NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

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INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is April 17th, 2009. This oral history with Bill Reeves is being conducted for the Johnson Space Center Oral History Project in Houston, Texas. Interviewer is Rebecca Wright, assisted by Sandra Johnson. Thank you again for joining us today. We'd like for you to start by sharing with us your experiences that you had with Skylab.

REEVES: I started in the Aircraft Program in 1972, '73 when Apollo was over. We were part of that program, but only in the sense that we had the same sensors and camera systems on board the high-altitude airplane that were on board Skylab. So we became part of some of the investigations. Whenever Skylab would be making a pass over the US, we were in constant communication with the [Mission] Control Center. They would give us an anticipated pass a day ahead of time, and then we would move the crew and the airplane to some staging base nearby. We would be in the air at altitude when Skylab came over, and we would take photographs and sensor data of the same target that they were taking data of. Then they would use our data as calibration data for the Skylab data. This is what they call multistage sampling.

In fact, there were times when we would have a target on the ground. Maybe we were doing a crop inventory, or some kind of a crop disease study, or soil erosion or something where there would be ground truth people on the ground taking samples. We would have a helicopter at a few hundred feet with some sensors on it and cameras. Then we had the P-3 flying at around 20,000 feet with cameras and sensors on it. We'd have the C-130 at 30,000 feet. We would be at 60,000 or 65,000 feet, and then Skylab in orbit. We would time it where everybody was over this target at the same time, and you'd get the same imagery with the same lighting conditions and everything for a multistage sampling.

You could take all that imagery, and you could calibrate and know what you're looking at. The problem with Skylab was that was really the first time we were doing a lot of this kind of work from space. Hadn't ever been done this before. When you take a picture from space of the ground, you don't know what you're looking at. You know kind of what you're looking at, but you really don't know what it is. If you're using different kinds of films and filters and different kinds of sensors, you have no idea what the sensor return is telling you. Is this a wheat field in an early stage of growth? Is it a mature wheat field? You just don't know what you're looking at. That's why we'd have to do this multistage sampling to figure it out.

All of that work led up to designing the sensors that went on the Landsat satellites and all of the Earth resources satellites that came into being later on. This was all the groundwork for doing business the way we do it today. You see these weather satellites, and you get used to watching the weather on TV and the weather reports and the pictures of all the stuff—that stuff didn't exist back in those days. We were doing all that stuff; designing the satellites of the future that led up to that. A lot of people don't know that. They don't realize that all of that work was very valuable work. A lot of the work that was done on Skylab was very beneficial to what we use today; it was pioneering a whole industry back in those days.

WRIGHT: As you said, multilevel.

REEVES: Yes, so that was my involvement in Skylab. I was not in Flight Ops [Operations] anymore, and I wasn't in the flight control business or in the Control Center. But yet we were involved in the program.

We had three of the high-altitude airplanes and we were just on the move all the time. We'd get a call that they're going to be over California one day, and so we'd move one of the airplanes out that way. The next day they'd say we're going to be over the east coast. We'd move another one over there. All night long we'd be moving our ground crews and flight crews and airplanes to some other base somewhere and be in position the next day and ready to go. It was pretty hectic, but we had a lot of fun.

WRIGHT: That was during the entire Skylab program?

REEVES: It was for a period, yes, during Skylab. You couldn't keep that up for months on end, but you had defined missions, periods of time, two, three weeks where you'd do that. It was interesting times, yes.

I wasn't involved in Apollo-Soyuz [Test Project] at all. When Apollo ended, they came up with the Skylab program and Apollo-Soyuz program to help fill the gap between Apollo and Shuttle. Apollo-Soyuz used a lot of the Command Module, Service Module, Saturn people. But I was Lunar Module, and all the Lunar Module people didn't have anything to do. Some went to Skylab. Some went over to the Aircraft Program. Then they used the Command and Service Module people on Apollo-Soyuz, so I didn't have anything to do with Apollo-Soyuz.

WRIGHT: You mentioned to us, I think it was sometimes around 1980 or so, George [W. S.] Abbey gave you a call and asked if you wanted to do something else.

REEVES: Yes. That was when I got "the call" from "the man." George did a lot for me in my career. If it weren't for him, I wouldn't have gotten to do some of what I got to do. He's responsible for a lot of careers in this business. Between him and Gene [Eugene F.] Kranz, they were the ones that gave me the opportunity to go to the Aircraft Program, which I'll be forever grateful for. Flying in high-altitude airplanes is just like an astronaut job; it's one of the best jobs on the planet, but anything gets old after a while. I can imagine even the astronauts get ready to move on. You reach an age and a time when it's time to go do something different.

I had already gotten to the point in the Aircraft Program where I was having the realization that I can't do this forever. As fun as it is, you got to do something else. When you quit growing and you quit learning, you kind of die. It was time to go do something different.

I had already gotten to that stage, and it was interesting that about the time I got to that stage, the phone rang one day and it was Mr. Abbey. He said that the aircraft program had served its purpose of filling the gap, but we were at the end of the gap, and Shuttle was getting real close. It was getting close to the first flight of the Shuttle. He said, "We've got a problem down in operations," with the remote manipulator system [RMS], which was the robotic arm on the Shuttle, and was going to fly on the second flight. It would be the first flight of the arm on the second Shuttle flight. There wasn't one on the first flight. It was built by the Canadians, and the Canadians were involved. He said, "We're having trouble getting started. We've got a lot to do to get ready to go fly the arm."

He said, “You’ve been out there having fun for all these years.” At that time, the Aircraft Program was starting to get into a little bit of a problem budgetwise. He said, “How would you feel about coming back to operations and helping us set up operations for the remote manipulator system?” I said, “Absolutely.” I said, “The timing is right. I’m looking for something else to do, and this is an opportunity, and you’ve done me a big favor. Absolutely, whatever you want.”

So I came back to operations. I went to work for Dale [E.] Moore. He was my section head over in flight control at that time, MOD [Mission Operations Directorate]. That’s where he had been set up as the section head for this RMS section, to form this organization to provide the operational support for arm. Dale’s background was landing and recovery back in Apollo, and then he was involved in part of the Aircraft Program.

The original plan was to put some flight controllers from Apollo and operations people into the Aircraft Program, and fill the gap, and then migrate them back into operations. All of this was starting to happen, and I came back with Dale. There were just a handful of us. There was like three or four, the way I remember it, folks forming the nucleus of this section. One of the guys was a detailee from a company called SPAR [Aerospace, Ltd.] in Canada that built the arm. His name was Pramod Kumar. He was originally from India, and he worked for SPAR. Absolutely one of the brightest engineers I have ever met in my life. This guy was so smart. He was in Dale’s section detailed here to help out.

So it was me and Pramod and two, three other people. This is a whole new system for the Shuttle that’s a little different than any of the integrated systems of the Shuttle. We don’t even know how we’re going to use this thing. We’re trying to figure out how we’re going to use it. So we laid out all the things we needed to do. We had to build the documentation for it. We had to do all the drawings for it, the operational drawings from the design drawings. We had to create all of the flight rules for how we were going to use it. We had to design all of the consoles and the displays and the telemetry and everything that would go along with the system and how to support it real-time. That's what we did. We set it up.

We had a couple of astronaut detailees or people assigned to that project. John [M.] Fabian was one of the first ones that I remember working with—very, very sharp; he spent a lot of time in Toronto where SPAR is—and Sally [K.] Ride and Judy [Judith A.] Resnik are the three that come to mind right off the bat, were the first three that we worked with. We all worked real close together and worked that project.

There was a payload deployment retrieval system program office in Building 1 that was headed by Clay [E.] McCullough, and Milt [Milton L.] Windler was his deputy, or I don't remember his title, but anyway he was the main guy from the program office that we dealt with. That was a fun project. That was just a lot of fun. The arm was an engineer's dream. It has everything from an engineering standpoint that you can imagine. It's got structural issues. It's got electrical systems. It's got digital. It's just an engineer's dream. We worked with that thing and we got it ready. We flew the first one on STS-2.

STS-2 only had two crew members, and Dick [Richard H.] Truly was the pilot and RMS operator. The first flight was what we called an unloaded arm. It was just the arm itself. We weren't picking up any payload or anything like that on it. We wanted to fly the system first just to find out how the system would operate in zero gravity, because the arm won't even work in one-gravity, down here at one G. The best we could do with it was at SPAR; they had an air-bearing floor where they could put the thing on pedestals and then they could float it. You could drive it on this air-bearing floor, but the arm was incapable of picking itself up in one G here on Earth. It was designed to operate in zero gravity.

