NASA HEADQUARTERS HISTORY OFFICE
ADMINISTRATORS ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

JOSEPH H. ROTHENBERG
INTERVIEWED BY REBECCA WRIGHT
HOUSTON, TEXAS – 12 MARCH 2004

WRIGHT: Today is March 12th, 2004. This interview with Joe Rothenberg is being conducted in Houston, Texas, for the NASA Headquarters History Office Administrators Oral History Project. The interviewer is Rebecca Wright, assisted by Jennifer Ross-Nazzal.

We thank you again, Mr. Rothenberg, for taking your day to spend time with us and share details about your contributions to the advancement of space exploration.

You began working for NASA in 1983, for [NASA] Goddard Space Flight Center [Greenbelt, Maryland], as the Hubble Space Telescope Operations Manager, but you previously were associated with NASA during your work for Grumman Aerospace and Computer Technology Associates. Could you share with us your background in those positions that led you into your job with NASA?

ROTHENBERG: Yes. Let's see. Right out of school, I went to a two-year school for an associate's degree, and that's what I could afford out of the [United States] Navy, and I got married in between, while I was there, so my wife helped me finish it. But I went to work for Grumman and then went to school for the next thirteen years at night for a bachelor's and master's degree. So that's sort of my educational background.

I started working at Grumman. I was hired as an instrumentation engineer, and I, having a technical degree, didn't quite know what that meant. When I went there, I didn't know, on day

one, whether I should wear a white shirt and tie or coveralls. So I opted for the white shirt and tie and I guess it got it right.

Fundamentally, my first job was as an instrumentation engineer, applying transducers, strain gauges, pressure transducers, all kinds of instrumentation to test vehicles. The very first one was a Gulfstream II airplane, when it was in its first corporate jet to be developed, and Grumman pioneered that with the Gulfstream, and I was lucky enough out of school to do the instrumentation on that for the wind tunnel testing. I learned a lot from that experience. I made a lot of mistakes and, in reviewing the mistakes, I'll never make those mistakes again.

Also during that same period of time—this was, like, the first six months out of school—I got to work on what was called the environmental control loop for the LM, the lunar module. Again, it was doing instrumentation to actually measure the pressure drops as they tested the system. That was interesting because, number one, we were all learning and I was learning, and we had built this large photo panel and it had a bunch of tubing and that tubing was going to mate to the vapor cycle, the environmental control loop test stand. They were built at two ends of a large hangar [subsequently converted to a clean room], which was ultimately the same hangar, if you have ever seen the photographs of all the lunar modules lined up in a row, that's the hangar they were all built in, converted to a clean room.

The day we were going to mate this huge photo panel, which stood about eight feet by sixteen feet and had forty-eight gauges and ninety-six tubes that were going to mate to ninety-six equivalent tubes on the other end, we were working at one end of the hangar, and this hangar was probably a couple hundred feet long, and at the other end, they had the environmental control loop. We invited the NASA folks in, who were paying for this, and the quality-control inspectors, as we were going to mate the two. If you can picture, on the back of the vapor test

stand, that we neatly lined up all of the outlet plumbing, which was basically two pieces of tubing from each gauge with a connector, like copper tubing, all along the bottom. And there were ninety-six of them in a row.

And as we brought up the vapor cycle test stand, we discovered that they created theirs in a matrix of like sixteen-by-eight. Therefore, the two wouldn't mate, and we suddenly realized that there was no way we could ever tighten the inside [connections] one or check it for leaks. So very early in the game I learned the value of interface control and coordination across interfaces.

That was very important to me, because that little lesson taught me in the future a skill that turned out to be very valuable, and that was to try to make sure I understood what I was getting into and what the other side of the interface was. …

Obviously, it was a big embarrassment for everybody involved, because neither side was wrong; everybody did the right thing from their perspective, but we never talked to each other, and it'll go a long way [to prevent problems by] talking to people. So that was [one of] the first thing[s I learned].

I also worked on a number of other things during that time frame, such as ejection seats. We were testing Martin Baker ejection seats and doing ordnance tests, where we would fire the seat off. We had an instrumented anthropomorphic dummy that sat in it and had [transducers to measure] cranial pressure, acceleration on the spine, [and] sound levels [at] the ear. We'd ride down the runway in a truck and we'd fly it off. First, we'd do it at sixty miles an hour. We were trying to get zero-zero—that means no speed and no altitude—ejection capability so a pilot could eject on the deck of an aircraft carrier in an emergency or at any time in the flight path.

Then I also had worked over that period of time, in [1969], as a test engineer on a device called the PX-15, which was a deep submergence submarine that we built for Jacques Picard on company money as an investment, because we saw the future of the aerospace emerging into being undersea technology. So we built this, and I actually got to go out in the ocean and make the first dive on it, with all the strain gauges on it to test it and make sure it wasn't going to come apart.

But backing up a little bit, in the middle of my first year, I picked up an assignment where I was to go to my first space program, the Orbiting Astronomical Observatory [OAO]. Grumman built a series of four of them. The fifth one was a prototype and I got involved right at the initial prototype testing. My first job was as an electronics expert. [My supervisor] called me that, not me. [My assignment was] to develop all of the electronic readouts for all of the testing they needed to do, environmental testing and clean-room testing; all the acceptance testing; development testing; the consoles that they would use to monitor the spacecraft and to do integration testing; breakout boxes that allows you to breakout signals from cables to actually measure prior to mating two connectors at an interface. So the interfaces started to play in again. All the interfaces between a spacecraft and a launch vehicle, I got involved in those and became the one who developed a way of making sure that they were compatible to each other when we plugged them in. Again, from my first lesson, I knew there were a lot of things you needed to do. So I contributed to all that as an engineer, and that started in October of 1964.

In January, about, of 1965, the group leader for that little group suddenly got promoted. His name is George Albright and he worked for Grumman for many years, and today he works at NASA Headquarters [Washington, D.C.], which [is] interesting. In fact, he got promoted, and there were five engineers and they all had degrees and advanced degrees, and I was just six

months out of school, struggling to go to school at night. And he turned around and said, "You're it. You're the new group leader." There I was handed the responsibility for the project, with all the money, and to manage a variety of things that I knew nothing about, of course, of people who knew far more about it than me and were also getting paid twice as much. A couple of them, actually, literally, were twice as much as me.

But we worked together, and I guess we were successful. We developed all of the launch equipment. I got to actually sit in a launch blockhouse, two years after school, at the first launch. That was quite thrilling. I actually pressed the button that put the spacecraft on internal power. Now, that [is] not a big deal today, but then, for a young person two years out of school that was a big deal, and to get to say it on the radio, because spacecraft on internal was one of these things that were reported out on the countdown and it was heard on the radio. So we flipped a coin on who would actually say it, between myself and another engineer and a technician who was with us, about three of us, and then we had five countdowns before we finally launched, so we each got a chance to do it once. And we would rehearse "Spacecraft on internal." Trying to sound like Walter Cronkite. [Laughs]

In any event, so that was successful. We had a lot of problems with the first spacecraft. That was one of the first telescopes ever put up. It had a lot of high-voltage electronics on it, and as a consequence, we, in three days, lost the spacecraft and learned a lot, though. Once again, as a team, we learned a lot. Our customer, NASA, was learning, too. None of us expected some of the things that happened there.

Going along, the second one was [sent to] Goddard for final integration and tests. We actually moved the operation out of Bethpage [New York] down to Goddard, so I spent a lot of time at the Center at Goddard, got to know a lot of the people. In fact, I was one of the few

contractors who were actually part of the Goddard integration and testing, mainly because of my knowledge of the ground support equipment. At the same time, the company gave me all of the flight instrumentation in addition, so now not only did I have ground equipment, but I had the flight system onboard. So I got to learn a little bit about flight hardware and, again, interfaces between flight and ground and telemetry systems and operations. So that continued.

Then I became in charge of [the Bethpage support for the] entire [Grumman] operation down at Goddard. At Bethpage, [I] represented it back to the program office and I was like [an] Assistant Program Manager for the fieldwork. So there I got to learn integration and test even more, learn NASA, obviously, Goddard very well. Learned operations, because now I had the responsibility of ensuring that the operations got the proper support from the factory and resources, the technical support, the engineering support, the anomaly resolution support.

And finally, the launch operations, still I continued to go down to the launch site, spend two months, activate the equipment. The hangar [Building] AE clean room, for example, is still there today at [NASA] Kennedy [Space Center, Florida], and that was a famous clean room for processing robotic spacecraft. It's still the biggest one they have for that on the Cape [Canaveral, Florida] side. One of my jobs was to make sure that was always ready. In fact, the very first time, before the first one came down, to work with the building contract to make sure it tested to all the specs [specifications, Grumman assigned me to certify] it simply because it was our spacecraft, we were delivering it to the government, and they wanted to make sure we were satisfied that it met our requirements.

And each time I'd go back down and make sure it was properly cleaned and ready for some testing, as well as all the cabling on the gantry, and when we put the spacecraft up [on the pad], we had all of this validation equipment that, once again, tested all of the interfaces before

you actually mated them, and including the flight ordnance and all of the installation of the pyrotechnics that allowed the solar panels to deploy, allowed us to separate from launch vehicle. That ultimately became my responsibility to actually supervise the installation and make sure that at launch they were all still ready and had integrity; we hadn't "duded" any of them, we hadn't opened any circuits, they were all going to work properly, and they did. That's a whole other story about learning that business.

In any event, my responsibilities kept growing because I kept learning more and more, and another thing that I always felt, to this day feel is important, [is that] we sat as a large project in what we called the bullpen, a sea of desks, rows of desks. The first row was all of the power equipment people. The second row was all, if I remember, the thermal people, and the third row was the stabilization and control, etc. These were like six [rows of] desks back to back. Well, you always knew what went on. You learned a lot because you knew about problems [each of the technical groups] were having and you would overhear how they solved them. Everybody knew about everybody's personal life also, but as far as the work life, it really worked out well.

In fact, in personal life; we were all young engineers, buying houses. We'd hear someone bought one; we'd find out about mortgages. We didn't know anything about getting a mortgage, and you'd go talk to somebody who just went through it and get some good advice out of it.

But the bullpen environment really allowed you to learn from a fire hose, because if you were at all listening, there was so much going on that you could learn all of the—and it allowed you to do a better job yourself because you didn't have to go to a meeting to find out if some change was going to affect you. You'd start to hear about it and somebody would just yell across the room, "Hey, instrumentation, do you know we need more transducers?" "Huh?"

[Laughs] Good communications is what it fostered and good learning for young engineers like myself.

The project lasted until 1972. We launched four spacecraft. During the same time, we did a lot of work on what today has become the heart of being able to service Hubble Space Telescope. We did a lot of work on satellite servicing for Goddard, looking at different ways of servicing spacecraft. How should we do it? Should we make them modular and change an entire module? Or do we change out a black box at the component level? How do we change out instruments? What's the right design philosophy? What's the right test philosophy? So all of that led up to us becoming somewhat recognized as understanding not only space astronomy, but, as a company, having some capability in servicing the satellites, and we were doing it under contract for Goddard and we were looking at the evolution of OAO into what in those days was called the Large Space Telescope.

Then we were doing studies that looked at, "Okay, what is the way to maximize the observing time on the telescope when it's on orbit? Is it servicing it? Is it building in reliability? Is it replacing it? If I take a ten-year period and want to look at the sky and survey it, what is the most cost-effective way of doing that, but getting the maximum number of photons collected?" And that's where the concept of reliability versus what we called up time, and then you could increase the reliability by servicing, because you'd now restore failed components and sort of start the reliability curve going.

The reliability curve simply says, if I build this much redundancy, etc., and design a spacecraft a certain way, it will last so many years without a failure. There are several ways to do that. If I don't have redundant equipment, then I could have a means of replacing the

equipment on orbit, and by replacing the equipment on orbit, I then compensate for failed components.

Well, it will be cheaper to build the spacecraft, but it does cost you something for servicing. So you take and you look at all those things and you do what we call trade studies and determine what the best profile is. Do I just build a higher-reliability spacecraft, and if it costs so much and has such sized optics and has such a size to launch, do I make it ultra reliable and that's the lowest cost and gives us the most observing time, or do I have one that I build at a certain level of reliability and plan on servicing? And the government concluded, after looking at that, that Hubble, or what in those days was called the Large Space Telescope, would best be maintained by having the ability to service it every three [years] and/or bring it down every five. The initial specifications were to return it to Earth, as you know, every five years.

Let me just look here before I jump to this, and make sure I've covered everything. A couple of other things before I get on to Hubble, but that was the kind of support we did to Goddard as part of our project work that laid the foundation for not only Hubble, but servicing the satellites on orbit while I was at Grumman, and I'll get to how that affected both Hubble and my life later. In fact, part of it will come out some more of my Grumman story.

So that was up till 1972. That was the kind of things I did. The one thing that's sort of a little out of sequence was that submarine, and that really occurred in 1969, the first couple of months, but I was so interested in getting involved in what was going on, that I actually did this on weekends, at night. I used to fly down to Florida, West Palm, where we were testing it on weekends, and only took two weeks where I had actually to be away from work.

Meanwhile, we were getting one spacecraft ready for launching. We had another one operating. We were getting one started to get into [the] test flow. I was going to school two

nights a week, and also President of the Instrument Society of America, Long Island section, and had a wife and two kids at that time; later on, we had the third. I still have the same wife and three kids. But I had a couple of busy years where I bit off more than I could chew, but I really was doing everything I could in those couple of years, except sleep, I think.

Anyway, I was commuting from New York—we lived in Long Island—I was commuting down to either Florida or Maryland literally every week and every weekend. I would come down on Monday to Maryland, as one example; stay there till Tuesday; take a plane back at five o'clock on Tuesday to get to school Tuesday night. Wednesday morning I'd go in to work at Grumman. Thursday I'd go back down to Maryland then fly back sometimes Thursday night to go to school again. Then Friday I would decide where I was going, depending on what I had to do.

Anyway, after I finished up the OAO project in 1972, Grumman was getting ready to bid on the Space Telescope, so I was part of that team. At that time, I left the project and went over to the Engineering Directorate. But in my transit over there, I had a couple-of-month holding pattern, where I had to go back to my old instrumentation group. The way Grumman was organized, it was a matrix of disciplines—instrumentation, thermal engines—and we got allocated to projects. Then you worked on the project and when it was completed, you went back to your home functional area and they theoretically had your next job lined up or had some work.

Well, when I went back there, they were just kicking off the Shuttle Program in the agency. Grumman had [bid] on it and lost. In fact, I was going to be part of the operations team on that, I had some job they put in there, but they lost it. But they won a lot of work, subcontracts, and one of them was to build all of the early wind tunnel models. We had an

excellent wind tunnel and, again, if you remember, I started doing instrumentation in wind tunnel work. They had just delivered a bunch of wind tunnel models to [North American] Rockwell [Corporation]. The wind tunnel model, the ones that I was working on were stainless steel. I can't tell you how big in scale, but if I could think about how big the Shuttle is, they were probably [2]00:1, at best, scale models. The goal was to put them in the wind tunnel and measure the airflow. You measured the friction and [and heating to model the flow], in this particular set of models [by] temperature on thermocouples. There are a lot of ways to instrument models, with pressure and other ways, but this one was temperature.

Grumman had purchased the thermocouple wire. Normally, when you get thermocouple wire, you test it to make sure it really is a thermocouple. Thermocouple is nothing more than two pieces of wire of dissimilar metal. Electricity flows relative to the temperature [at the] junction [of] the two dissimilar metals. So it's important that the metals are dissimilar, and they're very different kinds, iron constantan, copper constantan. They all have different temperature ranges and different costs. So you pick the one that's right for the application.

Well, the wire they bought was not real thermocouple; it was just copper-copper wire, and they inadvertently went and built these things. They used 36-gauge wire, which is a little bit thicker than a human hair and had to install the thermocouples under an electron microscope. So some technician installed all these; [Grumman] delivered them; and we found out, of course—the customer—"Oh!"—blew up, and they were our competitor in many areas, so they loved to point this out.

So my boss said, "Hey, I've got this little assignment for you. Go make them happy." He said, "Go fix it. Go fix the problem." So I looked at it and I discovered that the wires weren't thermocouples. That's why none of them worked. So I then built the process by which

we screened the wire at the company [receiving dock] level [and again in the laboratory]. That was important for the company [progress] in general; it [was not] with just this one.

Then the Rockwell people came in and I showed them—I set up a test program and [did] every other thing [needed] to show them that this would never happen again and here are the steps we put in place. Then I ended up learning how to solder a 36-gauge wire and work under an electron microscope, because I never did it before, so I wanted to try it. So one of those models that they used to evaluate the Shuttle, I actually did all the soldering on. And Grumman was a great company in that it didn't have a union, so there were engineers doing what techs [technicians] should be doing occasionally, and more often than not, techs bailing out engineers, and so you could really learn.

So I did that and, again, it was an interface problem. It was somebody that didn't look at what they were doing and test prior to turning it over to a customer, test the wire prior to building it, and it took a lot of time to build these things. They were not cheap [to build]. Grumman was pretty good about that; they rebuilt them on their own nickel, and they paid for the rebuilding.

So when I finished that, I was casting about for my next assignment. I could hang around in the thermo lab and play with models or something, and that wasn't real interesting. The Project Manager on [OAO] had just been made the Director of Engineering Operations and Test, and he came over and approached me, asked me if I wanted to go over and become a Project Engineer. What that was, was a staff position, for the most part, that either went out and solved the problem or went out and actually ran a test or went out and worked the proposal where they developed a test program to support a particular kind of mission. It was everything from spacecraft to aircraft. It included mission operations for spacecraft. We didn't normally get into operations for aircraft, because that was basically a military function. It came with an operations

concept already from the military, or it was developed by people who were experts in that, and certainly that wasn't mine.

But we developed how to test it and how to do structural test and life test prior to deploying to the fleet. My experience came back again on the Gulfstream where NASA was wanting to buy some aircraft to simulate the Shuttle in flight. They put out an RFP [Request For Proposal] and Grumman proposed on it and won the proposal, and I was the guy who developed part of the test program, the ground test program for that Shuttle training aircraft, and they are the Shuttle training aircraft they fly today. So another connection with the Gulfstream II and the Shuttle. And, of course, fast forward to 1998, when I took over the [NASA Headquarters Office of] Space Flight, here were the Gulfstream Shuttle training aircraft again.

… I teach courses in NASA now—little tidbits that make a difference in getting the job done, that people don't realize. Things that I fought, that I had not wanted to do and I was made to do. Go to a class. Why do I want to go to that class? I'm not going to learn anything. It's just taking away from my job. And it wasn't going to the class for two weeks; it was meeting the people [that I later realized was important]. I had a problem later on and some of these same people, [who I would not have met if I had not gone to NASA Senior Executive Service Training for 2 weeks], it [helped me prevent] a disaster. I mean, a big disaster, and I'll talk about that specifically. One that, in hindsight, the whole agency would have come down.

I mentioned that I was working proposals, so global positioning satellite, Teal Ruby [Satellite], a number of satellite proposals for the Air Force. We weren't successful on any of them, really. We were on one, and it turned out it was one I didn't work on. There may be some corollary there. The company had not a lot of success in those days [on bidding new space programs in the early '70s]. There was a lot of people bidding on them. On the other hand, we

won a few things; [for one] myself and another guy wrote a proposal to build a beam builder that could build trusses, like they have on [International] Space Station today, on orbit. We actually developed the test article that built it and we actually built a beam. It was going to fly on the Shuttle right before [the Space Shuttle] *Challenger* [accident] and then, obviously, [after] *Challenger* [NASA] rethought the whole program.

It was made out of commercial rolling machines, but it was kind of fun. I did that as this staff job. I was a troubleshooter in a lot of cases. There were problems where customers of us for ops [operations] and tests—we had all the test facilities at Grumman, the wind tunnels—were not happy with what they were getting or there were problems, and I would be dumped into it and, [in most cases], solve [the] problem.

That was another little aspect—I'll retrogress just slightly—during my the last OAO spacecraft, it was about nine months—no, it was less than that, it was about nine months before launch—it doesn't really matter exactly how much—we discovered that we had a set of defective solar arrays. These were very large. They were [over] a hundred square feet of solar arrays, if I remember that right. There were eight panels [actually the total area was] probably two or three hundred square feet. They were fairly large solar arrays.

Anyway, the point was there were eight panels, honeycombed, 88,000 solar cells laid on them, and we discovered that the solar cells were lifting, and Goddard directed us to build new ones. Period. They didn't care. "Build new ones. We want to hold the launch date and we're not going to count on these things working. You fix them."

So it comes up—we used a TWX in those days; which was a teletype message—it came in. The Vice President said, "Make it happen," and passed it on to the Program Manager, who

looked around the room, and I guess I was the only one standing there, and he handed it to me and said, "This is it. Go build these things."

I said, "I don't know how to build solar [arrays]—I don't know anything about them." We hadn't built any in six years. All the ones we built were six years old. So my job was to go figure out from day one—and not only that, I had to have them by next May and every set we built in the past took two years to build.

So I'm starting to think—I got a list of who had worked on them in the past. I found one guy who was still there, and I grabbed him. His name was Pete Fugaro, I'll never forget it. I said, "Pete, we've got this—."

He loved it. He said, "Oh, I've got a chance to build something again." Because the program was coming to an end. It wasn't clear what his next job was going to be.

Between he and I and a couple of people, we pulled that off. We got the solar cell manufacturer to make 88,000 cells. [We sent him the blank panels and he mounted the cells.] We got tooling that was rusting behind the hangars up and going again. Every morning I would go into the machine shop and start off and say, "Where are my parts?" I'd say, "Okay. I can help. I can carry them over to inspection." Whatever it took to get it going. We laid out a detailed schedule and tracked it every day.

But the ironic part is the day I took this TWX and went with the head of manufacturing down into the shop at Grumman and said, "Hey, we need help," and he was sitting there—and his name was Angelo Galgano. My brother was a manufacturing engineer who put in place a lot of the automation at Grumman. That was his whole thing. He was putting all the automation in place. He was on a special project for the President for about three years, went all over the world, buying automation machines, getting them in place. That's important; not an aside.

So I went to see Angelo, who was this rough-and-tumble guy who now has two thousand employees out here on the shop floor, with this thing, and I said, "Hey, Angelo, I need help. This is what I need."

And he sits and he looks at me and he said, "I don't even know why I should talk to you." He says, "This morning we just got directed from the same Vice President," who was the Executive Vice President of the company, Ralph Tripp, "to demote everybody one level." He said, "I am no longer the plant manager; I am this," and he went down every lead man is now who is the lowest level of supervision, is now on the bench again. And he said, "Had you want me to go through hoops to build something for you?" He said, "Rothenberg. Are you any relation to Ed Rothenberg?"

I said, "He's my brother."

He said, "He's the G.D. cause of this whole thing. He automated this place." [Laughs] That was what I walked into. And he was dead serious.

I said, "This may not be a good time to talk." [Laughs]

He said, "We'll talk about it Monday. Come back Monday." He sort of cooled off. He really wasn't blaming me for what my brother did, but he, in essence, saw a connection. They just demoted everybody. They said they didn't need as many people, not as many supervisors.

And we pulled it off. We actually delivered the solar arrays and we went through every obstacle you can imagine. Things didn't work. One day we'd come in and it would look like a disaster and we were never going to get there. We worked through those problems.

I always tell the story, there's a game down on the boardwalk down in Rehoboth Beach, Delaware, which is sort of our closest beaches in Maryland, called Whack a Mole, and it's got a table and there are these moles, like the guys in *Caddyshack*, who pop up out, and you get a big

rubber hammer. Your trick is—a mole—you whack him down. Another one comes up—and you get to do that for five minutes and you relieve your frustrations and it's over. I always kid that project management is exactly that, and the name of my talk, one of my talks I give is "Why is Project Management Like Whack-a-Mole?" And I wait until the end of the talk and then I tell them.

