in the missions, the mission activity. He was nervous about where we were headed and how we were going, and I'm not in any control position whatsoever on this thing. I'm just saying my job was to get that data book up to the same level of quality that I had for Option C.

I was asked if I would want to be on the management team, but they at that time had this concept where they would only have three SES [Senior Executive Service] positions in all of their structure there, and of course, that's contrary to the way programs have been in the past. Usually there's a significant number of SES positions plus senior GS [General Schedule]-14 and 15, that's how they pyramid the management of the program. I was already at 15, and I told this guy, Doug [Douglas R.] Cooke who had asked me that, "I could do you more good if I come back in engineering at JSC than by my being here doing—so I much prefer to go back to JSC if I got a choice in this thing."

He said I obviously have a choice, and that's what happened when I got through. I came back here, and they had finally decided that JSC was the lead Space Station activity, and they reassigned us all back to JSC. I came back here; worked for about a month over in Building 4 to finish up the data book. By that time they had selected Boeing to run the program or be the management. I did not participate in any of that activity, but it seemed to me that a better deal could have been worked. But then again, we were telling them, "You will do it," instead of them

proposing and trying to buy the job. Instead they're being told to do the job, so we paid a lot to get the services that we got.

I finished the book late October. I told them that, and I gave it to the Boeing guys once the Boeing fellows came in. The guy who received it was very gracious with me. He said, "We've never had this kind of detail or this kind of information given to us as the starting point for where you guys want to go."

Because in this case, they had not gone out and designed this thing and we had critiqued it and we had done the evaluation and said, "All right, we'll buy your product." In this case, we've got the product, and we're handing it to them and saying, "Here, this is what we want you to build is something that's based on this design here." So it was rewarding to see their response to it, but, of course, once they get ahold of it, they've got a lot more detail and a lot more that they've got to go through to do that. So my value added there would diminish greatly there unless I got into a senior level on that, and I wanted to go back to engineering. They allowed me to go back, and I went back to my old job in Crew and Thermal Systems Division.

WRIGHT: Now you mentioned that you came back or you were talking with the Boeing guy in late October, and then it was in September of '93 when they made the announcement that—

JAAX: Yes, in September they made the announcement.

WRIGHT: —International Space Station. So did you have to make adjustments now to this book, or did you stay your course?

JAAX: I stayed my course, but of course, I deemphasized the systems that were in the Russian module. We now knew that the—FGB? I don't remember the acronyms now.

WRIGHT: Zarya.

JAAX: Yes, the Zarya, they call it now. FGB [Functional Cargo Block] was what they called it.

WRIGHT: FGB.

JAAX: What was going to be in it, what was going to be the second module that's up there, because we needed to know what assets they had, and then the description would be all of the stuff that would be inside of our spacecraft, elements that would be going up there. So my emphasis was to try to get an integrated design, but you don't know what the Russians really are bringing in this thing.

But as it evolved, why—I'm going to jump back now to the life support area, which has been dear to me—the parts that were given to the Russians, and that included the life support system responsibility, which meant that there wasn't monies available for technology to continue looking for better ways to recover oxygen from the CO_2, or water from the urine and the sweat and showers and various other uses that you had, on a system. Marshall had the lead for all of this activity, so at JSC here we pretty much had to drop all of our effort on that, and the Russians, they'll continue to have problems, and they had problems on the Mir Spacecraft. You remember there was an oxygen [problem]?

So over here we kept telling the world that, hey, this life support issue is something that needs to be really addressed, but it wasn't one that we could really control. The way the agreement was set up with Marshall back on Space Station was they would have responsibility only for the environmental control and life support system on the International Space Station or Space Station. All technology development for future applications, like to Mars, was still JSC's responsibility. But there was no money, really, available for that future stuff down here. So whatever work was being done was really to solve the immediate Space Station Programs, and of course, Marshall was very much interested in just the systems that they promoted or felt were good systems to do that.

Before I left the division, one of the things that we had done is set up a chamber in there so that we could test these integrated life support systems, these technologies that we had been limping along with. So I had put together a chamber for human testing while I was there. Or—put together—I had been in charge of a group that was responsible for making this 20-foot chamber in Building 7, something that you could put 3 to 4 people in for an extended periods of time.

What we did is we added some volume to it, because it needed to be bigger than what we had, so we put a collar, you might say, that was between the shell on the top and the rest of the circumference of the structure here to give us the volume. Then we started outfitting it with the hardware that it would be necessary to move the air around or move the water and to interface with systems that were on the outside that would do the actual recovery. The goal was to put this regenerative hardware into this same environment with the people, close the door. Any maintenance or repair that had to be done would be done by the crew. That way we'd get some

hands-on experience with 30 days, 60 days, or 90 days of occupation by the crew, working with this life support systems, and to do that.

While I was Deputy Director of Engineering, we finally made that testing program a real thing. The division conducted a 15-day test. In fact, they integrated a—one of the things you have to do is also produce food, and so they put together a chamber, and we'd been working on this for some period of time. We would put a wheat crop in there. They've also got little chambers where they grow tomatoes and various other items that have been determined to be good candidates for a crew that's going to Mars or someplace else to grow along the way, because you want fresh food if you can somewhere along there.

So they put these racks of wheat in during the cycle of wheat growing, and the wheat will absorb the CO_2 and give off oxygen. It can be a regenerative cycle to get in there, and so they would blow air over to the 20-foot chamber and then back to where this wheat area was growing. That's a way to see that.

The way the test program was set up is first they took this small chamber; it was a 10-foot chamber, as they call it. It has two big compartments, one big compartment and the one smaller. We outfitted that with a dorm-type capability for a man, and for 15 days we put Nigel Packham in there, and he lived off of the oxygen that was being generated by the wheat as it was removing the CO_2. Now, we were able to supplement in case things didn't go quite well or the wheat crop failed. But it actually worked very well.

We then expanded that. Didn't use the man in that 10-foot chamber, but put the crew of 3 or 4 into the 20-foot chamber, and we then tested it for 30 days, and it was just using regenerative systems. Then we combined the wheat-growing capability with the regenerative systems in there, and we did a 60-day with closed crew, and then 90 days. We had a control

room there where the engineers were, like I did when I was doing the testing in Chamber A on the active thermal control system. I could change things or, in this case, they pretty much just monitored what was going on, because they didn't want to upset things any more than the system would upset. And, of course, they had some upsets.

But it was getting some practical experience with how to deal with this equipment that you're going to have to live with as you go to Mars, so I was able to see, while I was the Deputy Director of Engineering, a hardware effort, technology effort, get matured to a point where we had success in going a full 90 days, 91 days I think it was before we just stopped, with a closed-loop environment with people being supported off of that environment. That technology, I think, is going to be used when we finally go to Mars, and it probably will be used in the lunar program.

The Space Station, to me, the biggest problem with Space Station as we have it today is it isn't being used as I would hope it would be for a technology demonstrator of what you have to do to survive or go to Mars or further human exploration. It is an outstanding test bed opportunity. You can take this life support system in a module. We were developing something called a TransHab, which was a shell that you could expand the volume in because it wasn't made of aluminum. It was made out of material like you wear in a—Kevlar—you have on a vest that the police use to protect them.

It was something that we could blow up from a very compact particle, from something that's less than 15 feet in diameter, to like 30 feet in diameter. It gives you huge volumes in here. But you could put some of this regenerative life support system in there, and you could attach it to the Space Station on one of the nodes that they've got there, and you could then run it for whatever duration it will run, in addition to what you've already got going on providing life

support. What you get is will this shell that's made out of this nonmetallic material here survive the UV [Ultraviolet] exposure of the Sun and radiation, and what kind of problems do you have sealing around the window that they'll have in there.

Inside you've got this piece of mechanical equipment that's operating at zero gravity, and it's doing its thing. Have you got the noise down? Are you having leakage problems? Are the seals holding? Is the materials—you know, it's constantly doing its thing, because in water recovery, we tend to use or prefer the vapor compression cycle. A vapor compression cycle really means that I take a liquid, heat it up to steam. That leaves all of the solids or whatever it is at wherever the source was.

In this case, we'd spin it so that they'd go out to the outer surface, because you've got to create a gravity in this thing here, and then you have the steam inside here; steam's clean. The steam goes out. You condense it on a cold surface there. You got the water then comes out, and your water is relatively pure. Then you can run it through a UV lamp or something like that, and you can put a chemical, if you need to, in there to keep microbe growth off of it, and then you could reuse it, drink it.

There are some problems with water, in that if you were taking—well, just between men and women, the urine has different—estrogen versus a testosterone or whatever it is, and you do get a buildup of some of those things. Give us a chance. We can test it here some on the ground, but we could also see how things interact up there with the other chemicals that are being absorbed into the water system, and make sure that we got the right filters; we got the right chemical processes that, where we filter the water through it, we remove the right ions, the right minerals, the right stuff.

If you're taking an antibiotic or you're taking medicine of any type, there's some residue of that that comes out that we've got to be able to understand. What's it take to remove it out of there, because what's good for you may not be good for this other person on there. So there's a lot of questions that need—and again, a closed cycle where you truly are closed in here in this test bed and test environment can give you that.

Same thing with the air, in that you have a lot of offgassing coming from the different equipment that's on there, plus the clothing, plus the experiments that you're running, or whatever it is. So to get a handle on how the systems that are collecting this stuff and processing, and over time because in the Space Station, the International Space Station, it would be a forgiving environment, in that you can close the door, and you don't need it anymore. If disaster occurred in there because it's not doing what it's supposed to, the crew is still safe. They're still sitting inside here, and we can just evacuate or flush out the air; or we can take the water system, and then we've got a truck, the Shuttle, that can bring water up for an extended period while we solve whatever that problem is that we've got there.