On the first flight, we just wanted to fly the arm to find out how the control systems and the control loops and all that stuff worked. Would the system even respond the way it was designed to respond? I remember on the first flight, we got on orbit with all the other things they had to do, and it came time to power up the arm and go use the arm. There was a shoulder brace attached on the shoulder of the arm where it sits in the cradle. There was a brace between the upper arm boom and the pedestal that holds the shoulder up that is fastened for launch to carry launch loads. When you get on orbit you had to release the shoulder brace or you can’t even lift the arm out of the cradle.

Right off the bat the shoulder brace wouldn’t release. I remember looking at the data and I thought—the first thing I told the flight director—I believe it was Don [Donald R.] Puddy who was the flight director at that time—and I was the RMS operator in the room. I told him to have Truly check a circuit breaker, because I knew that there was an AC motor that drove this release, and the same circuit breaker that drove that motor powered some lighting on a panel. I asked him to check the lighting on the panel and see if it was lit. Truly reported back that no, the lights weren’t on. So I told Puddy, “It’s got to be that circuit breaker. Go have him check circuit breaker so-and-so, and it’s on row three, fourth breaker over.” Something like that, on some panel. Truly called back. He said, “Well, it’s in, that breaker is in.” It hadn’t popped, wasn’t out. So Puddy said, “Well, now what?”

I kept looking at it and looking at it. I said, “It’s got to be. That’s the only thing it could be. It’s just not getting power.” I said, “Have him check that breaker again and if it’s in, pull it out and push it back in several times and just reset it.” Truly called back. He said, “Oh, my mistake.” He says, “The breaker is out.” They had missed it in the procedure. He said, “The breaker is out.” This particular panel was down in the middeck and the control panel for the arm is up on the flight deck. When Truly went down to check that breaker, he went down through the middeck, and he was upside down. He counted the rows from the bottom instead of the top. In zero gravity you don't know a lot of times whether you're right side up or upside down, so it had caught him. He realized that he counted the rows wrong. The second time he did it right and he says, ―Oh, that breaker is out," so he punched it in. Everything was fine. We got to use the arm.

The arm checked out real good. We had designed a program throughout the whole program where we had a simulator program for the arm, to predict how the arm would behave. That's the way you do any system. You design a computer program to emulate how the system is supposed to work, but then you got to have some way to validate that system. We had the foresight. We knew that in the future you're going to be operating all kinds of payloads with this thing. Every mission is going to be different. You're going to have to have a way to be able to train the crews and to be able to predict the behavior of the system. There were certain parameters that on a flight-to-flight basis, but you had to put special parameters in the software based on what you're going to do with the arm.

We knew this program, this simulator, was critical to the use of the arm in the future. But you got to have some way to verify that it's really telling you the right thing and it's doing the right thing. We put together a flight test program where the first flight was the arm without picking anything up, called an unloaded arm test. Then the next flight, we had a little bitty light payload. It was only a few hundred pounds. I believe it was called a PDP, which stood for plasma diagnostic package. Then the next flight was a thing called a PFTA, a payload flight test article. That was just a big hunk of iron or aluminum with a bunch of grapple fixtures on it in different locations so we could emulate different weights. Then we just kept getting to a bigger and bigger and bigger payload and higher mass up to the limits of the capability of the system. We would fly all of these flights, and pick up that payload, and put it through a standard set of operations that we did the same thing on every flight, so that we'd know and we could compare the behavior of the control algorithms and the arm with the predictions. Then we could come back and tweak the simulator where we needed to get it to respond like the real system.

It was a beautifully laid out program. I give Milt Windler a lot of credit. He did a masterful job of orchestrating all that from the program office and pulling SPAR together with us and all that. It was just a great effort.

The RMS has turned out to be one of the greatest projects and systems in the Shuttle Program. We would not have a [International] Space Station up there today if it weren't for the arm, and the arm being as reliable as it has been and as useful as it has been. It led to the development of the arm that's on the Station now, which is designed after the Shuttle arm. It's just a fabulous system. It was a fun project to work on.

WRIGHT: You called it a dream for engineers, but were there specific areas that sometimes could create a nightmare that you had problems getting through?

REEVES: Yes. My background, I was an electrical engineer. There was a lot of electronics in it, a lot of electrical stuff, and that was fun, but a bunch of the arm issues are physics-related, and loads and structures. We had some really good experts that helped us over in Engineering Directorate and at SPAR that were good structural engineers. The original design requirements of the system were that it could handle a 60,000-pound payload, which was the limit of what we could carry in the Shuttle. You had a system that can't even pick itself up down here on Earth, that has to be able to handle the mass and inertias of a 60,000-pound payload once you're on orbit.

It's a really incredible system. By most robotics standards that people were familiar with, like robotics in manufacturing plants, it's a crude system. There are robots in plants and assembly lines that can precisely put a transistor into a hole within 1,000ths of an inch and do it repeatedly. Those are pretty sophisticated robots. By those standards, this is a very crude system, but when you think that it has to have very limited power, use very limited electrical power, it has to be lightweight, yet able to handle a 60,000-pound mass, it's a marvel. It's just an engineering design marvel to be able to do that.

These robots in factories and plants, you don't have a weight problem. They're big as a house, and they're on these big pedestals, and they have massive computers. We only had limited computer capability to be able to design the system with. SPAR just did an unbelievable job of designing this system. It's a great piece of hardware.

WRIGHT: You had years of experience in Apollo, building the systems and supporting the Lunar Module. Were you able to apply a lot of those lessons learned or was this a completely different environment?

REEVES: Oh yes, it's like anything else, you just keep building on your experiences and you get to apply stuff you've learned in the past—mistakes we'd made back in Apollo, even stuff I'd done in the aircraft program and things I'd worked with there. You take all of that experience, and it becomes useful when you get in on a new system like this.

It's just amazing how you can build on your past and it just keeps coming back, because when I went back to operations for Shuttle and I was on the RMS, I was the RMS front room operator in the Control Center and supported that system. Then later, probably in around the 1982 timeframe, the RMS system was getting more mature, and we were getting further along with it, and we had the operational support established. We wound up combining the RMS operations with the APU [Auxiliary Power Unit], hydraulics and mechanical systems part, and put it under one position called MMACS officer. I became a MMACS [Mechanical, Maintenance, Arm and Crew Systems] officer, and then expanded from the RMS into APU, hydraulics and mechanical systems, and picked up those responsibilities too.

It was when I was doing that that a flight director call came out. They were looking for flight directors. I put my name in the hat for flight director and got accepted. That was in 1983. I was in the class of '83. Then when I became flight director, I didn't actually go over to the flight director office until '84. It was the largest flight director class ever selected, and there were either seven or eight of us. Half of them went immediately when we were selected in '83, and they wanted to hold the other half back and go in the early part of '84. I was the RMS operator, and we were coming up on the Solar Max [satellite] mission, which was a disabled satellite on orbit that we were going up and rendezvous with and try to repair. It had a lot of arm activity. They asked me if I would stay as the RMS MMACS guy for [STS-41C], and stay back and support that mission. When that mission was over, I'd go on over to the flight director office. Of course I agreed with it.

So I did that. When [STS-41C] was over, I went to the Flight Director Office and got into the training program. The training program in the Flight Director Office, it's about a year-long process where you study all the other systems and all of the policies and agency policies and protocols and all the stuff you have got to do. Then you start getting in simulations, and then you get assigned to a shift on a flight. We always started out as a planning shift flight director. That was always your first assignment on a mission. My first flight was STS-14 [STS 51-A]. That was the first flight I supported as a flight director, but everybody in the Flight Director Office always has the system you came from as your expertise. When you look at the Flight Director Office, there are little pockets of expertise within the Flight Director Office where if you're having a particular mission that has a heavy involvement of that system or has issues with that system, then you grab that flight director and put him on that problem.

I wound up getting a lot of good assignments on flights that had RMS as a heavy player in the flights because of my background. Again, it was building on your experience and being able to use your experience and go into other things. Also in the Flight Director Office there's a lead flight director for every flight. You get a lead job. You're the lead for pulling together all the operations for that flight. You do the operations integration for that flight. You help pull the flight control team together, working with the crew when the crew gets assigned. Then you help develop the flight plan and what the mission is all about and the details.

