NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

WILLIAM D. REEVES
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is March 9, 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. Thanks again for joining us this afternoon, and we'd like for you to start by talking about your background and what led to your interest in applying to the Manned Spacecraft Center.

REEVES: I grew up as a child of the 1960s in junior high and high school, and I graduated from high school in '62. I grew up in Arkansas, northeast Arkansas, and had never been anywhere. Of course, I can remember the first launch of Sputnik [Russian satellite] and the news about it. That was the starting of the whole space business. It got my attention, but at that time I was in junior high. I was very interested in it, but I was also one of these kids that was always interested in engineering and taking things apart and doing things, and seeing how everything worked. I was always that way as a kid, mostly because of my dad.

My dad didn't have a formal education beyond high school, but he could do anything, so I learned a lot from him. I knew at a very early age that I wanted to go into engineering. That appealed to me. That was the line of work I wanted to get into, as much as I understood about it.

When I got out of high school, I went to Arkansas State College, which was in my hometown of Jonesboro, Arkansas, to take what was called a pre-engineering course. You couldn't get a degree there, but you'd get the first two years. I knew I wanted to go into electrical engineering. I took the first year at Arkansas State, but then I realized I was going to lose a lot in transferring to another college. I wound up going to Oklahoma University [University of Oklahoma, Norman Oklahoma], where I went another four years to get a bachelor's degree in electrical engineering.

When it got close to time to get out of college, in my last year which was 1967, I was interviewing every company that came by. OU had a terrific placement program. There were a lot of companies that came. I interviewed with lots of people. I really wanted to interview with NASA, but NASA's docket was full and I couldn't get on the interview list. So I just picked up one of the government forms, and filled it out and mailed it in. I wound up getting interviewed twice over the telephone, and I was very interested in NASA. A guy from my hometown, who I went to high school with had gone to OU. He graduated a semester ahead of me and came to NASA here in Houston. We talked, and he was telling me how great it was. I really wanted to go to the southeast United States, and I had my eye on Texas or Florida. I wound up getting interviewed twice over the telephone, and then I got an offer to come to work for NASA via telegram. I still have it.

I accepted the offer to become a flight controller in the Apollo Program. Now, of course I was graduating as an electrical engineer, had absolutely no idea what an electrical engineer did, had no idea what a flight controller did or what it was all about. I just knew I was going into Operations and I was going to be working on the Apollo Program, which appealed to me. When I got here, it was in June of 1967, and at the time, I went into the LM [Lunar Module] Systems Branch and Flight Control Division, where we were in charge of the Lunar Module. I was assigned to the electrical power system group; we were responsible for the flight operations of the electrical power system of the Lunar Module and all of the pyrotechnic systems on the Lunar Module.

I'll never forget it. I got here, got sworn in, showed up in Building 45 in the room they told me to go to, and I was put in a room with four other guys that worked on that particular system. One of them was a guy named Bob [Robert D.] Legler, who was a Philco-Ford employee at the time. There were a lot of contractors with NASA, and I was civil service. Bob had been around forever. He was here in the Mercury Program, Gemini Program, and he really became my mentor. He took me under his wing and really started teaching me everything he knew and helped me a lot.

My first assignment when I walked in—you walk in as a new employee, and they give you a desk and they give you a big stack of books and pencils and papers, and you don’t know what you’re going to do. I didn’t know a Lunar Module from a school bus, and so the first assignment they gave me was converting the actual systems drawings that Grumman—that was the contractor that built the Lunar Module—built the vehicle from, to operational diagrams for the handbooks that we would use on console to support the mission real-time. Taking these real complicated wiring drawings and simplifying them. Quite frankly, the background I had just worked with electrical schematics and [my experiences in] tinkering with things was more help than my college education on that, because that was really right down my alley. I picked up on it really well and got immediately into it. They gave me an assignment on particular parts of the system, and so I would work on that.

In those days, we didn’t have computers or anything. Everything was done out on a tabletop with a pair of scissors, scotch tape, pencil, and paper. You’d make the drawings and tape them together, then turn them into the draftsman, and the draftsman would make them pretty and print them up and make them the right size and everything. We used to have these big drawings in the hallways taped to the walls, all up and down the building and all around the room, and that's where you would work on the full-scale drawings. None of this computer, CAD [Computer Aided Design] stuff or anything they've got nowadays.

At the time I had gotten here, it was right after the Apollo 1 fire. They were in the downtime after the fire and trying to recover from it. We were coming up on the first launch of a Lunar Module, which was an unmanned, Earth orbit test flight. So I got familiar with the system, and then went through all kinds of training. The Flight Control Division had wonderful training where they'd train you on all the different systems, and the console operations, and how the network worked, and all that. At that time we didn't have TDRSS [Tracking and Data Relay Satellite System] satellites like they've got now. We didn't have anything. There were no satellites.

We had remote sites all around the world, and the flight controllers would actually go to the remote site. As the vehicle came over the horizon, you'd have control of it while it passed over your site. Then after the flight, you'd pick up the phone and call in a report on what happened. I missed out on that because when I got here, the first mission that we were supporting was the last flight for the remote controllers to go out to the sites. Some of the group that I was working with went out on some of the tracking ships to some of the remote sites. But then they started scaling all that back, started having resident people at the sites that would call in and take care of the passes. Then, of course, later we got TDRSS satellites up after Apollo and started relaying all that information in.