But when you're on the way to Mars, you have no choice. There's no truck following you. It's got to work. It's really got to work, and you can't be like we have, limp along like we have with the Russian oxygen system and some of the water systems you've got there. So that's where I think the Space Station—that was the ideas we had was to, in addition to all the science for microgravity, use it as a test bed to check out the life support system, because I never want to hear the words that were, "We've got a problem with our system, and we're still a month away from Mars, and we don't know how to get back." Or, excuse me, "How we can get this system running enough long enough to be able to do that, or the spare parts."

One of the ideas that we had out there that I had—Leonard [S.] Nicholson and I had discussed when we had our Manufacturing Group, was that you may need spare parts to fix this thing, so is there a way that we can manufacture out of carbon or something a gear or a filter or whatever it is, to repair this thing in here, because if you don't bring it with you as it's needed, it's not going to exist. Can we do some mold injection process or something that is literally sort of like a garage that's attached to this Space Station that's gone to Mars? You won't need it for the Moon, because it's only three days away, or four days away. We will put in enough safety factor or backup systems to reasonably get you back home. We can't solve all the problems, but we can—I don't think that's a problem, and it will never get the attention.

But when you're sending somebody away for two years, once they leave Earth's atmosphere headed to Mars, it's going to be two years before you see them again. It's going to be 6 months and then 30 days there and a year back. It's just that transport time that's going to be there. You just can't get rid of it unless the propulsion folks come up with a super way to accelerate us a lot faster than we've got right now.

So that's been my wish is that the Space Station as we evolved it, and then we looked at what could we really do with it, that that be a part of the thinking, a serious part of the thinking. To me, if they're really going to get serious about going to Mars, start thinking about using the Space Station as a test bed to check out some of these things, instead of the talk that we hear now about handing it over to the other nations and letting them run it or use it for whatever they need.

I enjoyed working the Space Station Program as it was. Did not get involved in International Space Station to any—other than the degree I did with the design of the Space Station Freedom, and that was mainly because I moved into senior management, and there was plenty of good people who could do the job.

It's a little rewarding now to go back a little. It's a lot rewarding right now to go back and share our technical opinions or design solutions and that with this generation that's out there now. As I have told you other times, we're still doing chalk talk or lesson sessions with the technical organization, my old organization, on the design of the Apollo spacecraft, and they're wanting us to critique the Orion environmental control system. I think that's an excellent use of our people, people of my generation, to share with them how they would do it.

I'm a little nervous about how the people in the division that are working there right now will feel about it being offered to them, because there can be some reluctance. These guys, they don't want to be dependent upon them for the solutions. But it's being offered. At least the guys I've talked to, they're just willing to share it. You can take it; you can leave it; you accept it or whatever. But I sure don't want you to have to reinvent what we already went through.

I guess if there was a criticism when I was Director, the Deputy Director of Engineering, of what Headquarters would have us do, there were so many tasks that they would ask us as a Center to do that were a repeat of what we had done just a year or two before. It was like we'd never done those things. Too often that was the situation, where a brand-new person got into a brand-new job, and they'd stay there for about only a year or two, and then another brand-new person, and they don't look at what was done, or they say, "Well, he did it, whatever, his way." But it takes a lot of energy and a lot of effort to do that. Once you know your core capabilities of the Center, and I know what my facilities are; I know what my people can do.

Once I've written it down, unless the Shuttle Program has been shut down or the Space Station Program has been totally refocused, it's the same today as it was yesterday or last year. I would usually, because I was assigned those kind of responsibilities for the Center, offer them and say, "We've got something we built last year that was a pretty good product. Not sure what

all happened to it, but can we start by a quick critique of it, of what was good and what's useful, and then build from that, given your new assumptions that you have here or the next product we have, instead of my going back to 800 people and saying, 'I need this.'"

They'll say, "But I just gave that to you."

I'll say, "Well, I need it again." That was not something I liked to do.

Let's see. International Space Station, I really was involved just in the early part of it. I did get to see the reviews of the technical products as we did, because Engineering does—I believe they still do this—a systems review each time the Shuttle goes up with components for the Space Station. So we would see the maturing of the hardware and get to critique the design or the products that were going up there. Mainly it wasn't, "Will it work." It was, "What issues have you had in the final certification? Is there any open issues that you have from prior missions or prior experience on orbit?" And we'd review it from that point. But usually by the time we saw it there, it was already a mature design.

If we did have a technical issue on it at the directorate level, we would pull in the experts from the different things. Or if there was a question that you as a subsystem manager did not believe that this was the right way to be going, we tried to give you an open forum to vent that, to talk about, to bring in, and we would try to identify who we thought the experts were in that area, to be able to get it all out on the table.

Then you'd have to make a decision. Usually we'd try to do it by consensus. Sometimes you didn't get everybody to agree, but if you could get 60 or 70 percent to agree, then that was what our objective was. And if the minority had a critical issue in that thing, we would hold off on the decision until we tested or could vet that a little bit more, and then we'd make a decision.

I liked that process, but I was out before the CAIB [*Columbia* Accident Investigation Board] Commission, but from the way they described it, I didn't hear any recognition that we did that kind of process or went through that prior to a flight or whatever it was. So I know they've done it, that we do some of that on the Space Station. I know we do that before these others. But I think it was a very useful process.

The benefit of my generation when we did that, most of us had grown up with this piece of hardware, so I would hear Leonard Nicholson, who was the Director of Engineering, he'd say, "Well, didn't that happen on Flight 63 or 57?" Of course, he was the Program Manager, so he was much more intimate with that. But if it was in life support or active thermal control, I could do the same thing. I could say, "Well, we had that same problem on 10, or we had it on 1, or we had it on some of the others."

But in today's generation you've got people who weren't there, so they don't have any of that history, so you probably don't get that kind of I'm going to say quality of a review as such, so you're more reliant on the technical folks who are just presenting to you. So that's a piece that's missing right now that I wish they had. But I think that technical review, where you and the subsystem manager are talking to the Director of Engineering or whatever it is, was a good, healthy exchange.

There wasn't a time when we said, "We're the smartest or knowledgeable at whatever." There was none of that. It was more just tell us what it is, and with our experience, it's sort of like what you're trying to do with some of this design knowledge capture. We'll share with you what we learned, and are you dealing with the same way or have you got some new, better way to do this? Certainly better, if it doesn't cost a whole lot more, is something that we want to do. You've got weigh the merits of doing whatever you're doing.

One advantage they have now that can be a disadvantage is that you've got far more instrumentation, and you've got far more data than we ever had to make a decision. So how to filter through that to get what really is the important stuff is difficult. What we didn't even know now today they're worrying about a whole lot. Then you say, "Well, is it really that important?" I mean, how critical is it to the whole situation?

As they go into this lunar program and Mars program, they need—certainly with the lunar program, they need to back up a little bit, because the reliability of the Shuttle is a different animal than a spacecraft that you're going to fly just one time. So I feel that they're certainly going to have to go through that, growing pains, as they get there to do that.

I haven't talked much about the years that I was Deputy Director of Engineering, but I don't know if that would be of interest.

WRIGHT: Well, sure. Now, based on the information you had given me before and our research, I think the other big phase of your life that was going on at the same time was becoming part of the Engineering Business Management Office.

JAAX: I'm going to talk a little bit about experiences with the teaming for Option C, in that they pulled together the lead people from the different disciplines to work this. One of the things I really enjoyed out of all that was the opportunity to work with people that you saw as maybe more in an adversarial role because you're competing with different ideas, they're from different organizations, and they're doing their thing, and you're doing that. You may be competing for money for a facility or whatever. I think my facility to grow plants is much more appropriate than your building another vibration facility over here. But instead we got to see their real

technical expertise in spacecraft design, which was a common goal for all of us, and we could all grow together.

On the Option C Space Station activity, we got to see the benefit of the fact that all of us had gone through a Shuttle design effort, so we all had strong knowledge of our technical areas there that wasn't based on conjecture, on viewgraphs, or anything else. The hardware was working. We all knew what was successful and what wasn't successful. So we could get together and share those, and you worked for a common goal. I'm reminded that this is very much similar to what we did with the ASTP [Apollo-Soyuz Test Project], in that it was again another small group of people who were selected.

This time, though, it was something where we had to come up with a design that the Russians would accept and the contractor would accept, because we basically were negotiating simultaneously with the Russians and with the contractor, telling the contractor, "This is the design." Typically it's the other way around. The contractor has told us this is what he bid, and you're then—you hopefully put your requirements such so that his response has got what you thought would be the right solution for this thing, and sometimes you're surprised, and you don't get what you thought.

But it was great there to see these other disciplines, the key people or people that others thought were good; that that was who you got to work with to do this. So as my career went through, a lot of those same people are the people you keep interfacing with, and you were able to do that. Today you have the TransHab and the X-38 programs that we did in the '90s, which are the same sort of growth platform for future leaders.

I think the side benefit that people don't talk about that really can be the most beneficial is that I get to know what you can do and not do, and who you depend upon. That ability to then

make quick decisions or the ability to come up with a good decision is really helped or enhanced by my having trust in you, already because of my prior experience. Even though I don't know your subject very well, I do know that when you put together your product to do that, that you did a good job on that, and basically you stood the test of the quizzes that we had on how that would operate, what it would do, how much money it would take, how much time it would take, and you would deliver. That helps make the decision making a whole lot easier.