The program office defines the requirements for the mission and what's going to be on a flight and what the mission of the flight is. Then the lead flight director takes it from there. The devil is in the details. [The flight director] uses the organization to develop all the procedures and the flight-specific flight rules and everything else that go along with doing that mission.

My first lead assignment was the Hubble [Space] Telescope deploy mission, STS-31, which was just a real jewel. I really lucked out. Again, I don't know for a fact, but I'm sure part of the decision to put me on that flight was my RMS background. This was a big RMS deployment. Biggest payload we'd ever deployed with the arm. I'm sure that had a lot to do with it, so I started working Hubble.

I don't remember what year I first got assigned to that, but I want to say it was about around 1985, somewhere around there. At that point in time, Hubble was supposed to fly somewhere around '87 or '88. Then we had the [Space Shuttle] *Challenger* accident [STS 51-L] in '86, and there was the year, year-and-a-half hiatus in the program where everything got pushed back. Hubble got moved down the road.

During that downtime for *Challenger* recovery, when we weren't flying anything, we all got assignments to go do various things. I got assigned to go work source board for Work Package 2 for Space Station. I served on the source board to do the contract selection for the prime contractor for JSC for Space Station. That was my first exposure to Space Station. I started learning a lot about Space Station through that ordeal.

We made the contract selection, then we were getting back flying again. I came back on flight status with the Hubble mission and other missions that I was supporting. Then Hubble kept slipping due to issues. You know how the manifest constantly is moving around, so it kept moving down the road. Of course, we finally flew it in 1990. That was my first lead flight job.

WRIGHT: Did you also work on a flight safety panel after *Challenger*? Were you involved in that?

REEVES: Yes. Right after *Challenger*, they put in what's called a NASA Flight Safety Panel. Bryan [D.] O'Connor, one of the astronauts, was put in charge of the NASA Agency Flight Safety Panel. It was a very small panel with just one member from each Center. I was tapped as the JSC rep [representative] on that panel supporting Bryan. Norm [Norman] Carlson out of KSC [NASA Kennedy Space Center, Florida] and Harry [G.] Craft from [NASA] Marshall [Space Flight Center, Huntsville, Alabama] was the Marshall rep.

We would meet whenever required. We would go to the various Centers, and we would announce our presence, and we would listen to safety issues where people felt like they weren't getting proper attention to a safety issue through all the normal safety channels and reporting. We let it be known if there was anybody that wanted to appeal something or felt like it wasn't getting the proper attention, they could come meet with our panel and tell us what their issue is and we would work it, make sure it got worked, if it was legitimate.

That was a good deal. That panel did a lot of really good stuff. As part of that panel membership, Bryan got us to attend the Navy Flight Command Safety School in Monterey, California, which is one of the top safety schools in the country, or the world for that matter, that they put all of their safety folks through. I went out there, and so did the rest of them at various times, and we went through that school. We had one slot every session out there, so we'd go out one at a time. I went through that school, and that was good. You got to use a lot of what you learned and apply it to our problems.

But that was just a side job. That was in your spare time kind of a job. My primary job was flight director. Then I served as lead on Hubble. We deployed Hubble, which was just a great mission. We had our share of troubles on that mission. We got the Hubble on the arm, and got it released from the payload bay. Then you had to lift it up above the payload bay. Then you held it while they commanded the deployment of all the appendages on it. You had two high-gain antennas, you had to release latches on solar arrays, then you had to deploy the booms on the solar arrays, and then you had to deploy the solar arrays and get them out and going.

All of that commanding and data and everything was done from [NASA] Goddard [Space Flight Center, Greenbelt, Maryland]. We in the Control Center in Houston could not talk to the Hubble, and we could not see any data from the Hubble. It was all done at Goddard. Our interface was operationally getting it up there and getting it on the arm. Then we had to choreograph all of the Shuttle operations as the spacecraft was going around the Earth and tracking sites and communication sites. We had to choreograph that with the activities at Goddard and make sure that everything worked.

Well, in simulations we had—this gets a little complicated. At that point in time, and even today with the TDRSS [Tracking and Data Relay Satellite System] satellites we now have up there that we do all our commanding and data from and through, there's a keyhole where you don't have complete coverage of an orbit all the way around the Earth. There's one little area, it's over by India, that you lose communications with the Shuttle. You can't talk to it, and you can't see data from it for about—depending on the orbit—anywhere from 10 to 15 minutes. But then you've got continuous coverage the rest of the orbit.

Simulations are where you really get to hone the timing of all of the events and everything. We had discovered that we would be approaching this keyhole when it was time to deploy the solar arrays. Goddard had to send the command to unlatch the solar arrays. Then you verify the latches are unlatched. Then you'd send the command to deploy the boom. It took a certain amount of time for the boom to deploy. When you verified it was deployed and locked, they would send the command to unfurl the arrays and deploy them.

In the sims [simulations] we had found out that the timing was such that when you unlatch the latches, and then when you send the command to deploy the solar array booms, we would go into this keyhole, and we'd lose data. The Hubble people at Goddard wanted to watch the boom deploy. They wanted to unlatch the latches and wait until the other side of the keyhole, until we got data back, and then deploy the booms. You couldn't do that, because once you unlatch the latches you're in free drift on the Shuttle. You have to go free drift. The attitude control system is not working anymore. You got this great big mass on the end of the arm causing the center of gravity of the whole stack to be different. It causes the vehicle to rotate. You can get real far out of attitude if you stay in free drift very long, and we knew that.

So we argued with them that, "No, you can't do this." Once you unlatch the latches you've got to unlatch the latch, deploy the boom, deploy the solar array. Then it was one of these, "so-whats." I'll send the command to deploy the boom, and then I go loss of signal into the keyhole, and the boom deploys. When we get on the other side and get data back you can tell whether or not it deployed or not. There's absolutely nothing you can do in between.

Well, they wanted to watch the thing. "No, you can't do that." So we finally agreed that we'd do that. We'd just send the command, deploy it, wait till the other side. We got in the mission, and everything was working just like it's supposed to. We got in the mission, went free drift, sent the command, unlatched the latch, sent the deploy command to deploy the boom. It was time to send it, coming up on the keyhole, and Goddard didn't send the command.

We kept waiting. Where's the command? Where's the command? I was asking my payload officer—I was the flight director during that time—I asked payload, "Where's the command?" "Goddard hasn't sent it yet." Finally we went LOS [loss of signal]. To this day I'm really not sure exactly why they didn't send it. I don't know if they had a com [communication] problem or whatever, or they just reverted back to what they wanted to do in the first place. I don't know. But at any rate, we came on AOS, acquisition of signal, on the other side of the keyhole and got data back, and the whole vehicle was way out of attitude.

We had rates building up on the vehicle, telescope on the end of the arm. They hadn't sent the command yet. We were just very, very lucky that we regained signal. When you get far enough out of attitude, you could get into a configuration where the antennas on the Shuttle can't see the TDRSS, and you might not get data back. We were very fortunate that we got data back. But we were starting to get into trouble because we had rates building up and everything else.

Then I got put in the situation where I got stuck between two opposing flight rules. There was one flight rule that said don't fire any jets, don't activate the attitude control system with the latches unlatched and the boom not deployed on the solar arrays. There was another flight rule that said don't get Sun directly shining into the star trackers on the telescope, because that would create a problem. Here we are with these high rates building up. Loren [J.] Shriver was commander. He's calling down and saying, "You know, the rates are getting pretty high on this thing."

This is my first lead flight job. Then I had the pointers telling me that the Sun was tracking toward the star trackers. If we kept going like we're going, we're going to have Sun in the star trackers. So I got caught between these two flight rules. [F.] Story Musgrave was my CapCom [Capsule Communicator]. I had to violate one rule or the other. I knew the star tracker rule was a really bad deal. And the "don't fire jets with the latches undone" was a little bit of a conservative flight rule. So I elected, and told Story, "Go ahead and have the crew engage the digital autopilot and stop the rates." So we did. He told Loren to go ahead and do it. He did. We stopped the rates and got the vehicle back under control. Then we finished what we were doing and got everything going again. But it was one little bit tense moment.

WRIGHT: No kidding. Baptism by fire?