My first mission was the first test flight, unmanned LM, and that was pretty exciting because it was all done by commands. You would send commands to the system and have it perform and do the things that you wanted it to do, and you'd collect all the data on it. Things were really different then because, like I said, there were no computers. In the whole Control Center, there weren't any computers. All the computers were the big mainframes downstairs that handled all the data or the mainframe computers over in Building 12 where they did analysis offline. We didn't have desktop computers; in fact, the only thing we had on the console was an old Friedan mechanical calculator that you'd punch in the numbers and pull a handle, and everything on it moved.

WRIGHT: They've become infamous, haven't they?

REEVES: Yes. That's quite an antique now, probably, but that's all we had for calculating stuff. We would do trend plotting by looking at the data on the screen and looking at the clock, and have a piece of graph paper on the console and you'd plot points. I've always thought you actually knew the systems better then because your head was right in the middle of the system at all times. You knew exactly everything that was going on, and today we rely so much on computers that we've gotten away from some of that. We don't think about it as much as we did in those days.

WRIGHT: Were you in the Staff Support Room on that first mission?

REEVES: Yes, I was in the Staff Support Room all through Apollo. I never did go to the front room during Apollo. By the time I got here, the teams had been pretty well established. So I was in the pecking order, and it took a while to work your way through the back rooms and into the front rooms. The front rooms were staffed pretty much by people who had been here through Gemini and were more experienced people. I did get rapidly to the point where I was pulling shifts on flights from the Staff Support Room; in fact, by Apollo 11, which was in July of ‘69, I was already pulling shifts. I was on Glynn [S.] Lunney’s team on Apollo 11 when we landed. I wasn’t on the shift that landed, but I was there in the room the night they landed because I was coming on as soon as the landing shift went off. That was quite a night. We all knew we were making history, but we all had a job to do and we were just doing the job. But you had to think about what was really going on and what you were really about to do. You’re doing something nobody had ever done before, and that was pretty fascinating.

WRIGHT: Can you give us an idea of what people felt? Especially for someone who had worked on the LM system.

REEVES: Nobody knew what to expect really. We had landed Surveyor [robotic spacecraft] on the Moon and had some unmanned stuff and some photos from the Moon. But nobody really knew what to expect. It’d be like picking a place to land out in Arizona somewhere and thinking the whole Earth is like that. You never know. Even if you have a lot of knowledge of one place, you don’t know exactly what you’re about to do, so it was the unknown that got everybody. By knowing the vehicles and knowing the systems as well as you did, you knew also what the limitations were. We knew we were taking big chances. When I look back with what I know and the sophistication of the vehicles we fly today—I look back at how simple those vehicles were and how little redundancy we had in some major systems and things. It was pretty gutsy.

We were really taking some chances, but they were calculated chances. They were risks, but in order to do what we had to do, you were willing to take those chances.

WRIGHT: From the time that you arrived to the time that we landed on the Moon, that was just, just two years, but it was two full years. Can you give us an idea of your schedule? Did you come here by yourself, or did you bring a family with you when you came?

REEVES: Yes, I was married at the time. We came down, had an apartment down in League City [Texas]. Like I said, I grew up in Arkansas, a pretty sheltered life. I had never been anywhere, going to school in OU. When I came down here, it was the only two places I'd ever been in my life.

I remember my first paycheck, which looking back on it now was hardly anything, but it was more money than I'd ever seen in my life, and so it was good. It was a great group of people we were working with, a lot of extracurricular activity. I got involved. We had a flag football team, and all of the different branches in the Flight Control Division and some of the other divisions would compete. We used to go out to Ellington [Air Force Base, Houston, Texas] and play flag football, lots of picnics and things like that. It was a good life. It was very good.

The other thing was the crews. We worked directly with the crews, which was nice, because in those days there were very few crew members. There were a dozen or a couple of dozen at the most by the time Apollo was over. We would work directly with the crew members and even brief the crews on our systems before they would go down for the launch. You got to know the crew really well, and that was good. That stayed with me my entire career. I still today associate with a lot of the crew members that we worked with back then. There's getting to be fewer and fewer of them, but John [W.] Young just left not long ago, and we used to work with him a lot. Worked with all the crews. They were great.

WRIGHT: Did that help when the crews returned, for you and your group to receive input from the crews of how your systems worked?

REEVES: Yes. We'd have debriefs, and private debriefs with them if we had some issue that we wanted to talk about. Then there were always the big splashdown parties, they called them in those days, that whenever the crew would get back here, there were always the big celebrations for the mission, and those were nice—where you'd really get to know them personally.

It's interesting to see where a lot of those people went in the program. A lot of them became top managers later. There was always sort of a gap between my class, when I came on, and the generation ahead of me. The generation ahead of me were the ones that actually founded NASA. They were the original group that came down to Houston from Virginia, and formed Houston Manned Spacecraft Center. There was always a little bit of a distance, separation, age-wise and experience-wise between my group and that group.

I was in one of the last major hiring groups that they hired for Apollo. I think they pretty much closed off hiring in large groups after that, because they had all the people they needed to fly the program. There's always small groups after that or small hirings, onesie, twosie stuff. I was in a group of—gosh, I don't even remember how big the group was, but I remember the swearing-in ceremony where you swear in as a civil servant. There must have been fifty or sixty people there, so it was a pretty large group.

Then I worked every one of the Apollo flights from the Staff Support Room. I was on for Apollo 13 when that accident happened. It happened right during as shift handover. I was coming on and Bob Legler, who I mentioned earlier, he was the EPS [Electrical Power System] guy that was going off-shift and I was coming on-shift. You have about a one-hour handover where the preceding shift goes over their notes and hands over anything that's going on. Then you get comfortable and you tag up with your front room operator after you've gone through your handover notes, and there's a big tag up. So it's a pretty regular thing that happens.