WRIGHT: Let's talk about those two programs. You mentioned a few minutes ago about the TransHab, and how you got involved with that.

JAAX: The Director of Engineering, Leonard Nicholson, came from programs that had—he was part of the ASTP, and he was a Deputy for it. It was something where we handmade some pieces. The docking module was something that came out of JSC that was built by Boeing, but pieces within that were provided from in there. Seeing the hands-on work by the engineers was something that really was a strong motivator for me. I agreed with them that we were losing that skill within the engineering organization, because there just weren't many opportunities.

In the early Shuttle Program, my old division, I talked about a lot of flight experiments that we put together or things that we conceived that were actually flown to give us the test experience with this device, or a lot of things were flown because they needed them at the time to fix a particular problem. But many other divisions didn't get that opportunity, because the guidance and navigation was pretty much fixed, although they continued to come up with different devices to handle different situations they had there. Structures, sometimes they'd get a

project, but more often they were dealing with the failures or the issues with the maturing spacecraft.

So what he conceived was an idea that we talked about in the TransHab itself, is getting some of our youngest engineers, who are freshly out of school, and putting them together in a team and giving them this assignment to come up with a spacecraft that would be able—or this module, you might say, because it wouldn't be a full, self-contained spacecraft that had propulsion and everything else, but would be a habitation module that could be maybe used as a storehouse for like a pantry or something on the Space Station where you could store some of the goods that you're going to use, or as a place for all the trash to go into, if you want to use it that way.

My preference on that would be to make it a habitation module, in which that's where the sleeping quarters are at, where the food processing is done, where the waste collection, where body waste and all that is done, and where the water recovery, 0_2, oxygen or air revitalization is done, and that's really sort of a self-contained area here. That can be a test bed for life support. That's my personal preference on it.

But what we did was pull together some structures people, and these people were generally in their 30s or less, out of school no more than 5 years, and put them together. Gave them a lead engineer, and that was Bill Schneider, and conceptual design is something he's got a real forte for. He's today working at Texas A&M [College Station, Texas] teaching classes on that, where he's training young college students—they're probably graduate students, undergraduates—on doing system design and coming up with a [design] similar to a TransHab and to a—well, it won't be an X-38, but it will be something a little bit smaller that they can do in a semester or two there.

So we knew that you could use inflatable materials to give you a large volume, but also the materials on there, if they hopefully had the right properties, you'd be able to—they'd be able to last in the environment of deep space for extended periods of time, extended as many years as such. So I said, "Instead of using aluminum, find something else half the weight, half the cost, half the whatever; twice the volume; you come up with it."

It's sort of like we did on another project that was a Mini AERCam [Autonomous Extravehicular Activity Robotic Camera], which is a little device that floats around, sort of like that little ball in *Star Wars* that you saw jumping all over the place. We've got something similar to that, only it doesn't move quite like that. But it's able to take pictures or to look at something with an infrared camera and tell you what the temperature is on that, or to sit still and have a camera in there so that when you vibrate the object out there, it can get the frequency of that vibration, and it's a little thing.

We had sort of conceived an idea, or we had, and flown one; it was the size of a medicine ball. So we gave them the challenge with this new team, again, the same thing as on TransHab, of, "Let's do it with the size of a grapefruit." I brought in one of my grapefruits off my grapefruit tree and said, "You can make it about that size." Then people aren't objecting to this medicine ball; they're objecting to a grapefruit. They're not going to object near as much if we can make something like that.

We want totally new ideas on this. "You know, many of you have come just out of school, graduate school or whatever it is. What's the latest things you're seeing as far as manufacturability, electronics? How do you use ribbon wiring designs in this thing? What kind of plastics or materials can we have instead of the hard—anything that will make it a lighter weight? What gases can we use in here that we can press down?" Of course, it would have to be

at high pressure or whatever it is, but it can give us the [imitates noise] to be able to move this thing around like you saw in the *Star Wars* type thing. And they did it. They put together something, but they didn't end up with a grapefruit. They ended up with maybe a one-and-a-half-sized grapefruit, which is about seven inches in diameter or six inches. They put it together. We came up with a technical design for that.

What it did is it pulled people from all the different divisions. You had to have somebody from Structures. You had somebody from Avionics. You had somebody from the electrical people. Life Support doesn't get involved, except for the pressurized gas and the volumes for that thing. They're the people that are the least involved in that particular time solution. But the robotics people get involved, also, because they're using these robotic things. You've got to be able to command it from a control center or whatever it is, and so they talk together. So you get these teams of people who get used to working together on short-term projects to build it.

TransHab was very much like that. Their goal was to build a one-third-scale and then a full-scale design of this thing. They built a one-third-scale thing, evaluated it in a swimming pool, somebody's swimming pool someplace. I mean, this stuff was done on the cheap. We did not have any money to spend on it, so you had to beg, borrow, steal, or whatever you could, to get stuff, and we have inventories of material. We did have to buy some of the materials for this thing.

At that time I could use some civil servants on this. I didn't use any contractors. You didn't want to use contractors, because then you'd compromise their ability, if you wanted to go ahead and make this thing, because if we sold it to Space Station and they wanted to do it, you'd want Boeing and Lockheed and all the biggies to have that ability, and of course, that's our

support contractor at work for us out here. So, again, it was keep it within the civil servant workforce and see if you can do that.

To pressurize this thing and then keep it in this swimming pool here, they had to have a system there that was airtight. All I remember is seeing the video of this thing here. The video is blowing water all—it held together, expanded and held together, but I think the system that they were using to pump the air into it and that was really a jury-rigged, Goldberg-type thing that we wouldn't do ever again. But the guys were being inventive on how can I quickly show, and it's not unlike what we did sometimes in Apollo at the early time there, trying to demonstrate that something would work. You'd just go out there and try to put together what you felt would do it, and pressurize it or whatever it is, and see if it really would. Then you'd go off and do the technical design that would make it the full, safe, quality product that you really wanted.

They want to put together a full-scale TransHab module, okay? In the way the design evolved that they had, it would be Kevlar and several other materials in here, all folded together around this cylinder. I don't remember the exact dimensions there, but it was something like four or five feet in diameter, and then you've got to tie all this stuff together. When you put gas in there, then all of this material has to expand, and it becomes like a big balloon that you have here, but of course it's going to have the shape that you're wanting out of this thing here, so you've got to have cords that sort of keep it constrained to the design you want.

That was their success story. I think just before Christmas in '99 or somewhere in there they were able to in Chamber A have a 30-foot-tall, I believe, element there. I can get you the exact stuff; I had it before. And they were able to pump this thing full of air in this thing, and it all expanded just the way they were hoping. Of course, we had some things that didn't quite go

right, but it was a demonstration, and we used the actual photograph we would take to people to show them.

Of course, they'd look at that photograph and say, "You put that together? Where's the millions of dollars that you spent to do this thing?"

We'd say, "It only cost us maybe—." It was in the $10,000 range or something like that, really cheap.

But we did have to do one thing. We had sewing machines. We had to sew all this material, because it's nonmetallic; it's this Kevlar and—I can't remember all of the stuff. But we had some sewing machines in Building 10 out there, and we probably got everybody who could ever operate one of these big industrial-sized sewing machines that's available in the local Houston market in there to sew these panels together so that we could build these test articles that we had, and sat in that big sewing room there.

There is such an operation already in Building 7 up on the third floor, and that's where the cargo bags or the—if you see these white bags made out of Beta cloth or whatever that carry things on the Space Station or whatever it is, we put them together up there. It's a GFE [Government-Furnished Equipment] product that we produce in there, so we had the experience. We knew what to do. It's just you've got to take it and replicate it by 20 machines or something like that. You'd normally just have one machine and one person. Used to, we had three or four, because the contractor would do some of the work, but we had downsized such that everything was there.

We had to go through a training program, and we had them working there. They were working several shifts. But that's where some of the expense would go is we'd have to pay for some of those to sew the stuff together, but the actual testing would be just some of our

engineers. At today's full-cost accounting it would cost more, because these civil servant costs would have been a part of it. Actual outlay of dollars that was appropriated to us for development was a very small amount, and that was a difficult thing to convince Headquarters or others. They'd look at it and say, "If it was this big, it must have cost that much," just because it was this big.

We'd say, "No, this is the problem. This is what we told them." It's sort of like what we did on the Mini AERCam, this grapefruit thing; the same thing.

WRIGHT: Did the TransHab get put on the shelf?

JAAX: Yes, it did. The idea was that we would demonstrate this thing, that it's able to do its thing. One piece that we were really working on was putting a window inside there, because you put somebody inside this module and they're up in space, it's sort of a living room type thing, and you need a big window in there. So we had worked out the design for this, but we hadn't tested something like that. But now we needed some funding from Space Station, because now it was going to cost real money, because we need this real window, and we need this real stuff here.

Took it over to Space Station, and of course, they were having money problems, and they just said, "We aren't interested in this thing." We pushed a little bit further, but we then had—I think Goldin was still in, but maybe the Administrator had changed, and they had even less interest in anything that was enhancing the Space Station. So it sort of died.

The technology was something that was attractive, and there's a company out there who now owns the patents, I guess, that we had patented, has bought those. It's the Bigelow

[Aerospace], and a guy by the name of [Robert] Bigelow, is the guy that's charge of it. His idea, he's pretty much captured the essence of what we were trying to do. His goal, I'm told, is to sort of have a hotel in the sky, because that's his background, I think; the [Budget Suites of America] are his thing, part of his wealth. He lives out in Las Vegas [Nevada], and he has a design team out there.