REEVES: But that's what you got paid for. That's why you were there. Really, it's fun. It's fun to work your way through a problem like that.

WRIGHT: Then you had an issue with the solar arrays. Is that right?

REEVES: Yes. When we deployed the solar arrays, they kept stopping. Goddard worked their way through that. They figured out there was a tensioner that measured the tension on the solar array. If the tension got too high, they automatically shut the deploy motor off because they didn't want to tear the solar array apart. They found out that this tensioner was just too sensitive. They sent a command to disable the tensioner and have the software ignore it. We went ahead and deployed it, and it worked fine.

In the meantime, we had an EVA [extravehicular activity] backup for the crew to go out and manually deploy the solar arrays if they wouldn't deploy. While they were working that tensioner problem, we weren't real sure what the problem was, from a timeline standpoint. I finally had to make the decision to go ahead and have the EVA crew suit up and get ready to go out. If we didn't get this problem fixed by a certain time, we were going to have to send the crew out there to go do it.

So Kathy [Kathryn D.] Sullivan and Bruce McCandless [III] were the two EVA crew, and they went ahead and suited up and got in the airlock and were getting ready to go out. Just about the time they were ready to go out, Goddard resolved the issue and got the arrays deployed. So we just stopped everything right where it was, and I left the EVA crew sitting in the airlock.

WRIGHT: Probably had two unhappy crew members at the moment, didn't you?

REEVES: Yes, I think to this day. Every time I see Kathy she still points her finger at me and accuses me of locking them up in the airlock, but it's all in fun. She knows full well we did the right thing. The problem is when you're getting ready to send the crew out the door, you depress the airlock from cabin pressure down to five pounds per square inch [psi] pressure. Then you stop and you do a check on the suits to make sure the suits are working. Then you continue to depress down to vacuum and then open the door and go out.

They were at that five psi check when we stopped them. We just left it there. The reason I elected to do that was because once you go to vacuum and once you open that door, you have opened yourself up to all kinds of issues. One of the things you learn as a flight director early on—and you're taught that from all your predecessors and everything else—is don't do anything that can make your situation worse.

You've got to be careful. It might sound like it's no big deal to go do it, but you got to be constantly thinking about the consequences of what you're about to do. Every decision you come up with. In the back of your mind is, ―Okay, now if I do this, what's the worst thing that can happen to me? If I don't do this, what's the worst thing that can happen to me?" You've got to keep making those decisions in your head. You have to do the right thing. To this day, if I had it to do over, I'd do exactly what I did. I could have gone ahead and said, ―Go to vacuum," had the crew go outside, and then we could have turned around and had a problem getting the hatch closed and getting the crew back in the airlock or getting the airlock repressed. A whole new set of problems.

You have to remember this was early in the program. This was only STS-31. It was still early in the program. We're still learning every time we fly the Shuttle, and we were really learning back then.

WRIGHT: That was the biggest payload that you'd ever done.

REEVES: Yes, that was the biggest payload. It was a very critical payload. There's always Monday morning quarterbacks that'll second-guess what you did, but I've really never had anybody say we did anything wrong. It ended just like we wanted it to, so it was a total success, as far as I would say.

What's interesting, it turned out later we found out on the first servicing mission when they depressed the airlock all the way, we found out that the vent tubes where the airlock pressure goes out in the payload bay impinged on the solar arrays on the telescope and made them flap. Everybody got real worried about it tearing up the solar arrays to the point that we actually modified the Shuttles to change that vent so it wouldn't do that.

I would not have liked to have found that out on that first mission. If I had gone ahead and depressed the airlock, we would have been right in the middle of that. It just goes back to never do anything you don't have to do.

WRIGHT: There are no go-backs, are there?

REEVES: No. It's just prudent to only do what you have to do.

WRIGHT: It's quite interesting, your history with the arm by itself. As you were talking earlier about being a part of the design element and then those first test runs, STS-7 surprised the ground crew by [configuring] the arm in a big 7. Was that a surprise to you?

REEVES: Oh yes, that was a big surprise. That was Sally Ride's flight. In those days, again, that's early in the program and early in the arm operations. We were still trying to figure out if the arm really did what it was designed to do. The crew went off and did that on their own. That kind of got a few people upset, including myself. It was just an unplanned activity that we weren't expecting. Goes back to the statement of don't do anything that you don't have to do.

WRIGHT: It's a memorable picture, but—

REEVES: It's a great picture and it was a great PAO [Public Affairs Office] stunt, and all's well that ended well, but it's just—I don't want to say dumb but it's just not—

WRIGHT: Not the best choice, right?

REEVES: Again, always think about your consequences of what you're about to do. People have gotten away with a lot. Not just in this program, but in life. You get away with a lot, but it doesn't mean it's right.

WRIGHT: That's true.

REEVES: A lot of people drive around the railroad crossing arms, and some people don't make it.

WRIGHT: They sure don't. You were talking about deploying, but you were involved with retrieving some of the satellites? Can you share with us about those activities and about the different types of planning for those types of events?

REEVES: Yes. One more comment on the Hubble.

WRIGHT: Okay, please.

REEVES: One of the moments that I'll always remember is when we landed after Hubble. I wasn't on the entry team, but I was in the Control Center during landing. After we got the crew back on the ground and everything else, before everybody signed off the loop, I got on the loop and made a little speech about what a great mission it was, and I told them then. I said, ―You all have no idea what we have just done, putting that telescope up there." It has turned out to be true. The [Hubble] has rewritten astronomy books. The discoveries have been amazing and has lasted much longer than it was ever designed to last.

At that time, you get caught up in doing your job, but then you don't realize the impact of what you've done. The bad news was it was about a week later or two weeks later that they found the flaw in the mirror. That really took a lot of the satisfaction away from the deploy team and the team that put it up there. As a matter of fact, all of the focus on Hubble has always been on the repair missions and the repair of the telescope and everything else ever since. I've always been a little put out about the fact that the deploy team kind of got left out of all of the hurrah, because we got it up there. We did our job. We got the thing deployed, and we did it the way it was supposed to be done. We didn't build the telescope. We weren't responsible for the mirror. It was just kind of sad it had to work out that way. It was a great accomplishment, and one of the highlights of my career was doing that.

As I told you earlier, my first flight as a flight director, my first shift I reported was the planning shift on STS-14. That was the Westar/Palapa [satellites] retrieval mission where we went up and retrieved those two satellites. We were flying the Manned Maneuvering Unit at that time. The crew flew out and speared these satellites and brought them back.

WRIGHT: That must have been an exciting time.

REEVES: It was great. It had everything.

WRIGHT: Kind of a Flash Gordon moment.

REEVES: A double rendezvous, robotics. Once they captured the satellite and they got an attachment on it, we could grab it with the arm and bring them in. We brought them back and we recovered those two satellites. That was a good mission.

Later I was on [STS] 51-I, one that I'll always remember. It turns out 51-I, Joe [H.] Engle was the commander. Dick [Richard O.] Covey, who's now the CEO [Chief Executive Officer] of the company that I work for, USA [United Space Alliance], was the pilot. [John M.] Mike Lounge, Bill [William F.] Fisher, and Ox [James D. A.] van Hoften were the other crew members. That was a mission where we took up two satellites and they were called PAMs, Payload Assist Modules, in the front part of the bay. We had a Syncom, which was a great big satellite, in the back part of the bay. We were going to deploy those three satellites. We were also going to rendezvous with a dead Syncom that had been launched on a previous mission that didn't work. We were going to recover it and repair it and redeploy it. It was a really full mission.

I was orbit 2 flight director, which is the first shift after ascent. Gary [E.] Coen was ascent flight director. He launched, and I remember driving into the parking lot. I was getting there a little bit early for shift handover. I remember hearing on the radio in my car as I was driving in that there was a problem with the Shuttle.

I went on in the Control Center and sat down with Gary. The way the PAMs were set up, they were inside of a protective sunshield in the payload bay. They had a clamshell cover that operated that would cover the satellites and protect them thermally from the Sun until you were ready to deploy them. During ascent, you couldn't close the cover because of interference with the payload bay doors. Once you get on orbit, you open the payload bay doors. Then the first thing you have to do is close these clamshells to protect the satellites.

Well, the minute they got on orbit they opened the payload bay doors. They went to close the clamshells, and on the front satellite, when the clamshell started closing, it hung up on something, and it bent the clamshell and jammed it and they couldn't get it shut. So they said, ―Well, let's get the arm out, and we'll go take a look with the camera on the end of the arm and try to see what's holding this thing up."