We were right in the middle of that handover briefing when the famous words were uttered, "Houston, we've got a problem." I had already sat at a console. Legler was standing up behind me. There was a strip charter recorder between me and the guy on my right, Dick [Richard L.] Brown, who was in charge of the power system for the Command Module. We looked over at his console, and his console was all lit up. All the limit lights and everything were on because of the explosion. He looked over at us and, he said, "You guys better be getting ready to power the LM up from a dead vehicle, because we're going to be out of power in thirty minutes." Then he followed up with, "I will bet you any amount of money that oxygen tank just blew up."

He knew that because the oxygen was stored cryogenically in tanks, and on the trans-lunar coast as you went to the Moon, in zero gravity the cryogenic oxygen would stratify and it starts layering at different densities, which affects the performance of fuel cells. So every once in a while, they would stir up the cryos. They had a stirrer inside the tank and it was manually turned on with a switch and they would stir it up. They can tell when they need to do that by the fuel cell performance. Dick had just told the front room to pass the word up to have the crew turn on the stirrers in the cryo tanks, and that's what caused the explosion. A short in the stirrer motor inside that tank. He knew right off the bat what had happened. He didn't know the severity of it, but he knew he was losing oxygen and he knew that he was losing power.

Without getting into a lot of technical detail, the problem is during trans-lunar coast, there was a set of umbilicals that the crew manually connected between the Lunar Module and the Command Module. The LM received just a small amount of power from the Command Module throughout the coast just to power some heaters. That was the only power the LM had on it. The LM was all batteries. There was one switch inside the Command Module called the CSM [Command and Service Module]/LM power switch, that when they got ready to go into the LM and activate the LM, they would throw that switch. Using Command Module power, it would turn on all the relays in the LM and bring the batteries on the buses and power up the LM.

Well, when the explosion happened, the first main power bus in the Command Module that they lost was the bus that powered that switch, so there was no way to turn the LM batteries on from the Command Module. That's why he said, "You'd better figure out how to power a LM up from a dead vehicle," he says, "because our bus is gone." So Bob and I sat there and, real-time, we wrote up the procedure for how to power the LM up from dead. It had never been done before, and you had to trick the system. That gets kind of convoluted so I won't get into all the details, but you had to go through some tricks to do that in terms of what equipment you would unpower by pulling circuit breakers. You had to turn an ascent battery on and get a bus hot in the LM, and then use that power to turn the descent batteries on, and then turn the ascents back off.

We wrote that procedure out and then passed it out to the front room, and they talked the crew through the procedure. That's one of the big differences between the Apollo 13 movie and the real world. In the movie, it looked like the crew just went into the LM and said, "We need to power the LM up." Well, they didn't know how to do that, and so in the real world the way it happened was, we talked them through the thing.

WRIGHT: Was this something that—since you had mentioned the word earlier about simplifying—was this something that was simply just between you and Bob, you could sit down and simplify this and put this together in a matter of minutes?

REEVES: Well, we knew the system so well. I mean, we lived with that system. Also, in retrospect, you look back at it and you think, "How in the world could I have spent an entire career, for years, working on this system when it's so simple?" (laughter) But there was a lot to it.

WRIGHT: It was simple to you, but it may not have been to everybody else.

REEVES: We were able to sit down and we knew what the problems with it were, and what to watch out for, and we were able to write it out. In the real world, when you're writing a procedure for something, it goes through all kinds of tests and verification in the simulators and all that. We didn't have time for any of that. I mean, we knew for a fact that we had to have a procedure on board in about thirty minutes, and so we were under the gun. We just had to write it out, and nobody questioned it. Nobody even thought about questioning it. They just read it and talked the crew through the switches and just did it.

That brings up another thing that—and my message has always been to young people coming into the program, you never know what you might work on or some idea that you have, how it may affect something in the future. Remember when I told you my first assignment was doing the simplified drawings? Well, one of the assignments my section head had given me—or my group leader—was he said, "We don't have any drawings for how to separate the Lunar Module from the Saturn vehicle, and all those circuits, and how the interface between the Command Module and the LM works." He said, "Why don't you focus on that and come up with those drawings?" So those were the drawings I was trying to make.

In the process of doing that, the two umbilicals I was telling you about that the crew mates up between the two vehicles—whenever I figured out that's the way it was designed to work and was talking with the Grumman engineers and everybody, it dawned on me that if all of the heaters in the LM were to come on at once—which is within the realm of possibility, it just depends on temperatures and the duty cycle of the heaters—that the fuse to those umbilicals wasn't big enough. It would blow the fuse and you'd be out of business, so I flagged it, I wrote a RID [review item disposition] against the vehicle and flagged it as a problem with the design. It went to all the right boards and stuff and they wound up picking up some extra, unused wires in the umbilical, and they hooked some bigger fuses in and ran some more wires, which seemed totally insignificant at the time.