We have sent engineers from Engineering out there to advise them on it, but they bought the technology probably in the year 2002, 2003. When I was leaving, why, we were in negotiations with Bigelow about transferring the technical knowledge over to them. We provided them with several experts. He hired a number of the contractor people to support that, and they have built a one-third-scale model, and they have flown it on a Russian spacecraft, and it did expand. This was done just months ago, and he still is pushing forward.

But the guy who really pushed our design probably to the maturity that it got was Bill Schneider. Bill retired in about 2000, 2001. He went to A&M. Bigelow got ahold of him and made him the Chief Engineer, so Bill goes out there about every two weeks, I'm told, and critiques the design, the progress they've made in it. So between the four or five individuals who they picked up out of this thing, they were able to pretty much keep it close to what we had in mind.

I would love to see the device come back to be a part of Station, because I still think it would be the right thing to test the life support system and some other things in there. But at this time, it's not—until the Space Station gets light put back on it as a useful test bed application, I don't think it will work. But the technology does have a life today, and it is being pursued and it's working, and I'm very glad to see that. There were some good young people who worked on

it here and then who have moved on to other jobs, and there were some of them who have kept their skills that worked for them.

I'm told today that we have pulled back some of our resources within the last two or three months that were supporting him, so I'm assuming he's going to continue ahead, but it would sure be nice if there was a continuing dialogue, because I think somewhere in the future we'll meet again where his product that he has there is something that's attractive to us to utilize when we talk about going to Mars. So that is a program that we started here from scratch that has now made itself into the private sector and is being matured there.

WRIGHT: Okay.

JAAX: I was going to go into X-38. The X-38 really was started in the'95, '96 time frame with a problem we had with the International Space Station. We had bought a number of Soyuz flights and Progress flights. The Soyuz vehicle is paid for—at that time it was being paid for exchange of services. We couldn't give them money directly, I believe. But anyway, at some point in time that contract was going to run out, and then we'd have to renegotiate. The worry was that since they were the only ball game in town, carrier in town to do what they were doing, they could cost three or four times what it was, and shouldn't we be looking at an alternate way of getting crew up there and back the way the Russians do?

So they came up with a—I'm trying to remember what the acronym or the name was of the vehicle before the X-38. But the intent was to be able to fly three or four crew back and forth from the Space Station and relieve ourselves of the burden, I was going to say, of the Soyuz problem that we had at the time.

That evolved into what we call an X-38, and the reason it became an X-38 is the experimental spacecraft or vehicle. NASA had gone through the X-33, the X-34 programs, which were done at Marshall; more technology demonstration of advancements we could make in spacecraft materials and their application. The next number available to us, I think, was like the X-38. I'm not sure what X-37 was, but X-38 design was based upon a reentry module or vehicle that the Air Force had done way back in the Dyna-Soar [Dynamic Soarer, spaceplane] program, a long time ago.

The neat part was that it had about the same—it's something that we could put inside the cargo bay of the Orbiter if we needed to by folding the wings. It was sized to handle, and we got it so we could put seven people in there. You'd all be laying down inside this thing, but it was a way to become a rescue spacecraft for the Space Station, and I think that's really what that first vehicle was is the International Rendezvous and Rescue or something like that, because it would be a rescue—it was something you attach to the Station and stay there. If an emergency occurred, they could jump into this vehicle, like they do on the Soyuz.

Soyuz could only take three people at the most. We could take seven with this vehicle, and then you'd be able to handle the full complement of people that were on the Space Station. Because with the Soyuz, if you put six or seven crew on there, you've got to put two Soyuzes on there, and so you've doubled your exposure, all the failures you're going to have. You're going to have to have access to both sides, and of course, the people who are doing the failure analysis will say that you're probably not going to have both sides. You're going to have one side. You can't depend upon that being available, so we were looking for other solutions.

So the X-38 had a lot—the design for the aerodynamics of the thing had been done by the Air Force and a wind tunnel testing and a lot of analysis, and they had flown vehicles very

similar to it. I think we increased the mold line, the outer design of this thing, a little bit, and we assigned that, again it really was the growth of this rescue vehicle concept as the next step, to John [F.] Muratore. John Muratore, I don't know if you've interviewed him or not, but he'd be a good one, because he's done a number of things.

He put together a team of people that their job was to build this spacecraft, and we actually built one that was in Building 220. We had a manufacturing capability, and we wired the thing. We structurally put it together. We had the composite outer surface built by Scaled Composites, who had built some of the—I don't remember the spacecraft that [Elbert L. "Burt"] Rutan, had [built], and it had flown around the Earth [Virgin Atlantic GlobalFlyer]. But it's not metal but a composite material that they have on it.

We put together a design team out of Engineering that was—it had all of the systems in there, and this is a true spacecraft. In it you need a life support system. You need the guidance system. You need the propulsion system. You need aero [aeronautical] surfaces. You need structures. You need mechanical systems to move things around. We decided that we'd use parafoil technology, and a parafoil would be the way you'd float the thing in so that instead of braking or having engines or something to slow you down, we'd be able to paraglide down to the surface of the Earth. We had to have the mechanisms that would be able to control that system on there.

It was a complete spacecraft design, in that the intent was to fly it up to Space Station inside the Orbiter, attach it to the Space Station. If an emergency occurred, the crew would bail into this thing, and it could be either flown or it could be just automatic entry. And back to Earth, you could pick your spot that you wanted to land. Of course, it depends on where you are

in the orbit at the start, but it was for a land landing, the way we had it set up, and we got into that very heavily.

At that point in time, Dan Goldin, who was the Administrator for NASA, got very engaged in it. I don't know if I described this before, but we had design reviews early on. These design reviews originally started out with him coming down here in the '96, '97 time frame; challenging us to figure out a way to get to the Moon and to Mars for what he said was three orders of magnitude less money than the Apollo Program took. Of course, that's taking Apollo dollars in 1969 or whatever it is, and saying three orders of magnitude less than that, versus the Apollo dollars of today and then three orders of magnitude of that, because that's a vastly different number.

Anyway, he would come down here, and we had a small group of people, John leading it, who would go up with ideas on it. We ended up with the final design that he saw, which, in our rough estimating of cost that got it down to what he was talking about, was literally a guy on a lander that was in a spacesuit with sort of like the World War I pilot with the goggles on the front and a scarf around his neck that's open air going down in, because that was the only way we could come up with a design that would meet his requirements.

What I recall him saying is that he accepted that, and said, "You guys have finally done what I've asked you to do. I know it doesn't look pretty or anything, but you're now thinking out of the box about how you can solve these problems. So the next thing I want you to do is look at Mars."

He had us go off and look at trying to get to Mars, but that didn't last very long. We were coming up with ideas on how to transport, and that's where probably the nucleus for the TransHab came out, because we knew that carrying, lifting all of that weight up and assembling

it up on orbit just to get the volume and get everything there was going to be horrendous. You'd have to have 16, 17 launches to get this fleet to go to Mars to do this thing if you did it with small modules, because they didn't have the heavy lifter vehicles to do that with.

But if you used a TransHab, I could reduce a lot of that down, because I get more volume out of this thing, and I could do it if you had some inflatable type thing, and that's what we worked in was arm waving and saying we have an inflatable. So later on Leonard used that as the kickoff for, "Well, let's try something. Let's just see what we could do there."

Then the X-38 became the thing, and he would come down here, and it would be literally, probably back in Goldin's days back at TRW, where he would sit in a design review and they critiqued the design. He'd sit there, and John's sitting in [Room] 945 on the ninth floor in Building 1 there, with the Center Director and the Director of Engineering and myself and his design team, and Dan Goldin is sitting there just picking away at this design and saying, "Why did you do this? Why didn't you do that?" I mean, deep technical discussions, far more than we expected.

John would go—most of the time he'd be able to have the right answer at the right time, and he knew when he could push it and when you didn't. John has a unique personality that you may have heard of, but he did a pretty good job of doing it. So we were doing great, and we built our first doghouse or test article to fly to see. We did this in late December, and we finally got—all these tests were either done at Yuma, Arizona, [Yuma Proving Ground] or out at Dryden Air Force Base, or NASA's facility there [Dryden Flight Research Center, Edwards, California]. I think we were at Yuma on this one. I wasn't there. I'd hear these back here.

We dropped it out of a cargo vehicle, and I think it was a C-130 or something like that, just to see if the parafoil worked. The ropes—it didn't deploy, and it literally augered in, just

like your worst-case scenario that they'd sometimes put in a movie, the tank that it's got this big—all the generals are sitting here, and we got this demonstration, this parachute drop of the tank, and of course, the tank just falls straight down. Well, that's what happened is it—of course, we didn't know it.

John calls back and, he says, "The success we had is we proved that gravity works." [Laughs] That's the only thing that he could say, but we weren't able to get the thing deployed and we cratered the thing. From that point on Mr. Goldin was no longer that interested in the program.

Well, you've got to have some failures or I don't think you're pushing the envelope to figure out what your successes are. In this case it was, one, it was cheap. I mean, no people were involved. It was just we tried our engineering best. Now, I'm doing this second- or third-hand, because I wasn't there; I'm just hearing the stories—but we really trusted the Army knew what they were talking about on deploying large, heavy objects out of these things. You would have these parafoils or parachutes, and that worked.