They powered up the arm and started moving it, and they got an alarm on the arm that they had a problem with the arm. When I walked in, Gary is sitting there, and he's got a problem with the arm, the sunshield is jammed.

He was glad I was there. We went ahead and handed over. Then Jay [H.] Greene was the lead flight director on that flight, and he came running in. The word was spreading fast that we had big problems. Jay and I sat there and had a little powwow. We agreed that we probably are not going to get this clamshell closed, and probably don't even want to get it closed, because if you get it closed, you may not be able to get it back open. We agreed that we were going to try to push it open somehow, but if we got it open, we have to deploy the satellite. Satellite deploys are timed to a certain time and certain orbit. It has to do with where you want the satellite to eventually wind up and how long you want it to last and how much propellant is on board. You have a customer for these satellites.

We were going to have to deploy it that day, if we could get the clamshell open. That created another problem, because the sequence was to deploy the middle satellite first so that you control the center of gravity of the Shuttle and have it where it can enter if you have a problem. Then you would deploy the first one, and then the Syncom later. Well, we were going to have to do it out of order. The one with the bent clamshell was the front one, so we were going to have to deploy it first. That screwed up the center of gravity of the whole Shuttle, so we were going to have to deploy the second one on the same day, which had never been done before—two satellites in one day, both on the wrong orbits, wrong day. But we agreed that's the plan, that's what we're going to do is go ahead and try to get the clamshell open, try to deploy the first satellite, and then deploy the second satellite, and then we'll be in good shape. We also had to work the arm problem.

I told Jay, “I'll go ahead and work that part of it.” Jay said, “I'm going to go back in the customer support room and start working with the program office and the customers and get agreement on going ahead and deploying.” So he left. I started working with the RMS guys and the arm. I started working with the flight dynamics people. I said, “I want deploy pads for every orbit for both of these satellites. Start putting together the plans.” Then we started working with the arm, and finally figured out what it was, and what limitations we had on the arm with this problem.

Mike Lounge was the arm operator, and the guys who built the sunshield were in the back room. We were asking them all kinds of questions and trying to relay it to the CapCom to the crew. “What can you see?” Finally I just said, “Hey, hey, wait a minute, guys, this is not working.” I got on the loop to the guys in the back room. I said, “The guys back there”—I think it was from McDonnell [Douglas Corporation] that built the sunshield. I said, “Tell them to come out here.” So these two guys came out in the front room where I was and came to my console.

I said, “Look, we're going to take the arm, we're going to go over there with the TV camera, and we're going to look.” I said, “That guy sitting right there is the CapCom. He's talking to the crew.” I had a TV monitor on the console, and I said, “You're going to see the picture right here.” I had a speaker on the console, I turned it on, and I said, “You're going to hear the crew talking. You're going to hear this guy talking. You're the experts. You see something, you tell him what you want them to do.” So I just took everybody out of the loop and put the guys who had the smarts in touch with the crew as close as I could get them.

We got the arm over there and we got the camera on it. These guys directed the CapCom to tell the crew where to point the camera. They saw what they wanted to see. They got all convinced that it was okay to push the sunshield, try to push it open, and then it would still be okay to try to deploy the satellites.

There were some cables on the inside, and they were worried about if these cables jumped off and you try to deploy the satellite, they'd hang up on the satellite. They were just trying to get comfortable with the fact that everything was okay. These guys got convinced, so we told Mike Lounge on the crew, ―Take the arm and go over and push.‖ We told him where to push. ―Push on the sunshield and see if you can push it open.‖

He went over and he pushed on it and it wouldn't move. He pushed again and it wouldn't move. Finally he was about to give up. He said, ―It's not working.‖ That's where my old RMS experience kicked in, because I went to the RMS operator, and I said, ―We're doing this in one control mode of the arm. How about trying it in this other control mode of the arm that actually gives you a little bit more torque on the motor and a little more push from the arm?‖ I just knew that from my old design experience on the arm.

He agreed and he said, ―Yeah it's worth a try, can't hurt.‖ So we told Mike, ―Hey, wait a minute, Mike, don't give up yet, go back and switch modes and push on it again.‖ He did and it just shoved right open, so we pushed it open. Then we went ahead and deployed. Then we deployed the second one. Then by the end everything was back to square one and we were in good shape.

We went on, and the next day or two we deployed the Syncom, and then we had a big empty payload bay. Then we rendezvoused with the dead Syncom. We went over to capture it. Van Hoften was on the end of the arm. There was a routine he was supposed to go through where we would get up close to it. We were worried about it having rates on it and how stable it would be. So van Hoften was supposed to—he had this quiver full of different attachments—he was supposed to put this thing called a handling bar on the Syncom where he could get hold of it and then stabilize it, and then once he got it stable manually standing on the end of the arm, then he would take that bar off, and he’d put another bar on there that had a grapple fixture on it where the arm could then drop him off and grab hold of it.

When he got there, the thing was so stable, and he’s standing there holding this bar in his hand. He made the real-time decision, “I don’t need the handling bar, I can go straight to the grapple bar.” He’s putting it back in the quiver and going for the grapple bar. About that time, we kind of lost the station-keeping with the satellite. The satellite wandered off and got over behind the orbiter and behind the engines.

Engle finally rendezvoused with it. Of course, all this time van Hoften is standing on the end of the arm bouncing around. Jets are firing everywhere. We got back to it, and he got the grapple bar on it. Then we went ahead and captured the satellite and fixed it. van Hoften manually deployed the satellite. Standing on the end of the arm, he took it and just threw it overboard and spun it as he let go of it, which he was supposed to do. We redeployed it. Then at that time, right after he deployed it, he’s standing on the end of the arm. He had a lithium hydroxide canister breakthrough on his suit, which means you’re not scrubbing the carbon dioxide out of the oxygen anymore. We declared an abort EVA for him and he had to go back to the airlock and get on the umbilicals in the airlock where he could get oxygen flow into the suit. He had to stay there while Bill Fisher cleaned up the payload bay. Then we closed out the EVA.

That whole mission was just nothing but problems from the first minute on orbit until the end. It was one of the most fun missions I’ve ever worked.

WRIGHT: Busy.

REEVES: Very busy, and there was a lot going on. They were all good. I look back at the ones I worked, and I just have had a great ride. It's been nothing but good missions.

WRIGHT: You mentioned earlier that you had been assigned the Hubble and then *Challenger* occurred. Where were you when you heard about the accident?

REEVES: At that time, Tommy [W.] Holloway was the head of the Flight Director Office. We were in Building 29, the old centrifuge building. That's where our offices were. I was in Tommy Holloway's office, sitting at his desk, using his office to have a meeting with the crew on the next flight. Rick [Frederick H.] Hauck was the commander. We had the crew in there, and I was sitting at Holloway's desk, and we were having a meeting on flight rules or something for the next mission.

We said, "Hey, we're about to launch, so let's stop the meeting and watch the launch." We had the TV on, and we watched the launch, and of course the accident happened. Everybody just folded their books up and got up and left and went back to our offices. That's what we were doing when it happened.

WRIGHT: How did *Challenger* and the rules that were changed affect your future missions? Did you have to make a lot of adjustments?

REEVES: Well, it still does. That was a huge cultural issue, and reset in the way people approach problems and the way people think. There were a lot of bad decisions made and a lot of things that led up to it. It's like any accident. There's never one single cause for any accident. It's usually a chain of events. You hear this constantly, in the chain of events leading up to an accident, there are numerous occasions where anybody could have broken the chain had they done something about something.

When you go back and look at the series of things that led up to it and the decisions that went way, way back, [Space Shuttle] *Columbia* [STS-107] was exactly the same way. There were several opportunities to have prevented that or headed that off. But you learn from that stuff. Then there are people who believe in fate and luck and whatever, and even if you had done something different, it might have just happened anyway for some other reason. I don't know. You never know that.

But absolutely the changes that were made in the program were all very positive changes from the *Challenger* accident. It changed the way we did business a great deal, just as *Columbia* was as well. We're still operating differently than we did before *Columbia*. So you always do. You always learn from it.

WRIGHT: One of the changes, was just the change of pace. You just didn't have as many missions that you were launching, and of course, the commercial satellites were gone.