But it is. You walk in in the morning and you've got three problems that are going to bring the whole project—whether it be the Hubble repair mission, the Space Station, or building these solar arrays—how am I ever going to solve that? Some company just went out of business, the only one in the world to build the part. Okay? Or something. Those kind of things really happen all the time. And you've got two more that are lurking in the background, but they all look like they're solvable, and three that you'll have finished by the end of the day, or by the end of the week. And by lunchtime, two of the unsolvable ones are solved. The other one looks like it might be solved. Those two that were no problem at all have now become loomed as—and by the end of the day, one of the three that were going to be solved by the end of the week has totally come off the track and you're never going to solve it.

And that's your job every day, is to look across at your problems. And they come from all flavors. Whether Headquarters calls you and says, "I'm going to cut your budget by 50 percent," or, "I want you down here. I want you to have a review tomorrow," or whatever, the Project Manager is continually dealing with these. So you learn that pretty quick [up] front [that it is important to understand the people or organizational interfaces]. If you [understand] the other half and know what his[/her] problem is, you may be able to solve [the] problem in another way than the way [the person is] asking you to [and better for both sides]. …

[After OAO]—along the way, in the area of doing proposals [at Grumman], I picked up the responsibility for all of the new business or business development at Goddard. I always wanted to be in marketing, and a marketing guy said, "You've got a great technical talent. Why do you want to join us?"

I said, "Well, I just like it."

[As a staff project engineer at Grumman], I [also] got to work on [a program during the mid 1970s] that set the stage for [one approach to satellite] servicing. [It] was a study that, I [recall] was called Landsat [Land Remote Sensing Satellite] D and E, if I remember. Landsat D and E came out of Goddard, and its principal purpose was to develop the multimission spacecraft bus, a multimission spacecraft bus that satisfied not only Landsat D and E, but presumably they gave us about a dozen other missions. They said if this one standard spacecraft could do that—and they laid a couple of other things. They said it ought to be serviceable [on orbit].

And we won one of the studies. And we won one of the studies in an interesting way. Our differentiator from the other two guys was, number one, we did a lot of the work on the MMS [Multi-Mission Spacecraft] design. In fact, I personally did the wiring [design for] the power system. I designed that on the [drafting] boards. One summer, we had a slow summer, I just said, "Instead of getting one of the draftsmen to do it, I'm going to do it. I'm going to do every wire. I don't need an engineer and a draftsman; I can do both." I tried it. Well, I didn't do too good at drafting, but I did design the whole thing and it worked, and we actually built the model of it, and [the design was close to what] actually flew later on. But the point is, we had done a lot of work preparing to get ready for this proposal, because we really wanted to win Landsat D and E, remote-sensing satellites. That was a big deal for us.

We proposed in it a concept called design-to-cost [which I dreamed up]. We said, "What we'll do is we can give you a certain capability for 100-million-dollar program, for 200 million, and 300 million." We decided in systems engineering the thing called a figure of merit. That says, what do I get out of the system for each increment of cost? We measured that in number of scenes per day, first in color and then in black and white, that we could get to the ground per day. For 100 million you could get so many, 200 million you could so many. It involved an onboard tape recorder of this size, whether I used TDRSS [Tracking and Data Relay Satellite System] to relay it. Each one of them had an increment of complexity and cost.

So we actually won because of that design-to-cost concept. We actually proposed three designs, we went through, and out the other end came a specification for the multimission spacecraft. We actually, again, submitted the drawings, we were so confident. Landsat D and E ultimately got kicked downstream, but [the Multi-Mission Spacecraft] became the bus that they were going to procure for Solar Max [Maximum Mission Satellite].

[It had designed] into it satellite servicing at the module level. You could replace a power module, a communications module, and/or an attitude-control module totally, or change out the experiments. We had some other concepts built into it that made it [into NASA design] when we did the systems engineering, we discovered that all of the spacecraft that needed onboard propulsion, rather than reaction wheels to control its pointing, were of a certain type and we found out we could satisfy them with a propulsion module.

Originally, the design had the propulsion system integrated with the spacecraft, but by having a separate propulsion module—and this was a Grumman innovation—you suddenly could build it cheaper. You didn't need to carry propulsion for every mission, so you decided what the basic capabilities you needed, and propulsion wasn't one of them, for all of the

missions, and you built one that the common denominator, if you could think about it that way, that was attitude control and common-data handling, and then the size of that varied from mission to mission. So if you built it modular, that you could add another battery when you needed more power, you could have a common design, you didn't have to repeat the design, a common test program, and, again, you're just testing for different configurations, but you qualify the basic structure and everything the first time and you don't have to pay the same costs over and over again.

Anyway, that whole modular spacecraft, that was this concept, and then the design implementation that made it the most cost-effective, we believe came out of the Grumman approach, and that was the one that got specified [by NASA for implementation]. But we really don't know what the competitors did either, so it could have been an amalgamation. But to us, we could see enough of us in it.

In fact, I just had breakfast this morning with the father of the Multi-Mission Spacecraft, Frank Ceppolina. He's the father of satellite servicing on orbit, and he and I were here on a business meeting this morning and I just happened to have breakfast with him this morning also. Just left him when I came here.

But the bottom line on that was the RFPs came out. I led the proposal [programmatic] team for the power module. … [NASA was buying the MMS in pieces.] They had one [RFP] for the spacecraft integrator, one for power, attitude control and data handling, and one for the propulsion module, and we elected not to bid the whole thing. We elected to bid the power module and then we were going to bid the missions [that flew on the MMS as these RFPs were released]. Landsat [was one we targeted] later on when it was going to be reconstituted.

We did the whole design and, if I remember right, five of them. So I said, "Well, the logical thing is we deliver one per year, so that we're around to support the customer when he integrates." This would be the logical thing. We came in with this bid and, if I remember right, it was 2.3 million dollars for maybe the nonrecurring [and] the five modules. I just don't remember [precisely]. I just remember that number.

Somebody else bid on it, too, and they said, "No, I'm going to deliver more in year one, and I don't keep this marching army for the next five years, so I can do it cheaper." So the government obviously bought that one. … Fundamentally, we lost, and it was my strategy to spread it out. Another lesson learned: read the RFP. Give them exactly what they want, and then give them options for better things. But give them exactly what they want first, and we didn't do that. We gave them what we thought was the best thing for them in the long run.

That was a trait at Grumman, by the way. … We did that with our aircraft and everything else. We would always come out with what we thought was the best thing [for the customer], and that cost us. We learned a lot. We lost a lot of proposals [due to cost]. Anyway, but the bottom line is, we lost that one.

… At that point I was responsible for all of the Goddard work. We won a thermal canister to fly on the Shuttle, which ultimately did, a major test article, and a couple of other things.

Goddard came to Grumman and asked Grumman to put together a team to be the flight operations team for Solar Max. Solar Max was the first one that used the multimission spacecraft. That was one of its characteristics. The other was being procured in pieces. They were procured in a module and then integrated, and they were doing the integration at Goddard, with Fairchild [Aerospace], who was the integrating contractor, as the primary support

contractor. There were a lot of civil servants working on it. So normally, a mission contract would provide the operations theme.

In this case, they didn't have a mission contractor, so they came to Grumman. I don't know whether it was out of consideration we did a lot of design work or whether they really felt we had good ops [operations] people. So my job was to go find somebody to run this thing and help build the team and do the ops.

I had just finished my master's degree at that time and the school was trying to ping on me to go back for a Ph.D. They said, "Free. Teach one course and you can—," and I said, "No, I don't want to do this anymore. I'm done."

Anyway, I talked to my wife and I said, "I think we want to move. I'd like to move. I've been commuting to Maryland for ten years. I wouldn't mind moving there." And the company heard this and they dangled a job right down the road from where I happen to work now, in Newport Beach, California. They were opening a new plant and I was a candidate for the Deputy Manager of the plant. So it was live in California or live in Maryland. But I said, "We're going to move."

Finally, my wife said, "Okay. I'll give you two years. We'll go for two years."

We had a family powwow and the kids, "No, no, no."

"Two years."

The kids didn't want to go, and she said, "No, no, I think it's time." She said, "Let's try it." She isn't real adventurous, but she said, "We'll try it."

So I kept poking around trying to find a guy to head this thing, and I was debating whether I wanted to do the California job. I really didn't want to do ops. I really wasn't an expert in operations, and for me to go down there and try, that was scary. I knew nothing about

operations. I knew more about building solar arrays now than I did about operations, and I didn't know a lot about that.

So I finally decided, after evaluating California, looking at the cost of living out there, the traffic and everything, it wasn't the place for me. I'm a California fan now, but not for raising kids, I don't think. So anyway, I said, "I'm going to sign up and go down and see if I can do the Maryland job." The one guy I really wanted didn't take it.

So we went down and the Project Manager said, "Okay. We'll give you a shot." This was, like, in April. "But," he said, "I don't have a lot of money in the front end, so what I want you to do is the first six months, I want you to spend defining how the job is to be done, writing the spec. Then the last year, staffing up, training the people, etc." That's a short period of time for operations to build up, but this was all he could afford. We were hungry [for challenging work], and I decided I wanted to move, so I said, "Okay." …

But in any event, the point I want to make about this is, in doing that six-month study, during that period of time, the budget kept getting less and less to do the one year of operations, and we started out with seven people per shift, three shifts, but you need four teams to cover three shifts, and that's twenty-eight people. Then we needed about seven or ten people on day shift, so it was about a forty-person job. Let me think about it. It was more than that. It was forty or fifty people, and that was down about twenty people from how we flew OAO.

He kept coming back and saying, "Hey, I got a problem with money." And he kept coming back to me. So finally, he kept coming back with a lower and lower number. So finally, one day—the significance of this; it's not just an anecdote—but one day, it got to a point where I can only afford to have four people where I thought I needed seven, and actually it turned out to be three people—yes, three, because he gave me back one later—but three people.

So I said, "Hmm. I've got to think of a whole new way of doing this job because I can't do it the way it's been traditionally done with seven people." So I said, "I'll tell you what. We're going to find out, having one [or two] screens come up [for the operator to look at]." We called them CRT [cathode ray tube] pages. "I'm to look at those. [I want the operator from these two screens to be able to determine that] the spacecraft is okay. If it's not okay, I want [the data to indicate] who to call or how to get it safe, that's all I can do [with three people]. I can't [have them] do any analysis."

First, I had to convince a couple of people who worked for me that we could actually produce in two screens what had been looked at in maybe twenty screens, and computer technology wasn't real sophisticated in those days. They could only limit it to two columns of sixteen numbers in a column, and they were numbers, pretty much. You couldn't put a lot of fancy stuff in there, and it was very fixed. And I said, "Well, the world is in three columns," like three axis, pitch, roll, and yaw, other spacecraft, so it would be nice to have three, and three batteries … [but we were stuck with two columns].

So I went and got my guys and I got them in a room. I had a small office, probably [six feet] wide [and twelve feet long]. I had a conference table, and no windows. It was just in a hovel. When we first moved into this office, we didn't even have a phone—there was a payphone outside—and I was trying to hire people. I came down from Grumman, Long Island, myself and two other guys, who I convinced [to join me]. … We [brought our families and rented] nice homes and a pretty nice deal. And I'm saying, "Okay, now I've signed us up for this [and we need to figure out how to safely operate the Solar Max spacecraft with three people using two CRT pages]."

They said, "What?" It had never been done before. Typically, you had many pages. So I said, "We're going to figure out what thirty-two parameters [per] page we can look at in the first one minute of [a ten minute] contact as the satellite comes over," [that would tell the operator everything was operating or what action he needed to take]. In the first minute, you'd like to know if everything's okay, and if it is, then you can go on with your normal operations. If it's not, then you have to get it safe or issue commands, and that's sort of the way you fly a satellite in low Earth orbit to this day. There are some variations on it, but that's the way they fly many of them.

So what we did is, we looked, and I began hiring my team, and they used to come in every day and sit around my table and analyze the spacecraft to try to find out what [sixty-four] parameters would tell them everything unambiguously.

They used to leave, many times, "It can't be done." And sometimes they wouldn't come back the next day. "Time for the three o'clock meeting." And I would sit there; I wouldn't get in the middle of it. I just kept probing them on. Finally, it took about, I don't know, I say nine months now. By nine months, we were ready to fly. It took probably less than that, but it took some time, a fair amount of time.

They finally said, "We don't need [sixty-four]. We can do it in [thirty-two]." Then they came up with these clever things where column one was the number and column two told you who to call or what to do, in just plain English. …

Then I went and bought myself one of the first PCs [personal computer]. It was an Atari computer, not the game, but it was a computer and it had [great] graphics and that's why I bought it. I spent 800 dollars, which was a lot of money, especially [since] between my wife and [I we didn't make a lot of money]. And I sat home and I programmed the thing to take those

[thirty-two] parameters and make a star such that if … I could [look at] this eight-pointed star, and if it was symmetrical and green, everything was okay. If one of the arms was collapsed, that meant the battery voltage was low or something, and it was a graphic way that you didn't have to look at numbers. I was convinced that the gate guard could monitor that.

I wrote some papers and gave talks on it, and we actually [operated Solar Max] not using the star, but just the thirty-two parameters. It flew for ten years and never did those parameters not tell you the status of that spacecraft. It really worked. But it became the beginning of like an expert system, using the computer instead of people to convert data to information that somebody could act on. Previously, the engineers only wanted to see data and they weren't interested in pseudo data or something that represented it, and we made this thing foolproof enough where it worked. And the star became interesting in that—I left a little later and made a lot of money with the star, when I left and went to CTA [Computer Technology Associates, Inc.] the first time.

But going back, Three Mile Island [Nuclear Station accident, Pennsylvania] happened at the same time, and then the [United States] Nuclear Regulatory Commission [NRC] sent out a team of people to NASA and, I presume, every other industry, but they really were interested in how NASA monitored satellites and how they knew when an operator needed to do something. They also wanted to know how, on the launch pad, when a spacecraft was about to launch and something was wrong, we shut it down. How did we know to do that? Was it automated? Was it a human? And how did we do it sometimes in milliseconds? So they looked at that, if a nuclear reactor was going awry, they could intervene, use the same kind of technology to contain the problem.

One of the things they looked at, because of what we did on Solar Max—not my star—because what we did on the pages, NASA brought the Grumman team on Solar Max, we showed them what we had in there, and they liked it so much, I said, "Hey, I'd like to talk to you some more. I've done a little more to this [that] might even be more useful."

And what they were going to do, is they wanted to build—and they did build—a situation room over in Silver Spring [Maryland] that had on the wall something representing every nuclear reactor in the country that was up and running, and they could know in an instant that there was no problem. They had a mandate to do this from the [United States] Congress. Again, you didn't have the Internet and all sorts of things you have today.

So they liked the idea, when I showed them the star, because then the operator didn't have to read numbers, he didn't have to know anything. And I had this dream that the Center Directors at Goddard would love to have that on the wall. In hindsight, when I became Center Director, I found out the last thing I worried about was how the operations was going. I had so many problems, that it didn't matter. [Laughs] But I used to think that the Center Director cared. When I got there, I found out he didn't. Anyway, he cared, but it wasn't his biggest problem by far. He'd rather have other things on his wall; anything but that.

But the point is, [the NRC] looked at that technology and they took a variation of it. Instead of the star, they came up with the Chrysler symbol, and they had a reason for doing that. Nothing to do with Chrysler, just that shape meant something to their technicians; it was used in other technology. They actually built a situation room, and I actually helped them later on in life.

But that all came out of that. It wasn't me; it was just the notion of using the computer to give you information instead of using the human to convert the data to information. Heretofore,

most operations weren't run that way and spacecraft operations, and it started a whole change. All of a sudden, because we were operating with only two or three people per shift—in fact, we went down to two people per shift, from four. We went up to four when we added the responsibility to watch the experiments, and we did the same thing. We said, "What two parameters," and we analyzed every one.

But that started [the trend to put] more and more pressure on the operations part of the contracts to [use] less and less people on them and come up with more innovative ways to monitor spacecraft, and that applied at Hubble later on when I ran operations for Hubble.

Anyway, so that was the first part of Solar Max. We got it up and running and we had a flawless operation up until the fuses blew onboard, and that ultimately led to some real heroic work by some of the Goddard people in developing software to allow us to keep it pointed at the sun and spinning and safe for two years while it took to mount a service. I'll never forget, I came in on Thanksgiving Day to see my troops that were on the console, and there were the civil servants working on the special software. I wouldn't have expected them to even be in on a Saturday, let alone a Thanksgiving Day, but a couple of guys really put in a lot of work, [Tom Flatley and Henry Hoffman]. They were just a couple of individuals that stood out in those days that helped us.

We then went into the safe mode. To me, I did what I wanted. I wanted to build the team, develop the operation, learn it, and get it running, and then turn it over. So I decided that I wanted to do something different and I actually got a job offer to go to work for the government. Well, I was to start—it was one of these things where the paperwork took months and months, and it sat there, and finally it got through the system.

I was very open. A fellow named Fred [W.] Haise, who was [an] astronaut on Apollo 13, he came to Grumman and Fred was my boss the last year I was there, at launch, Solar Max. I worked directly for Fred and he said, "Okay, when this is finished, I want you back up north to help me with proposals. I want to chase some work," etc.

I had mentioned my wife didn't want to go. The end of the two years was up. What I didn't mention, we were in Maryland three weeks and my wife said, "Your job is to figure out, if you can, how we don't every have to go back to Long Island." She liked it so much, and the kids were totally immersed [with their new home, school, and friends]. And to this day, [we]'re still friends, close friends, in fact [with the families we met during those first two years in Maryland, so we decided to stay]. … And we've lived up the road a little bit, three or four miles from where we lived then, but they are all still close [friends].

But the point I want to make is that I had signed up to come to the government, and [President Ronald W.] Reagan announced there was a hiring freeze on the 20th of—it was the day, the 20th, which was Tuesday, which was inauguration day, if I remember—Monday was the 19th and I was supposed to start on the 26th of—whenever Reagan got elected—1980. I was supposed to start. I guess it was '81 when I would have started. The election was in '80.

Anyway, I was due to start. I had told Grumman way back, when I started thinking about it, that [if] I got an offer from the government it would probably take four or five months. [So I began to train] my replacement. Picked him out of my group. [By the time I received my offer letter from NASA], he was running it and I was just sort of doing odd jobs, waiting for this to happen. I didn't have any interest in monitoring the spacecraft day in and day out or dealing with the people anymore. [I was excited that I was finally going to realize a long-term dream to be a part of NASA.]

So when the time finally came, and I remember they knew I was leaving, they all supported it. Fred Haise understood my decision, in fact, endorsed it. I decided I'd [give the company two weeks notice, even though I had in effect already given them several months. This put my start date on the 26th of January 1981.] In the middle of this [was] Inauguration Day, [January 20]. The President, [in his speech], announces he's freezing hiring in the federal government. Personnel says, "Not to worry. They never make these things retroactive. You've already got a bona fide offer in hand."

Well, we go through the week. That Friday, we're having my second going away luncheon of that week, and I'm there and the Project Manager, who originally got me out of Bethpage, Pete [Peter] Burr, who later on became the Deputy Center Director. … But the point was, Pete said, "At staff meeting this morning, they're talking like that hiring freeze is retroactive." He says, "Has anybody talked to you?"

I said, "I talk to them every day."

He says, "I'd call them one more time." He says, "I'll call when I get back." He says, "Let me see what I can do to try to make sure you got the right answer, but I don't think they can hire you."

And three o'clock, lo and behold, the same guy that had been calling me every day, Jerry [W.] Simpson, who's now the head of Personnel at Goddard—I made him the head, in fact, when I was Center Director—he called me and said, "We got a problem." He said, "You're going to get a fax—," a telegram at that point—"delivered to you that says we rescind the offer indefinitely. We don't rescind it, but it's on hold indefinitely. You can't start Monday."

Fred Haise said to me—I called him up and I said, "Well, it looks like—."

He said, "No problem. If things change, go to work there. Don't worry about it. I'll take care of you. We got some things you can do."

And I said, "Well, I'm not really worried about it. It was just kind of something I really wanted to do. I wasn't worried about working; I had my heart set on working for [NASA]."

So that didn't happen. The government, of course, said to me, "Hey, we can give you a contract to do the same thing."

And I said, "No, I really wanted to work for the government and I don't want to let you off the hook. You guys have got to figure out a way to get me through the door or not. I don't just want to go as a contractor."

That's when I ran into the owner of CTA at a conference. I gave a talk on [space operations] and he called me up and said, "Hey, would you like to [come work for CTA]?"

I decided, well, let me go out and seriously look for a job. I went to every company that was in the area and I lined up, in the end, seven job offers: Lockheed [Missiles and Space Corporation], Fairchild [Corporation], OAO Corp. [Corporation], you name it. I had seven of them all lined up. The one that was most intriguing was this one with this new start-up company, CTA. They were doing the kind of work, systems engineering, which I had somewhat of a background in, and that was always the way I looked at [engineering].

… I went there and actually helped build up a third of [the] company [by the time I left to join NASA about 20 months later]. We won the planning for the Solar Max repair mission. We won what I call the independent test and validation contract for Hubble, integrating the Hubble flight and ground system and operations and science ground system. It was [just] me when I came there and I just started to be able to get some work. We did the science operations ground system user interface for TRW [Incorporated] as a subcontractor [to] TRW for the

Science Institute. I had [brought into CTA] a lot of interesting work and I had [built my part of CTA to] about twenty-five people, [which was one-third of the company].

Well, as one example, they went on and [supported the planning for] the Solar Max [repair] mission [in 1983]. What happened is, we were in the middle [of a lot of NASA projects. In early 1983], there was a big shakeup in [the Space Telescope Program at NASA]. They needed more money, like to the tune of 300 million dollars more. It was run out of Marshall [Space Flight Center, Huntsville, Alabama], managed out of Marshall, [but Goddard had a major role for both science and operations]. At the same time, they changed out the management at Marshall, they changed out a bunch of the management at Goddard, put in new management. Well, most of the new management they put in were people I had worked with on Solar Max and knew from other work, and when they came in, they decided they wanted to get a new ops manager. It turns out, the ops manager that was there was interested in leaving [earlier], and I actually interviewed him and hired him at CTA. I said, "But I've got to tell you, I might be taking your job." I hired him and I hired a second guy. I hired a guy out of Martin Marietta [Corporation], named Ken Ledbetter, to run the office out in Denver [Colorado]. He was going to be my ops guy in Denver. We were doing some work out there with the Air Force. And I hired John Martin out of Goddard, who was the [Goddard Space Telescope Operations Manager]. I [told him at the time], "I'm interested in your job." He just laughed. He didn't take me serious, but I said, "I'm serious. I might not be here in six months." He said, okay, he still wanted to [join CTA].

And, lo and behold, the government came after me and asked me did I want his job, and I said, "Yep." They knew I would like ops, and so I went through another process. In fact, [Dr.] Noel [W.] Hinners, who was the Center Director at the time—[Dr. A. Thomas] Tom Young was

the Center Director when the process started, but when it finished Noel Hinners was the Center Director. Noel called me in one morning—it was a snowstorm and I got up at I don't know what time. He wanted to do an interview with me because he was hiring me in as a GS [General Service]-15 and that's a high level. At least that was my interpretation of why he wanted to talk to me. So I got in at six o'clock in the morning. We had breakfast in his office and he said, "I just want to hear why you want to come to the government." I went through why, then we talked about mutual acquaintances, and we finished and he said, "Okay." He didn't say one word or another. He just said that was it.