It didn't. Much like the movie, it didn't work. So we ended up instrumenting the thing. We ended up putting cutters on there and having to literally figure out the layout of this thing so that when the thing unpackages itself, you don't have cutters cutting cords, because that happened on it inadvertently. So you've got a riser here, in which it's got to be connected to the weight that you've got here, and all of a sudden it gets cut off. Therefore the load is redistributed to these others. They aren't sized to handle that, and you suddenly have disaster happen.

Plus you're trying to package this thing, because on the X-38 you can only have this much volume to package this parafoil into as you're doing this. It took a couple of years, but we probably at that time had the smartest people with the most knowledge of how you deploy a

heavy-weight object under a parafoil; you get that deployed parafoil to take its shape and successfully do its thing there. I'm sure we helped the Army out a lot. This was before the Afghan activity and all of that activity, and so later on they were flying things that went into caves.

So that technology was a feedback from the stuff that we had learned there. We put load sensors—they had never used that—and other things on there, so it was a mutually beneficial thing from that standpoint. From our viewpoint, though, of course, we had the softest problem, because we were going to be flight testing—not flight; well, we intended to fly it. We were trying to get manifested on the Shuttle to get this vehicle.

But we went ahead and did. Our next flight, the thing deployed like it was supposed to. We still had some areas where we had burning on the—it's a pressure material there, as the ropes went across, you'd get the rope burn. Of course, that means you get a hole in it, and if you get holes in it, then you get a rip. That means you got less area up here that is protecting you or giving you the flotation that you're looking to do, and less controllability. We solved most of that, but it took a number of flights to do that, to get the packaging working out.

Meanwhile, we're working on the shape of the thing, because we've got to go through the entry profile of the X-38 as it comes, because it's coming in sort of like the Shuttle, just coming in without any power and just coming through, and you've got to keep it flat through this thing, so it's got to have stability through the different—you're coming in at orbital speed, and then you've got to slow down to 5-mile-an-hour or 10-mile-an-hour type speed here. So you're transcending through a number of transition points that we knew, from Shuttle history, would be difficult points. I don't know enough aero science to tell you where those are, but our guys learned an awful lot in trying to do that, get that shape through there.

What we would do on our tests out at Dryden [Flight Research Center] is that each time we would drop a X-38, we would take it up higher and higher to get more velocity on it so we would get more and more in that envelope of the speed at which this spacecraft's going to be exposed to, so we could make sure we had the stability of the design, because that's very critical, is the shape of the body of this thing, because we had expanded it a little bit bigger than X-38, but tried to keep everything proportional.

Basically, it was working. It was working fine going through this, and we dropped seven or eight times. We had a full-scale test article that we dropped several times. We were building a flight-like or flight piece of hardware out there where we actually were doing the wiring in that, all in 220; had it built. But we had a change of Administrators, and Mr. [Sean] O'Keefe felt that first of all, we were spending a whole lot of money on the X-38. Again, we were using our own resources here. We could do it a whole lot cheaper than a contractor.

Our intent was not to build the fleet or whatever it was. Our intent is one which I really support, and that is that we were going to learn enough about this design on how this thing operates. It's like when I did the Apollo-Soyuz docking module environmental control system. We knew each piece of that hardware, because it had already flown on the Apollo. So when we did Option C, we knew the pieces of hardware we put together, because we'd all flown it, tested it, designed—had been involved in its development activity.

That philosophy is what we were trying to do with the X-38, in that we would have enough experience with it, knowing that it's aerodynamically stable. It can handle the volume for the crew, because we've already done a cockpit layout and we've already laid the crew in there. We haven't put people in to drop through the thing yet, because this thing's made out of fiberglass. It's still got to be made out of the real materials that you'd use, and you'd use the

similar type of tiles that we use on Shuttle to give you the aero-heating protection that you need. You'd have working surfaces up here that we'd control that gave you just a little bit of control, whereas they've got to work for a long time, a fairly long time when you come through entry.

We could have enough experience with it that I could take the drawings resulting from that and the materials that I had and I'd literally lay that out for bid, and you could represent Boeing. You could represent Rockwell. You could represent OAO [Orbiting Astronomical Observatory]. You could represent anybody, and they all get the same drawings. They can all bid to it. We don't expect there to be 10,000 change orders whatsoever, because we've already solved the basic problems. There are going to be a little, but this is going to be a very mature design, and it's got to be the cheapest way—the cheapest way—to build something.

Plus I'm getting people; I'm giving them hands-on experience at actually designing something, and the best part of it is you get to see it fly, or you get to see what happens on that. That's probably the most rewarding thing for me, like during Apollo-Soyuz, I did all this analysis of what would happen if this would happen. Well, sure enough, there was a situation in the Apollo docking module combination where one of those was a real-life event. It happened, and I had a solution and gave it to Flight [referring to the Flight Director], and they used it right there. There's no better affirmation of whether you're working towards the right level, if the product you're producing is something that's useful to someone, than to be called upon to do that.

So we thought the X-38 approach would be that, and that's what we were evolving towards. But because it looks like a spacecraft; it's got to smell like a spacecraft; it must cost like a spacecraft in traditional dollars, plus it wasn't invented—this is my opinion. It wasn't invented by this particular regime or the Administrator. It was something else. Why should I

champion something here that's got a checkered past? There's stories about this augering-in situation.

Of course, budget becomes a big issue at the time, so that would be a very visible thing you can cut out that you're not dependent upon yet. But, it's gotten a lot of publicity, because it was in *Aviation Week*, and it was in lots of newspapers every time we had a flight that people could see it from Dryden. If they wanted to go out there, they could watch the thing do its thing.

So they cut it, and then we went through a very painful—okay, cut. The direction we were given was, "You will stop right now. Just do nothing more on the thing."

Of course, we said, "That's not quite what should be done. What should be done is let us take it to the maturity points at which we can transfer this knowledge to some other program. If we stop now, I will not have done a static test on the thing." That is, to take a load and see if I had the thing distributed right. "We're only this much away from it. It doesn't take much more money, very little, because we'll do it all with the few civil servants here. I've got one more drop, and that drop will prove that this device works and this technique works that we've been working towards in here. Let us do that, please."

Well, it took a lot of convincing to get them to allow us to do the drop. We were able to do a static-loads test, and this sort of occurred right after I left, but we were accused of all sorts of things, because John has a very—either the people work for him joyfully or they don't work for him. I mean, he's got some very enthusiastic people. And I usually got to be the guy who had to explain to whoever it was, when he got in trouble, why we're going to work this out, whatever it is.

There was a photograph that showed up one day that showed the X-38 being pulled down Avenue B or whatever it is from Building 13 area, or 30, up to 49 or whatever it was, along

there. He's on top, and he's got this flag, pirate's flag, because his group was known as the "Pirates" or whatever, because they got this stuff for nothing, and his people walking beside it very proudly. It's on the front page of the *Chronicle*, or a page of the newspaper.

Of course, it didn't take long for Headquarters to say, "What are you doing? I thought this program was dead, gone, killed. Here it is. I see this." So we explained to them that we didn't realize and he has been properly disciplined or talked about on this thing.

Meanwhile, what they were doing was celebrating the fact that they had completed the static test, and they were taking it back to the thing. It was their last show, because they knew it was. But it was interpreted totally differently by the people up there, and the program was deep-sixed.

I'm glad we went through it. I wish it would have been taken to maturity, because I think the concept is an outstanding concept. Engineering here has a lot of talent. It has a lot of capability. In this case it wasn't just Engineering; we had Mission Operations. Every time we dropped that vehicle out at Dryden, we had a room in Building 30 right next to the control room, just like that, and they had consoles just like you have in mission control, with each operator there following his subsystem, plus the team of people that were out at Dryden then.

So you were educating people on how to fly again on a different vehicle instead of always just doing the Shuttle, always doing the Station. They were working up new techniques and working up alternate ways, because that was one of the challenges we had on X-38 was try to do this thing differently so that it doesn't cost as much. Can we get the quality that we're looking for by—we give them some license to do things differently. But you had to justify it was what it was, so that you didn't compromise safety as you went through it, but you could approach it a totally different way.

We'd put blinders on for a few days to sort of see what—and then you'd see what happened as a result, and I'd get a call once in a while if things didn't work out. But it was a great experience, because it gave them an open book to solve this new problem, instead of saying, "Here's the textbook. This is the way we do it, and that's the only thing you can do."

Part of the problem, I'm sure, came from the contractor community, because when we hand you a design, they don't get to design. They just build something like here. It's like a pilot for an airplane. If you've got an autopilot capability and I just ride it, it's no fun. What's fun is being able to pilot this thing. The same way with designing these spacecraft. You come up with the solutions. So there was a lot of, "They're doing work that we should be doing," and, "Why have you got those people doing that when they could be doing other things?"

Of course, those of us down here would say, "That's the very thing that we are here for is to do this," because, okay, today you're building an X-38, but tomorrow you're going to be building a C-135 or whatever it is. We're going to be flying this thing, so we're going to be living with this baby for the rest of its life, and it's very important for us to understand how this thing operates in life.

WRIGHT: What position were you in at the time that this was going on?

JAAX: I was Deputy Director of Engineering, so I got to defend the budget, got to defend the schedule, and got to be John's confessor. Well, he was on a very good relationship with the Center Director, George [W. S.] Abbey, and George was very much in favor of what we were doing there. He supported us, but he could be very demanding and very critical if he wanted to,

but much of it was in a learning way. I always felt we had his support, although there were times that John, I'm sure, thought that his career was less than good or was going to be short-lived.