REEVES: Yes, but I'm not sure that really was related. The way I remember it, that was a President [Ronald] Reagan decision to eliminate commercial satellites on the Shuttle. It had nothing to do with all this other. The way I remember it, he wanted to not use this government asset for deploying commercial satellites to try to kick-start the commercial launch capability in this country. He wanted to incentivize people to develop commercial launch capability to launch commercial satellites. He felt like you couldn't do that as long as you were getting cheap rides on a government asset. There was no incentive to go out here and take risk and spend money to develop a commercial launch system. I think he did that as a forcing function to create an industry, so I don't think it had anything to do with the *Challenger* accident the way I remember.

WRIGHT: When you were flight director, or as a flight director, are you able to make changes on procedures and how things are done?

REEVES: Oh yes.

WRIGHT: Do you remember leaving any new ways of doing things or making changes?

REEVES: Yes, as a flight director one of your responsibilities is to chair the flight techniques meetings, which is where you work through all of the operational issues for getting ready for a flight. There are actually two types of flight techniques meetings. We had generic flight techniques that work generic issues that apply to any flight. Then every flight, the lead flight director chairs a flight-specific flight techniques meeting to work flight-specific issues that you only have for that mission. In that process yes, you are defining processes that are used over and over and over again. I was involved in lots of different decisions that defined the way we operate today, as well as every other flight director in the office has been.

I remember when we worked the Westar/Palapa retrieval mission, for instance, it never had been done before. One of the big issues was these two satellites have been out here dead in orbit totally unpowered for a year or something like that. They're fully loaded with hydrazine, which is the fuel for their jets. The concern was what happens if the crew goes out in the suits, and we capture these satellites, and they're around them, and this hydrazine leaks and gets on them?

Now this stuff is bad news stuff. You get it on you, and you come back in the cabin and bring that back in the cabin and then get out of the suit, or expose the rest of the crew to it, that's bad. Bad stuff. It's fatal if you breathe it. The concern was that you had this dormant propellant system going out through freeze-thaw cycles. The engineering community had figured out that there was a possibility that you could rupture the lines due to the freezing and thawing of this propellant in the lines, and that once we captured the satellite and got it into the payload bay and got it in a stable thermal environment, there was a chance that you could have a busted line thaw out and all of a sudden this propellant spray is everywhere.

So as a result of that, in flight techniques we worked all of the procedures with the medical community and the EVA community and everybody else to figure out a detection method for how you would detect the presence of hydrazine on the suit, how you would disposition it if you did. We developed what they call the bakeout. There are flight rules on the books today as a result of this, that if you get exposed to hydrazine and if it's visible, you can brush the visible stuff and then you bake out, you lie in the Sun for an hour or whatever. I forget the times. You can bake it off, and then it's safe to come back inside.

We have Draeger [gas detection] tubes that they carry, that you can detect the presence of the stuff once you get back in the airlock, get the airlock pressurized. If it's there, then you depress again and go back out and bake out some more. Those got put on the books as a result of working those issues for that flight, and they're there today. They've come in handy for Space Station and building Space Station and working around propellant systems. So we've got the rules in place. We know how to deal with that if we ever have an occasion to do that.

That's one example. There are lots of techniques for how to use the arm with different things and in different ways that were developed that way. The rules are on the books today, and the procedures are there today.

A lot of the emergency contingency procedures were developed that way. So yes, you leave your mark behind. The folks over there today that are building Space Station, and every time you add a new piece to Station, and a new capability, and new systems, and learn how to manage the power systems and the new solar arrays that we just put up there, and manage them with the rest of the systems, and develop the software to do that and the procedures to do that, these people are breaking new ground every day. These people are leaving footprints behind for future generations on how to do this stuff. That's one of the really neat things about all this.

WRIGHT: Well, for a few years you stepped away with an interruption in your flight director—

REEVES: Yes, that kind of gets back to the statement of even the greatest job on the planet—which an astronaut and a flight director job are probably some of the best jobs on the entire planet, and flying in high-altitude airplanes was an incredible job—but no matter how glamorous it is or how much fun it is or how interesting it is, sooner or later you get tired of it. I've always figured around seven years, five to seven years seems to be sort of the—you're in your comfort zone. You haven't learned everything there is to learn. You could stay a flight director for 50 years and never learn everything there is to learn, but you finally reach a point where you know it's just time to go do something different. Some people never get there. Some people are perfectly satisfied in what they're doing forever. That's fine.

But I got selected in ’83, and by the time I did the lead job on Hubble in 1990, there’s seven years. Even though I had an interruption with the source board, it was still seven years’ worth of that kind of work. Once I’d done my lead job and got Hubble deployed, you’re sitting there thinking, “How do I top this?” After I came back from Hubble mission, I was starting to work my next assignment, my next flight. I remember sitting in my office and I’m thinking, “This is great. This is absolutely great. But as great as it is, it’s sort of been there done that, and I’d kind of like to do something different.”

I decided I wanted to go to the Shuttle Program Office and try something different, try management stuff. Leonard [S.] Nicholson was head of the Shuttle Program at the time. He got wind of the fact that I was looking around, or somehow I stumbled into him or something. I don’t remember how it happened, but he called me one day and he said, “Come over and talk to me.” He had something in mind. I went over and talked to him, and he said he wanted to bring me over to the Shuttle Program Office and let me get my feet wet in how the Shuttle Program—which is totally different than the way operations works—get a little comfortable with the way the Program Office works. But we had this thing coming down the road called Space Station. It was going to be built from the Shuttle, obviously. We needed to start thinking about how and what we needed to do to the Shuttle Program and to the rules and to the requirements and to the vehicle itself in order to be able to build Space Station.

He knew about my background with the source board and my exposure to Space Station. I had some knowledge of Space Station, so he said, “We’re going to build a Space Station Shuttle Integration Program Office function under Shuttle Program to start trying to get the Shuttle Program ready for Station.” He had designs on me to work my way into that.

I said, ―Hey, that sounds great.” I came over. There was a slot open as a branch chief under Larry [E.] Bell in cargo engineering, which was a great place to go to start, because that's the area that was going to be impacted the most by getting ready to fly Shuttle. It's how you do the integration stuff between a cargo, which to the Shuttle, Space Station was cargo.

I went over and went to work for Larry and managed that branch for about a year, or I forget the timing. It was about a year, year and a half. Then I worked with Rockwell [International Corporation] at Downey [California] that did all our cargo stuff then. Then he moved me in with Jim [James L.] Smothermon to form this Shuttle Station Integration office. What we were working at that time was: what do we have to do to the payload bay of the Shuttle, what do we have to do to the Shuttle vehicle, what do we have to do to the RMS, the remote manipulator, the arm, how are we going to build this thing called Station? We really don't even know how we're going to build it yet. It was starting to take design, but we didn't know how we were going to do it.

We started writing all the interface control documents and requirements as to how and what we needed to do. We got into this discussion of how we were even going to dock or berth to Space Station. At first we didn't know whether we were going to build a docking system and dock to the Space Station or whether we were going to—there was one concept where you would fly out to the Station and you'd grab it with the robotic arm and you'd pull the two vehicles together.

There were a lot of concerns with an active docking system, because of the energy and the forces involved if you flew the Shuttle into the Station. There was one school of thought that it would be better to just fly up and grapple the Station and gracefully pull the two vehicles together.

We worked all of that. How do you build a tunnel in the Shuttle to be able for the crews to crawl from the Shuttle into the Station? That was the purpose of that office, was getting all that stuff going, and we got all that stuff going.

It's interesting, when you go back to your background, and how your background keeps coming into the present. I had control of a budget there, a fairly large budget. In order to get ready for Station, we ran into a big issue with the robotic arm, that if we were going to berth with the Station, if we were going to grapple the Station, as the Station got larger and larger, it far exceeded the capability the arm was designed for, which was originally a 60,000-pound arm. Once Station gets big enough, the arm is having to move a 250,000-pound payload, which is called the Shuttle. No matter how big it gets, sooner or later when you're pulling the two vehicles together, all of a sudden the smallest mass you're moving is the Shuttle attached to one end of the arm. So it's bound by the size of the Shuttle, which loaded is around 250,000 pounds. We realized we had a problem with the arm that it wouldn't do what it needed to do. We were talking with SPAR about what we could do about it through the payload deployment and retrieval system program office here.