So I didn't think anything of it and we went through the process. Again, I gave my boss the lead time. Well, I mentioned that guy I hired, Ken Ledbetter, for a reason that will come up [later]. He's now the Program Manager for Hubble at Headquarters. I had an opportunity when I was running Hubble to endorse hiring him over into the government. He applied. He's an amateur astronomy and wanted to work on Hubble all his life, like we all did in the telescope business, one way or the other, and he really wanted to do it. So he actually left CTA and went back to Martin Marietta and did the Viking operations and then [left Martin to join the Hubble Program at NASA] Headquarters and he's still down there. He and George Albright, the guy who gave me the first job, that promoted me [at Grumman], they're both at Headquarters. They're probably ready to retire, but they're there.

But going back, so I started and about a month after, I was flying to Marshall with Noel Hinners, and Noel was sitting next to me and I said, "I guess I passed that interview with you."

He said, "Oh, that wasn't why you were there." He says, "I was trying to figure out why you would want to leave this up-and-coming company that's doing real well, to come to work at NASA." He was trying to understand why I would leave this great job.

And I said, "I had a good job, but I was going to the greatest job in the world here." He understood it, but he was trying to see why I was leaving the one company, and understanding why would someone leave industry, and I was trying to say, why wouldn't someone want to go to the government? We were looking at it from a whole different perspective. Anyway, so we had that neat discussion. I'm still friends with Noel. He and I are on a number of committees together today.

So I joined Hubble. At that point, I was the Operations Manager. We started very early in the game. A couple of interesting stories about Hubble. It was designed pretty much by Lockheed on Marshall specs, but there was no systems engineering, so it was build a spacecraft; build an optical telescope assembly, that was Perkin-Elmer's [Incorporated] part; put the pieces together; do operations at Goddard; build science instruments. Put the pieces together, but no one stepped back and looked at it as a whole system, and that was one of the big changes in [19]'83.

I got the opportunity to look at operating it. And one funny anecdote, which was I created—even to this day, in my company I've created—Goddard uses it, even the Space Station—I created a top ten. I said I always want to know my top ten problems and make sure everybody knows them so we all know where we should focus our energies and solving. I learned that from my Grumman days; I learned it from one of the Project Managers that I worked for, in fact, the guy who became the Director of Ops and Tests [at Grumman] that I mentioned I work[ed] for. So I kept the top ten spacecraft operations problems and I said, "But five of these have to be fixed before launch; [the rest are efficiency problems we can fix later]."

And Marshall said, "We can't put any more money into it. We're not going to fix it. We're happy the way they are. It's your opinion versus ours."

I said, "Well, I've got to fly the thing." … I would go down to Marshall every opportunity I got [and try and make my case that the top five had to be fixed before launch]. The [number one problem] was—let me try to put this in a way you can understand it. We had onboard a flight computer, and in order for the spacecraft to be able to talk to the ground, you needed to have that flight computer on and running, okay? In order to be able to have it on and running, you had to put software onboard. If the software worked and it ran, no problem. If you loaded the software up and it got corrupted in transmission, which is not unusual, it wouldn't work. You would not know whether it got onboard and it was bad—if the design was wrong or it got corrupted in transmission or what. You have no idea why it's not talking back to you, and it can't talk back to you.

So my first observation was, how is this going to work? You're not even going to be able to do this on the ground when you try to load it, let alone when it's on orbit. Then you're really worried. You don't know what's happening for as long as it takes to figure out. Marshall said, "It's designed to work; it'll work."

I said, "No, it won't work." I said, "One day it's not going to work." If I know something from the test programs I'd been through, that sort of testing you learn pretty quick. You've got to think about what happens if it doesn't work. Do you have the ability to recover it? And a satellite on orbit, you'd better, because if you don't, it's over.

So that was one. And the anecdote there is I was so convinced of that, I'd stand up in front of the Center Director, who was a tough old guy, a German, one of the Germans who came across with Dr. [William R.] Lucas, Bill Lucas, down at [Marshall], who turned out to be a good guy, it just—getting us to have a relationship took a while, because he was a cold fish. And I'd stand up there with these top ten and I'd finish [my quarterly reviews to him and the Marshall

team with them]. Well, since I was from another Center, they couldn't tell me to sit down and shut up. They'd listen to my spiel, but that was the end of it. It never got anywhere. In the past, I had [this] happen until I proved my point, then I was suddenly given a "Go fix them all" kind of thing.

On this particular case, I said, "You guys are not even going to be able to load the computer and turn it on in integration and test."

And Marshall, "Yes, we are," and, "Lockheed guys [think you] are nuts."

"Okay. I don't know. I'm just an ops guy."

So the first time they tried to turn it on, we had these quarterly meetings [as part of the Hubble spacecraft integration and test at the Lockheed plant in Sunnyvale, California]. It was right before the quarterly, and [they loaded the software and], and they tried to turn on the flight [computers]. I told my guys in the [Goddard] control center, "Plug in. … Let's watch what they do." And they [also] were Lockheed employees back east. And they looked at it, and [laughed], and [as predicted], they never could [get the flight computer running]. It went on [for the next three months].

So we got to the quarterly, which was like a week and a half later, and they reported, "Well, we got the flight computer in; we turned it on, we loaded it up; but we haven't got it running yet, but it's only a week. That's not unusual."

I got up and gave my spiel. I said, "My guess is, you'll never get it running." [Laughs] And I got beat up. In fact, the Project Manager took me in the woodshed after the thing. The Goddard Project Manager thought this was funny.

Three months later, another quarterly. They still haven't got the flight computer turned on. "Dr. Lucas," I said, "I'm not being facetious this time. There is a fix. It's really simple.

You just load up a very short piece of software that enables you to talk. Then you load the brains up and all the rest." I said, "Then when you get that thing loaded once, you leave it there. You never change it. You always leave it there forever so you've always got a way to talk to it." I talked to the Lockheed software engineers and they already had it, because they know you need it. They know someday they were going to need it to test. They were not thinking of flying it.

So he looked at me. He just looked at me funny and he said to the Project Manager, "You fix his problem," meaning mine, "and you'll fix yours, I'm willing to bet."

We had the little huddle. [They] took me to the woodshed again. I said, "I've been telling you every month. I mean, nobody's listening." It was fixed overnight, once they [put in the simple software fix I suggested].

But the real point here is, had we launched in that configuration, it would have been over. We could have never talked to it again, and we would have been trying to troubleshoot it for months. As it is, they had enough embarrassments when they launched it, and we would never have found out about the mirrors. [Laughs] They would have launched a 1.5-billion-dollar mute. There was a number [of other similar] things in the top ten.

[A] second one was, it took [about sixteen] commands in order to just turn [Hubble] on the very first time, while it was in the Shuttle bay, and the reason was that they interpreted the Shuttle safety constraints in such a way that they had three or four layers of safety and then they threw a few more in for good luck. So I said, "Well, that's probably not a problem, but it could be. But I'm going to have procedures on the ground that issue every one of those sixteen commands in every combination they can possible do, even if it takes two days, so we have backup," because if something gets in the wrong sequence, then you've got to unravel—it's like one command, then you open one door and then you've got to open a second door and third.

Well, if the second or third door is opened, the next command might close it after you opened all the other doors, and you don't know where you had a problem.

So the point is, you shouldn't have something that complex for something as critical as that. It's got to be foolproof. So my standard joke was, "I'm going to issue all the sixteen commands in every combination and then I'm going to issue the seventeenth command, and that is, print 1,800 résumés, because that's all we can do, guys." [Laughs] But I went down [to Marshall] and finally got all the top ten fixed. All the ones that were really important got fixed, but it took [these ways of getting the Project's attention to accomplish].

It was tough because there was such a distrust between the two Centers and the two cultures. Sometimes one culture was right and sometimes one was wrong. The Project Manager, I think, was super, Jim Odom. You couldn't ask for a better Project Manager, but he couldn't always figure out which guy's horror story was really real and which was just a worry and which one was over-dramatic. So there were some times we were right and some times we were wrong on something. [Many times] they said, "Just do it our way," and we did and they were successful.

So that was what it was, the distrust of the cultures, the suspicion. And some of that was built up in the early part of the project. [In the beginning], it wasn't [a] Goddard project, [so] Goddard didn't put the first team on it, and [it appeared] all they were doing was trying to get more [funding] for Goddard [because Goddard didn't have the experienced folks who could technically convince Marshall of their needs]. They kept bringing things up and everything cost money, so after a while, the Project Manager just couldn't take that anymore, so he just didn't trust them anymore. "They're just going to ask me for money; they're not going to solve my

problem. They're just going to tell me they need two more people." [Later on], anyway, I turned it around, I think. I built up a trust with them and that worked out well.

The other thing I did on Hubble, I started out by looking systematically at operations. Then we did the same with the ground system. If you remember, when I was at CTA, we won that independent test and validation contract I mentioned. Well, I made that the centerpiece of pulling together the ground system, and we put in place a whole bunch of what we called ground system tests, [which tested the ground system and operations procedures together with the spacecraft in a systematic fashion]. The first [system level test] was to be run [with the spacecraft] in thermal vacuum and got dubbed the ground system thermal vacuum test. That became a joke. Somebody thought we were putting the ground system in a thermal vacuum [chamber]. However, its function was to be able to run the spacecraft like you were flying it, while it was on the ground, from the control center back east, through TDRSS and everything [while the spacecraft was in thermal vacuum test]. We had everything set up to do that, and no one believed it the first time that you could do that. You want to do everything right, so it was a great time to [test it like you would operate the Hubble on orbit, but] on the ground while you could solve [problems].

Leading up to that were a bunch of tests like issuing one command and seeing if it reacted to it, then issuing a group of commands, then loading the computer, dumping. You did a whole bunch of things over a couple-year period, getting ready to do that. Once again, don't ever put all your eggs in one basket.

I'll one more time regress back to Solar Max. When we were developing Solar Max operations, the one thing we put on the wall is we said we wanted an opportunity for one day in the life of the spacecraft to have the spacecraft for a whole day. We really wanted it for a whole

week, but we knew it was a short schedule, so we said we wanted it for a day, and the Project Manager said, "No way. I'm not going to let you do that."

I said, "Well, we've got to verify we can talk to it."

He said, "You can have one hour, and you'd better get it right."

So we said, "How about giving us two half hours?" So the first time, we verified we can talk and listen to it, and the next time we do something more complex.

He said, "Okay. We'll give you two hours." We left it at that. The first command we tried to send didn't work, and when we troubleshot it, we found out the reason it didn't work is there was a problem with the spacecraft design. It was the receiver; not the ground system, not our procedure; it was the design. It was actually a design flaw, and there would have been [real] trouble [if the spacecraft was launched with the problem]. It probably wouldn't have been a mission failure, but there would have been problems talking to that spacecraft continuously. It would have been an operations nightmare. And when [the Project Manager] saw that, he said, "Okay. How many days do you want?" [Laughs] He suddenly realized the value, because I had a whole list of what we ought to do and [each was logical to be tested by my operations team since] there was no place else it was done [in the test program]. I wasn't just going through an exercise. We found that two pieces of the ground system couldn't talk. A lot of things we found from running those kind of tests. So when it came to Hubble, the first thing I did is, I went and staked my claim out on the schedule for these periods of time. People weren't real sure they were going to leave them in there, and I kept telling them this horror story about Solar Max.

It's amazing how we debugged that ground system, but leading up to it, we developed a simulation of that test where we did it on paper on the wall. We had everybody stand up and say exactly what they would do in this day in the life of HST. We found things like the onboard

flight memory wasn't big enough and all sorts of things, just by walking through a day in the life of. So that became another model of the way to do business is do a systems engineering analysis of the system.

A lot of this was [the result of] what I told you originally; there wasn't a systems engineering group that started the program and evolved the system in a certain vision of how I'm going to operate it. It evolved in pieces, and many pieces [had small incompatibilities with each other]. So this test program we put in place and the steps of the analysis leading up to it drove out a lot of [the flight-to-ground operations problems] we wouldn't have found until we were on orbit and spent a long time debugging. It would have been a series of nightmares, because the debugging there would have been in line with trying to take observations. When [we] finally [got on orbit, we] found the mirrors skewed, and that took [two months] to find that out, it would have been even a bigger fiasco than it was. …

Then you asked a question about *Challenger*, and you said, how did *Challenger* impact. Well, the ground system thermal vacuum test was run after *Challenger*, and it took a while to fix all the things. Many of them were efficiency questions, but efficiency would have manifested itself in data not coming back and people not knowing why, and it took much longer, days instead of hours, to get imagery back and stuff.

We were able to use the next two years of delay of really getting all the bugs out of all the procedures in the ground system. So when it launched, the thing operated flawlessly. There were no questions about how it operated. You knew how to command it. Therefore, they were able to understand what it could and what it couldn't do really quick, and they got the spirit of collaboration, as probably most people remember. Within sixty days, they declared that they knew exactly what the problem was. My point is, had we not had *Challenger*, there would have

been so many other things they would have been debugging and masking, that the whole thing would have looked kind of chaotic. As it is, they had a couple of little problems on deployment, but I was off now as Division Chief.

I left in [19]'97, when they asked me if I wanted to take over all Missions Operations Division, and I said, "Gee, taking some little ops guy and giving him that job, that's neat." So they told me I had to apply for it and I went through that process. They actually had a committee and I got selected and did that. That was probably the best job I ever had, [well] almost the best one, running a division.

[Pause]

ROTHENBERG: The final end-to-end test that we did on Hubble, the first one of the ground system integrated test to demonstrate that the operations procedures, the spacecraft-to-ground system, all played together was an unexpected resounding success. Nobody expected it to work the first time. We went twenty-four hours, I think, we operated it flawless. Everything worked together. It was the buildup of getting to do that test that debugged, all of the little tests we did leading up to it that did all the debugging and all the little analysis and all of that. That happened on a—I want to say on a Monday. No, it was a Friday we ran. We ran Friday, the end of the week, and then the following Monday was when I was to start the new division job.

So that was the deal; I wanted to get that test [in before I left the project]. I had worked so long on it. It was the kind of thing where we had to convince the instrument people we weren't going to break the instruments; we had to convince Lockheed that we weren't going to compromise the spacecraft; we had to convince Marshall—we had to build up a lot of confidence

along the way, and all the little tests and the analysis, and there were so many things that became team-building.

Every week we had a team meeting, and I would get on an airplane usually on Monday night, fly out to California, go to the West Coast team meeting, the spacecraft side, talk to them, tell them what we were going to do, and generally get abused because, "It isn't going to work," and "Why are you trying this? Why are you making my life miserable? We don't have time to do this, too."

Then I would get back on the two o'clock flight and fly back in time for the Wednesday meeting on the team on this end, and I had to get all the contractors—this thing was built, the ground system, by at least five different teams of people. The Science Institute people were doing the science operations. The ground system that we used for the science was a multiple-part ground system, and that was built by TRW. The command planning and operations management system was a software system called PASS [Payload Operations Control Center Application Software Support] built by CSC [Computer Science Corporation]. The real-time command and control system that took the offline science data, the command management system, and uplinked all of the results up to the spacecraft and did the real-time monitoring was built by Ford [Aerospace], I guess Loral [Corporation today]. It changed names, but Ford or Loral at that time. I don't know which name they were. Same people. And, finally, the operations to operate the spacecraft to operate the spacecraft, in fact, were run by two different groups; one, the people who actually communicated with the spacecraft and that was run by Lockheed, and one that operated what I called the backroom, which kept all the computers running that they used, I guess was called Allied Signal [Corporation] at the time; now they're Honeywell [Incorporated].

And all of these people had different leads, so one of the things we did with these tests, we pointed to different—this event here, we're going to test loading memory, and that forced people to make deliveries. The fact that we'd built a team, nobody wanted to be the one holding up the thing, and I had my top ten, and nobody else wanted to be at the top of my top ten. We never made it pejorative; we never made it we were beating them up. We just stated a problem, the impact, and what we were doing about it, that was all, but nobody ever wanted to be up there. They liked to be not on the list at all.

So we used that whole thing. That was another little thing on the side. If you picked these things that are non-threatening or non-visible and use them to build a team and force people to deliver things, it's a way of pulling together pieces of a system. There's no other way. You can't do it contractually or any other way. You've got to have something like this. Their senior management, I looked them straight in the eye and I said, "This is what we need."

And they said, "Okay, I'm on the team," and they bought in and they made their troops do things that they would normally not have done to produce on my schedule rather than whatever other schedules they were committed to, and then we'd try to put it together at the end and we'd have a disaster. I needed it delivered incrementally.

The Division Chief—that was an interesting challenge, because I took over a division that hadn't had a lot of young people hired in years. [One branch in the division, for example], hadn't had what I call a fresh-[out], someone out of college, hired in somewhere around fifteen years. In one of the branches in there, the guy who preceded me was retired in place for the last two or three years, and I knew that. I knew him. He was retired in place and they had a lot of old systems that he was afraid to change out because, "New technology. Why should I learn it?"

or, "It will never work, because I'm retiring." That was his mentality. He told me that in plain English.

So the first thing I had to do is [learn my job]; I came from the customer, the project side of Goddard, not the institution. This was an institutional division. [Fortunately] a lot of [the staff] knew me because they worked with me over at [Hubble and Solar Max], so that wasn't my worry. I didn't know much about running an institution. I knew roughly what this division did, but not exactly, and I found out kind of quick that there were five branches in the division, each about twenty people, and they didn't know what each other did across branches. They were all in the same building. They were all on two floors. They owned the whole building and they didn't know what each other did. They just had no idea. And there were people who wanted to leave and go on to other jobs, but they just wanted a change. They didn't ever think there was an opportunity [within the division to do something different] because they didn't know what the [rest of the division] did. Some groups did a lot of on-the-floor testing, and they came in in jeans all the time; the others came in in white shirts and ties. And they looked at each other funny because they didn't know whether these guys were the maintenance men [or engineers].

So I had to first establish what we wanted to do with the division and then I had to build [the] team. So I did everything. The first thing I did is give them a chance [to recruit staff]. There was no hiring. At that time there was a hiring freeze on, and [I] gave them a chance to recruit from internally. So [I told each branch of the division] they could have a two-hour on-stage open house, which they told all the other branches what they did for one hour, and viewgraphs and song and dance, whatever they wanted to do. For the second hour, they could take them on a tour of their labs, their operations centers, their facilities, their antenna ranges, whatever they wanted to do, like an open house. And we ran this till each of the five branches

did it. One branch brought over its communications trailers and parked them on the lawn and had walk-throughs.

Then the second thing I did, I told them they could invite anybody else from the Center that they wanted. This was great for recruiting people. Then they could talk about announcing they had job openings. I said, "You get five minutes that you could talk about jobs that might be available," because if I openly made it a recruiting thing, everybody else would come down on me, all the other divisions in the Center and everything else. But it worked. People changed. Then we restructured the division to do the work better. I eliminated some things we were doing that I thought were antiquated. And we got some hiring, just enough to sprinkle enough fresh thinking in there, and that really changed the thing.

Then I got them to form [the] team in a different way. I decided that we'd have an Olympics and a Halloween party. We had all sorts of prizes—oh, the other thing is, the day I took over the division, I wanted to have an all-hands meeting that Friday. So this one woman, who was my financial analyst and I knew her socially, I told her to stock the conference room with beer and wine. I never thought about [inviting the head of the directorate, my boss, but] because that was the only complaint I had. But I had the meeting at three o'clock in the afternoon, and it turns out—I had taken over the division on Monday. That was that Friday, and the Director was going to come over and he wants to talk to me at three o'clock. He comes in my office and I'm sitting there with a glass of wine on my desk. [Laughs] He says, "What's that?"

I said, "Wine." It didn't even dawn on me, [when I heard he was coming over].

"Wine," he said. "What's going on?"

I said, "Well, we're having a get-to-know-you little thing in the conference room here in about a half hour and I'm testing the wine to make sure it'll be okay."

And he said, "I'll stick around."

But I did things like that that were nontraditional. And projects, we always had wine and cheese probably one Friday a month at least. And the big Friday month [after a milestone] was no screw-tops, no cartons; real wine, corks. That was the joke, the standard joke. "Is this the screw-top Friday or not?" For the screw-top wine bottles, or is it good wine. But in the institution, they really didn't do those kind of things, so I [changed] that.

A Halloween party—I mean, everybody participated. I still have photographs that we took of the innovative costumes people came in. One guy came in wrapped as a mummy. We had no idea who it was and he did the whole party as a mummy and was drinking through a little opening. Another guy was in a box and he would just put out a sign, "Give me a sandwich. Give me a beer." Another guy had [what looked like] three people together, all in jeans. They all moved together with boards and flannel shirt. He had a head on them and a wig. We still have a picture of this thing standing at the three urinals. The three urinals, we had them spaced so they just looked like there were three. He actually had to go to the bathroom and somebody followed them in and took a picture. Nothing wrong with the picture. It's just a funny picture.

Then I had pictures of everybody in the division taken, in their work situation, hung on the wall, all the contractors and the civil servants. It turns out, people were bringing their families in to show their picture was on the wall. I had a professional photographer come in and spend two or three days doing it. … [We] hung them, and people [brought their family] in to show their [picture]. Everybody else in [for] Flight Projects had pictures of spacecraft hanging

on the wall. I said, "Well, our asset is our people. Let's put our people on the wall," and that's what we did.

[Back to] the Olympics [we held]. We took each [of the] five divisions and told them they could do whatever they [needed to]. We were going to have ten events: basketball shooting, Jell-O-cube sucking, toilet-paper wrapping, watermelon-seed spitting, softball. Some conventional things and nonconventional things. I guess if she was a day, she was fifty-five, the fifty-five-year-old secretary won the free throw, ten straight baskets from the foul line. Her husband got killed in Vietnam [War] and so she was a single parent, so she did all the sports with her son and she became pretty adept, I guess, at basketball. Because she was not athletic at all, not fit, not in shape, but she went out there and shot ten.

But with the Jell-O sucking, the watermelon—and I participated in all of the silly ones, just to [take] part [in] it. But it got everybody talking. They trained. They found out who could spit the watermelon seed the farthest. They put them in.

But I turned this division from one that didn't have any morale, they were not hiring; they sort of didn't know where they were going, and then I built a team. Then we took the team and turned around and we actually changed the way Goddard does business with operations. You can have fun, but you really need to produce something, and that was a good system.

Then we actually put in place the first missions to fly little workstations, using little workstations rather than large computer complexes. We actually took all the weather satellites and we put them on a PC and they took up rooms worth of equipment, but space was my biggest problem.

Then I had another notion. I said, "Well, the other problem is, if I didn't have to operate them on my Center, I'm not interested in operating them day-in and day-out," and I met with the

local universities and we actually moved, later on in life, moved some control centers out to universities and have students operating them, and not because they're cheap labor. We made it actually part of a curriculum. They developed a curriculum. We put one of them, when I was Center Director, over at a historically black university, and they didn't even have an Engineering Department. They did a great job. They built a facility in their library. And we weren't paying them. They paid for everything. We paid 50,000 dollars to report the software; that was it. Everything else they took care of. One of our contractors brought in an instructor to teach at the school, and now it's part of their curriculum. Some of the kids are actually going on to engineering school, which before they were dead-ended.

We did that there. We did it out at a university out west in Berkeley [California]. They wanted to put it in the Science Department; I made them put it in the Engineering Department. We then formed a partnership with the University of Colorado [Boulder, Colorado] and I had myself as a Division Chief and all the other Division Chiefs going out there once a month—we rotated; not all together—out there and actually spending a day with the students, teaching a class on satellite operations, and they were operating some satellites out there already. In fact, that's what gave me the idea.