What we would do is Leonard and I would go talk to George every week; about every week we'd have one-on-ones with him. This is what I was going to talk about, you know, the Deputy Director type thing. But that's how we kept in touch with him. George had a management style where he collected information from anywhere and everywhere. Almost every time you'd go in there he'd have the information you're trying to get to him already from some other source. It caused problems a few times, but basically we'd go in for one-on-ones; last for a half hour, maybe a little longer. John [W.] Young, he was always in the meeting, just listening, probably because he was interested in what Engineering was doing, because we were doing some neat, creative things at the time, and we were also dealing with Shuttle and Station issues.

What you tried to do was give him sort of a heads up. You didn't explain. You'd give him the subject and what you're doing—or what the problem was and what you're doing, and that's it. And then go on to the next one; go on to the next one; go on to the next one, because that's really all he needed, because if he wanted more information, he'd ask you. It sort of, to me, was a very effective way, like we tried to do with our Division Chiefs, too.

I don't need a full-scale, blown briefing on the thing. Just tell me that you had this problem, that this is the issues, and this is what you've done, are doing right now, and give me a minute while you're doing that to—I can help you a little bit, because I've got the resources or something else—to ask a couple of questions if I need to, or I'll just say, "Okay. Keep going with it."

When you encourage them to be open, I think they feel that they've done their duty. They need to talk to you, but also you give them reassurance that you feel they're competent enough to do that job, to go ahead and go to the next step. I think there's a lot in team building in doing that, where you say, "Okay, that sounds good. Let me know if you need any other help." Or, "Did you talk to such-and-such, or did you go to see this?" Or, "Isn't this the second or third time? Why don't we have a bigger session on this and spend some time on it."

That's the way we'd handle most of the meetings or most of the discussions, and George was pretty much that same style. In talking to George, though, he'd have a television going on back here that was volume twice as loud as you would ever imagine it. You could barely hear George talk, and you're listening to the weather back here or whatever, because a lot of times he'd have the weather on there, because he was flying out to someplace or something else. But there were other times when he'd sort of nod off. You're not sure if he's awake or whether—but he's awake. He just looked like he was nodding off.

We would go through that, and it was reassuring to have a Director of the Center who was willing to listen to you, because he could give you midcourse correction, and did sometimes say, "Oh, I don't think we ought to be pursuing that," or, "Hey, why don't you let somebody else deal with that," like what we would do with our people. The fact that technically he was knowledgeable enough to know, have a good feeling as to whether that was an appropriate thing to be working on, because you do have, when you've got 800 people, you've got some latitude as to what all they're doing, so you can have some focused areas over here.

Like when we wanted to test the 15-day, 30-day, 60-day, 90-day tests, that takes some resources to do it. But what we would tell George is that, "Where we've taken this top technology so far, and this is where we want to go with this thing. In order to do that, we're

going to have to do these series of tests, and that's what I'm going to be telling my Division Chief."

Usually you try to tell him a little ahead of time so that you didn't commit to something with your under-person that you'd have to go back and say, "Well, I couldn't sell that to the boss." But you'd let him know ahead of time that that's where you want to go on that. That way you'd get the feedback on should we put that resource or those resources to work on that kind of thing. And you'd get to see whether or not he's focused just on Shuttle or he's focused on the full range of things. With George, he was pretty much the full range of activity. Others may not have had that visibility or insight, but we'd talk about most anything.

Leonard always had this three-by-five card, and I did the same thing, or I would take this little book that I've got here, Day-Timer book, and what we would write, it's like you see one line here, one line here, whatever it is. That's all I needed was a memory jogger so that you went through the list, and we'd literally check it off as we went, because there would be at least—sometimes maybe 20 items on your list, or it could be just 4 or 5. You only had 30 minutes. That was pretty much locked in. You wanted to be able to hit each of those.

We'd talk personnel problems, too. If we've got a personnel issue that he should be aware of or dealing with, we'd briefly just give him a heads up and then move on and do the other. I think that management style worked well for us, and I hope they're continuing something like that, because it worked. It helped us resolve some things early that could have really festered. But through his grapevine he was able to find some things out before us, so it became a challenge.

If we had a safety issue occur, like a person was hurt or a fire alarm went off in the building there, the divisions were instructed that they immediately called us as to what it was.

Of course, the problem you have with that is the first answer or the first vision of what this thing is, is usually only about 50 percent right. Yes, there was a fire. Yes, there was smoke. But what caused it and what was damaged out of that is not known.

Because of the speed with which George wanted to be informed of everything, we had to have that instantly and tell him at least what we knew. What we gave him is it told him we were aware of it, we were working it, and we'll let him know what the answer is. And that's all he wanted to know, he said. You're aware of it; not that you're off doing something else and meanwhile that could get to [local television news stations] Channel 11 or Channel 2 or Channel 13 helicopters flying over the Center is going on.

So it taught you that kind of respect for the work we do and its potential impact on the environment around us, and the environment includes the newspaper and the papers as well as the air. Didn't have that appreciation before I went up there, but you could understand it. It's just that sometimes there was a ritual or a painful to get there, to get that information to him. But I enjoyed it. I enjoyed working up there a lot. It was a lot of fun.

WRIGHT: Why did you decide to retire when you did?

JAAX: I decided to retire when I was—you get to be 55, okay? Now I'm walking across the campus there probably months before I'm getting to be 55 and saying, "I've got my 30 years in, and so I'm eligible as soon as that day arrives. When that day arrives, then I can decide when I retire, and if I get moved to a job I don't like, I've got an alternative." Up until that time you just sort of, you know, I can be—like I was. Today I'm a Branch Chief here, and tomorrow I'm on

the staff, and the next day I'm working the business organization, and the next day I'm doing this. For me, it was all fun. For a lot of people, it's not that way. So I was toying with that.

My parents passed away when they were 75 of heart attacks. My wife is a dietitian, so she has kept me very healthy, or at least we're trying to do that. I figured that if genes are such that I've only got 15 more years to go when I'm 60—or 20 years at 55—what do I want to do for those next 25 or 20 years? I got to be 55; I wasn't ready yet. I'd been up as a Deputy Director for two years as such. I did have an appendicitis attack occur during that time, and 200 years ago I would have been dead because of that. That's a little sobering, but I decided I'd really like to work another 5 years or maybe 10 years.

But also I know that when you're up in that kind of position, you can't stay there forever. You're going to have to be moved around after a time. I was fortunate enough to stay there seven years. That's almost unheard of to be in a senior position that long. Plus I was doing a lot of stuff for the Center on teams that represented the Center at Headquarters, so it expanded to be more than just the Deputy Director of Engineering. There were a whole bunch of things that we could go through later that you get involved in there that really give you an eye of the breadth and depth of what this Center does.

I get to be close to 60, and I decided that 60 is when I'd like to do it, because if I've only got 15 more years or whatever it is, I'd rather spend it with my wife, and since we still enjoy each other, we do a lot of things together. If I stay in the area here, I could probably have some consulting. I had no idea if there would be any opportunity, and it certainly has worked out fine. I'm consulting now about 15 percent of the time; in other words, about 300 hours—year 2000 hours—so right now this year, it's been closer to 400, which is about right. It's about 15 percent

time, and I discovered that I could set the time at which I come or don't come, and that was totally different from what my life was for 35 years.

At 35 years, the retirement system is reasonable there where I could get enough that my wife and I felt okay with the monies that we would have there. My children were out of college, and the house is all paid. I did make a list, and I still carry it with me here. Here's the things I want to get done before, and these are the things I'd like to do afterwards. I could show you the list. Almost everything is checked off on the "before." A lot of things are checked off on the second one, but there's still more to do there, and I look at it every once in a while. Get the car paid off or a new car? And a new car is what my goal was.

Get the house paid for. We've been in this house for a long time. Didn't make a whole lot of money. You know, it has not accrued a lot, because Clear Lake has not done that good. The house is totally like new, because we've changed out everything, so that was all taken care of. Health, still okay, and we're both in great shape. Plus, my brothers and sisters are still alive, so they can come join the celebration.

That will be the second time that they came to Houston. The first was when I got hired. Thirty-five years later they came back. [Laughter] I don't know. Then, okay, what month am I going to do it in? Now I look at schedules for my daughter's M.D.-Ph.D. Program at the University of Washington [Seattle, Washington]. My son is working in the area, so he can come at any time, but she, I've got to work between her class schedule, so August turned out to be a opportunity in there. Plus my relatives, again, could come here during the summer. They wouldn't have to have school, because their children—I'm the oldest, so they've got some children still in college at that time, or other obligations.

It worked out great, so I was able to get them here, and we had a big celebration in Gilruth [Center] for me, did a video, and all that stuff. It was really pleasant. I was able to give my siblings and their families a tour of the Center, because I've given lots of those, gone through all the engineering buildings. Of course, the accident didn't occur until—9/11 [September 11, 2001 attacks] had already occurred, and 9/11, that was a weird—I mean, that morning, 9/11, because I'm running the telecon.

Engineering has a telecon at eight o'clock in the morning, in which the Division Chiefs are all on, plus the staff offices, and we do a quick tag up of what's going on during the day or is there an issue that's brewing out there that we need to talk about later on. The first plane had already hit, and our secretaries had already seen it on TV. I'm doing the telecon, and I've got the TV over here in the conference room, and I can see what's going on.