There was another problem coming up, that by that time the arm had been in existence so long that technology had advanced and the arm now was considered an old system. This happens with programs that last for a long time. You suddenly start getting into issues with the electronics and the hardware that some of it they don't even make anymore. In order to sustain the system, you can't even get the parts you need to do that. That was starting to become an issue with the arm, so we started talking about this upgrade program to bring technology up to date with the arm and give it the capability it needed to handle Station berthing if that's the way we went.

I wound up paying for these mods [modifications] out of my budget and contracted with SPAR to do that. Jim Smothermon, myself and some others—we got a big contract, sent all of the arms, one at a time, back to Canada and had them take them completely apart. Had them upgrade it to new technology, state-of-the-art digital systems, and give it this extra capability. We cycled all of the arms through that process and got them all upgraded.

Had we not done that, we would not have been able to do some of the things we've done. In fact on this next mission, the Hubble mission [STS-125], we're doing the rescue mission. We have a rescue mission in case something goes wrong with the Shuttle, since we're not at Space Station. If we have a problem with the Hubble vehicle, we have to launch a launch-on-need rescue mission on another Shuttle, and the plan is to grapple the one vehicle with the other vehicle. Had we not upgraded that arm system back then, you would not be able to do that. So it just keeps coming around.

That was one of the things we did while we were in that office. Then we got a lot of the documentation put in place to get ready. We were pushing the design of the external docking, moved the airlock from inside the orbiter cabin to out in the payload bay for the external airlock, had the Russian docking mechanism modified and put it on top that we use today. We were the Program Office getting all that started.

Then a series of events started happening. Over in MOD, Mission Ops Directorate, there was an office called the Space Station Assembly Office that was an office built for the sole purpose of trying to define the operations required for all the assembly flights to build the Space Station. What sequence do you build things, how do you manifest the different pieces, what order do you have to put the Station together, how do you do that? That's what that office was doing, the operations part of that. Bill [William H.] Gerstenmaier was head of that office at that time. Bill made the decision that he wanted to go back to Purdue [University, West Lafayette, Indiana] and get his Ph.D. He wanted to take a sabbatical and go do that, so he had announced that he was going to leave for a while and go do that.

Unfortunately at that very point in time was when the agency decided to restructure the Space Station Program from the old [Space Station] *Freedom* Program. They totally rearranged the program and changed the contract structure and the design. They had this effort going on at Crystal City [Virginia] in Washington, DC, that was where they had orchestrated this redesign of the Space Station Program.

This assembly office played a key role in all that, because whatever they were going to go from and to, they needed to be able to work the assembly sequences. It was really bad timing for Gerstenmaier to leave at that time, but he had already made that decision with the school and everything else. They needed somebody to run that office to support the Crystal City redesign effort. The Shuttle Program was restructuring at that time, and they were moving a lot of stuff around. I had several discussions with several people, and because I had the background with the robotics, I had the background in operations, I had the background in Space Station with the source board activity, so I was familiar with Space Station, plus the stuff we'd been doing in the Station Shuttle Integration Office, they asked if I would go back and run that assembly office.

I made a deal with them that I would on the condition that when this redesign activity was over, I would just go back to the Flight Director Office, because the Shuttle Program got redesigned to where they didn't need this Shuttle Station Integration Office anymore. We had done our job, and it was past that point, so then it got phased into the normal operations of the program. Everybody agreed, yes, we'll do that. I went back over to MOD, and I managed this assembly office. I made frequent trips to Crystal City to support the effort going on up there, and we got through the program redesign. Then when we got done I went back to the flight director office.

I think I told you in the first episode I've never had a career plan in my entire life. I just keep stumbling from one good deal into another. It's just been amazing. That turned out to be another stumble on to another good deal, because I went back to the Flight Director Office just at the time that they had made all of the deals to fly the Shuttle to the Russian Space Station *Mir*. They'd made this political agreement to do that, and it was also a learning process to figure out how the Americans and the Russians would work together in space and how we could operationally work together and how to work Space Station, which we hadn't done other than Skylab. Just about the time I went back to the Flight Director Office, when we were starting to get involved in this [International Space Station] Phase 1 program, which is to fly the Shuttle to the *Mir*. I got immediately right into that, and got to go over to Russia and made frequent trips to Russia.

WRIGHT: You were on the consultant team, is that correct?

REEVES: Yes, I went over to Moscow. I took the first team of flight controllers over to Moscow and set up operations in their [Mission] Control Center to support the first Shuttle and subsequent Shuttle flights to the *Mir*. What an experience! My first trip over there was probably late 1994. That was after communism had collapsed in Russia, and there was nothing over there. It was pretty bleak, and we went over there, and we didn't know what to expect. They didn't know what to expect. When we first started meeting with them, you could sense that neither side knew what to think of the other side. There was this standoffishness or cautiousness or whatever the right word is.

When I first got there, my first trip, we had to have interpreters and translators and everything. They had assigned an interpreter to me named Boris Goncharov, who was actually a research scientist for the company TsNIIMash in Moscow that manages the Russian Control Center, which is where we were. But he was fluent in English, and he moonlighted as an interpreter for this company TTI [TechTrans International] that provided all the translators and interpreters. They had assigned him to me or me to him or however you want to say it. When I got off the airplane over there in the airport and got through customs, I met this guy for the first time, and we became just instant friends. I mean we hit it off from the first day we met. This guy was fantastic.

Then the more I got to know him and realize how smart the guy was and how outgoing he was, not only was he a great friend, but he was very knowledgeable of everything going on over there. He was a smart guy. But the other thing about him was you know how you get in a group of people and there's always the life of the party, or there's the one person who can just walk in a room and change the entire mood of what's going on—that's this guy. Everybody on the Russian side over there just loved this guy. He knew everybody, and he was just one of the most likable guys you'll ever know.

Unfortunately, several years later he passed away due to cancer. But I tell you this guy—and Frank [L.] Culbertson, the astronaut who was also manager of the Phase 1 Program, will tell you that this guy was a key to us working together. We were just best of friends. Frank loved him. We got to know each other real well. He opened all kinds of doors. He would introduce you to the right people. I got to know him real well. Then you could tell he was talking to the people on the other side and convincing them that hey, you were an okay guy and you could trust him. We built up a common trust that just served us well.

Learning the way they did things, which is totally different than the way we do things, made the Phase 1 program really pay for itself. I would shudder to imagine how we would have ever pulled off building Space Station had we not gone through the Phase 1 program. Through the Phase 1 program, we learned how to deal with them, we learned them, they learned us, the way we operate, the way we live, the way we think. It just ironed out a lot of the procedures that were used to build Space Station. It wouldn't have happened. Maybe it would have, but it wouldn't have happened as easily as it has happened.

We got over there for that first trip, and they took us to the Control Center and gave us two rooms, three rooms that were adjoining rooms. One of them had a couple of old Russian consoles in it, and the other one was sort of a secretarial office entry area, and then a separate room that didn't have anything in it but a couch or chair or something. They said, "You can have this area to set up your operations in." So we did that. We established a library of the documentation that we needed to support the upcoming flights. We immediately started talking to them about trying to set up a simulation of the Shuttle to get the flight control teams working together, and the crews, and training exercises to figure out how to dock the Shuttle to the Station and how to operate together. Simulation was a totally foreign concept to them. They didn't do things that way. We had to work our way through all of that, and we set up all the communication links that we needed and then supported the first flight. So it was neat.

WRIGHT: Were you here or there for STS-63?

REEVES: I was there. In fact STS-63, Jim [James D.] Wetherbee was the commander. It was a fly-by. It did not actually dock to the *Mir*. The mission plan was to fly up to within 35 feet of the *Mir* and then declare victory and then back away. We had established the rendezvous techniques and the communications techniques and got all that done, dress rehearsal for the real thing.

I was over there with our little flight control team. There were only five of us. We were it for operations on that side of the ocean. This was something else we were building, was this whole concept of a Moscow operations team, which later evolved into a Russian operations team over here. We established through that process the need for having resident people from either country in our respective Control Centers. There was just a huge advantage to that. We suspected that when we started out. We figured that's what we were going to have to do. So we got over there and set all that up. It's just amazing history.