But it turns out on Apollo 13, right after the explosion and until they got control of everything, when the fuel cells died on the Command Module, they had to turn on the entry batteries to get some power to do some things. The entry batteries are the batteries they use during reentry, and once they're gone, they're gone. Well, they used some capacity out of them. I don't remember the number now, but they did use quite a bit of power out of them. This became a big worry as we were trying to figure out how to get them back, and what we were going to do on entry. We came up with a way to use excess battery power we had in the LM to recharge the entry batteries in the Command Module. You did it by, again, tricking the power system out and running LM battery power back through those umbilicals to the Command Module to power the inverter in the Command Module, to step the voltage up high enough to where you could charge the entry batteries and get the battery charger working. In retrospect, had we not increased the size of those umbilicals, we wouldn't have been able to do that.

I'm sure we would have come up with some other solution, but it's just ironic. That very first assignment I had was where I found a problem that later turned out to be a player in the Apollo 13 accident.

WRIGHT: On that procedure that you just talked about, did you test that one?

REEVES: Yes, we tested it. We had time to test it then, during the mission, because we had several days to work it. That was one of the most exciting things I've ever done, was worked on Apollo 13 in that problem. There was a psychological thing that came up in that mission to me. I was interviewed by the team that put the Apollo 13 movie together. They came out here and interviewed people who had worked on the flight when they were writing the script for the movie. I had told them this in that interview, but they didn't use it. But it always struck me, and I had talked to several other people that were there and it struck them the same way.

In the main room and on all of the TV tubes, there was a clock or a counter up over the main board, the main screen, that was "Miles from Earth." As the vehicle was going outbound toward the Moon, you'd see this counter counting up, the number of miles from Earth. Of course, the explosion happened on the way to the Moon, and the fastest way to get back was to go ahead and loop the Moon and come back. It was a day after the explosion, the counter was still counting up. You were going the wrong way. You had this major problem, and you wanted to get that crew back and you wanted to get them back home, but they're going the other way.

It just struck a lot of people, myself included, as very disconcerting that you're going the wrong way, even though everybody knew that's the right thing to do. Then when the vehicle looped the Moon and it started coming back and that counter started counting down, there was a noticeable change in everybody's emotion or the way people were thinking. Everybody was really, really worried going out that we weren't going to be able to pull this off. When you were coming back this way, you started feeling like, "Hey, we've pulled this thing off. We're going to be able to do this." It just really struck me as something that stuck in my head and it's been there ever since. I remember that very distinctly.

WRIGHT: Were you there for the duration of the mission?

REEVES: Yes. I was in the Control Center for every minute of every Apollo mission. They had a dormitory in there in those days, and you could go in there. You didn't have an assigned bunk. You'd just go in there and find an empty bunk and you'd sleep. I ate, slept, and breathed that program. I was there. I didn't want to miss a minute of it. I was on one eight-hour shift out of twenty-four. I was there for the other two shifts and I'd go grab some sleep and come back. Anytime the crew was awake, anytime an EVA [Extravehicular Activity] was going on or anything going on, I was in there just taking it all in.

I was a real space nut in those days. I still am, but I remember when I got here, I'd go over to the library and check out movie reels of flight test programs and Mercury and Gemini, and I would check out a projector, and I'd take them home and I'd just sit and watch hours and hours and hours of these old flight tests and movies of previous missions and things. That paid off. It's just good experience, and it was all available to you. You could get anything you want.

WRIGHT: I have to think it gave you a deeper understanding of where the program had been and where you had come in.

REEVES: Yes, and you fill in a lot of blanks of how you got to where you are. The evolution is very important as to how you get to where you are. Then as you stay here for 42 years like I have, and you see the pendulum swing back and forth and different programs come and go, you hate it, you hate to repeat mistakes that are so obvious from the past. But we do that. There are good reasons why we do it, but you wish you didn't have to do that. At least you know where the mistakes are and you know what the outcome was, and it helps you. It helps you a lot in trying to put some sanity to what you're doing.

WRIGHT: You helped to design the controls and displays for the console.

REEVES: Yes. That was the flight controllers' jobs. You had to do your own tools and make your own tools. The controls and displays, even back then, were much simpler than what we have today. I mean, when you looked at the CRT [cathode ray tube] or the tube on the console and you looked at the data, it was a list of parameter numbers and the value and what the value meant. It would be a parameter 2V-6000-4T or something like that, which is a temperature. Then it would be a number that was the number of degrees, then it would say over to the side, "Degrees F," or, "Degrees C," or whatever. It was just columns of numbers, and those were the displays that we were putting together in those days. It was just taking all the telemetry data and putting it into a format that you could look at on the tube and make some sense out of it.

Then later, way on down the road when I got into Shuttle—all flight controllers do this. You influence the displays that you're going to use real-time on the console. Of course, in the later years you had more sophisticated tools and you could make diagrams and do all kinds of things with them, different colors. Back in Apollo, you didn't have different colors. You had one color. It was green or green on a dark background. That was it. So it's just things were so different, so different.

To send a note from the Staff Support Room to the Front Room, we used a pneumatic tube system. You'd write the note out on a piece of paper and you'd put it in one of these carriers, and you'd put it in this pneumatic tube system like you see in banks and things. You know, a drive-in bank where the tube goes up the tube? We'd send notes back and forth from the Main Room, or over to the Computer Center, or to other Staff Support Rooms. There was a network of this pneumatic tube system in the building, and that was your email in those days. Just everything was so different from what we do today.

WRIGHT: Well, another type of a tool is the operational handbook. Did you help also put those and the mission rules together, some of those?

REEVES: Yes. Again, all flight controllers do that for their system. You write the procedures for how to operate the system, and then you write the malfunction procedures where you "what-if" the system and you put the drawings together. Then you "what-if" the system and say, "Well, what if this doesn't work? What if this breaks, then what do you do?" We would build the malfunction procedures that we'd use real-time, so if you get this light on, you get this indication, then it tells you steps. It's all pre-thought out so that you can do it real-time. If you didn't do that, you couldn't do this real-time. We still do it today. It's the same way we do it today.