So the workstation technology allowed us to eliminate a lot of facilities we had. We freed up a lot of space. We were looking to build a new building. We didn't need it. We didn't need power. We didn't need air conditioning. We didn't need false floors anymore. I got Headquarters to commit to build the first one and we'd fly it for the first small Explorer mission. It was nothing. We just said, "We'll do it. Now we've got to figure out how, but we're going to make this date," and I made it real visible and championed a bunch of people, and they did it.

Put one company in business which is now an 80 or 90 million-dollar-a-year company. It's [even] on the New York Stock Exchange. They were the guys who came up with the idea [to use work stations in place of large computers for spacecraft operations], and we gave it a try, and between the NASA folks and these guys, they put the first system on and they turned it into a business, and they're international now. In fact, that's one of the people I'm going to go see Monday. Time to do some business with us now. "Remember me?"

But we changed that whole thing. Originally, when the engineers wanted to look at how a spacecraft was doing, not the operators, but the engineers, to see how the power system was, they would have to go to the control center. Well, when we got finished, they could do it from the PC on their desk. They could get access to the spacecraft data either daily or weekly or trend data or whatever, where previously they had to come to the control center, request data. But we changed the whole way, over the two years, the way they did business.

At the end of two years, I put in sort of a strategic plan for the division. They never heard the words before. "What are we going to do? When are we going to change over these workstations for all the missions coming up?" I had people that did the analysis that said, "This is the right time to do it," and that's when we picked the way to do it. So I put some vision to them, made them a team, and had a lot of fun.

And I really had fun because I had young people we were bringing in out of school and we put them through a real neat two-year training program. We had people who were retreading, who had whatever they used to [was no longer needed] and we were teaching them how to do new things, give them new opportunities, and we were paying attention to them, rather than just waiting for them to retire. I couldn't afford to, because I had more work than people. We made

partnerships with some of the other divisions, where we were originally competing for people, and we exchanged people. We developed an exchange program.

There were some things that backfired, but there were a lot of things that worked. One exchange program, the really fresh-outs I put in place, I lost probably the best guy that I'd ever hired, because after about eighteen months, he said he wanted some stability and found a place where he could go have stability, and I was making him change just like he was in college, and that's the way he told me in the end. I said, "Well, we could have stopped that."

He said, "Yeah, you could have, but I didn't realize what I didn't like until I found this other job," and he said, "I'd really like to do this other thing," so off he went.

I was having fun, and the director of [the Mission Operations and Data Systems Directorate, my boss], left and his Deputy and I were in contention for the job, and I didn't want the job. I really wanted to stay in this division. I had a wonderful office suite with my own shower, the only division in the place that had a shower. I wasn't allowed to use the shower because that's where we stored the Xerox paper, but, nevertheless, once a year we took out the Xerox paper and turned it on to make sure it still worked. But a nice little facility. It used to be a higher-level office and then when they reorganized the Center, it became available as a Division Chief office. My predecessor snagged it and I got to take advantage of it. And we had our own building and it was all self-contained. We had all the control centers, flight software laboratories, everything all in one building, so it was the whole MOD [Mission Operations Division] kind of thing for Goddard.

They picked the other guy, [Dale Fahnestock], who had been a Deputy, and he would have been passed over a second time, to take over the directorate, and that didn't bother me in the least. [Once in place, he called and said], "I want you to be [my] Deputy."

I said, "No, I didn't want the [job]," and I told [him] four times no. I went away on vacation, came back, walking by his door, going to the staff meeting one day, and he said, "Rothenberg, come in here." He said, "I just got off the phone with [Dr. John W.] Jack Townsend [Jr.]. You're it. You're over here tomorrow morning. You're it." He said, "I need you." Jack was the Center Director. He said, "Jack was a little hesitant, but finally he agreed."

I [wondered], "Why would he be hesitant when he talked to me about running the thing?"

…

Then Jack called me up and he said, "Are you going to do it?"

I said, "Yeah."

He said, "Don't worry. Just go in there and do it and everything will be fine."

I said, "Well, I really liked the division."

He said, "Well, I knew that, but I really wanted you to go head up the EOS [Earth Observation Satellite] ground system." He said, "I'm in trouble there and that's what I was trying to convince Dale, and Dale said he needed you, so you weren't staying in the division no matter what."

I said, "Oh." I would have done the ground system, too, but I said, "Well, okay." So I'm here.

Unfortunately, [Dale] got sick and he was out for six months and then I got a chance to run the [directorate]. … [I had a lot to learn about what the directorate did.] The first thing I found out is we were getting on to the next-generation TDRSS. I didn't have anything to do with the GOES [Geosynchronous Operational Environmental Satellite] at all, other than we were building a ground station to support it during launch, but had no involvement with the GOES satellite—the GOES H and I, the ones that had trouble—whatsoever. I did later when [Goddard

procured] the next-generation GOES [for the National Oceanic and Atmospheric Administration]. We can talk about that [when we talk about my] Center Director [experience] because we did some things differently there [for GOES H and I].

But I guess the main aspects of what went on, they were building what they called a customer data operations system, and this was the Holy Grail, that they wanted to have a control center that would operate all satellites. [The prior head of the directorate] had fought for the money and got the money. And I never agreed with that, and when [they] gave me the keys to the car, I cancelled the program and I gave the money back. I said, "It's not needed. It's the wrong program. Ten years ago, that was the right program. But today's technology, [decentralized operations centers using] workstations is the way is the way to go." And I convinced my boss [of that] on his sickbed. He really just had a back problem, but, nevertheless, he couldn't get out of bed for three months, then it turned into flu. It was one thing after another. He was having one problem after another. He got over it and he's healthy as a horse now. He's not much older than me, and I think he's still working.

So I changed the way [the directorate systems engineers] were thinking about how they were going to put in the [new] systems. [Until I cancelled it], they were really going to revert to [a Central Data and Operations System (CDOS). It] was going to be the be all to end all for the Earth Observation mission [operations], and I said, "You need a different kind of system."

The second thing that happened is the White Sands ground terminal [White Sands Test Facility, Las Cruces, New Mexico] was being upgraded and was called a Second [TDRSS] Ground Terminal—[STGT]. The point is that they had put in place a plan to build the software for that, the scheduling software, in-house, and the [STGT] was built by General Electric. They kicked that off and we were to build the software.

When I first took over the job, there was a problem. [The STGT software] had just missed [a development] milestone. They came in and explained to me why, [and] it was a major visible one. We all went down to Headquarters with a new plan. A new plan. This was in August, and we had [the annual] Christmas party [in December], and the head of [the software project] comes over to me and said, "You know the January delivery?" He said, "Going to be late." [For months he had been holding firm to the January date.]

I said, "How much late?"

"Oh, I don't know. Maybe a week, two weeks. I don't know."

"What do you mean you don't know?"

"We haven't started yet."

I said, "Wait a minute. You had a three-month schedule laid out."

He said, "Well, it got bigger. It's going to be five months."

I said, "So that means it's not even going to be three months." So I had gone down and prostrated myself in front of the AA [Associate Administrator] the first time and said, "We're going to straighten this out." Well, the second time, "[What am I going to say]." So I thought about it for about thirty seconds and I said, "Okay, let me go back to the beer machine here and get my head together."

In the morning, we got together and I said, "I've got to come up with a radical plan," so I did what all NASA managers do. I called up the AA and said, "The software's in trouble again." I said, "Look, I've now instituted—," by the way, I'll talk about—one of the things I instituted during that time was a monthly meeting where [my boss and] I went down and met with [the AA] and just talked about—no problems—whatever he wanted to talk about and whatever I wanted to talk about, for one hour. The first time I tried to do that, he—"Why do we want to do

this?" Da-da-da-da-da-da. It was before my boss was out with the bad back, and my boss and he didn't get along. And he said, "I don't want to go."

That's when I said to the secretary, "Schedule it." So I scheduled it. "We're going with Dale."

"I don't want to go."

"We're going." I said, "Charlie wants us to do this." So both of them are reluctant why we were there, and his Deputy and me are sitting there and saying, "Okay." We started talking and immediately got into an argument. The AA wanted to shut down the Guam Ground Terminal. He had some reasons. My boss said, "This is nuts." And they stood there and argued for the first fifteen minutes.

I said, "That's it. Round one. Now let's get on to other topics." And we got into some real meaty stuff, which was why and thinking. At the end I said, "You guys can schedule an hour on your own. You get your boxing gloves, swords, whatever you want and you can go fight about that. It's history. It's done."

Well, as we're leaving, the AA says to me, he said, "Go get with her and make sure you get next month and two or three months in a row and lock them up. This was a great meeting."

And of course, the other guy, [my boss, is saying], "Don't ever schedule another meeting like this."

And I said, "Hey, we really have to do this. We've got to build this relationship." Well, then he got sick and I was down there every month with them. So [when I called the AA up] when I got [news about the missed STGT software January delivery schedule], I said, "Hey, here's what happened. I'm just telling you out of the blue, I don't even know why they're late or anything, but I want to stop everything and personally spend the next whatever it takes, bring in

a team of people, find out what's going on, what they're doing wrong, and how do we straighten this thing out [based on the trust we built during the monthly meetings]."

He said, "Okay. [Come back to me when you understand and have a plan, rather than react.]"

I said, "I'm probably going to need like two to three months, because I got a real job, too, but I want to lead this thing, because it will help me understand if I'm going to be in this position. I don't know anything about this stuff."

So I dug into it, and about a month into it I realized, "You know what? I have a bunch of plumbers doing electrical work." They really didn't know what to do and they didn't know how control their requirements. They'd never built software. They were really ops guys who built little patches. So I said, "I'm taking this whole job away from you and I'm giving it to this other division." I had to convince the Division Chief he was going to take on this problem. And he did. He stepped up to it.

And then I went and I said, "Now I want this other division to lay out the job and how we're really going to do it." So I called him and I said, "Another thirty days, and here's why. Here's step one."

He said, "Great." He said, "I probably could have told you that, but you wouldn't have believed me if I told you that you had the wrong guys doing the job. …"

So we moved it over there, and then they came back and the job was like 30 million dollars to start with. These guys came back with an estimate of I want to say 90 million dollars for the same job. I took 1 million dollars and put it over and left it with the old division for some help. Then I went and got all these guys the right clearances so they could—this was a classified project—get all the stuff cleared. So then I've got to go make the pitch downtown and tell them

that this job they had budgeted [10] million is now going to be [27] million. So I had to put this story together and work on a story.

Then I went off to school for two weeks. This is when they forced me to go to one of [the NASA training classes]. My boss came back and I said, "Well, you can go give [the presentation to the AA]. I'm not going down there and telling them the story," [maybe] because he didn't believe it. …

So I had to come back from school, drive all the way back from Wallops [Flight Facility, Wallops, Virginia], to go give the briefing. So I had really worked it, so I pre-briefed a couple of the people, and I get there and I give the briefing, and when I finished the briefing, I expected to be stoned. And he said to me, "Why are you leaving the million dollars in that other division?" That was his only—he asked a lot of questions along the way, but as far as the [27] million dollars, he never even reacted. The budget got put in place, and we did the job, and they delivered.

But it was just one of these things where I was proud of what I did, because we straightened out a long—by the way, [the original division doing the work] had a ten year history of [software development management] problems, which I didn't know about until we dug in, that they never delivered anything on time, [in some cases] they were years late. I think [the AA] felt that [27] million was far better—he probably had a different budget in mind all along.

But, seriously, it showed the value of this whole directorate. This directorate was 500 people, civil servants, and another 2,500 contractors, and it showed them the value of getting the right people on the job and doing it right, and these guys delivered it, and that software development wasn't something you did casually. You had to freeze the requirements. It set a whole tone for it. So I did that.

We also took back—TDRSS at the time was owned—and we leased it, and at that time we actually—I was there to take the keys when we took it back from the contractor, or they gave it to us. We bought it back for a dollar or whatever it was. I didn't really initiate it, but I was there to do that. We started closing down ground stations when I was there, because we were now using TDRSS more.

[In closing down ground stations there were] always some interesting problems [to deal with]. We learned a lesson there. We took the Bermuda tracking station over. The Navy had an annex, but we were connected to it, and on it was a little drawbridge, actually, and the Navy was moving out of Bermuda, so we said, "Free land? Free facility?" and they gave it to us.

Well, the first thing we learned is they left us an environmental mess, and the second thing we learned is we had to maintain the drawbridge. So I was spending money maintaining a drawbridge in Bermuda, which I never could go to see, I never had time to go to Bermuda to go see the thing. So we learned never to take something for free. A little like when the Navy gave us [some of] the [current] Ames [Research Center, Moffett Field, California] facilities and [later] we decided we didn't need them anymore. And when they closed down the hangars [they] found out that big balloon hanger—if you've been out to Ames, they have this huge dirigible hangar. Well, that's a historic landmark and you can't tear it down, so you've got to maintain it. And the county didn't want it; the state didn't want it; nobody wanted it, so we're stuck with it. So that's when they turned it into [an academic, commercial, and government] research park. They just did that. That was a Harry McDonald brainstorm. "How do I get this thing off my bill?"

The only way we got Bermuda off our [roles] is close it down completely and give it back to the Bermudans, after we [environmentally] cleaned it up. We also did that with Ascension Island. We had a tracking station there, and the tracking station, behind it was a big

crevasse and they were dumping waste material down there for thirty years. Ascension Island was owned by the British, I think—I forget—and they said, "Well, we'll take it back, but you have to do the environmental cleanup on it." And we started to evaluate what it was, so we brought in a company that does environmental cleanup. We went back there and we found an American LaFrance fire engine, pickup trucks, you name it—those were some of the big items—were dumped down there over the years, and we had to get all that stuff off the island. It cost millions and millions of dollars just to clean up the Ascension Island site. …

I was only [in the Deputy Director of the Mission Operations and Data Systems Directorate position for] a year and was at one of my monthly meetings with the AA, and somebody called me up and said, "Hubble—they discovered spherical aberration." I knew that. Everybody read that in the paper. And they said, "We'd like you to come back [to the Flight Projects Directorate] and run the repair mission." And it was like a demotion in a way. I was now a Deputy Director of a directorate, and now I was being brought back down to run a project, only it wasn't such a little project. And I didn't even think about it; I thought about it for about thirty seconds. It was about that much, and I said, "Hold on one second." I said, "Dale, I'm about to tell you I'm leaving." He looked at me. I said, "They've asked me to go over and fix the Hubble, and I've been watching it and I think I can go over and help them." I wanted to go over and just help. I didn't care whether I—"But they've asked me to head the thing up and I think I'm going to do it."

He just smiled and he said, "That's a challenge." He said, "You'll like that." Apparently, he and everybody else but me knew about this. They had all worked all the traps with the Congress. I didn't know that. I had no idea whatsoever, but he didn't tell me that at the time; I figured that out later.

I said, "Pete, I'll do it," [to Peter Burr who was the Director of Flight Projects at the time].

He said, "Can you come over tomorrow morning and we'll talk about it?"

I said, "I'll be there at eight o'clock."

And he said, "[Dr. John] Klineberg, the new Center Director, is going to fly in from Cleveland [Ohio] to meet you at noon."

And by noon, I had the job and I had it straightened out with Headquarters. I said, "I want all the money sent to me. I don't want to have to call Headquarters for reserves. I want the project moved from Marshall to Goddard immediately, not in nine months or six months or three months. I want to take over starting tomorrow morning. I don't want to operate that way." And they agreed.

And even Marshall, I called up the Project Manager down there and said, "This is what I want in order to do this."

And he said, "Okay." Then he called me back and he said, "Look, I talked to the Center Director. In order to make this appear that you're not yanking it out of Marshall, could we—I'll let you run it day in and day out; I'll give you everything, but let's not make the official transfer date until October 1st." He said, " And we'll announce now when we're going to do it."

I said, "Sure. I don't care. I just need to get my arms around it." And that sort of led to a whole new thing, because this happened from a Wednesday to a Friday. By Friday morning, I was in the chair, I was actually sitting at the conference table with the original Project Manager, at his desk, cleaning out his desk—and he's a personal friend, still is, to this day—but he wasn't up to this job mentally. He believed that because Marshall screwed it up, we should not take it. They felt strong, and his Deputy felt the same way, and I wanted his Deputy to stay. He was

very important, to me, anyway. And I convinced him, because I had hired him into the government, so he was somebody I knew, and he was the guy that was needed in that job. So he agreed to stay.

Then I sat down and said, "Okay, the first thing we've got to do is find out what's wrong with it. The second thing we've got to do is find out what it can do the way it is now." Everybody knows what it can't do—David Letterman [television talk show host], the paper, Congress, and everybody. Meanwhile, I've got the press calling me every hour on the hour. I had my whole staff, they did nothing but deal with the press. The Deputy, not [Richard H.] Truly, but [James] J. R. Thompson, [Jr.] wanted to hear, "Isn't there a way we can bend the mirror with actuators when it's up there right now and fix it so the problem will go away?" He sent me out of the office. "Go look at that. Come back, talk to me about it tomorrow or next week, but just take whatever time you need, but I think you can do it that way."

I said, "I don't think so, but smarter people than me have been looking at this for a month."

But we laid in place a strategic plan. The first thing was, make sure we fully understand what's wrong with it. The second is, spend whatever it takes to find out what it can do today and start getting the best we can out of it, [is] what we have to do. The third, knowing what's wrong with it, decide what it takes to fix it. And the fourth thing is, fix all the engineering problems it had besides the optical. It had a number of engineering problems. Then the [fifth] thing and final piece was preserve the follow-on servicing mission and instruments. We laid out that and then we said, "We're going to have the first servicing mission in June of [1993]; the second servicing mission in—," and we picked a date, and I don't know what it was, three and a half years later. And we set these dates, and they were important because we had instruments being

built for those follow-on missions. It's pretty easy to go steal [all] the money from [these] to solve [today's problems if you forget you committed to preserving follow-on missions].

And the science community didn't trust us at all, so I had to go see the science community and [build trust]. I said, "Here's [the plan I have and budget]. … These are my goals." I said, "And I'm going to give you the keys that you can tell me whether I can take a nickel from [the future instruments] to solve problems. I'm going to make you involved in everything I do." At best, I got a little bit of trust. I worked with a couple of them previously, but they didn't trust NASA. They were real unhappy. The Science Institute was there and they were viewed as part of NASA in that time. And Congress didn't trust anybody. You know, "techno turkey," all those kinds of names were being—all over the country were looking at the Hubble as a big joke and NASA as incompetent.

So then we started with—the committee found out what as wrong with it, then we put in a program to measure and verify what was wrong with it that was consistent, that could verify that the numeric discrepancy was consistent with the one that was predicted on the ground, and, lo and behold, we found that out.

Meanwhile, we set in place an early observation program that was out doing images. Well, I would kid, because they were producing spectacular imagery—we found out that it just took longer, because a blurry mirror just means you got to wait a little longer to collect more photons, because you're not as focused. For certain kinds of observations and in other kinds, you couldn't get as clear, but we found out you could have some ground software to make a fairly good correction on that. They used it in the military and we were able to get that, but it took a little while to get all that in place.

Meanwhile, every observation we produced was spectacular, and it's with this flawed system. And they started to change from the first whole paragraph being about the flaw to, "In spite of its flaw—." It started to change, little by little, but we had our press conferences two or three times a week. I became first-name basis with most of the reporters in the industry, and still am with a bunch of them, but the point was, we were very guarded, but they were always still beating on us. We didn't get off the hook. There was an event that got us off the hook, and I'll talk about it in a minute, in a funny way, but the fact that we were getting credible observations.

Then the scientists went off and came up with a plan to correct [the optics]. We already [planned for] the next instrument, [the Wide Field, to] put in a [correction] lens, and we would get clear images, which was the one you see most Hubble images from. It's the one that gives the prettiest pictures. It would correct one out of five instruments. To me, that wasn't real satisfying, but one good image from it and the public would have gone back to sleep and we could have said, "We did it," and we were heroes, and that was all we had to do.

The science community said they wanted to go off and look at what can we do with the rest of them. And I said, "Great," and they went off, and three weeks later they came back with a thing called COSTAR [Corrective Optics Space Telescope Axial Replacement], which said—the instruments sit like four telephone booth-sized boxes, in a square like this [gestures], one, two, three, four, and in the center is where the light comes in from the telescope, and what they said is, we take out one and in the other three, put in three monocles, [one] in front of each one of them, or whatever you want to call it, eyeglasses in front of each one. We can correct the other three; we only have to remove one instrument. And the principal investigator [Robert C. Bless] for the one instrument, [the High Speed Photometer], agreed to do it, which is—he worked on that thing for fifteen years of his life, and he saw the greater good. In exchange, they allowed

him to have a lot of observing time while it was up there, because it would be ending, and it was only reasonable in his theme.

So they came back—well, the fact they came back in still said I had to find 25 to 50 million dollars. So they came in; one of the companies, Ball [Aerospace], came in with a proposal to do [COSTAR for 25 million dollars], and they had a reason they could do it. They [already] had [an instrument] structure. I doubled the number [to be sure we planned for enough money] and I said, "Okay, now I've got a 50-million-dollar problem [to solve]."

So I played around with my budget, and Headquarters grabbed me and said, "This is great. We gotta do this, but you can't have any more money," and that was about all the guidance they gave me. … "We're going to need this, but we won't give you more money."

So I said, "Okay. I'm going to commit to do it and I'll figure out how to get the money." I don't know how I'm going to do this.

So I went back up and talked to the science community. I said, "We're going to commit to do it, but I want to have a review. We're going to take some money from the follow-on instruments, but the principals, I've already talked to them and they agree they'll give us this much money on the margin." [We went to the follow-on instrument developers and identified the sources of money. We called in] the science community, and I said, "I want to you to review [the COSTAR progress] in three months, six months, and nine months, and verify that we're still on track, we can do it, and we're not stealing money from any other place. Here's how we're dealing with all our issues."

And they put in place a committee, to their credit, of university people, and said, "Okay, we'll go along with your little game." Because you have to understand the history of building instruments is they take two or three times longer than ever predicted, and cost four or five times

the price, because they're all pushing the state of the art in what they do. Otherwise, you wouldn't be flying them. So these guys are always pushing the state of the art.

So the science community believed that [was] what was going to happen, I was going to steal all the money from the follow-on instruments. I said, "I won't violate that strategic plan." And to this day, that's the strategic plan we followed.

But what we [also] found out is it was going to take six months longer than I had to meet the schedule. So right before we ever got committed to building it, I went back to the community and said, "Instead of June, I want [to launch in] December." I think it was December 1st or 2nd. I don't remember the date right now, of [19]'93. "That will be the target date," I said. "And that's the only thing I'm asking. I don't need any more money to make that date; that's the date."

They bought it. Everybody bought the date change. Headquarters was, "Oh, that means we're not going to have this clear picture and get the public off our back for six more months."

I said, "Well, we're starting to get some images that are making them happy and they're making all the newspapers."

So everybody bought into this thing and I committed to it and we did it. Bottom line is, again, [playing the Project Managers] game [of] Whack-A-Mole, monthly, weekly, I can tell you one story after another about problems that [we had to beat down]. One story that came out of this that is quite interesting, remember I mentioned these little mirrors. Well, they're called aspherical mirrors. As far as we know, very hard to make. The major optical houses in the country, Perkin-Elmer, [Eastman] Kodak [Company], UTOS (United [Technology] Optical Systems)—I don't remember; there's one or two others—all, when they looked at it, "This is very difficult."

We did a little mini search of the industry. Found a little company out in Oakland, California, [Tinsley Laboratories] who said, "We can do things like that." So we put out three contracts. There were three sets of mirrors we needed. Six mirrors. We put out three contracts and told each guy to start a different set of mirrors, and we gave the little guy in California the easiest set, we thought. We gave the one in Utah, Perkin-Elmer, they came in for a proposal for a million dollars; the little company in California came in for one for 600,000 dollars; and UTOS came in for one about a million-three.