Finally I think the second one hit about two minutes or so inside this thing, and I'm sitting here thinking, "Should I acknowledge what's just gone on here, or should I just play this through the routine and then at the end just say that, 'Hey, there's some things gone on up north there that you're probably seeing on TV'?" And that's what I chose to do. I said, "I'll just go ahead and finish what we normally do, because I don't know what they're—," because as soon as you say this, why, there instantly you've lost all communication with them, because they're going to be looking to see, get that TV on, let me see what's going on.

So I chose to finish the going around everyone like a normal day, but I did end it up, though, saying that, "I don't know if you guys have seen the TV, but there's things going on in New York that are very disturbing that we need to deal with." That was probably the most awkward telecon, and I ran those for seven years, as to what to say real-time when it's going on, is do you take something that's as far away as we were from there and make it the total focus, or

do you try to keep business as normal as you know. But by noon, of course, we're sending people home and all sorts of things like that. It was just most unusual, or difficult.

So we went through that day, but it reminded me of the days that we had to in the late '90s when we'd have these budgets not be approved, and therefore we had to determine who was needed and who could be spared. You're going through telling Division Chiefs that, "You're really not needed."

Of course, some of them took that very personally. "What do you mean, I'm not needed? I'm not critical?"

I said, "Well, just for this exercise here, we have been told that we can only have these people here or this number of people here." I was the one who chose who stayed, who went, and whatever, and that's not fun. That's not part of the fun memories that you have around here, but it goes with it and you go there.

Anyway, I think there's an opportunity to talk about the Deputy Director type activities, because we were the focal point for a lot of things, but also the directorate had a lot of interaction with the Center and the rest of the agency. So we can go through that.

Oh yes, my retirement. We were at that.

WRIGHT: That's where we were at, yes.

JAAX: Right. Those were the reasons. The real reason was, and I still have a little bit of concern about going. You know, I've now got 11 years left, or 10 and a half, if all that came to pass. So I'm able to do most everything out there, but I felt very comfortable at retiring at 60, although I will say that when I told you—if I told you I'm retired and I'm 61 years old, I've got a little bit

of uneasiness as to whether I did it a little early. Felt comfortable; but now that I'm 64, it seems like that's the natural age to be retired. Of course, my wife would never accept being retired, and she essentially was for about five years before I retired. So she's now been retired about eight or nine, so it's very easy. But we go to class at Rice [University, Houston, Texas]. We just finished this semester; took two this time. We travel some, and our children are both now married. No grandchildren, so we're not that fully engaged in all those activities, but kept my hobbies going.

That's the other thing. I think if a person has got something to do afterwards that's not totally dependent on work—there are a lot of people who have not made an outside life. At the same time I was doing all these other ones, I was an Indian Guide & Princess and was head of the Indian Nation, the Nation Chief for the Indian Princess Program. Went into baseball and softball. Got on the board. Managed the teams for both the boys—well, for the boys' team, and then I did the girls' team a little bit, and we got another guy that we alternated with, and I was on the board of directors for about five years.

And the same time I'm involved in soccer and was the coach of my daughter's team for all nine years and my son's team for eight of the nine years. I was on the board for it; head of the competitive teams. Both those teams are very successful. My daughter's team went to being state champions twice and have gone to the nationals, and my son is a state champion. So we did well. You could mix all those things and stay in the community and be involved.

I started growing hibiscus as a side hobby. What really did that was a fellow by the name of Dick [Richard E.] Mayo at JSC, who used to work in our division. I'd see him bring these flowers in every once in a while, and I didn't know what they were. I got intrigued with it that he brought them in every day. So my last seven years or so I brought flowers in, like I did to you

guys today, every day to the secretaries up there in Engineering. Sometimes, when you've got 200 plants, why, I could bring in 15 or 20. Sometimes it would be one, and there'd be a few days when it would be zero, because there wasn't anything there.

But it was just a nice thing I could do, that growing up on a farm, I could still grow things, and people could appreciate them. I take them to a local restaurant here every once in a while, and they put them out on display, the Colosseum Italian [Restaurant] there in Clear Lake.

I had those opportunities, plus the genealogy work that I'd been involved in, so I had something else to do, and I think that's important. If you're going to retire, you've got to be ready to have a change in things. In my case I have had a number of opportunities for going on to work for full-time, so I have not accepted any of those. I expected for about four or five years, three or four years, for those to be numerous. But as you get to the fifth and beyond, it's going to be a lot less, because the group that you knew at JSC is all changing over, and it's pretty much done that now.

The opportunities are going to be less, but still it's been rewarding to be able to go back to the division that I grew up in and to talk to them about the technical work that I really did, because most of those people have no idea that myself or Will [Wilbert E.] Ellis or some of the other guys really were heavy into the technical part for the first 20 years of our career, because they only knew us the last 15 or 20 years, and at that time, you're into the management side. So, "He's a manager. What relevance has he got to the problems I've got to deal with every day?"

We'd turn around and say, "I worked most of those problems you had, you've got a lot better tools and you're probably a lot smarter than I was, but we've got some experience here," and to have them ask you to come back to share that information is very rewarding. Right now I'm trying to set up a meeting with about five of us, four of us that worked the Apollo and other

program environmental control systems for the division, so that they can go through the schematic, and we'll look at the Orion schematic. I hope it turns out to be a good experience for them, but the e-mail I'm getting back is they're all excited about it and saying, "Hey, make sure I'm there."

WRIGHT: What do you think, if you had to pinpoint, would be the most challenging aspect of your career?

JAAX: Let's see. Probably the Business Office. [Laughter]

WRIGHT: Let's talk about that. We haven't had a chance to talk about that yet.

JAAX: The Business Office came about in '94. This is after the Option C activity and my Space Station tour. That got me to October. I go back to the division to be the Deputy Division Chief in Crew and Thermal Systems Division, and we're working now on this new Space Station and Shuttle; the Shuttle is flying still. I get a call on August 15th or something like that, just before—it must have been about the 13th—from Leonard Nicholson, the Director of Engineering. He's just been, I guess—yes, during Option C he was made the Director of Engineering, so it's only been a few months there, and he'd already probably talked to Will Ellis, my Division Chief, and asked him if he could do this.

But he said, "We'd like you to consider being the head of this Business Office for Engineering." There wasn't such a thing, and he said, "They're going to combine together the procurement, the resources,"—that's the money aspects of it—"and the support contract," the

contract that Lockheed had at the time, "into an office in which you'd be responsible for it, but you'd have to work in the Business Administration Directorate," a new directorate that they had formed at the Center that pulled together procurement and business resources. "You'd be the Engineering Business Office, Business Management Office, lead."

Of course, I'm somewhat stunned. "Okay, does this mean my career has gone that-a-way, or what is it?"

He said, "No, don't worry about it."

I said, "Well, let me think about it and talk to my wife tonight about this opportunity." So, of course, there's no real thinking. It's just, "Okay, when do I start?"

The problem was that you have to set it up all from scratch, but the Business Management Office is being led by a person, Terri [Terrence A.] Hesse, a woman who has just been hired recently from the IRS [Internal Revenue Service], who isn't familiar with JSC, and what she has just done is taken all of the former leaders of the different organizations that were there and sat them down and picked new ones to replace them in all organizations. But Engineering was able to get its own lead, me. MOD, Mission Operations [Directorate], was able to get Carl [B.] Shelley, another experienced person there, to be their lead, but all the rest were from the business organization or the procurement organization. So you had a bunch of junior people who don't know why the senior people have been fired, in effect.

In my case, I'd never worked that area, although I did a lot of the business management stuff. I was the guy that did the budgets for Station. Another guy did Shuttle. But I set up most of the formats, most of the stuff. I worked with the resources folks; worked some contracts with the procurement folks. I was familiar with a few of them, so it wasn't totally out of the blue, but they didn't trust it really, so they gave me two deputies.

One of them was the lead guy, or the guy who formerly had been head of the Procurement, all of Procurement. He's my deputy now, Bill [William P.] Bays. Great guy. It turned out great. We never had any real problems. But they had literally sent him down from being top to now working for Engineering.

The other guy they gave me was John [H.] Chisler. John had been Gene Kranz's business lead, and so he felt for sure he should be leading one of these business organizations if they're going to do this. That didn't happen, so John and I had sort of a rough tour through this, because he kept wanting to make the engineering business look like Mission Operations, and I kept telling him that we don't deal with—you know, "You guys do things a whole lot differently. You only have one contractor or two. I've got,"—it must have been 60 or 70 contracts. "I've got one major here, but I've got all these others," and it's more than 60. It's a large number; it's 200 or something like that.

Plus he had a centralized business office, because MOD only had about 300 people, 350. We've got 800 people, and I've got 10 different divisions. Any one of those divisions are bigger than—you know, I'll put two or three of those together and I make one of your organizations here. So each one had its own business office, so EC had one, ET [mail code for Systems Engineering] had one. But he wanted me to restructure all that. I told him, "No, I'm not going to do that."

Plus we had an integration function, where you take the input from the divisions and bring them into the directorate. Okay, the directorate is going to consolidate this into a package that can go forward as a directorate, "This is what Engineering is going to do." We had three women there, very competent, very capable, who could do that job, had been doing it as such. It's just now they're moved to this organization. The last thing I wanted to do was ruffle their

feathers, because everything was working fine, because I'd been working with them for 8 years, 10 years, as just one of the divisions that supported them. All four of them were very competent people.

One of them got moved on me, so John did recommend a couple of replacements, and they turned out to be very good, from what he had there. But he kept wanting to get rid of that function and do it a different way, and I said, "I'm not going to do that either, because it's working fine. This whole rearrangement they've got here is not because we're doing things so bad. It's just they want to have it speak as one voice from business in there."