Then you write the flight rules, which are the rules that, again, are pre-thought out, conditional problems and you think through them and you say, "Well, if this happens, here's what I'm going to do. If this happens, here's what I'm going to do." So you write those, you write the flight rules and you capture those rules. Each flight rule in the flight rule book today that governs Shuttle and Space Station, every flight rule represents hundreds of hours of debate and discussion, panel meetings and board reviews. It's just amazing, the process it goes through to get that rule down—and they're constantly changing as things change. But yes, we wrote all those procedures.

WRIGHT: What aspect were you involved with in the simulations to prepare the flight controllers?

REEVES: We all did the simulations. That was your training, a big part of your training. You would have classroom training where you'd have an instructor and you'd go over different parts of the system. Then you would rehearse the mission or different pieces of the mission by having simulations. We got to spend some time in the simulators ourselves to go work with the various systems when you could. Simulator time is a premium, and the crews have priority and get most of the training. Then you'd have integrated sims [simulations] where you'd have the crew in the simulator and you'd have the flight control team in the Control Center, then you'd do the actual rehearsals and you rehearsed different parts of the mission. But yes, we all did that. Still do it today, it's still the greatest way to do it.

WRIGHT: How well did your training serve you, for instance, in Apollo 13?

REEVES: It was outstanding. Flight Operations has always had the best training I've ever seen anywhere. Even today the company I work for, USA [United Space Alliance], has the Training Academy over here which trains all the flight controllers and everybody now, and it's just wonderful. It's just some of the best training you can get.

You have to have dedicated people in the training organization that are there all the time, focusing on teaching. There's always going to be new people coming into the system and people leaving the system, and you've got to have a mechanism for training them. You've got to train to each mission. Each mission is unique and different, and you've got to have people who can train you on that stuff. My hat is off to the founders of this agency and these programs when they recognized the difference between operations and engineering, and they've always kept a separate engineering organization and a separate operations organization. That is most important.

The other interesting thing about it was there was always a healthy competition between the operations people who were engineers and the engineering community, trying to outdo each other and be smarter than the other person in your system. All engineers cannot do operations, and all operations people cannot do engineering. They are two totally distinct and different jobs, and a lot of people have never come to grips with that.

There are a lot of operations people today even that believe they can do the engineering job, and there's a lot of engineering people even today that believe they do the engineering on the systems and they can do the operations. Well, it's just not true. It's absolutely not true. Number one, the operations people that think they can do the engineering job don't even understand what the engineering job really is, and the detail engineering that has to be done. The engineering people that think they can do operations have no clue what it takes to operate the integrated systems, and operate in a real-time environment. Engineers in engineering work do a totally different time schedule, time-frame.

When you launch one of these vehicles, there is a finite amount of time when that vehicle has to be back on the ground, in Apollo it was a 7- or 10-day mission. Today, Shuttle missions are 12 to 14 days, whatever. You know when it lifts off, it's going to be back on the ground in 7 to 14 days, whatever the mission is, and you try to accomplish everything in that 7 to 14 days and handle any contingency that comes up. You can't think like an engineer in that environment.

When I later became a flight director in Shuttle, one of our jobs was—and we'll talk about this probably in a different session—one of our jobs was to train. We'd have training sims where there would be new, young flight controllers coming in and you would have training sims where you would train. You'd have an experienced flight director on with a lot of new people in different system disciplines, and you're helping train them and then you certify them. Well, in my career I have had, on occasion—fortunately not too many times—but I've on occasion had to not certify a flight controller because they just cannot operate in a real-time environment. I'd have to tell them, "You're a fine engineer. You've got a wonderful career ahead of you, but you're not going to cut it in operations. You just cannot function in a real-time environment." And that's true. There are people that just can't do that.

WRIGHT: I'm sure it helped, the fact that you've had both those backgrounds, in being able to help make that decision.

REEVES: I always knew that to some extent, but I really, really didn't see the difference until I left NASA. I retired from NASA in 2001 and I spent almost my entire career in operations. When I left NASA in 2001, I went over to United Space Alliance. I went into Orbiter. I was the Deputy Associate Program Manager for Orbiter as my first job at USA, which is an engineering organization to take care of the Orbiter. It was a shock. I found out that there were people worrying about things that I didn't even know people worried about, and you get down to talking to these engineers that are detail experts, not on a system but on a piece.

You have an engineer who is an M&P person, Materials and Properties person, that understands metals and ceramics and tiles and the properties of the materials. It's got nothing to do with the operations. These guys are detail experts in the real science of how this hardware is made. You've got mechanical engineers that are just experts on fasteners and screws and bolts and washers. In the operations world, you don't worry about that stuff. In the operations world, you worry about an integrated system and how it operates and all of the what-ifs and alternate ways of doing the job. It's like you know somebody built this car or this airplane that you're flying, but your job is to fly it. You don't know a lot about whoever built it, but in the engineering world, there's some sharp people over there. It's just amazing, some of the experts you run into.

WRIGHT: Do you find it so different from when you entered the Apollo era?