So we start the [contracts] going, and about two months later, almost like in the mail, comes—it was a little more formal than that, but comes first set of lenses from the little guy in California. Meanwhile, UTOS and Perkin-Elmer are still trying to figure out how to attack the problem, and they spent like a quarter of a million dollars or something. They spent a lot of money in the first couple of months. And the little guy says, "Let me know about the mirrors."

Well, our optics guys look at it and say, "These are the best mirrors we've ever seen in our lives."

The little guy comes back and says, "Hey, we didn't spend near all the money. You want us to build the rest of the mirrors?"

"Okay. Why don't you give it a try." Two months later, the rest of the mirrors come in.

Two months later, Kodak and those guys are saying, "Well, we think we got a way of doing it." [Laughs]

We get the mirrors, the guys look at them and say, "These are perfect."

And the mirror guys say, "We don't know much about your business, but you probably want a set of spares. We could give you back the rest of the money, or we could build a set of

spares." And [within the] 600,000 dollars they did that, and we actually we needed a set of spares. They built a set of spares.

For all I know, Kodak and UTOS and Perkin-Elmer are still trying to figure out how to build those mirrors. They spent all the money and produced zero.

And this company, Tinsley [Laboratories], we then got them into building these mirrors for a [microcircuit etching] device and a whole bunch of other things. They had credentials now, because they did this. We got them awards and [national recognition].

There's a whole other story about some of the contributions Hubble has made to the biomedical industry. We just heard a talk—in fact, heard a piece of it this morning repeated, about a talk that they just gave about—a symposium, where these women came up and brought in letters why they feel they have a life now because of the biomedical stuff that came out of the Hubble instruments. Breast cancer [detection for example]. They can do a nonintrusive look with the imaging device that was developed with the Hubble detector technology, but the resolution is so fine that they can actually pinpoint when they just go in with a needle now and can pull out the affected cells. My wife actually just went through that not too long ago. That's a direct result of [Hubble]. And in some cases, they're detecting stuff that they would not have any way of detecting with past technology.

And there's a guy—if you ever want to hear those stories, talk to Frank Ceppolina. He's the actual Project Manager who ran … the servicing side of Hubble, because we had the science and service. He developed all the instruments and is still there running the project. He stayed. That's what he wanted to do for the rest of his life. But he gives talks all around the country on this kind of stuff; what came out of Hubble. He was just the Inventor of the Year for inventing satellite service; National Inventor of the Year, congressional-level award. The guy is super.

Anyway, but he's a Project Manager at Goddard still. He's sixty-eight years old and this is his whole life. That's all he's ever done.

Anyway, so we defined the strategic plan of what it could do. We initiated COSTAR. We formed a team. We [still] had the same [public relations] problem on Hubble. When you went home and told your neighbor you worked on Hubble Space Telescope, right after they found out about the spherical aberration, it was a joke. People were embarrassed to go home. I hadn't thought about that when I accepted the job. I knew I didn't cause the problem, but I hadn't really thought much about it. But we needed to get people—we couldn't get people to work on the project. They fled like lemmings. So I bought them with [civil service] grades. We got them some nice positions [and] grades. I had to fight—this was the largest number of civil servants on one project at Goddard ever, so [the Center managers] were not real happy about—and I kidded. I said, "I've got the number one priority in the agency. First, I'm going to take your people; then I'm going to take your money."

I put on a recruiting campaign. I did things like—and I got a state license plate [for] HST, and it was Hubble Space Telescope, and it was numbered, [HST] [0]001, [0]002, [0]003, and people took a lottery out to see who got what number and they went and got them. And still, to this day, you can still apply and get a Hubble state license. I have number one, my wife has number two, and my Deputy has number three, and I think his wife has number four, and [the rest were] lottery drawn. …

But anyway, the point is—and you can still see them. They're probably about a hundred of them. But we did things to make a team. We got into the wine and cheese things and the no screw-tops and all that stuff. By the time we finished, we had about 180, 170 civil servants on it and lots of [contractors and university personnel], there were about 1800 people.

A couple of anecdotes that are technically interesting. One of them during that period—let me see if I covered what I wanted to talk about in that side of things. The COSTAR was the [first] big [addition, but in addition] we had gyros fail and we had to understand about gyros, and there were lots of things along the way that the mission kept growing bigger and bigger.

Two things were happening. Number one, [the mission was] getting more and more complex. The second is, JSC [NASA Johnson Space Center, Houston, Texas] was treating this just like any other EVA [Extravehicular Activity], [assigning] a team the year before launch. And what we were saying is this [mission is far more complex, and the crew needs to be assigned now], not a year [before launch]. And I would [go] down [to JSC] and I'd see the Deputy Center Director—the Center Director, [Aaron Cohen], was up in Washington at the time. … Then [Paul] P.J. Weitz was covering the Center.

I'd go and see [the head of the Astronaut Office] and they'd make a promise, "We're going to go to work [on getting the EVA crew assigned very soon]," and nothing would happen. They'd change [out office heads] and I'd come back and have to sell all over. …

So finally, in comes one of the infamous review committees, the Stafford Committee. So anytime a review committee comes in, I said, "if I'm going to have to put up with three days of dog-and-pony show for these guys, I'm going to get something out of it." So I made the theme, "We need the astronauts named now." That was the theme. So every one of my guys who presented had some reason why, "Well, if we had the astronauts—." We had some assigned to us, but we knew they weren't going to be the guys in the end. Because maybe the guy in the end is a left-handed—maybe he or she is a left-handed, not a right-handed person, and that would be a different procedure. Or maybe they don't like this type of tool, or they're different heights. That means we got to put the foot restraints at—all of these things you're orchestrating. It's a

ballet; every little piece of it has to be in place, and in order to do that, you have to have [the people who are going to do the job on orbit helping to developing how on the ground]. We didn't, [for example], find out till six months before launch that we had all the backup tools stored inside the Shuttle, which meant if you had a problem, you had to go back into the Shuttle and get the tools. That meant another airlock, up pressurization, depressurization, and that was the constraining thing on the number of days, and therefore, you would never have completed the mission. You wouldn't have been out there without—for want of a Philips screwdriver, to pick something simple.

Tool temperatures. We had to deal with the fact that we didn't know whether the particular repair activity was going to occur in the light part of the orbit; we had no way of predicting that at the time. We had to accommodate that also. We had ratchets that were sized for hot, normal, and cold, so they would pick the tool, the temperature. It was that complex, everything we did.

So to learn all that, [the crew] wasn't going to do this in a year [and we needed their experience to develop the right plan]. So I used that chant [throughout the review], and [Thomas P. Stafford] came at me, when he sat me down [after the review and said], "It sounds like your recommendation is that we need a crew [named now]."

And I said, "Like already, yes, tomorrow." He called back up the Administrator at that point and said, "I need a crew named," and he said, "Here's why, and I validated this, and this is their number one need, and if they don't do it, they're going to fail." And we had a crew named within a week. … [In reality, JSC already] had some picked [most of the crew] and, actually, they were arguing about one or two, and they were going to [assign them] to us probably about fifteen months [before launch], and [after Tom's call to the Administrator] we got them about

eighteen months before. [Without Tom Stafford's help, they would have continued to wait] in making a decision and then we would [have lost valuable] training [time]. They would have been undertrained. And training has paid off on [when] had a number of [on orbit] problems. …

The second review we had was the same thing with the number of EVA days. Typically, we only allow one. We said we need two. We finally filled up two and then some. So we used the second review to point out how it's mandatory to make these fixes [to HST], and this is how many days we need to do it, and go find out how we can do that. We knew [the Shuttle program was] holding EVA days in their pocket as reserve, so we [convinced Joe Shea, the chair of the second review to recommend four EVA days as our critical need, which was the number we ended up getting].

So we had eighteen independent reviews. We used every one of them to get something out that we needed. Never money; we never needed money. We met the schedule in the end. In fact, we tried to launch one day early and the weather came in and it held us up. And I said, "See? I told you we weren't going to get off until the 1st of December," or the 2nd or whatever it was.

So we met [all the mission objectives]. We had some interesting problems on orbit, which I can talk about in a minute, but there was a couple of other little things. One is probably little known, but it's real. The gyros needed to be replaced.

Well, let me go back. When we first started planning on what we needed to do, to do the servicing mission, we decided we wanted to put on the ground an electrical and a mechanical simulation of Hubble, in the clean room. One, for a lot of reasons, it gave the team something to rally around. It gave us something to test against and test anything we wanted to bring up and make sure [electrically and] mechanically it's going to work. It gave us the opportunity to have

the astronauts to come in and see exactly what they were going to see on orbit. And most of the equipment was available. We didn't have [the space money] to spend—but it was still like a 17 or 18-million-dollar decision I had to make. So I looked at it, "I want the pros and cons," and I committed to doing it.

Now I had to sell it to the science committee I made as a partner, because I did make [promises I would run by them any decisions which might impact the program in the future. They thought these simulators were a waste of money.]

I finally had to overrule them. I said, "I'm going to put 25 million dollars out of the budget for this. I can't tell you all the things it's going to do for us, but it's clear that my team wants it; I believe it; and I want to support it." So I got booed off the stage [by the science community] and I took the 25 million anyway and we built it.

Now, fast forward. We've got to change gyros. We want to test the first set of gyros. So we bring them to the clean room, plug them in, and the next thing I know, I hear, "Hey, they blew a fuse."

I said, "I blew fuses plenty of times as a tech." They're probably backwards connectors, but find out what caused it and make sure the procedures are such we don't do it again. Well, two days later. Blew a fuse. "What was wrong?"

"Nothing."

"Well, what's the size of the fuse?" Stick a penny in. You have to be old to remember putting pennies in fuse boxes. They used to have these screw-in fuse [in homes], and if you ever blew a fuse and you didn't have a spare fuse, the tendency was to take a copper penny and put it in there, which obviously the house would burn down before that ever blew. So sticking a penny in was always the answer when you blew a fuse.

Anyway, so continuing on. So [the team] went and looked at the drawings and said, "You know, that fuse is undersized."

"It can't be. It matches exactly what's on orbit." Because we had to spend a lot of time making sure we understood what's in orbit. That was another thing we did [to make sure we built these simulators right, not just look at drawings; we] went out and talked to the engineers and technicians [who built the HST].

So we went and did a little test and we said, "That's the wrong size fuse." We looked into it and we found, I don't want to say all, but a large majority of the fuses on the spacecraft that was flying on orbit, were not sized for bringing up a new piece of equipment, plugging it in, and turning it on. Well, it turns out it was designed—we're back to every five years—it was designed to bring it to Earth, replace the components on the ground in a perfectly benign environment. The fuses in a vacuum—if it's a one-ampere fuse of current, when it blows, if it exceeds one ampere in a vacuum, you derate it by 50 percent, because in air, it uses air to take away the heat, so that helps the fuse function as a fuse for one amp. In a vacuum there isn't any air, so it will only take a half amp to blow that fuse, so you've got to make it twice as big. And if you bring it back to Earth, you don't have to think about it that way.

So what did we find? We found that there were some areas where they either added equipment later or [just sized buses wrong]—we do not know. … Why else would it be that they'd have them designed that way? This wasn't an accident. [We redesigned the fuse modules and replaced them on orbit as part of the first servicing mission.]

But what would have happened, had we not had built [the simulators, we would not have discovered the buses were undersized and] we would have went up their on orbit, plugged in the new instruments, turned it on, blew a fuse, [and we would have failed to fix Hubble]. You can

imagine the agency would not be an agency today. It would have been the embarrassment. A lot of people viewed Hubble as a make-or-break for the agency. [Something as simple as blowing all the fuses] would have been an extreme embarrassment, and we only [avoided] it because we [made the decision to build the simulators and more importantly test everything no matter what it took before we brought it to orbit]. I am not the hero on this; this guy Ceppolina, who wouldn't let me sleep at night unless I funded [the simulators is the hero].

The [instance in which the HST simulators paid off] is [when] we were testing, replacing COSTAR. We had the astronauts come in and we had the real COSTAR plugged in, and they stuck it in and they said, "This doesn't feel right. I don't want to push it any further."

We said, "Why?"

They said, "Well, we've been training with the mockup you sent us from Ball, sent us one or the other instruments in the water tank for six to eight months now, and this is not the same feel. It feels like it's binding."

So we didn't know what was going on, so we pulled it out, we looked at it, and after a little while we found that there were two different instrument designs. One had a little lip on it and one didn't, and the one they were testing with didn't have the lip. …

Technically, they just had to push the instrument and it would have went in, but on orbit we wouldn't have done that, because we would have said, "What's going on? Something we don't understand." We were always worried about insulation, [for example, blocking the instruments].

But again, having it in the simulator, finding out, and then using that to [fully test the flight operation which led us to discover that] there's two different [instrument housing] designs. … [We avoided what would have been another major] problem.

But I guess the biggest one was the fuses. There would have been no escape from that. Everything we plugged in would have blown the fuses and then that was it. It was over. Over to the point where Hubble—we couldn't even have released it. We would have put it out and it was dead. I mean it was over. We couldn't come back again. We could have released it, but we couldn't have come back again. I'm not sure we could have released it safely, because we couldn't fire up the gyro to know it was going to be stabilized when it went off, it might start doing this [gestures]. But I don't know. That's stretching it, but on the other hand, the real point is that it would have been a dead spacecraft and the agency—I don't know if it would have survived from that embarrassment.

WRIGHT: Where were you when the crew was doing the servicing?

ROTHENBERG: I was in the mission management room [at the Johnson Space Center Mission Control Center]. I had to approve anything that was outside the nominal plan. For instance, I was the one who, when they had to kick off the solar array—I [knew that once the old array jammed during rollup, it posed an EVA hazard and schedule risk to try to unjam it. I decided] that I didn't want [the crew] to fiddle with it anymore; let's just get rid of it. The Europeans were furious. Everybody was pounding on my desk. "You can't do that."

I said, " *(A)*, I don't want to spend any more time fiddling; we've only got so much time up there. There's no reason I need to bring that back, and I don't want to take any chance of even remotely tearing an astronaut's suit, even put a little perforation, sharp edges and everything else. I'm getting rid of it and that's it." So that was one.

Another was—only a couple, two or three decisions I really had to make. That was one and it was minor. The other [I always needed to ensure that] was at the end of every day, [after] we shut up the observatory and the astronauts went inside, that if during the night there was a Shuttle problem, we could release the observatory and we could come back to it another time; it was safe.

[As an example], one of the other problems we had was they couldn't close the doors back up over one of the instrument compartments after changing out an instrument. Story [F.] Musgrave was out there and he said, "Hey, I've got a come-along," which is a very high-torque device. They use them in auto shops. He said, "I've got a come-along up here. I can put that on and I think it'll work. I've practiced it [in the water tank at JSC]." He did, and a lot of people didn't want to do that; they wanted to go analyze it.

And I said, "I want to leave that thing so I know tomorrow morning, if I wake up and the Shuttle's gone, it's out there safe." So I said, "Let's do it." And you don't just do it that easy. You've got to bring the team together, hear all the things, and they say, "Do it," and you've got to do that in rapid time. You're out there for only so much EVA time.

But other than that, it was pretty benign. I did the press conferences and I would just sit there and watch every little step. And then periodically, actually, there were a couple of other things I intervened on, too, but I don't remember. But in general, that's what it was, and if I needed to talk to the crew, I went into the MCC [Mission Control Center] and did what I had to do from there, but I never did.

Anyway, that was kind of the Hubble servicing. I don't know if you have any other things.

Had a great team. My job was really to deal with Headquarters and Johnson [Space Center] and the outside. Inside, my goal was to balance the ongoing science program and the money we were putting into that, taking money away and making sure I kept feeding Hubble.

One other minor thing. We were on the front page of the newspaper all the time. Hubble this and that. The thing that got us off the front page of the newspaper, [Operation] Desert Storm. We were just reminiscing this morning. We were driving back from Perkin-Elmer and it was snowing. We were supposed to fly out of an airport in New York and couldn't get off the ground, so we took the rental car and kept on driving. There were six of us packed in this car, because originally we turned in one car, and realized what was happening and we kept the other one. We piled us in the car and we drove south. They announced we were now actively bombing Iraq. My first reaction was, "That'll get us at least below the fold, if not off the front page." We did not surface again for about five months, in the paper, actively, until we announced our service mission with [moving] forward, "NASA's planning this high-risk fix," and all that stuff, rather than "in spite of," an embarrassment, [which prior to Desert Storm was typically] the leadoff [for Hubble] articles. So [the] diversion [of the press from Hubble problems to Desert Storm, was a relief for our tired Public Affairs Team].

That's really what made me laugh, if you think about what went on with a couple of incidents when [President William J.] Clinton was having problems with—what is it? *Wag the Dog*. That's so true. You create a diversion. We didn't quite create the war, but at that time, if you remember, he was going to bomb some place or do something at the same time he was having trouble, and it sort of took him off the front page of the paper. Well, that helped us in Hubble, that same little—so that made my life a little easier, because if you get in the paper, then

the Congress and Headquarters keeps calling. If you're not in the paper, they forget about you, for a little while, anyway. For at least a week.

WRIGHT: Soon after the Hubble reservicing mission was over, you left Goddard.

ROTHENBERG: Yes. What happened is, at the end—and I'll talk to that and then we can pick up the next chapter in a minute. What do you do next after you do [a HST]? I wanted to do something fun. I just didn't [want to] run another project. The Administrator talked about one day maybe—when [the Goddard Space Flight] Center Director retires, certainly he'd like me to step into that job. …

So I casted around, and CTA had bought this little spacecraft company called Defense Space Systems, DSS. They bought DSS from a combination [of owners]. TRW owned 20 percent of it and the company itself. And when [Daniel S.] Goldin was with TRW, he was the guy who bought the 20 percent of [DSS]. It was a small company, 200 people. It had built twenty spacecraft at that time and they had five in the queue, and it was just neat.

… I knew some of the people there. And when [CTA] took them over, the President wanted to retire. He and I had talked one day at dinner about me actually coming to work for them a couple years before, but I didn't want to leave the government; I was doing the servicing mission. I said, "Maybe later on we can talk again." [He] called me as soon as the Shuttle [landed] and said, "Okay. [I] want you to come and take the company over. I want to retire. We'll work together for a year or so and then I'll step down and you'll take it over." And that was kind of an opportunity that I couldn't refuse, and I [also] became President of [CTA]

International, which has since sold a big communications satellite, and Executive Vice-President of [DSS].

Well, [I went] there and then restructured the company [for pursuing high technology satellites and] had fun. … One guy built the company, had everybody reporting to him. Really wasn't much of an organization. They had some overhead management problems because [the President] was picking and choosing who he put on what program personally, and when he didn't have time to do it because he was wrapped up in technical problems that people didn't charge overhead for weeks.

So I went in there and the first thing I did is I looked and we were about ten people over [budget], so I said we had to get rid of ten. I got rid of ten and then I told everybody else if they were charging overhead more than an hour [a week], they had to come see me—two hours in a two-week period—they had to come see me and tell me why. I wasn't going to fire them, but they saw these ten people that were let go and they said, "Hmm."

So then I structured the company to have other people [than the President] who could evaluate who should be on what job and who was worrying about "Do you have a job charge?" kind of thing. I actually cut their overhead down. I renegotiated the lease, and that was a surprise. I was renegotiating to keep the same price, and the landlord came back and offered us at least 25 percent less than we were paying, so we took it. In fact, as we hesitated a minute because we were flabbergasted, he dropped it a little more. He said, "I forgot. There's one other thing I can take out." And he did it by showing us how he could do it, not just "I'll make it cheaper." So we signed up for five years.

Then we had a company that owed us, in my mind, 3 million dollars, and in their mind they didn't owe us anything. I went up and saw them and I said, "The contract didn't say that

because we overran the budget by 3 million dollars, you don't pay us. It's a cost-plus contract. Cost-plus."

And they said, "Well, we don't have a cost-plus with the government. We had a cap."

And I said, "Our contract doesn't have a cap." And we had delivered our spacecraft to them and they weren't paying us for it. I said, "You've got our spacecraft. If I really thought about this [before] I wouldn't [have] let it leave the factory."

They said, "Don't worry. You'll get your money when we get it with the government."

I said, "But you're not going to get it from the government [soon]; maybe never," and I said, "You still owe it to us." This was Westinghouse. So I said, "I'm going to do something. I don't know what I'm going to do, but we can't let you have the spacecraft. I want my merchandise back." There's a mechanic's lien—a guy does something on your house [and you don't pay him which has him paid first when you sell the house], and we found out we could get a thing called an injunction, [which did the same thing for our spacecraft]. So I had the [CTA] attorney get an injunction.

What an injunction meant is [Westinghouse] couldn't sell that spacecraft to recover their money without paying [DSS] first. I had like first mortgage on the thing. And, son of a gun, if they didn't sell the spacecraft. So, *(A),* they paid us the money; then, *(B),* the guy who bought the spacecraft gave us 2 million dollars more to modify it; and number three, I talked Westinghouse out of a bunch of equipment that they had, that could we borrow it, and it was so much easier for them to give it to us. Well, when they give it to you, it goes on your books. So not only did we recover our [lost] money, we made a huge profit associated with it. Now, write up a profit. The company went from being in the red into the black. In fact, when I left, they

gave me the [larger cartoon] check for 2.4 million dollars, the upfront check for the spacecraft. I still have it someplace in my junk in the basement.

Anyway, I had a lot of fun and I got them into the high-tech business. We won a prime contract building a high-tech spacecraft, which they never did, which we pulled together a team with Lockheed Martin and we were the prime and did that. We also won the small spacecraft contract at Goddard, which was a 200-person contract to be their small spacecraft builder. And it was only a 200-person company, so I doubled the size of the company and also got them into high tech. That was a great year. All these things I didn't do alone; I did it with a lot of good people, but it was what happened while I was there and running things.

Then Goldin came after me and said, "I got a deal for you." Originally he talked to me about being the Director, but he said, "I really would like you to come in as the Deputy Director and help me find a Director who's a scientist. I want you to run the Center and I want a scientist."

I said, "Great. That makes sense to me." I really wanted to go back to NASA anyway. I really liked having a mission. Making money was one thing, but having a mission is fun. And after three months, we interviewed a lot of people. We couldn't find somebody who wanted to take the job, and I took over the Center. I'll talk about that, the reorg [reorganization]. That was whole process. The reorg was—the first thing we did was lay out a strategy, what we wanted to be when we grow up. What business are we in now? The environment has changed since the Goddard Space Science Center was formed in the last thirty years, and we can talk about that after we—

WRIGHT: Okay. Let's take a break.

WRIGHT: We left off when you were getting ready to accept a job as the Director of Goddard.

ROTHENBERG: Yes. Let's see. As I mentioned, I came back, and the first thing [I found was that] the agency was going through tremendous changes. They just had gone through the zero-base review, which you probably have reams of stuff about. They declared that Goddard—Goddard was at that time the largest Center in the number of people, and zero-base review concluded, or was asked to conclude, however you want to think about how they got there, that Goddard was too big and they ought to reduce the size of it. So that was point one. It was at 3800 people, and about 3000 people was the target. So that was a fair [drop]. I became Deputy Director; the Director and I talked for one week, and he left and that was it. Although I had access. Even to this day, he and I are friends. That's not the point.

But there was no Deputy; it was me up there. So that was a little scary, a little bit, because you're going from a Project Manager—I did a little of the institutional stuff for about three years and then suddenly become Director of the whole [Center], it's kind of a big jump. Usually you come in and you have a Deputy and a staff, and I really had to start from scratch. That was the first part.