The day [STS] 63 was supposed to launch, we went out to the Control Center and we were ready for the launch. It scrubbed. I can't remember whether it was a technical problem or weather, but for some reason they scrubbed and they didn't launch. So we were sitting in the Control Center. We said, ―Well, we're not going to fly today. What are we going to do?" We decided it was the end of the workday, so we said, ―Let's go downtown. We'll just go downtown and go get something to eat."

We went down to the metro station to get on the metro. In the metro station, there were card tables set up with magazines and sunglasses and newspapers and whatever people were selling. I walked past this one card table and there were a bunch of newspapers from the newspaper called *Pravda*, which is an old communist newspaper in Russia, it's been around forever. *Pravda* stands for truth, but it's been around for a long time. There are these newspapers on this card table, and this big picture on the front page of a Shuttle lifting off the launch pad in Florida. The headlines were, “Shuttle roars into orbit headed to Space Station *Mir*.” It had that day’s date on it. They had already printed the paper. This was a picture from some other launch they’d put in the newspaper, and they’d already printed the papers up, and they just went ahead and sold them.

I bought a whole stack of them, this is sort of like “Dewey wins” kind of a thing. I bought a bunch of them to give to the crew as a souvenir when they got back. Here’s a picture of your launch on the wrong date. In fact, Wetherbee told me he still has it. He’s got it framed over his sofa. It’s one of his great mementos. I had those papers up under my arm, and we got on the metro and there were two, three of us standing there talking. It was cold, it was in the winter if I remember right. I remember we all had coats on. There was some little Russian standing next to me. Crowded metro.

There was a guy standing next to me, a real short guy. I’m a six-footer or a little above. Most Russians aren’t that tall, but anyway, this guy was a little guy. He was an adult, but he was a little short guy standing next to me, he had one of these big furry hats on, big coat. I could tell he was listening to us. He was eavesdropping. We were just talking amongst ourselves in English. Finally, you could tell he couldn’t stand it any longer, and he looked at me, and he says in impeccable English, the guy says, “Are you Americans?”

I said, “Yeah.” He got this real puzzled look on his face and he says, “Why are you here?” I said, “Well, we’re supporting the space program and we’re here to support launching the American Space Shuttle to the Russian Space Station.” He looked at me like, “What? What are you talking about?” So we started talking, and this guy was from some little village out in somewhere in Russia, and he had come to Moscow. I don’t know where in the world he learned

English. He spoke English not even with an accent. He was obviously highly educated. But he had no idea that there was such a thing as a space program, as a Russian Space Station. It was total news. It was like we were from another planet.

I pulled those newspapers I had under my arm out. I thought of those, and I pulled them out, and I showed him the picture on the front. I said, “Shuttle, American Shuttle.” His jaw hit the floor. He could not believe that there was such a thing, which just kind of tells you where we were. I’ll never forget that minute. It was just one of those minutes you’ll never forget.

We went ahead and went back to the Control Center the next day, and we were ready to launch that day and we launched. We had a thruster leak right after ascent. One of the primary jets on the Shuttle was leaking propellant. Well, the Russians got all worried about this. They said, “Oh, no, no, no, no, no, we don’t want the Shuttle coming anywhere near our Space Station if it’s leaking propellant. We’re not going to allow that.” Of course, it’s a two or three-day rendezvous to get to it. We had procedures for isolating the manifold the jet was on and stopping the leak, but I spent two of the most unbelievable days in my life talking to Russian engineers through interpreters over there in meetings trying to convince them that this was not a problem.

We had the normal loop set up where it was flight director to flight director. Those conversations were going on. Our engineering people were talking to each other. But I was sitting there face to face with them. Just meeting after meeting after meeting and just going back through drawings and going through the same thing and showing them pictures. Just over and over and over. That’s something we learned, that’s the way you have to deal with the Russians. It’s almost like if they hear it enough times with confidence then they believe it.

So we had all those meetings. We finally got up to the rendezvous, and we were getting close to the *Mir*, and they still had not given a go to come on in close. Victor [D.] Blagov was their head flight director. We had gotten to be pretty good friends by that time and we were really close. I had already had one conversation with him that morning in a meeting room with [Vladimir A.] Solovyev, who was head of their operations. He's an ex-cosmonaut, flown about five times. Victor and all of his top folks were in this room. They had a model of the *Mir*, and they were showing what they were worried about. I went through it one more time with him. But they still hadn't decided. The go-no-go was coming up.

I went back to the room where we were operating out of, and I told our folks in the room that I was just going to go for a walk. That's something else. I had by that time become trusted enough over there to where I could walk around by myself, which at that time not very many people could do. I could walk around the Control Center unescorted and by myself, and people knew who I was and all that. That was another thing that I sensed early on that a lot of other people that have gone over there have sensed—working with the Russians is all about personal relationships and establishing personal relationships. When you do that, you can work your way through most anything. So we had done that.

I took off for a walk, and I was walking down a hallway that was pretty dark, because they tend to turn all the lights out when they don't need them. There was a little room where their flight directors go when they're on shift and nothing's happening. They have a little room that they go to, like a lounge. It's got a desk and a couple sofas and things.

It's right across the hall from the door that goes into their Control Center, onto the floor of their Control Center. I'm walking down this hall and Blagov comes out of this lounge room, flight director lounge. He was walking into the Control Center and he saw me coming down the hallway. Well, Blagov speaks broken English. I had learned—I kind of taught myself Russian, and between my broken Russian and his broken English we can talk. He saw me coming down the hallway, and he walked over to me, and he said, “Bill,” he says, “We are getting very close to making the decision to allow you all to come in to the 35 feet.” He just kind of winked, and he went on into the Control Center.

I turned around, and I ran back up to my room and I got on the phone back to Bob [Robert E.] Castle, who was sitting at the MMT [Mission Management Team] position in the Control Center, the MOD rep console. I talked to Bob and I told Bob. I don’t remember where Culbertson was at that point in time. He was over there, but I can’t remember if he was there or not. But anyway I talked to Bob, and I told him about the conversation I just had with Blagov. Bob started laughing, and he said, “That’s very interesting considering right now this minute as we’re talking,” he said, “the Russian Control Center is telling the crew on board the *Mir* that they’re going to give a go, that they’re giving the go to us to come on in.” They went ahead and made the decision, and they told their crew first, and then they came to the regular ranks and flight director to flight director and told everybody.

We flew to 35 feet, declared victory, waved off. Remember, this was the first mission. This was the first time. But we waved off. The Shuttle started backing away. We still had a bunch of mission left in front of us, and I’m sitting there at the console along with our other flight controllers. All of a sudden Blagov and a couple other guys come walking in with Boris Goncharov, this interpreter, and they walked up to me, and Frank Culbertson was standing there, and they said, “Come go with us.” We said, “What?” They said, “Come go with us.” Okay, so we took off and followed them.

Well, they took us back into the back of the Control Center, and there’s a big ballroom back there, and they had this big party set up. They had all kinds of food laid out and everything else. This is big celebration for everything that has just happened. I mean we had one of the best times in my life. Really got to know those people through that whole mission and that whole episode, that served us for the rest of the Phase 1 program and now even.

I wound up going back over there as what we call Moscow Flight [flight director]. We had established the fact we were going to have an American flight director in their Control Center for every flight, and a small flight control team, just for the reasons that we had needed them on [STS] 63, was to work any issues face to face with them. Then we established Russians in our Control Center, and they came over here. They decided hey, this is a good deal, this is the right thing to do, so they started doing it too. We did that all the way through the Phase 1 program. Then when we started Station, it just grew into our ongoing ops support in Moscow now that we have over there. We built a facility in their Control Center over there. We always have a resident flight director over there. That's the way it all works now.

Then I went back for the first flight to Station. I was Moscow Flight for the very first launch of the Space Station, and I believe the second one. Well, the first launch was an FGB [Functional Cargo Block] launch, and then I forget the sequence now. But anyway I remember going over there. I was there for the first node launch and all that when Bill [William M.] Shepherd flew. *[For more information about his involvement with the Shuttle-Mir Program, go to http://spaceflight.nasa.gov/history/shuttle-mir. To read Mr. Reeves Shuttle-Mir OHP transcript go to http://spaceflight.nasa.gov/history/shuttle-mir/people/oral-histories/reeves.pdf.]*

WRIGHT: Well, this might be a good place for us to stop for today, and then when we get you to come back for the next time, we can talk about your involvement in Station and what led up to what you're doing now, and how it's yet one more time leaped to the next part of your career.

[End of interview]