REEVES: No. I just didn't realize it then. I look back on it and it's always been there. I just never realized it before. When I told you before, back in Apollo, I always liked that healthy tension between engineering and operations, where we were out trying to outdo each other. In the electrical power system, over in engineering there was a subsystem manager in charge of the power system, then he had working for him battery experts, and relay experts, and wiring experts, and all this kind of stuff. Switches. Detail people that understood all this stuff. We would use all of that stuff, and we knew how to operate it, and we would try to learn as much as we possibly could, but there's no way.

You can't write procedures and malfunction procedures and flight rules, and execute them, and keep changing every mission, and work into the new script, and learning what the whole mission is about, and training. You can't do all of that and stay current on the current engineering state of technology, which is their job. We would rely on them. We were constantly talking to them all the time about, "Hey, explain this to me. How does this work? How does this work?" They'd be tickled to death to tell you.

Even today, we still have the Mission Evaluation Room, the MER supports the flight real-time, supports the flight control team. That's where all the real detail engineers are. They have access to even more detail engineers and this huge network of detail engineering. If you have a problem with a valve in one system or something not operating properly, within minutes through that system and that network you can get down to the person who put that valve together, and find out what company built it, and who built it. It's an amazing network, really amazing.

WRIGHT: You mentioned earlier about Grumman building the LM. Did you have a lot of dealings with Grumman personnel during those days?

REEVES: Yes, yes I did. I got to know quite a few of the engineers, and we had a great relationship. I went up to Long Island [New York] once, again, never having been anywhere, as one of my first trips I went up to Long Island where they built the LM, and went up there for a big battery test that we ran and got to work with them. They were always coming down here, for meetings and things, and we'd talk to them all the time on the telephone. Really, really sharp people, real nice folks. I often wonder what happened to all those people. I'm sure they moved on to other programs.

WRIGHT: There was never a lot of lead time with the LM, from what I've read. For instance, it wasn't on the schedule that the NASA management had wanted, so that's one of the reasons why Apollo 9 had to be a little delayed. Did you find a lot of new information always coming in about your systems as they were developing the LM?

REEVES: Yes, and we were the cause of some of the changes in the system because we would operate the system, we would see how it operated, and we would uncover problems during a flight. You'd see something not operating correctly, then you'd get with the engineers at Grumman after the flight and you'd say, "Hey, this is not doing what it was designed to do, and it's not doing what it did in test," and so everybody would go analyze it and then you'd figure out if you needed to make a design change to the system, but that's the nature of this business. We're always doing that.

We've flown the Shuttle 125 times, and every time we fly it we learn something new. People have talked about, is it an operational system versus a flight test program? Well, it's a flight test program. The vehicle has never become operational. In Apollo, the vehicles were never operational. It was a learning experience every time you flew it. Apollo was just so different than anything else I've ever done because you were doing everything for the first time and it was so new. You were going to a different heavenly body.

Even as fascinating as it was—and I don't know if this is just my nature, or the nature of the beast, or whatever—but even as fascinating as it is, toward the end it got to be the same old same old. Even though the missions were all a little different, and to the geologists it was just heaven on Earth to them, but to some of us that had sat in on all of the Apollo missions, they all started looking alike. You launched. Three days later usually you're landing on the Moon. That's all great and exciting and wonderful, and now you spend two or three days on the Moon. Then you come back. One mission started looking like every other mission. We used to talk about this on the console. We'd sit there and think, "Here we are, sitting here flying people to the Moon, and why is it getting mundane?" It's just something I've always observed, is that when you quit learning, you die. I mean, when you quit growing, you die. I've always noticed, somewhere in the five to seven-year time-frame, it's time to do something different because you just have to go get into something different and do something different.

Shuttle has lasted for 30-some odd years. Every flight is so different, but even it gets that way. I look at my own career. I was a flight controller in Apollo from 1967 till the program ended in '72. So there's your five years, and by the time it was coming to an end, I was really starting to think about, "It's time to go do something different."

Now, Apollo ended abruptly. I don't remember exactly how it happened. We all remember things differently, but I remember very little talk about Apollo ending. We all knew it was a finite program. We knew it was going on out to two more flights beyond where it actually ended. But it was almost like coming to work one Monday and finding out, "Hey, the program's over. They just cancelled the last two flights and the program is over." It really ended abruptly. I can't say that I was sad, because I was ready to do something different. I didn't know what. I've been so naïve my entire life. I've never had a career plan my entire life, and I just seem to fall in from one good deal into another good deal, and I always have.

WRIGHT: Maybe because you're open for opportunity.

REEVES: Well, I don't know. I guess. It's a lot of luck. I just have lucked out and been in some fascinating things. I guess anything is what you make it.

WRIGHT: Did you ever make it down for a launch?

REEVES: Not in Apollo, no. I never saw a Saturn; I was always here during launch. I was with NASA for 34 years, and in my 34 years I saw one launch and it was Shuttle launch. Since I've been with USA now, I have a console in the firing room and I go down for every launch. I've even lost count of how many I've seen now. But yes, I would have loved to have seen a Saturn launch, but never got to.

WRIGHT: You mentioned about so many of the flights having so many similarities. But were there a lot of differences from one mission to another in the LM?

REEVES: Yes, there were some changes over time. We changed the LM to what they call the Extended LM, where they increased the hover time and increased the stay time, and we added an extra battery to the vehicle so we could stay on the Moon longer. We modified the systems and added that capability to it. Then later, we added the [Lunar] Rover, the little car that we'd take up there, and we had to put that on the vehicle and figure out a way to deploy it. And the science experiments that we carried, every time were always different. Of course, the crews were always different. That was the biggest thing that was different was getting to deal with the different personalities, and that was fun, a great bunch of people.