Plus when he espoused his theory, that made the integrators immediately job-security-conscious, and they immediately formed a—it was sort of you don't want an army of people out here who don't like you when you're trying to make a success out of this thing. They instantly polarized themselves from where John was, and that went on for the full year.

It gave me a little license, though. Well, first of all you've got to write out here's what my job is going to be, because I'm trying to figure out what it is. So I'm one of those that will write down—like I did the books early in the beginning—that this is what the Director—okay, what is your expectation for this thing? I wrote it out and gave it to the Director of Engineering, and he said, "Great." That is Leonard. I gave it to Terri, and Terri wants to mark it all up.

I'm sitting here saying, "The Director of Engineering has already accepted this, and he's your customer. It should be okay, right?"

"Well, I don't want to do that." So she refused to sign it for about four months. I'm working for her, and, she has a retreat. They don't give her a deputy; they just give her a couple of senior people to be on her staff, but they refused to give her a deputy.

What helped me a lot was Bill Bays, this guy in Procurement, and John knew their jobs. John did his differently than we did, but I had enough experience with Engineering that I knew what ours was. So we could go toe to toe and come up with a solution. Fortunately for me, I could outrank him every once in a while, and we'd go this direction; but other times I'd go his direction. But I knew enough to do it.

Terri did not know how we did business there whatsoever, and pardon me if I was—I don't know if it was done on purpose or not, but I several times went to the guy who was advising her, or who would be her deputy if they had one, and told him that, "You need to give her a deputy or someone with some experience who, when she comes up with an idea, can share with her that we've already done that, and this is what they didn't like about it, or this is what we did as a result of it. So when you introduce it to the folks, you could start out by saying, 'Hey, I know you did this, but I'd like to change it a little bit,' instead of saying it's a brand-new clean sheet; this a new way of doing business."

Where I got exposed to that was at the annual retreat. Of course, it's shortly after everybody's been changed, and Carl and I don't know really what we're supposed to do or not do. It's out at Columbia Lakes [West Columbia, Texas] there. We get together, and she talks a little bit about what changes she'd like to make. She came up with a couple of things that I couldn't resist raising my hand on, and I said, "I think we've done something very similar. At least I have worked it from the engineering standpoint to support several of these people in here for this thing here. If you could tell us what didn't work about that, we could share with you what we learned by doing what you said, and we can modify it to capture what you're trying to get there."

The other guys, instantly as soon as I started speaking, they said, "Yes, we did do something like that." But nobody would say anything until I'd raise my hand and say, "Terri, let me help you a little bit or share with you that we've done some of this." You know, you're trying to get these people to talk to help her, but they really didn't. They really wouldn't. She would come into our staff meetings with George, and she'd be shaking like this, [demonstrates] because he can be very intimidating, and if he doesn't like the direction you're going, he will not mince words on what it is. I was very fortunate to never, ever experience it, but I saw others that did.

At the same time the Center has gone through this Zero-Base Review. Zero-Base Review was probably the—well, there were probably others that were as significant, but it was the first major budget cut across the agency in trying to reduce the Space Station Freedom. This is while Freedom was still—they were trying to get it to the International Space Station there. What they did is they assigned Leonard Nicholson to lead it. He was the Director of Engineering. Because I'm his business guy, he pulls me to be his budget coordinator, you might say.

What we do is we go to each organization, like Center Operations or MOD, and we look at their budget, and they would present it to us. Then Leonard would just start slashing and burning; I mean slashing and burning. "Why do you do this? Why can't you get rid of that? If you do that, okay, but with half the people," or whatever it was, because we had a huge budget problem. He'd lay the scene with you, and then I'd have to come back and get the agreement that said, okay, this is what it represents in contract dollars or manpower implementation or content that you want to get, because we had to list those things as this is what we're taking out of the program as a result of that, and get everybody on the same thing.

So we'd go back and forth. The best way to do that is not only to get the Manager, whoever their Director was, but you had to have their Business Lead, because the Business Lead had all the numbers. He knew, or she knew, what was there. But, of course, many of these people had just gotten into their jobs, so they're sort of figuring out what it is. So relationships had to be rebuilt to make that happen. Fortunately, they did a reasonably good job doing that.

I'm given an assignment to collect some sort of data, and Terri is late at a meeting that George has. We wait about four or five minutes and she's not there, so I go ahead and make—I would either have done this at the end of the meeting or I could do it at the beginning while she's not there, and she's really not involved in all this activity, because this is all being done by the different organizations in the Business Directorate, and I'm not representing the Business Directorate. I'm just representing Leonard in this activity, who's been assigned by—I think this was Carolyn [L.] Huntoon at the time when we did that, and Carolyn, and George was her Deputy. She was meeting with George on this, I think.

Anyway, she came back from our meeting, and I've got all of the business heads, and I'm talking to them. "I need this, I need this, and I need this by this date no matter where it is, and this is the way we'd like it structured. This is the content that we're looking for," to give them all a heads up. She came in the door, and she immediately said, "You can't do this. You've got to stop doing this. You can't take over this organization."

Of course, I'm sitting here saying, "All I'm doing is trying to give them an action that we had on this thing."

She said, "Well, you're not going to take over my—."

So fortunately, a couple of the other guys said, "Terri, he's just sharing with us. You were gone, and we're going to be back—we need to know this information, because this is what's necessary for the Zero-Base Review."

She says, "Well, I don't understand. I don't agree." So she immediately says, "Come to my office."

I go in there with her and Howard [L.] Renfro, who's this other guy who's been advising her. She proceeds to dress me up one side and down the other about what am I doing, why am I doing this, what have I—she's fearing that she's lost total control over her organization, and we're going to run this thing in our own manner.

Fortunately, Howard backed me up. He just said, "He was just doing what he needs to do to get this action done at this time. Don't worry about that." After that our relationship was better, but boy, she had a real fear that we were going to just run over her and not listen to her. I think a lot of that was because she didn't have a counselor to advise her on what does work well and what doesn't work well around here, so that her initiatives or ideas could be tempered with that so that she could benefit from this new responsibility and show a positive input and a helpfulness in here.

I, to this day, keep reminding those people that, "You put a person into a position here that really wasn't prepared for it to start with, and then you didn't give them backup to help that. Okay, I went into a business position, and I didn't have any idea how I was going to do it, but you at least gave me a good backup so that I could." The other part was I knew the Center. I knew who I could talk to because of the years I'd been there. She's been here a month and hasn't done this.

I went through the full year. I got a note that I read "1223s." I don't know if you've ever heard that term, but it's when your company reports its expenditures or costs for this month. They fill out a form that's Government Form 1223 or a JSC Form 1223, and it has the actuals to date and your estimates for the next month or whatever it was. I've used those, and EC has such, but Terri didn't believe we understood those documents. In fact, my integrators were the ones that were on the team at Headquarters that were trying to get them standardized across the agency. They knew it far better than I did, but I was familiar with it, and I knew how to use it and how to fill it out.

"You're all going to take a class in this." Of course, we're assuming that this is told to all the office heads, and we're assuming that she's talking about the people who are actually working it from day to day. No. It's going to be all of us managers here who are going to learn how this 1223—again, I raised my hand to sort of indicate some of us have worked with this before.

"Are you sure you want us and not these people who are going to work—?"

"No, I want all of you to do that."

So on this telecon, this eight o'clock telecon, I'm now just the Business Office on there, and I say, "I get to, for the next two days, go learn about 1223s."

So I get a note back from one of the Division Chiefs saying, "I heard you talk, but now when people come to me and complain about what they have to do in a day, I tell them that, 'You could be a Business Manger, and you could go sit for the next three days or two days listening, or learning—relearning, again how to prepare a 1223. So just think; there are other people who have problems that you've got to do.'"

As far as working with the people in the divisions, it gave me a different view and helped me as a Deputy, because I knew the business side of the house. I got to know the Lockheed contract quite well, because it's under my responsibility. I got to work with the COTR [Contracting Officers' Technical Representative] and various other people who have a role in that. So from a training ground, it was really quite well. In a mechanical engineering degree, you could have a minor degree in it, so I'd taken business. I was already familiar with accounting management; I'd had some courses on that.

It was not totally new territory, and I recommended that strongly to my children. They didn't do it, but I would think anyone who is going to do that that expects later to get into management, that you get some formal training on that stuff. It wasn't that bad from a being able to go into the world; it was just the personalities were somewhat different that I was exposed to. But I got some real good friends as result of it, and on August 14th, I went back the next year. Since this was a one- two-year tour, I went back to Leonard and said on August 13th, "It's getting close to the time when I'll come back. Am I still going to come back here?"

So on the 14th he called me and said, "Well, how would you like this new job?" and then asked me if I'd be his Deputy Director. So it turned out quite good for me as far as a career standpoint. Then our dilemma was to find a replacement for me, and that took a while too.

WRIGHT: I would imagine. [Laughter]

JAAX: Too long. Well, also, some other things have changed, too. But they now have reverted and the procurement is now a standalone organization, and the business resources is standalone. It worked the other way, but I do think, though, from a career standpoint, having the two

organizations give the career path for all those procurement oriented to a senior level, and for resources, that I can understand, because JSC is big enough to be able to support such a thing. If you had a much smaller organization, then I'd combine the two together. But from a learning experience, it was good for me. I enjoyed it. But there were days—

WRIGHT: Well, we're about through for this morning. We could close for now, and then maybe see where we want to go next time.

JAAX: Okay.

[End of interview]