So I spent a fair amount of time deciding what was wrong with Goddard and what was right with Goddard. I came in with the focus that I was going to make change. I never even thought about leaving it the same. I don't know why. To this day, if I look back, I don't know what gave me the [idea that Goddard needed change]; it may have been the discussions during my interview with Goldin. …

So I came up with what I thought was a plan, and that was first to go survey all the people that deal with Goddard, walk around and find out what do they think about Goddard. I started even before I came onboard, as soon as it was sort of public knowledge, and I came to the conclusion that people thought [Goddard was] insular. You hear that about Johnson, too; they were insular. That they thought that the world revolved around them and that nobody else out there could do what they could do; therefore, they were [a national] mandate. So I had to remind [my staff] that the cold war was over. [We needed to ensure that we remained relevant to the nation]; we were a luxury, and plenty of people can build spacecraft and fly instruments, and they don't need us, and they build launch vehicles and they don't need us. That [came as an awakening to the Goddard staff]. You can say that till you turn blue; [at first] they don't believe it. The first point.

The second thing that was wrong with it is they were not forward-thinking and it was part of the same result. [The Goddard scientists] were an exclusive club in the following sense: when there was a scientific investigation, they wanted to lead it, and if they couldn't lead it they, [if they didn't], in many cases, wouldn't play on the team. And in many cases, that led them to losing the competition, the scientific competition. Therefore, in essence, the best science and the best scientists should win a scientific competition and the team should be made up of the rest. They didn't view it that way, so they were continuously trying to win and they were spending a lot of time just bidding, writing scientific grant proposals and not really as high a percentage of wins as you would expect if you do a sanity check with a world-class institution. So the second thing is, they had to find a way to partner and engage the external community.

The third thing is, there were many fiefdoms in the Center, where they built up, for a lot of reasons—in fact, I was probably as guilty as any of building a fiefdom up at Hubble, where

instead of going to the Center Engineering Directorate and getting engineers, [projects] went and hired their own, and they formed many engineering groups all around [the Center], and [in] the Sciences Directorates [also], so there were many engineering groups. …

Number four, there was no way of prioritizing the work for the [Center] workforce [as a whole], because every fiefdom prioritized against their own funding source instead of prioritizing it against the Center [needs]. …

Then the next [challenge] was that technology had changed. Not only had the environment changed, but technology had changed, and there were technologies now that actually allowed us to do things or buy things commercially that we were [still] doing ourselves. NASA had a belief that if we wanted to go to High-Definition TV [HDTV], we had to develop our own; we couldn't just go buy a commercial one. I actually got in the middle of that, because they tried to do that on my watch. The TV guys came to me [and proposed a plan to develop a unique NASA approach to HDTV] and I got in the way of that and forced them to do something different. Actually, I wrote some notes down about that, because I'd forgotten about that until I started to think about the whole way I started this thing.

They weren't buying commercially available stuff. They didn't have a systems engineering [approach], they were attacking things piecemeal and coming up with "This is the design," without thinking about the big picture. In that case, they weren't building as good a product as they could or buying as good a product as they could. It didn't matter whether they built it or buy it; they didn't apply the right thinking process to it and we had a lot of trouble with some of our satellites because of it. They worked on orbit, but it was more costly to get there.

So I sat down and I laid down [some strategic transformation guidelines]. I had seven things, and each week at my staff meeting, I [rolled one of them] out [for discussion]. First I

rolled out all seven of them and I said, "Here's what I think is wrong. We're insular, we're this, we're that." Then I said, "I can say what's wrong, but here's what we're going to do about each one. We're going to become viewed as an enabler by the community. We're going to get rid of all of the infrastructure [for] the things that can be replaced by [commercial] technology, and then buy things commercially. And we're going to put together a strategic plan that recognizes the current value [of Goddard] to the community and what we need to do in the future [to increase our values], and they're going to either like it or we're going to change." In other words, they're going to drive us instead of we're driving them."

I turned it around and said, "We have a customer, and you can look in the dictionary. There really is a word. It's spelled with a *C*, not a *K*, and that's why you never could find it before. But the science community is our customer and we're going to service them. Therefore, we're going to respond to them rather than inviting them to help us when we run out of ways to do it ourselves." I went through these things and I became a drumbeat. I did this from day one. I became Deputy Director. I was going to run this place and I told them that, no matter what happens, this was going to happen, and I kept trucking down that [path].

Then I got involved with the Administrator in putting together the project management approach for the agency. He saddled each one of [his direct reports] with some kind of [agency-wide assignment]. That diverted me on one day a week or something, but, nonetheless, that actually turned into being the 7120 document came out of that, which is NASA's strategic project management plan.

[At Goddard], I commissioned a bunch of young people, the [potential] next generation [of senior management], who offered to come up with a Center strategic plan, but I told them they had to get everybody to buy into it. In other words, they couldn't just go off with twenty-

five people in a room. They had to form teams and [having Center wide] focus sessions and lunches and, "Don't worry. I'll buy food," even if I have to by it out of my own [pocket] to get people to come so we get the whole Center engaged in this activity.

So that got them to thinking about it, and we didn't really give them a lot of guidance as to what did they think we needed to be in the future. Then they'd come back and present to us and we interacted with them. It was interesting, because we had them put together a set of Center values. In fact, we didn't [ask] them [to] put together a [set of] Center [values, but] the first thing they did is establish a set of values. What did they think the employee values were? They came back with "Integrity, partnership, a balance between your work," and a whole bunch of things.

Then we said, "Okay. If that indeed is the value system of the employees, we've got to change the reward system to match the value system," as an example of where this one avenue took us. That was just this little piece of it. And ultimately, we put in place a different promotion system. We put in place a different [set of criteria for] Goddard awards [to reflect these values]. I couldn't change the NASA awards, but I could change the Goddard awards. [One example is "teamwork."] The guys who got rewarded were the ones that formed partnerships and teams—you got an award for that—rather than being the best inventor of the year. [As another example, we changed] supervisory awards to be for mentoring employees versus [the past where it was for] having the technical strength and being the technical leader. It's got to be the [people] who develop. The guy can be dumb technically, if he's great at mentoring and developing people, but he needed to know his business really well, because we were a technical organization.

Anyway, [as we reformed the Center organization along with the new strategy plan], I started out with eighty branch-head-level people. Forty of them disappeared. I took forty out of the eighty and said, "You guys are the branch heads [in] the new organization. Take it from there." The other forty, I put together a team [which] normally [would have had] the Division Chief [doing the] interviews. I said, "No, I want people outside. Here's the criteria they're going to select them from. You can have someone on the team who can understand the technical qualifications, but I want someone from HR [Human Resources], not who's just a cop, but somebody who really is an HR person, not just a clerk. I want somebody from Programs," the ultimate customer. I made different people form these teams, and we actually came up with forty new branch heads who all were people-[oriented not just technically focused]. … And I had not one EEO [Equal Employment Opportunity] complaint. Had not one complaint against—I worked the unions and everything else to do this. I removed a bunch of Directors of and I just changed a bunch of people. They were [in the] wrong [jobs and needed to be reassigned for the future growth of the Center].

[Some actually] came in and volunteered [to be reassigned]. They saw where we were heading. They said, "You need somebody different. I'll help you, but I'm not the right guy to do that."

I convinced everybody we had to turn it over to the next generation, is what I really did. I took one of my bright young guys and told him he's the Director of this new directorate. That didn't work, by the way. He did it. He stayed there [for two years], but he didn't have all of the skills necessary to make him an effective Director. Eventually it got absorbed by another one because it didn't work out for more than one reason, but [only] part of it was the leadership, that was a mistake on my part.

But going back, I had [the seven guidelines], and the first thing I had to do was get everybody onboard. It was clear I wasn't going to get anybody onboard easily. They all listened, they did what I said, but they didn't feel it. They had to feel it. If they didn't internalize it, we were never going to get there, because I couldn't make every decision day and night. That wouldn't work. That never works.

So I spent from April till September [of 1995 when I returned to Goddard], then in September we went away on a [senior staff] retreat and I gave each one of them, each of my Directors, I think I gave each one one or two of the seven items, and I said, "What would you do to go from where we are today to where I think we ought to be?" And they came back in and we came out with a plan. That's where change the value system came into play, and the strategic plan and all that.

Then the strategic planning activity went on for the better part of a year, maybe even more, maybe eighteen months before we actually published it. So that was going on in the background.

Then at the end of the strategic plan—I was going to reorganize around the strategic plan, and I then needed some immediate early wins. The only way to get something like this to work is have some things that are early wins, such that everybody sees the value and the benefit of change. That's a textbook approach, but that's what we did, and we picked three areas.

One, when a scientist needed a spacecraft to support his mission, he generally had to [go through a six to nine month procurement process just to get a study contractor for the spacecraft] even though he was only going to propose against an announcement of [competency against] forty other [teams for one or two studies]. But he needed to have a spacecraft contract agreeing to build for a price, so he could submit a [study] with a price [to implement his science

investigation]. So he had to go through a regular formal government procurement process, which is a waste of time [and money at this stage of the process]. And having come from this little company, [DSS], we were getting ten, fifteen, twenty requests for bids, to submit bids where we knew they might at best only one would win, and I [didn't have the bid and proposal resources to support that many proposals] in a small company, so I'd pick three [to respond to]. And I'd say to the other fifteen, "I can't support you." And I was just spending the government's money, because it was bid and proposal money, which is in your rates, which is charged back to the government. So we're throwing the government's money away by doing this. So I wanted to [fix] that.

Then the second [piece of the same problem] is, it takes too long [to procure a spacecraft and it doesn't have to]. It takes six to nine months to run a government procurement process. So I formed one team [to work on the spacecraft procurement process to reduce cost and simplify the scientist's task in both the study and final proposal phase]. I said, "Okay. I want you guys to go look at this and tell me how—." Before we did that, we set a bunch of metrics for the Center, and we almost pulled them out of our ear, but myself, my Deputy, Center Director, and a couple of other people, [looked at the problems and said], "Today it takes us nine months to buy a spacecraft and get the contractor on the contract, even if we're not buying it, we're only buying a paper design, to get a proposal in and select one. I want that to be three months by the year 2000, and I want it to be one month by the year 2005. The second thing, it takes us thirty-six months to build a spacecraft now. I want it to be twenty-four to thirty months, depending on the complexity, average by 2000, and eighteen to twenty-four months by 2005."

And there were a bunch of other metrics [we set for the Center to improve our processes and customer support. We set goals for the Center and published them.] … Then I formed

teams to start to look at how do we [achieve] them. One engineer, one Project Manager, and one procurement person [formed the spacecraft procurement team to figure out how to achieve the metrics we set]. I'll just take that one example. I'll give you two. There's probably four good ones, but I'll give you different depths on each one. …

[In the midst of this, Dan Goldin called me and told me I was his selection for Center Director.] I got the Center on the pipe and just said, "Hey, you're stuck with me." See, that was one thing. I'm one of the few Center Directors at the agency that grew up at the Center. I did every imaginable job; support service, prime contractor, every kind of job there, Division Chief, Ops Manager, Project Manager, so I knew a lot of people. So that helped, because I could make changes and I knew how to do it without doing the wrong ones, in most cases, like anybody. Not all cases. I didn't know everything. In fact, I learned a lot that I never knew that I should have known when I became Center Director, about what we did and other things, and probably a lot I didn't learn that's still going on that I don't know about.

[Back to the Spacecraft Procurement Team], this little group came back to me and said, "Well, we looked at it and we found it takes three to four months to write a spec and four to five months to run a competition. Two months to get the proposal in and three months to do the selection evaluation. So if we made the spec [time] go to zero, no engineering, it would still take us five [months]; we can't get from here to there, [buying a spacecraft in three months]."

And we said, "Try again." It was like what we did when we were doing that propulsion modular spacecraft that I talked about earlier. The same thing. The designers kept coming back in with more complexity and we kept sending them back. They finally came in with an answer that made sense and they were happy and we were happy.

But in this case, I said, "Try again," and we sent them off. Meanwhile, a couple of vendors were coming in, and contractors were coming in and saying, "Hey, we've got these standard spacecraft. Have you ever thought of buying these things?"

And our engineering people, "No, no, no. Every mission we have is unique. You must never do it."

So Al and I had a little chat and I said, "What if we told them that they could buy a whole bunch of standard spacecraft or have a catalog of them, and what they would do when a PI [principal investigator] wanted a spacecraft, is just say, 'What changes need to be made to this standard bus?' And if we had five of them, there's bound be one that's close to what they need."

So we talked to these guys. They came back and they bought into the idea. They figured out a way—and we had procurement regulation issues and every other thing to overcome, and they came up with a proposal [approach to being able to pre-qualify spacecraft contractors and use a simple task order competition to select s/c as needed]. And we had criteria for how anybody who had a spacecraft could qualify it, and put it in a GSFC [Goddard Space Flight Center] catalog and we would publish [the] catalog and we would give them a chance to update it every six months or a year. … They couldn't have a paper spacecraft; it had to have gone through environmental tests, okay, and have some level of credibility. And there's an on ramp, by the way. If you want to submit a proposal and say, "But I recognize I'm not going to be in the catalog until I get to this point," you can do that. … We weren't trying to exclude anybody. [The team who] looked at doing this [also ran the procurement that] put it in place; [it's called the "Rapid Spacecraft Catalog" or something close.]

Well, the first space spacecraft got bought [from the catalog], it went from "I need a spacecraft" to having it under contract in thirty-two days. It went from "I need a spacecraft" to

launching it in thirteen months. And the [initiative was] a success. It's got written up—but it stemmed out of saying we've got to do things different, environment changes. So there was a win, but the value of that win wasn't to be seen for about another year and a half or two years from the time we figured out what we wanted to do. But we kicked it off, and it's changed the way industry supports Goddard. It's changed everything. So that was one of the things of the strategy that worked successfully.

The other thing we wanted to do is [reinforce the] new value system, so we wanted to change the promotion system, and one of the things is there was only so many GS-15 slots and GS-14 slots the Center had, and there was a lot of people encumbering them and who really weren't working at a GS-14 and –15 level. They were retired in place. Some of them we inherited from other Centers, Headquarters, and things like that.

So I sent off a team to look at the promotion process. Everybody considered their promotion process like naming a pope. We went into a room and, white smoke and you got elected; black smoke and it wasn't your turn. It was a negotiation. We had a process; it was a pretty good process, I thought. I inherited it and I continued to support it. Then I looked at it and said I can't think of a better one, and no one else could, but the employees had no belief in it. They believed that somehow it got into favorites [promoted]. Generally I really looked at that hard. I looked at all of the names. I looked at the ones they brought forward and all eligible at the Center. I spent some time trying to understand, and, yes, there was some selectivity based on time in grade and stuff that we didn't allow people who were too quick, no matter how good they were, just because there was enough good people at the next level up that we—we had some way of screening them and filtering the process.

So what we did is, we changed the system. I got, again, a bunch of employees, [including] secretaries [together], and said, "Build me a new promotion system."

Anyway, they went off and they came back with—well, all they wanted to do was make more GS-15 slots available. That was what the whole thing—we knew that. Everybody knew that. That's what we all wanted to do. There's nothing wrong with that. We had a number of deserving people. We called this the promotion reengineering team.

Oh, by the way, I had everybody go to reengineering school, and whenever we started up a new project or process—I believe in reengineering, as a former systems engineer, and I've been doing it all my life and I've seen it done all my life, and somebody called it reengineering, packaged it for management, and it's really thinking about things as a systems process. In fact, it's one of the things I teach occasionally now.

So all the senior management [also went to reengineering school]. We all went and had our fun. At that particular school, you make this little solder thing. [We learned to] make it better and faster and cheaper [than our first try]. So everybody understood the process [and I continued to encourage Center employees to learn about reorganizing]. … And we got that going to the point where, when I formed [a] team [to deal with a problem], they knew how to approach the problem in a reengineering sense.

Well, [the Promotion Reengineering Team] laid out the problem analytically and [worked through a process] and they came in with [a] recommendation. And here I am, with all my directors, and they said, "Well, we got the [solution to the promotion] problem. What you've got to do is we've got to make sure the promotion process is fair and everybody sees the grade structure is fair at Goddard." And they said, "Clearly, the first thing you have to do is demote all of these [retired in place GS-14 and 15s]," so it became known almost in a microsecond as "Oh,

they're really going to love this. We told the entire workforce that senior management was going to go off and work and put in a better promotion process, and senior management got it wrong; they made it a demotion process, and it was going to be named the demotion process." Suddenly, the word started leaking out what was going on, and we cut that off at the knees. We said, "Okay. That's not going to work."

We actually had them go back, and they did came up with a better [proposal], and they came up with a [process that involved] a lower level [of] employees [in the promotion recommendation process]. Previously, the recommendations all went up to the Director. Now we put in some lower-level committees that actually looked at them [first]. There's a lot of reasons why people would argue with that also. You can look at that, and it also gets into a favoritism, but senior management is not omnipotent, so they make mistakes, too. So you could argue either way.

But they put in a system where there were—and it was the same with the award system. It was the same thing we put in [reengineering teams which proposed new committees and rules for] the award process, and I sat through a few of them, and it was surprising that people got awards that normally wouldn't even have gotten visible. We put a secretary on all the awards committees, and that made a difference because she looked at things from a secretary's viewpoint. And we changed some awards where administrative people could get awards on the same par with technical people. Their contribution might not have been as directly recognizable, but their contribution was there, clearly.

So we did things, but those were the kind of things that we went through [at the same time]. We went from 3800 or 4000 down to 3200 [employees]. Didn't have a layoff. Didn't have to do anything. We were able to do it by attrition, by watching our attrition, and selective

hiring, allowing the attrition to exceed hiring by the right amount. And I made some deals. I brought in some new work that I knew that would take care of a certain group of people [whose current jobs were being outsourced].

Then I tackled the organization. I went through a whole bunch of reengineering. I got a strategic plan. The strategic plan centered around enabling the external community; we becoming recognized as the experts, but we enabled the external community. We formed joint centers of excellence with universities, where we jointly pursued research, and that really worked out well. We got fifteen or twenty of them in place with major universities in the country. It became a real model for a way to do business and also made it inclusive instead of exclusive. I had to get all the advisory committees and all the science groups and talk to them and tell them why we were doing this, because otherwise they [would be] beating on [our] scientists for operating differently. The scientists began to hate the word *enable*. You say *enable*, and they say *Rothenberg*.

I took apart one division that was building spacecraft in-house—they thought that was the only way to build a spacecraft—and said, "No, we're actually going to buy them," and they couldn't understand how you could do that. That's the division my daughter-in-law was in, [and she heard more than once], "Oh, what's your father-in-law doing now?"

But I actually sat down with that whole division, face-to-face, more than once. One time I was down [at JSC] during one of the follow-on servicing missions, just being on Center in case there was a problem, and I spent every night answering e-mails. [I] remember my twelve hour [shifts]. I wrote personal e-mails to everyone in that division who wrote to me, explaining to them why. They bought in after a while.

I had Senator [Barbara] Mikulski to deal with. "Why are you doing this?" And she listened for about two minutes and she said, "You're doing the right thing." And I felt good. She said it in front of 500 people at dinner, because one employee stood up and started questioning it, and I wasn't about to debate it. She listened and she thought about it for a couple of minutes, and she looked at me, and she said, "I think you're doing the right thing, Joe. Keep it up." And she said [to the employees], "I think you ought to talk to him, not me."

And I said, "We've talked."

I had union problems. I could tell you some of the union problems I had were not over that. I formed a—I'll call it a partnership council. I don't know what I would have called it, but every once a month I met with the union guys and said, "Tell me what's bothering you." I made them partner the whole reorg, and that all worked out well.

I had some union problems that were caused by one particular individual. They weren't union-related, but he tried to turn them into union problems and fizzled. He ultimately got voted out. But that's an aside. It has nothing to do with running the Center.

Let's see. I'm trying to think of what else in that whole—well, the strategic plan was such that it [was timeless, and is still the basis of Goddard's plan today]. It wasn't a budget-driven one. It said "This is the business we're in; this is one we're not in." I restructured everything, having spent time in a small company and having spent time in industry a couple of times, I knew about full-cost accounting. [In my view Goddard had to get ready for full cost as part of the restructuring of the Center we were undertaking.] … So what I had to do was look at, okay, how does that apply? How do we get ourselves ready for full-cost accounting in a government situation?

Number one, typically, one of the things you can do in industry, is when you don't need a group of people, some people, you can downsize. You can't do that in the government. You're stuck with the civil [servants]—so you have to have a system that accommodates the variation of [budget] or workload, but deals with the workforce fluctuation, and that's where support service contractors can—but in order to take advantage of that, you've got to be smarter than the [contractor workforce to be a smart buyer] you've got to keep the resident expertise, and we didn't do that. A lot of it was in the support service, so we had to recognize that and we weren't going to change that overnight, if we changed it ever.

Then we had to allow our scientists to be competitive. So when I set up how I was going to set up the overhead structure for the Center, I had to make sure that we could keep the [Center overhead] rates [competitive]. So I found out what everybody else's overhead was. They didn't even know what their overhead was. We went and figured it out. I sent a bunch of analysts off, even contractors off, to go look at the books at the other Centers and find out how much they spent on infrastructure each year, how much they spent on program budgets, then made some assumption about how much the Center Director is ripping off for his own funds, which I knew how much I took. We went in and figured out how we could be competitive with other scientists and other Centers and universities, what overhead rate we had to have on our science work.

Then we structured the rules on how you charge and what you work and what gets charged direct and indirect in order to get [the overhead to be where it needed] to be. Now these guys didn't understand it. They're government employees. They don't understand that, but I was able to each week get people in and [explain it] to them [in small groups]. And I didn't understand it all either. I learned a lot [in the Center Director position]. I knew what I wanted to

do, but I didn't always know how to do it. Al Diaz, my Deputy, worried about programs and I worried about restructure. That was the division of labor. That's what I wanted to do.

So every little piece had to all fit together. I started this little flowchart. If I thought about it, I had all these things written down. This is not something—there was a little logic chart and it said, I'm working on the workforce here, I'm working on the procurement process here, I'm working on the organizational structure here, and this is where they intersect and when I have to deal with both of them. And I kept that up and I used to explain it, and people ultimately didn't understand it, but I thought I did, so after a while, they began to believe I was crazy. "You don't have a plan."

And I said, "Sure. Here's my plan," and I'd show these bubbles up there and they'd all look at them. They'd turn it upside down and they'd make a big joke about it, but we generally followed that plan. It led us to the point where we had a strategic plan.

The point I want to make about—employees used to be able to [pick and choose what they wanted to work regardless if it was a Center priority] with full-cost accounting, they no longer could pick and choose what they wanted to work on. It had to be consistent with what was core business for the Center. We put in place a core process. We said this is the process of our Center. We get inputs, [i.e. customer requirements to support a science investigator], we system-engineer [them]; we define the best way to [meet the requirements], and then we apply the technology, buy, apply, steal, or develop, whatever, the technology [is needed] to do it, and we supply that to the [science] community, [our customer]. … Everybody bought into that, and that was another thing that went into the strategic plan, our process.

What was happening, though, was we had to call—I'll take one example. It's probably one of the most that makes sense. The [United States] Marines [Corps] came in to us and said,

"We want you to give us some help designing the next-generation amphibious vehicle. We want to use lightweight aerospace structure technology composites, and we know you guys do that all the time." Well, this would have been a dream [job for our engineers]. The guys would have loved to go off and divert themselves and go play with Marines and go down to [Marine Corps Base] Quantico [Virginia] and all that stuff.