WRIGHT: Any stories come to mind that you can share?

REEVES: There's lots of stories. Lots and lots of stories. I remember one story I've told several times. I remember prior to Apollo 11, we were over in Building 45—I think it was in Building 45—and we were having a flight rule review, trying to finalize the flight rules. In testing, they had uncovered a problem with the landing radar on the Lunar Module. There was a big debate between the people who made the landing radar and the other folks about how it would operate, and in testing they had uncovered some problems. They were trying to write a rule that said if the computer on the LM, which wasn't much of a computer, but if the computer on the LM wasn't accepting landing radar data by 60,000 feet above the Moon, then it would be an abort because you wouldn't have the landing radar to tell you how high above the Moon you were.

They debated it for hours. It was a big room full of people. I was in the room. I don't even know why, but I was in the room. Up at the head table was Neil [A.] Armstrong and Aldrin and Gene [Eugene F.] Kranz and I don't remember who else. After a big long debate, they finally say, "Okay, that's the rule, everybody agrees. If it's not accepting data by 60,000 feet, it's abort." Nobody said anything, and Neil was sitting at the end of the table with his hand on his head, and his head was down, and he was shaking his head. I think it was Kranz, looked over at him and said, "What's the matter, Neil? You don't agree with that rule?" Neil looked up and he says, "You must think I'm going to land with the window shades down." It was funny. You got the impression from him that he was going to land no matter what.

What came out of that was a very interesting thing that the flight dynamics people did. They actually came up with a modification to the trajectory so that as the LM came down—because there was no point of reference on the Moon. You look out the window and you see the rock, you don't know if it's as big as a house or if it's just a pebble. You can't judge any distance, so they shaped the trajectory to where as the LM pitched over and as it came down, you could see the shadow of the LM on the Moon. Then, as you came down, you just flew the shadow, so you could tell where you were with respect to the ground by where the shadow was. It was very clever, and it came out of all that stuff.

But we used to have just one comical thing after another with Pete [Charles C.] Conrad—Pete Conrad was just a stitch. He was more fun to work with, and when they put him and Al [Alan L.] Bean together on a flight, it was just amazing. I can't remember any specifics right now, but I just remember how much fun it was listening to those two guys and some of the things that happened.

WRIGHT: One thing, when you were talking earlier about being in the room and not missing anything, the thought for you that the electrical system is, of course, what powers that LM to get where it needs to go, and to know that Pete Conrad and Al Bean made that pinpoint landing for Apollo 12 had to be fun to listen to for you.

REEVES: Yes, it was. Those of us that worked the power system always—everybody likes to think their system is better than anybody else's. But the beauty of the power system was it was the only system on the vehicle that interfaced with everything on the vehicle. Nothing on the vehicle worked that didn't get power, and so it was fun.

WRIGHT: That's what made me think of asking about the—because if one thing got changed, it had to impact your system, whether the weight was increased or decreased.

REEVES: Yes, and we were just constantly going around, talking to all the other system engineers about their system and trying to learn as much as we could about everything. We put timelines together by hand where we would take the checklist and the flight plan, and we would interpret every single switch throw as a change in power level. We would put together these power profiles, hand-computed, because the batteries were the only power system you had, and you only have a finite amount of power in a battery, so you had to know how long they would last. We had to know every minute of the mission what the power levels were, and as they changed we'd recomputed the power. We knew how much power it would take, so we knew how long the batteries would last. Later in Apollo, as computers were getting more and more en vogue, we developed with the Mission Planning and Analysis Division a computer program to model the power system, and we could input the checklist and flight plan into this model and it would compute it for you. We built all that stuff and we developed it from our old hand calculations, so we helped design the computer program and then developed that capability. So technology was changing right along and we were adapting to it as we could. Whenever something new would come along, we'd jump on it.

WRIGHT: As well as you knew that system, did you have any hesitation when, after Armstrong and Aldrin got back into the LM, did you have any hesitation that that LM was going to ascend the way it needed to?

REEVES: Well, that was a tense moment. Everybody, especially those of us that knew the vehicle, you knew everything had to work.

WRIGHT: It had sat there for a while?

REEVES: Yes, and it had never been done before. You can test and simulate all you want, but until you actually do it, you don't know. It's like the first [Space] Shuttle flight. The first Shuttle flight, there was no test ever for the Shuttle system. The first time that vehicle every left the pad, it was manned. In Apollo, we launched several unmanned test flights with every phase of it. We had the luxury of doing that. You couldn't do that in Shuttle. We flew two or three unmanned, low-Earth orbit LM test flights. Then we flew some manned low-Earth orbit test flights before we ever went to the Moon.

WRIGHT: I was going to ask you if you had any memories or anything you'd like to share about Apollo 9 and 10. They sometimes seem to be the unsung heroes.

REEVES: I've heard lots of stories about that, and they don't jive with the way I remember it. In fact, I read something just recently about there was some political motivation to why Apollo 10 didn't land versus [Apollo] 11, and that's not the way I remember it. The LM had a severe weight program, like all vehicles do. Constellation today, you read all about it, it's got weight problems. Well, all new vehicles have weight problems.