I said, "Okay, guys. Is it in the book? Is it in our business? Is this what we're going to do or not?" So this is the [U.S.] government [asking for help]. We can't just toss them out, out of hand, and say, "Hey, go fend for yourself." We needed to help these guys. So we said, "Okay. We'll give them four hours. Let them come. Four hours is our budget. Let them come in and we'll talk for four hours, and at the end of four hours, we'll decide what we'll do or not, and I'll go talk to the Commandant, if I have to, and tell him why we can't do it."

So we listened for four hours and then we came up with a bright idea. We said, "What you need is not us; you really need access to the right—and we can help you there—contractors who really know how to do this. They're not building amphibians and they're not already polluted and doing it the old way," and we hooked them up with the right contractor. The Marines loved it, our guys didn't get diverted. In the past, we wouldn't have done anything different. They would have come in; we would have put ten guys; they would have told the projects who needed these engineers they took, "Go hire them." The projects would have cost more money, and that was the way they operated. That was the [old] way the Center operated.

I then made a couple of other rules. I said, "One Engineering Directorate and we're finished. Not fifteen little fiefdoms." And that took a lot of selling, because these teams were around for years together. I said, "They're all going to work for somebody different. I won't move them from doing what you're doing now if you have work for them, but if you don't have

work for them, I've got to have another job for them." Full-cost accounting. I brought that where I needed it. That was not my only reason for doing it. I wanted cross-fertilization of people. But full-cost accounting was as good a reason as any.

Then I set the organization. Well, I didn't really know how I wanted the Center organized. I knew I wanted one engineering [directorate to manage engineering]. I wanted a systems engineering function, so I again formed teams. "Go off and come back in with some recommendations on how to organize." Well, I wasn't getting anywhere. I was getting back the same organization. Turned sideways, upside down, it was the same organization.

I had one wise guy who came in and gave me a package of organizations at Goddard ever since it was—forty years. He says, "Here's every organization we've ever had. Pick one." He says, "You want me to pick one?" He says, "It doesn't matter. We're doing the same thing."

I said, "Well, function ought to follow form," and I said, "I want a systems engineering organization." So I finally just one night went home and drew out an organization on a piece of paper, came in the next morning, and the biggest guy that was impacted was the Director of Engineering. I said, "I want to take apart your directorate." His name was [Allan] Al Sherman. I said, "I want to form this systems engineering."

He said, "That's exactly what's needed." He says, "I'll help you. I want to head that new group." And I couldn't have a better guy step up and say that. About a month later, he realized he shouldn't have done this, [he gave up a great job], but anyway, he agreed to do it.

So now we started to—and I said, "I want to take this Code 500 that does all [Mission Operations and Data Systems]." I said, "Eighty percent of that we could buy." I said, "I want to disband it. It's gone." I said, "Here's want I want. I want to create jobs for these people to go to. I want special provisions that even though they're not doing that job, they can go in and

apply for a GS-14 job that has some skills, and learn on the job." I forget what we called them. We had a name for them. It became an agencywide—I forget. It was Job Opportunity, or Opportunity Jobs, or something, or Career Opportunity Job. It had a unique name that distinguished them from a normal posting where everyone was just going up the chain in a technical discipline and applying for the next job. We worked with Personnel, we worked with PAO [Public Affairs Office], we had a job fair [to recruit for these new opportunities in the] auditorium. … I was trying to create a "go-to" rather than a "push-them-out" [flow of employees to new jobs that were more in line with Goddard's future]. I wanted people to run to new jobs rather than push them out. We were[n't] offering [civil service] grades. We were offering a chance to do something new.

So we published the [job listing], and it backfired. Everybody that applied were in jobs that we wanted to keep them in. [Laughs] But it turned out that we went through with it and we moved them. It turned out that took a little longer [to move the right people], but it caught on. … The problem was that their—this directorate, rather, with [the] 500 people [I was disbanding], the problem was the Division Chiefs were saying, "I need you. Don't go to a new job," and, "Don't go looking for a job," because he still had work to do, and [the Division Chief couldn't see how a] transition [to having their work outsourced] was going to happen.

So we had to help that, and once we did, people more and more—we actually reprogrammed almost all of the people. We never had to lay anybody off. We [reduced the 500 people] down to a group of 80 people, which is what we needed, and the other 420 either retired or went on to other jobs. And again, we didn't fire anybody; we didn't make anybody feel uncomfortable, although they got the clue that I might have put them all in one big corral and abolished that division, and therefore could lay them off. I sort of let that out as a hint, but I

wouldn't do it. I probably wouldn't get away with it. But I might have to abolish some of these things.

Well, abolishing something, some people can get good financial benefit out of that in terms of early retirement. We got special early-out provisions. All the kinds of carrots you use to get people to change.

So we set the reorg in place, we set the teams in place, to say, "Okay, now that we know the big chunks," and I fought through all the engineers [in fiefdoms around the Center] who didn't want to move, and again, I met with all of them many, many times, and we finally got them to agree that they [would] all [move into] one directorate.

Then I took Wallops, which was a remote site—I'll talk about Wallops separately in a minute—and we said, "There's one Engineering Department, even Wallops. Wallops is now part of Greenbelt. But, by the way, to make them feel not as the outpost, I will have the branch head—a couple of branches are down at Wallops, so the branch is headquartered down there." So there was this two-way—some of the guys got really clever. They bought collaborative engineering tools so they all used the same tools [to make the Wallops and Greenbelt staff to be able to work our design together as if they were in the same location]. …

Then we set in place what's the next level of organization : [the Center, the directorates and the divisions within directorates]. It was kind of not one I would have chosen, and still to this day I'm not sure it's the right one, because, [in one case], it put a lot of power in one organization in the Center. However, it's there and it's still working.

Once we did that, again, we established focus groups. Every afternoon we had two or three hours. People could come in and just talk or we scheduled and invited people. We made sure that we brought along as many people as we could so when it actually came out, it wasn't,

(A), as bad as their wildest fears; and, *(B),* they had heard a lot of it already. "So what are you telling me new?"

Continuing on, we put that in place. Then we had to go to the union. After some fits and starts, the union finally rolled over. They spent the first three months—one guy in particular. It wasn't the union. It was one guy, the union leader, and he was a problem. He was trying to give me a hard time because I closed down his [auto] club. Well, I closed it down. I reopened it, but after he took down what I didn't like what he had hanging up in there—not what I—what the employees didn't like what he had hanging up in there. … We shut the thing down. He had a bunch of stuff hanging up in there that we thought was inappropriate. We told him to take it down. He said, "No, you can't. This is my own wall."

And I said, "On my property, endorsed by my council, and I'll shut the whole club down."

"No, you won't."

"Yes, I will."

"No, you won't."

"Security, put locks on the place." Senator Mikulski and [Congressman] Steny [H.] Hoyer got intimately involved with that one. [Auto club members] went to their congressman.

"You got my son's car in there."

"You can move the car out." I got special keys for people to do things to get one out. I wasn't going to open it until they took down what they had in there, and I wanted an apology.

[The union and auto club president] put out a newspaper [for] this club and had me hung in effigy on the cover. Eventually, he did what he had to do, signed in red, as a sign of defiance, and then immediately the membership voted him out, because he didn't even tell them he was

having this loggerhead with me until I closed the club, and that's when they figured it out. I gave them a lot of latitude to get their stuff out.

But he was also president of the union, so now—and this was all going on simultaneously. I put the reorg out in September. My goal was to get it in place the first of the year. I shut the auto club down at the same time. So this is not good timing on my part, but I can't let this other thing stand. The other thing was too serious, in my mind.

So I went through this process. We'd sit at the table and he would argue about not the reorg, but a bunch of other lists of things he had that—we were talking about the size of the table, before we could get around talking about the reorg. We went through this—so [we hired] a lawyer. I got myself a labor relations lawyer, attorney, and asked him what my options were.

He said, "Well, the only thing you can do is try to get him to negotiate. If he refuses to negotiate, and he says it, and he doesn't show up after you tell him there's two negotiation sessions, you've got two weeks, if he doesn't come in fourteen days, it's over." …

So one day we decide we were going to rile him up, we said, "All this stuff is stupid. We're going to either put this reorg in place without you and you're going to take us to court or whatever you do, or you're going to negotiate."

He said, "I won't negotiate with you guys."

His lawyer told him, "Listen to what they're saying."

"No." His ego got the best of him.

We said, "Okay." Meeting ended. Scheduled a negotiation for Monday. Scheduled one for Wednesday, one for Friday, one for Monday, Wednesday, and Friday, and go in the room and sit down. I sent my negotiating team. These were all SES guys, these people, and my labor relations lady, and they'd sit at the table. He doesn't show up. They leave. Sit at the table.

Okay. It's now—one week's gone by. I said to Personnel, "Get all the forms ready for transferring everybody. Just work on it. Quietly work on it all next week."

Next Friday was the deadline—and this was right before Christmas—at four o'clock in the afternoon, he hadn't made any negotiation sessions. At four o'clock in the afternoon, we sent him a telegram saying the reorganization is approved and effective Monday, and it was like four o'clock. We knew he left at four o'clock, but he hadn't shown up. Monday morning came and we had a fax on his fax machine, an e-mail on his machine, and a letter through the door. And we never heard from him again. About four months later, he got voted out [as union head]. I don't know what happened, but we never heard from him again.

But that's the kind of thing you have to put up with. The personnel issues you put up with as a Center Director are incredible. Things you wouldn't believe people do. And these are sometimes find out that somebody who's a very very—great employee, straight in every aspect, and has some weird thing that they do, and they become offensive or, in some cases, criminal.

WRIGHT: You spent three years as the Center Director?

ROTHENBERG: Just about, yes. Okay. We can jump on to the next one. But, anyway, that's sort of the whole thing. In that time, we had basically no mission failures. We had a great set of programs. We changed how the Center did business. They're buying spacecraft now rather than building them, for the most part. We put in place an in-house program for employees to do some in-house work. We got us out of the ops business in a big way and turned it all over to contractors, which do [the] work anyway. We put more control centers at universities, [established university] partnerships, and [left a] good strategic plan.

If you ever get to Goddard, the strategic plan—one other thing I did–I wanted to get buy-in when we first told employees, so I hired a guy—I wanted everybody to have a poster on the wall of the strategic plan. I got a guy in and I told him roughly what I wanted. I said, "I don't want it to be too traditional; I just don't want it to be a list." I didn't know this, but this guy was a pretty accomplished cartoonist, professional. He came and worked this immense cartoon that depicted our—he went around an interviewed people, not a lot, but he got enough to get the flavor, and he came in with a cartoon of the whole strategic plan. But it wasn't a cartoon with cartoon characters; it was just cartoonish in the way it was drawn. To show that we were taking down—we were no longer insular, we had bridges over the moats between organizations on the Center and outside the Center. We have geese and deer—geese population. They were spread around. We had scientists who were always teaching in the classroom, but we had the new strategic rules for what they were doing written on the blackboard. This is an immense poster.

When he brought it in, I looked at it and I said, "My god, what did I ask him to do? I'll never be able to show—." I had some pretty stoic scientists there, who didn't like to be viewed as a cartoonish organization. They looked at this and said—I looked at it for about five minutes and how do I tell this guy—and I spent I don't know what for this thing. Then I said, "Let me get the people that I think are not going to like this the most. Let me get them to go and look at it, but let me tell them what I want to do with it." I said, "What I want to do is, I like it. I really do. Let me get and put a border around it. I'm going to have every employee sign it and then make it into something they can—," and I brought over the Sciences Director. He is a really good guy, but he's just very formal. He looked at the thing, and I told him what I wanted to do with it.

And he said, "I like it." And that was it.

I said, "Okay." One more time I got the key people who I knew, if I don't get their buy-in, I'm going to hear forever grumbling. They control most of the workforce. Got them in and they bought it. And it's hanging up all over. It's still hanging in the Administrator's office down at NASA, in his conference room.

One other [institutional] thing we did [during my tenure], and I'll get off the Center Director. We decided [after] I had been at JPL [Jet Propulsion Laboratory, Pasadena, California] one day and they were having a Multicultural Day. They had ethnic foods being cooked out on the quadrangle out in front of that big building, and all the employees came out to get free samples of all the ethnic food. People were dancing and [singing ethnic] songs.

So I said, "We're going to have that and we're going to call it Celebrate Goddard Day. We're going to do that. We're going to do the same thing." So I got a bunch of employees in and told them what I wanted to do. It was an employee [multicultural advisory group]. I had a bunch of employee [advisory groups].

[As an aside, these groups were highly motivated and achieved things that represented NASA and their heritage well. One group] put in place remote mentoring for the Hispanic population up in a couple of parts of the country, where they could call in and get mentoring, the Hispanics who wanted to do something. So we tied in this remote mentoring, and that became a hit. We actually got a congressman to change his vote because of it. He couldn't believe what we were doing for his community, and he never voted for a NASA budget; he was totally against it. Union City, New Jersey. In fact, the school board came down and gave us a recognition award, they were so thrilled at what we were doing with kids there. Anyway, beyond that, it was a heavy Hispanic area. Beyond that.

[But to celebrate Goddard Day], I told the employees what I envisioned [based on my JPL multicultural experience]. I didn't think anything of it. The next thing I know, I get calls [from my staff], "Did you authorize—they came looking for 2,000 dollars from me, out of my budget, to do something about celebrating Goddard Day."

I said, "Two thousand dollars? What are they doing?"

He said, "I don't know, but it sounded good." I gave the money.

So people started asking me what was going on, so I said, "I just want to have a day when we take time out to do a lunch." Period. That's what I wanted. Maybe late in the afternoon and—it became, after a while, it took on a life of its own. I get [a request from] one of the facilities guys who wants to run major [conduits for electrical wiring] from one of the buildings out to the grass mall in front of my things. "Why?"

"Well, they got an electric band."

Bands coming in. I said, "Well, no, I'm not ready to dig up the road for [Celebrate Goddard Day] yet."

He said, "Okay. We're going to have to do it with temporary cables, but that means we're going to have to close that street that afternoon."

I said, "Okay." It got out of hand. I can still remember the day before, looking out my window, and now I'm on the sixth floor, and I see this red and white striped thing being erected. They rented an immense tent because they heard it might rain. A tent that 200 people could—no, more than that—could get under, [maybe as much as 500]. … They had bands from every nationality out there playing. They had vendors coming in with trucks selling stuff as well as people giving away stuff. They had art. Not only that, [there] were [sessions of some form] in rooms all around [the Center]. They had lecturers coming in. I started to get the gist of this

thing [earlier], but the tent I didn't know anything about [until I saw it being erected]. I didn't realize how big it was going to be, *(A)*, the whole thing. I knew they had various things, and they had films that talked about—they got into EEO stuff, how people were treated, and I got into one group—I had a little refereeing to do there. But it's now become a tradition. It's Celebrate Goddard Day, they [still hold it annually].

We did another thing where we did that with technology. Again, people didn't know what technology was, right on the Center. So I had [a] technology [fair] come and show you technology. We had a three-day technology fair. It became such a big hit, we were inviting people from outside the Center in. It was open house. People from other Centers were coming. And they were down to the nitty-gritty technology, and people walked away and found it useful. The attendance we got was tremendous. [Again this is still an annual event.]

We then decided we were going to go for the President's Quality Award. There was only one [other] Center that ever became even a finalist. It was Kennedy, and they won some kind of a second-tier award and nobody had ever got even in as a finalist on the first try. This took engaging the whole Center, including [a week long series of all-hand activities in the auditorium]. I, [for example], had [one normally] very formal Director, up on stage in a hula skirt dancing in front of all the employees and singing some jingle [to raise employee awareness prior to the award committee visit to GSFC]. I didn't tell him to do that. Every day for a week, we were getting everybody sensitive before the committee comes in and spends a week with you, going around and finding out all your processes and every other thing. So I said, we've got to get everybody to [participate in these prep sessions]. So, what do you do? I do the one thing you need to do to get people to come to a meeting at Goddard, serve food. So every day we had food and then we had a skit on stage.

Well, the people heard about it. The auditorium was packed. It was on the TV. People stopped work for two hours every day to look at this for the week. Every Director of got up there and did something. They didn't have to do a skit. They could just get up there and do "rah, rah, rah." Well, a bunch of them banded together and got up there in hula skirts and sang. It was funny. It was a funny show every day. By Friday, it was "Can you outdo this?"

We had that, and then we had a serious panel discussion, and we sensitized everybody to it. And we actually became one of their finalists and recognized as the only one that had ever did it on the first shot. Then we decided it was too much money to do it. Actually, the committee said to us, "You didn't have to take the whole Center and try to sell it to us. If you just took this little piece of it, you're doing more than most." We didn't think of that. We were having so much fun. So that was my life at Goddard.

Then the Administrator called me one day and said, "Hey, Will Trafton just retired, and I need a head of Human Space Flight, and I hadn't thought of you [since you already have the best job at NASA, but] would you like to come down to [Headquarters to head] the Office of Space Flight?" That was like a big jump for me. He said, "All the Center Directors know you because you did a lot of work with them." I spent a lot of time down there at Johnson and Kennedy. I spent two years at Kennedy when I was with Grumman and they were getting ready for the first launch of that satellite.

But it took me again about overnight [to say yes]. I said, "Well, let me let you know in the morning."

He said, "You don't have to do this. I know you're having the most fun you ever had in your life. I'm asking you to leave the best job you ever had to maybe take on the worst one you'll ever have, because it's a tough job."

In the morning I said, "Time for a change."

My wife said, "I knew it." She said, You weren't getting up at five o'clock every morning going to work anymore; you were not getting up till six some mornings." She said, "I could tell." So then I went downtown [to Headquarters].

WRIGHT: Did you have any hesitation, since you hadn't had direct management experience in Human Space Flight operations?

ROTHENBERG: No, the only reason I hesitated is it put me further away from where the [actual] work was done, working in Headquarters. There were two things I always said I'd never want to work in Human Space Flight and I never want to work in NASA Headquarters. I used to say that because Headquarters, to me, was just a paper-pushing place at best; not a lot of value added in my simple mind, from my view. And the second thing was Human Space Flight was the formalisms and the processes were so rigorous that your impact on the whole thing was kind of small and, as one person, I really—that wouldn't be fun. I couldn't see the result of what I did, right or wrong, good or bad. That was my only hesitation.

But I got really tired of hearing all Human Space Flight getting all the credit for everything, and I decided to go down and get part of the credit, or something, or get in the middle of it. Seriously, I got tired of hearing all the problems about Space Station and all this and all that, and I said, "Maybe I can go do something about it." That was part of it. When he asked me what went through my head, I said, "Well, maybe I can go down and help." And, of course, he was into sell mode. No matter what I said, "Yeah, that'll work."

WRIGHT: You walked in at a very interesting time. Could you share with us when you took the job in January 1998, some of the first issues that you were tackling?

ROTHENBERG: Well, clearly the image of the Space Station at that time was that—there were two things. The image of the Shuttle that was going down the tubes because we were turning it over to USA [United Space Alliance] to operate. And the Space Station image was that the Russians sort of had some rusty hardware they were trying to put together to become a space station. They had this other rusty hulk up there called *Mir* that I had to send people to and risk their lives.

Then the third thing was that the U.S. was building things, but they were so far out of whack in terms of schedule and cost, we'd been working on them for fourteen years or so, from when President Reagan said we'll build a space station in 19[8]4.

When I got there, I found that nothing was further from the truth. There was a well-organized team building Space Station in the United States. I went to Russia. Right away, they were committed to building it. Yes, they didn't have enough money, but by hook or crook, they were moving forward. And a lot of the rhetoric you read in the paper was because they do things differently than us. So the third thing, they had just come off of a major overrun on Space Station and they were just waiting for a report out on the committee on what went wrong and what can you do. Well, that's always an opportunity to get well, so I wasn't worried about that one.

But I didn't understand all of that, the implications of it all. All this is hindsight. The first three I certainly understood. The one to get well, I really could have gotten even weller. I could have asked for more and I should have, in hindsight.

[One of the first things I needed to do was set a first element launch date for the Space Station or a visible committee goal.] Unless you have a visible goal that everybody is working to, you're never going to move forward, because nobody—I'm not going to come in on Saturday or Sunday if I don't know that I'm going to have a launch or something at the end of—if somebody says, "Well, if it launches Thursday or next week, it doesn't matter." Well, why am I going to give up my personal time and put in that extra effort to go do it sooner. I'll do it when it's needed. If no one cares, then I don't care. It's just human nature. So that's why you always need a launch date. That's why, even when I did the Hubble, I said, "I don't care what happens with the Shuttle, we're going to have a launch readiness date on this date, and that's when we're going to shoot for. And if the Shuttle manifest changes, that's okay. We're going to be ready for that date."

And when I told George [W. S.] Abbey that, we did that on Space Station. He said, "That's a great idea." They started calling things launch readiness dates. So it was independent of what was happening on any other device—the Russians, the Shuttle—your job was to get that ready for that date and that was your target.

So having said that, once I got the lay of the land, I went and did my thing. I had to testify in front of Congress right off the get-go. Budget time, you know. Got that behind me. And I took that very seriously the first year. I didn't by the third year, because I found out it nothing ever changed. It was a theater. You went there, did your thing, they got credit for beating you up if you were doing [bad], giving you credit if you were doing [good], and you went [home and] you went on with your lives, and that was it. Nothing changed. The boss tried to tell me that, but I took it real serious. I really thought I was representing what we were doing, where we were going, and I wanted them to understand it, and if they were going to beat me up

for it, that's okay, but [I also expected that if I needed help], they were going to help me. … [In practice], when [hearings were] over, [committee members] shook my hand and said, "You have a tough job." And they'd go home and we'd go home and we'd get on with our [jobs].

Anyway, so after I got through [my first set of congressional hearings] I said, "Okay, now I've got to figure out when we're going to launch the first element." So I assessed everything, and I said I was going to pick this date—I think it was November of [19]'98—for the first element, which was the FGB [Functional Energy Block], built in Russia, but we paid for it. Well, the one faction of the Russians, Energia—it's like a Center, but it really is industry, in Russia, had no desire to launch it, because they were operating *Mir,* and the minute we started putting up Space Station, you started to have shut down *Mir*. That was sort of the rules and the agreement we made. And the Russians kept saying yes, but their culture—it was really tough shutting that down. We had to keep a lot of pressure on them and we had to weave a lot of politics over there. And of course, we had people like [F. James] Sensenbrenner [Jr.] who would just say, "Get rid of those Russians. Why do you have them on the program?" Or "Tell them what to do." Everything. He'd say it publicly. Privately he'd say, "Boy, you've got a tough job." I used to [pre]-brief him and he'd be okay. Then he'd turn it right around on us at the hearing, but again, he'd do it for rhetoric, and then he'd go home.

So we picked a launch date and Energia comes into play, because they don't think it's going to be ready. The [FGB] was going to be ready to be launched. But it meant that we had to be ready with our [first piece, "the Node"]. The minute we put a gauntlet down [by setting the first element, FGB, launch], it [signaled to] everybody, "No fooling. You can't just have one piece up there. … You've got to keep putting pieces up." And it set the [pace for the next two years].

So first I had to convince the Administrator and he said, "Go for it." Then I had to go over and sit and convince the Russians, I mean really convince them, even though it was our thing, that we were ready to launch. And it took me three hours in a restaurant out in California and a lot of vodka one night to finally convince [Energia's President Yuri Semenov that] they had no more arguments; they had to launch. We picked a launch date and I said, "I'm telling you when it's going to be."

He said, "No, I really want it to be the sixth—"

I said, "No, it's got to be here. Here's why." And this was through an interpreter and with a guy who had no motivation. I don't know whether I convinced him or he gave up. I filibustered him, but the next day we made the announcement. He [took] it back to the Russia, and I told all of [the ISS Program] that we succeeded [in setting a date] and that was it. That set the gauntlet down and then after that, it was figuring out how to make sure everything worked, and the program did an outstanding job. It [was a tremendous credit to the ISS Program that everything] works as well as it has. Different cultures, different countries, never talked to each other. All the interfaces were different. Being built and all coming together and working the first time up there is a big deal. I don't know how you do that. I talked about this sort of thing with ninety-six pipes at the other end of a room. You could look at it and figure that out. And in this case, we had multiple partners build the multiple pieces, internally to each box as well as each major node, and it all worked. So they did a [great] job.

The second set of challenges I faced is we had John [H.] Glenn [Jr.] to launch, and that was interesting, because that was a thrill for me to meet him. Then he tells my son I'm his newest employee when he meets my son at a social event. He, coincidentally, met my son and

my daughter, who was getting an award, and he was there to give it. He said, "Rothenberg. Are you any relation to—?"

"That's my father."

He said, "I'm his newest employee." That's the first time in my life my son thought I did anything useful. He was impressed, he said. That was the only time he's ever said that, and the last time.

So that was somewhat of a challenge in that it was the whole media. It was not the mechanical—well, defending why we should fly him was always interesting, because whether it was political or not. I thought it was something we owed him. I thought that from—we didn't fly him because we didn't want to lose a national hero before. I thought we owed him an opportunity if he was up to [flying again]. I think it was good for the space program and good for him, but the media kept poking at it, [claiming it was because Senator Glenn supported the President]. I knew nothing about the politics, [but I for one was glad to see him get the opportunity to fly in space again].

Then as we were closer to launch, all the preparations we had to make, all of the dealing with the White House security because the President was coming, and every other thing. I learned a lot. …

[Then we had the Chandra launch commanded by the first female Space Shuttle commander, Eileen M. Collins.] Then the problems we had on that launch. [On launch], we lost one pin out of the engine that was a wakeup. We had a short in the wiring that was a wakeup. We put in place a review process, which started really looking, a hard look at the aging of the Shuttle and came out with a bunch of recommendations [for actions], which we put in place. Some of them still have to be completed to make it better, but it still [remains that there are an]

inherent set of risks [in flying] the Shuttle, as we've seen from *Columbia*. No matter what you fix, there's always something outside that will bite you. They're dealing with the problem on the wing right now, but there's a [lot of] other ones that can bite them next time. And they're not going to find them all. Hopefully, it won't result in the same thing [as *Columbia*]. There's nothing we can do about that. That's space flight and the Shuttle is complex. Even a replacement vehicle is going to have inherent risks.

What else? The other thing, challenge that I had when I took over, the Friday before I took over, OMB [Office of Management and Budget] in its wanting to deal with the Space Station budget zeroed-out the budget for both people and money for any exploration work. Now, what that did is it took a bunch of people and told them they weren't going to be able to work on what they really wanted to work on in developing the exploration technology. That was one thing, and maybe that's okay.

But the second thing it did is it told the rest of the people that there is no future for NASA. There's no exploration work being done, so there is no future. This happened Friday. Monday morning, I got a—in fact, I called all the Center Directors Monday morning to kick off how we worked together, and they told me about what happened Friday and they told me the implication. I said, "You're right. We've got to do something." So I immediately decided that I've got to convince OMB that I need some level of civil servants, and they—like 200 out of the whole [9],000 that work [in Space Flight], and I need some small money, 10 million dollars for the year, just to give them some inkling that they can get some work done when they need help.

So I called them up and they said "Okay, but—." They didn't want to give the money.

So I said, "What if I just find the money someplace in my budget and do it?" They didn't say anything, so I just went and did it. Well, when I submitted the budget, they, of course, took

[the 10 million dollars I had carved out to continue exploration] and used it for something else instantly.

Second point is, I said, "Okay. I'm going to do it again." Not getting it the first time, so I pumped in 10 million dollars in from another place. Oops. They took that, too. And I said, "I got it. I got the message." So I had to keep it in 2 million dollar chunks and call it different things and tell my guys how to get at it, but I got the 10 million in there, because I needed it. I had to do that for morale. I had to do that to save us a future and so we didn't lose some of the bright young people.

Then about a year later, the Administrator called myself and Ed [Edward Weiler]—[Dr. Wesley T.] Wes Huntress, [Jr.] who was the Associate Administrator for Space Science, when he left, he made a presentation to the Administrator, myself, and a couple of other people on where he thought the future of space science was and how important humans were to help them build large observatories in space. …

[About that time], we laid out a strategic plan for OSF [Office of Space Flight], and it was the first time, [they had a credible one in many years]. When we published that thing a year and a half later, it was one that was believable, because it didn't say I have to have a new program. It said this is where I want to go. This is how I get there in very small steps, until the budget frees up, or I make enough headway where I can say, okay, now I can take this next big jump. …

So we developed [the OSF Strategic Plan], then the Administrator took that and he told [Ed] Weiler [the AA for Space Science, who succeeded Dr. Huntress,] and I, "Why don't you guys get together and figure out an [integrated] plan for Space Science and Human Space Flight." And that's what we did. We actually had our strategic plans woven together. We

worked with a bunch of bright young people for three years and put together the makings of this exploration plan that the President announced with the Moon, except our destination wasn't the Moon. …

But everything else is the same. It wasn't a destination; it was a process by which one gets there. It was pay as you go. It found ways of getting to the [Mars] in thirty days versus the six months it's taken traditionally. It built in overcoming some of the limitations of the medical care. It built in a way of dealing with that, because you got there faster and got back faster. It had a way of engaging the public and formed the base of the way we presented it to the new administration. It's teamwork, done it for three years.

These people—[the team Ed and I assembled], first there were some that were totally against human space flight at all, and some totally for science, and never the twain shall meet. And they came up with a plan that was far better—it's what started this whole thing the President just announced, except it wasn't the Moon. It went to a place called L-2, which is where the gravity of the Sun and the gravity of Earth are equal, on the far side of the Earth, away from the Sun, and that turns out to be a place where you want to build large observatories.

So what we wanted to do is to get the tools humans need to live and work in space longer than away from low-Earth orbit, send them to L-2, build a habitat there, and that was easy to do with some technology that existed, and have them build these observatories. And the money was already there [for some of the Space Science missions that needed humans in space to assemble the spacecraft on orbit]. And [the plan was that] by the time we were done [with these missions in the next decade], we were getting science [as well as] on the way to learning how to do—[the plan was that] the next step was to Mars. And all the technologies [that need to be developed] were identified and it was [an integrated plan]. …

Anyway, I [hope the current exploration plan] will morph back to that, because it's the only logical plan. By the time we're finished going to the Moon–if we keep on going to the Moon, it's going to cost far more money [and for less scientific return than the original plan]. When we get [to the Moon], we're going to find out we've been there and we haven't learned—for what we're going to spend in the end and the time, it's going to disappoint people, I think. I don't know. That may not be true, but right now, that's my view of it. Something could change my mind, but I haven't seen anything yet.

Why don't I take a break.

WRIGHT: Sure.

WRIGHT: Can you talk to us some about that and how you were involved in some of those negotiations?

ROTHENBERG: Okay. Let's see. Some of them are a little sensitive, but let me start with—they had sent us a letter saying they were considering sending an American up. I think it was the first one, the American, [Dennis] Tito—may have been the journalist, but anyway, they sent us a letter saying they were considering doing that, and they said in the letter, "We ought to get together and talk about it." We took the letter and said, "Okay."

I looked at it and, to me, I almost looked at it as there's no policy we have against it. It's their business and they need money, and we ought to figure out a way over time that makes sense, to do it, but let's not make it get in the way of the operational mission.

Well, there were certain people in NASA who didn't believe that. They merely said, "Can't be done. The taxpayer will look at that as a folly. They spent all this money to fly tourists." Well, if we didn't give away ownership of the Space Station with the Russians when we brought them onboard, in effect, that would be true, but we gave away an awful lot to get them to engage. So they are a sovereign country and they did own the rights to do certain things and they could do them unilaterally, and anything we wanted them to do differently was going to have to be negotiated, not mandated and not entitlement. So we spent a lot of time, first, trying to convince them, "No. This is dumb." Secondly, saying, "Okay. Maybe it isn't so dumb, but you've got to pass these criteria before you're ready to do it." Then third, when they passed the criteria, said, "Never thought they could."

So we—I say "we" as an agency collectively, although a lot of people had quite different opinions—were polarized [against flying Mr. Tito at that time]. We spent a lot of time going over, line by line, what the safety rules were and all that stuff, and a lot of time ignoring it and saying, "Nope. We're going to go back and fight one more time not to fly. This is too hard," and we kept getting sent on a lot of missions to go fight that. In the end, we had no leverage. They were going to do it. Period. We, in the final analysis, figured out a way to save face and go let them do it, and that's what happened.

WRIGHT: Right before you retired, there was a report that came out, one that the Administrator had commissioned to study the Space Station Management Cost Evaluation Task Force. Could you give us some background how that came about? Was that something that came out of the Administrator or based on the Administration?

ROTHENBERG: No, no. Well, what happened is, going about eighteen months before that, there started to appear a bunch of new work needing to be done that was unfunded. Nobody planned on it. Everybody thought it was done; didn't know it was needed. What we found is that it rolled up to about 4 billion dollars and it rolled up right at the change of administrations, so that made it very sensitive. Did the old administration fail to disclose that? Did we just find it? What was the truth? That was part of it. Then, how did it get there? Well, the bottom line is we looked at pieces and it got there like any money, typically it crept up on the guys and it crept on. And part of it was OMB took about a billion and a half to two billion dollars away from us, between OMB and Congress. So it really wasn't 4 billion; it was 2 billion, but that was last year, when you didn't look like you needed the money. See it was hard [to defend against OMB and Congress looking to use the money they saw as unspent by Space Station to solve other problems].

What happened is the program—well, let's stick to the trail. So we went and I formed a team to go down and start to understand it and we found out it was about 4.8 billion, I think, at the end. Then we brought back about a billion or so in savings. Then we always said we wanted an outside committee—you've got to do it in something like that—and we—[with] the Administrator—we sat down and we formed the committee. We picked the list of people that we thought were the right kind of people; ran it over to OMB; ran it to the Congress; they said okay. We asked [A. Thomas] Tom Young to head it up. I was involved in that. Then we went and had them look [at the program and overrun].

They concluded that the way the [program] was capped in the first five years, by Congress, at 2.1 billion [per year], forced things to be kicked downstream in reserves, and content to be moved, because you couldn't fit them in the [2.1 billion dollars annual cap], and

[the] reserves ([budget] margin) they had [with the cap for unforeseen problems was actually spent to accommodate new requirements such as bringing the Russians into the program]. That led you to not knowing—and not a set of good project management tools to keep track of that [work] as it moved [into the out years]. That was what they concluded in a nutshell, I think, is the essence of what the problem was.

They also didn't like the idea that we managed to an annual budget, but unfortunately, I don't think they got it, because that's the only way you can manage a large [federal government] program, is to an annual budget. You don't have a lot of flexibility, because from year to year they take money away. You can't save money and say, "I'm not going to spend it this year." That's when they take it away. They say, "Well, you don't need new budget. I've got other problems." Well, they only live from election to election, so you really have to consider that. I don't think the committee ever did get that one. Many times I said it, and they said, "Nobody can manage it." They all fundamentally came from industry, "Nobody can manage a program like that."

I said, "There isn't any other choice. You don't have any other choice. Give me another choice." That was [our push] back [for which they had no answer]. This was in the closed-door sessions, when I was inputting the report. I was the sanity check on their conclusions. I was the one they went to and said, "Okay. Here's what we think we heard." And where I saw things where they were coming out of whack, I'd throw my two cents in, but it didn't always change them.

WRIGHT: Then you retired in 2001, three years after you took that job.

ROTHENBERG: Four years. Since the 1960s, I'm the only person to hold it for more than two years.

WRIGHT: What prompted you to retire at that time?

ROTHENBERG: I wanted to retire the year before. I had always said I wanted to retire at sixty years old and [and pursue my sailing and photography hobbies as well as spend more time with our grandchildren and travel]. That was always my goal. I had a sailboat, and really had that intention. We had a sailboat for thirty years and I loved the bay. Anyway, I still go to Italy and I have family there. So I planned it. And the Administrator asked me to stay until he [understood whether he] was leaving or not.

And [at the same time the] Space Station problem started to pop up and I said, " I think we're going to need help getting through this. I don't want to leave in the middle of it." So I decided to stay around about another year, and that was it; it was time. Simple as that.

WRIGHT: Currently you serve—

ROTHENBERG: Also—one other little minor thing—I was also being considered for, in my mind, [by] the Administrator, if he stayed on [for] the Deputy Administrator—that's what he told me; and I was told by the incoming administration, when the new Administrator came in, I would be high on the list for Deputy. I wasn't sure I wanted that as a political appointment. I wasn't sure I wanted to go through that hassle. But, on the other hand, that was another reason I stuck around, to see [what I might do next in NASA] but it became apparent to me that the new

administration wanted a new breed of people, a different kind of people, and if they brought in who I thought they were going to bring in—not the person, but the type of person—they wanted somebody else besides me as Deputy. They'd want an astronaut, because there's going to be somebody [as Administrator] that really has no space flight experience at all, and [certainly] no human space flight experience, so they need the most credible one in that second slot, in case anything ever happens, and that's what they did. That was just common [sense]. Then the other thing, Tom Young is a personal friend. He was the Center Director at Goddard for a while, and I talked to him about an exit strategy relative to that.

He said, "Well, I can only tell you that if the new administration wants you, they'll get you no matter whether you're there or not. Don't hang around waiting for the new guy to be named and come in." And that just cemented it. My wife and I went off and spent some time in Italy at the end of that summer. That's when I really made that decision. Even before the Young Committee had started, or just about the time, I made the decision that this was it; this year was going to be it.

WRIGHT: During your decades with NASA, there was always a lot of discussion about privatizing and/or entering into commercial ventures with private companies with NASA. Could you share with us some of the issues that you faced?

ROTHENBERG: I was a champion of commercialization, privatization. In fact, one of the things when I was Associate Administrator is, I developed the plan, got the bids, and signed the first agreement where NASA and a commercial company went into a partnership, where NASA actually had 25 percent ownership, and would get 25 percent of the revenue of this company—

what the heck was the name? Dreamtime was the company and they were going to publicize NASA's data archives. In exchange for that, they were going to give us 100 million dollars and they were going to give us HDTV, which is why I said, I said there is no way—I got HDTV for it.

Then we got something out of it. They got nothing out of it. They had about 5 million dollars invested. The rest of their investors, who I met, were all DotCom [Web-based business] people who made a lot of money. Unfortunately, they lost it right about the time we started this. But that was one piece.

The second thing is I put in place a commercialization plan for Space Station, and this was a piece of it, in fact. That was my direct doing. I believed in it. I went over and sold it to Mark Uhran, went over and sold it on the [Capitol] Hill and everybody else, and I was into advertising—there were a lot of things we wanted to do that I felt were doable. It also involved commercializing the Shuttle in some ways. We actually tried that.

In addition, [I was pushing to get in place], much like the Space Telescope Science Institute, the [International] Space Station [Research] Institute. In fact, the RFP was about to come out [this past] January [but after the Space Station science was curtailed by NASA], they put it on hold. But I, even as a consultant, worked on that thing. But myself and Mark Uhran [championed a Space Station Institute] and sold it [to the Space Station community, Congress, and the Administration]. It took a tough job to sell it.

The Shuttle [commercialization, privatization] was the toughest one [to get industry interested] in that the infrastructure to operate Shuttle is very expensive, and the rules on what you can fly as a government payload commercially, there are some rules about what you can actually fly. Then the question is, does the commercial guy pay full cost? Does he pay for one-

sixth or one-fifth of the annual operating costs, including the infrastructure, or does he just pay the marginal costs? Well, if you're paying for the annual operating costs for the total thing, you're talking about six to eight hundred million dollars a Shuttle flight. If you only have four flights a year, it's even more—now it's at five. If you're talking about the marginal costs, you're talking about 90 million. That's competitive with conventional launch vehicles.

We put together a plan that closes—a business plan on that, the USA could never do it, so we ultimately scrapped—well, we didn't quite scrap it. We were still looking at a few things when *Columbia* happened. They were still looking at it and then they just—at this point, it's been neither scrapped or—just so far on the back burner that—

WRIGHT: You touched earlier on the challenges of Centers working together and the different cultures meshing. How was it different for you when you were in the Associate Administrator's job directing the work of four Centers, where you were not trying to work as a partner, but you were directing those Centers? Were you able to make a difference on how those cultures meshed?

ROTHENBERG: That's a tough thing to do. I did. I believe I did [achieve some inter-Center collaborations], anyway. I did some things in place that forced them to work together. I moved the Delta Launch Vehicle Program out of Goddard. I agreed to do it while I was Center Director and I finished it up when I was AA, and moved it to Kennedy. Then I forced Marshall to be the engineering arm of that, which Kennedy was going to try to go it alone, but I made a partnership there. They actually have collaborative engineering tools between Marshall and Johnson, so that the engineering expertise of each other are tapped, because they don't have the same expertise.

Little inroads like that, but they were all small. There is such a suspicion between Centers. It's a little kids, "He got three extra ceiling points; I want three extra ceiling points."

That's the other thing I did as AA. I made the case, and won it, to stop downsizing. We were downsizing. In fact, if we continued—we started out at 11,000, we went down around 9,000, and we were heading toward 7,000. We were probably at 8,500, and I was able to finally convince, through data, that this is a disaster. We stopped and turned it around, and now they're probably at 9,000, 9,500. But I bring that up because it was all part of when we did that, who got more slots, who got less slots. Everything was a big negotiation. You can't do it unilaterally. You can't just say this is—you can do that, but then you've got to be prepared to defend it, and that's what the negotiation is all about.

WRIGHT: Through your years with NASA, and even back when you started with Grumman, through the years as you've worked with the space industry and space agencies, is there a time you would consider to be one of your most challenging?

ROTHENBERG: Each in a different way. That's hard. Most enjoyable—every one was challenging. If you think about it I've always been dumped into—ever since I was dang solar arrays, or even the very first thing, when I went to the wind tunnel on the Gulfstream, that was a disaster, and somebody handed me a rat's nest of wires and said, "Make it work." But I've always been dumped into a problem, so unless I have a problem to work on, I lose interest rather quickly. So each one was challenging.

Hubble was obviously the one that made the most impact on the agency, I think, clearly, and the one that I grew the most in, in managerial skills—well, I think so, yes. I was always

building on something I learned in the past. I just found different ways to apply it. But certainly that was the thing that enabled me to be the Center Director and all those other things.

WRIGHT: You mentioned earlier, too, some little tidbits that you learned as you went through the line, that you feel is important to get the job done. Would you like to share some of those little tidbits with us?

ROTHENBERG: They're just little things, like the top ten. That's just little tools. Things that people, unless you tell everybody what your priorities are and think about them and write them down, sometimes you don't know what they are. Everything is in chaos and high priority.

Oh, get well. Look for opportunities to get well. When you're managing a project and the leader, and you don't—every time you start to see money problems or something like that—panic. You look ahead and say, "Are there going to be opportunities up ahead or am I running out of runway to get well?" "Is there liable to be a schedule slip and I can use that to add some money or save some money?" You know, "How can I get well?" And "get well" isn't always brand-new things. So those kinds of things.

The third thing is, go in there, even if you don't know what you're doing, but you've got to act confident or everybody else is going to follow suit, so you've got to always be—sometimes you've just got to just play the leader and say, "We're going to succeed," and not even knowing how, then go in and help figure out how. Because once you commit to it, your brain goes into a whole different level of working, and you figure out some ways, "If I don't do that, I'm going to embarrass myself big time."

There are some that were impossible. When we were trying to find 4 billion dollars to make the shortfall up; that one I determined was impossible at some point. I finally went and told the Administrator, "It ain't gonna happen."

WRIGHT: Before we close today, I was going to ask Jennifer if she had any questions.

ROTHENBERG: One other minor thing—not so minor. It was important at the time, but the other challenge when I took over at Goddard was that they had decided to close down Wallops right before I took it over. Senator Mikulski got over there and said, "Over my dead body." Stood up on the cafeteria table and said, "We're going to duke it out with those newcomers on the mainland. We're not closing Wallops."

The Administrator called me up and said, "Go find a mission to make Wallops useful and make the Center happy." We spent a fair amount of time going to Wallops. I liked it down there; it was fun. They have a great bar and a great pool table. But other than that, I'd go down there. I appointed a person—there was Navy on the base there, so I had a woman Navy captain that worked for me and I suggested that her job was to figure out a mission for Wallops, and I gave her some [new] work for [Wallops] when I reorganized, I took the attached Shuttle payloads and moved them down there and I said, "They got an airfield. They can fly into the launch site. They're great for that. They used to working with universities." So I made this the centerpiece and then I built this—I think it was called Mission 2000—for Wallops. But basically, it had some meat, but it [unfortunately wasn't a lot of new work for Wallops]. We didn't have a lot to give them. …

The Administrator [had] me present it to Senator [John] Warner and Senator whatever—[Charles] Robb, and [Senators] Mikulski and [Paul S. Sarbanes from Maryland]. And everybody thought this was the greatest thing since canned soup, and Wallops had a vision. … As part of that I got the [Virginia] spaceport licensed, helped them get their license because that was languishing, and we put [the spacecraft into Mission 2000 for Wallops]. But right now they're in exactly the same throes. People are [trying to close] down Wallops again.

WRIGHT: You have retired from NASA, but currently you serve as President [and a member] of the Board of [Directors for] Universal Space Network, a company that has a history and future connected with the space agency. Can you tell us some of the projects that you're working with and how they do tie back in?

ROTHENBERG: Let's see. We own [a Spacecraft Tracking Network of ground stations and network operations centers]. We [used commercial investment for their development], and clearly, what we're doing is [pioneering the outsourcing of] a function that used to be done by the government [and by spacecraft builders with their own private networks]. … The government used to have the whole ground network of antennas which collect data from satellites and relayed it to the users. NASA has agreed to outsource, get rid of their own. They're not investing in them anymore. [Neither are the spacecraft manufacturers; both the government and the spacecraft builders are learning it is more cost effective to buy tracking devices commercially.] … We're one of the few companies—there are only two in the country that [provide the service], so we're in great shape for that. And the other company works with us

because they fill a hole we can't fill, or they fill it better than us—we've tried to fill it—and we do the rest. …

We're now looking to get into the operations business, where we're going to be the [satellite] operators for some commercial satellites. We're negotiating with multiple ones simultaneously and don't know if any of them will ever come to pass. …

WRIGHT: We thank you for spending the day with us. Are there any other areas or anything else that you'd like to add before we close? Any other thoughts about the great pictures that Hubble just released?

ROTHENBERG: I haven't seen them. Are they the ones the ultra-deep space field? Yes, the first time we pointed the camera out into deep space was in [19]'93, '94, the deep space [survey]—no, I'm sorry. It was about a year after, and that one alone was just startling. For all intents and purposes, from the ground, everything they ever looked was, at best, sparsely populated. They looked at it and it looked like we were looking at our own galaxy, it had so many galaxies. We weren't just looking at solar systems; we were looking at galaxies out there. This [survey] was even more [scientifically] interesting [than anyone imagined].

See, I don't believe we [on Earth] know very much at all. In fact, we're certainly not alone, in my mind, as a living thing, but we're certainly not alone maybe as a universe. I think there are other universes out there. Whether they're just like ours or totally different, I don't know.

WRIGHT: I guess we'll just have to wait and see, won't we?

ROTHENBERG: Unfortunately, I'm not sure it will happen when I'm around. Now, maybe you young people. [Laughter]

WRIGHT: Thank you again.

[End of interview]