The LM had a severe weight problem, and we went through a major weight reduction program where they took weight out everywhere they could. They shaved metal off of things, they took boxes, systems off the vehicle, anything they could to get the weight down on that vehicle. The LM that flew on Apollo 10, was the last vehicle that had not been through the weight reduction program. The vehicle on Apollo 11 was the first reduced-weight vehicle. Apollo 10's LM could not land. It was overweight. There was no way it could land, and so they already had it built and they had the mission design and everything else, and then they said, "Well, let's just do a full dress rehearsal. We can get a lot of value out of this by doing everything but land." Because there were a lot of things we had never done before. Apollo 8 went to the Moon, but it was just a Command Module. There wasn't any LM.

WRIGHT: That was with the full dress of the LM and the space walk, [with] Rusty [Russell L] Schweickart and also [David R.] Scott.

REEVES: Yes, but that was Earth orbit, wasn't it?

WRIGHT: Yes, it was still low-Earth orbit, yes.

REEVES: Yes, yes, that was Earth orbit. But Apollo 10, they said, "Hey, we can do a full dress rehearsal. We've never separated the LM and the Command Module and done a rendezvous in lunar orbit. We have never abort staged the LM. We've never flown the ascent stage by itself with a crew and back to dock with a crew. We could do all of this stuff and get a lot of value out of it in one mission without exposing you to the risk of landing, even though we couldn't land." It was very, very, very good use of a lot of good hardware, so they put together the Apollo 10 mission and said, "We'll go do that." So they flew to the Moon, got in lunar orbit, and then they separated and they flew down to within 60,000 feet of the Moon and abort staged the vehicle and came back.

That was a hairy moment because when they abort staged the vehicle, where they separate the ascent and descent stage, while the engine was burning, the vehicle did a 180-degree maneuver unexpected, and you heard the crew go, "Whoa, what's going on?" Everybody saw on the telemetry, saw the vehicle turn around and you thought, "Holy smokes!" Well, it turned out there was a switch out of position. There was a rendezvous radar antenna on the front of the LM, and at the time they abort staged, the Command Module was behind the LM catching up with it in orbit, and because the switch was in the wrong position, when it staged it told the computer to have the rendezvous radar lock onto the transponder on the Command Module—which was behind them at that time. So it turned around so it could see it. It was just doing what it was supposed to do, but just nobody expected it to happen. You always have surprises. That's what makes this great.

WRIGHT: I guess that's what keeps you on your toes there.

REEVES: Yes. That's what makes this fun.

WRIGHT: You talked about the simulations a while ago, and the training. I know that there's sometimes practical jokes played to create some levity of what was going on. Were you ever the target of one of those, or even the instigator?

REEVES: No, no. I don't remember any practical jokes played on me, and I didn't play any on anybody else. I was always pretty serious about it, and I don't remember ever being the brunt of one of those jokes. In fact, right now I remember there were some, but I can't remember just offhand any of them.

WRIGHT: When did you learn about the Shuttle coming online?

REEVES: Well, toward the end of Apollo and around the [19]70-71 time frame, they were already talking about this thing called Shuttle. They would select some of us to go off and be on these Tiger Teams to start writing the requirements for a system for this thing called the Shuttle. I spent some time on some of those Tiger Teams. They would say, "Hey, for the power system of the Shuttle—" At that time, they didn't even know what the power system was going to be, and was it going to be all batteries? Was it going to be fuel cells? Was it going to be a combination? Was it going to be nuclear? What should it be? So we'd have these team meetings, and we were trying to define the requirements for this thing. We were already starting to talk about it. We had these concepts of what a Shuttle was and what it was supposed to do, but it was the very early, early, early design days.

But then when Apollo ended, we were faced with the gap that they talk about today with the end of Shuttle and the start of Constellation. They're talking about a five-year gap, six-year gap, whatever the number is nowadays. Same thing was happening back then. When Apollo ended in '72, the first flight of Shuttle was supposed to be '79 or '80. That was the projected first flight. Turns out it didn't fly until '81, but at that time it was about '79, I think. So you were looking at about an eight-year gap, worse than what they're talking about today, and everybody was really worried about that.

They threw together a couple of programs called Apollo-Soyuz and Skylab to fill the gap with using some old Apollo hardware, leftover Apollo hardware, to do something very useful and to keep people employed and keep the operations team together to help plug the gap. So these two programs sprung up and helped fill that gap, but that took care of the Command Module people and it took care of some of the other people on Skylab and some of the Saturn folks. But us LM folks, we didn't have a job basically. I didn't even think about it. I figured, "Well, I'll do something."

Gene Kranz was head of Flight Control Division at the time, and he had put together a little Tiger Team of people to go out and try to figure out some way to keep the team together and some other things that they could do. A friend of mine was on that Tiger Team, and he told me one day that they had discovered this aircraft program, Earth Resources Aircraft Program, that was over under Science and Applications directorate at the time. He said it's a neat little program, it's got several airplanes that do Earth resources work, and he said they've got their own budget and everything. It was something that they could put a bunch of people into and make something out of, and people could learn a lot and it would keep the team together for many years. He said, "This is right down your alley." In particular, one part of the program was the high altitude airplanes, the WB-57F, which flies real high. He said, "That in particular is one that you ought to think about." I got whatever information I could about it, and it sounded pretty intriguing.

Then this Tiger Team convinced Gene Kranz, "Here's something viable, here's something you can do something with." He jumped on it and he went to the Center Director and he got the program moved from Science and Applications Directorate over to [Flight] Operations [Directorate] as an operational program. Then he put a letter out and he says, "We've got this new program coming into the Flight Ops [Operations], and they're looking for volunteers to staff up that program." One of the jobs they were staffing was called a mission manager, and there were mission management jobs on the B-57, the C-130, the P-3, and some helicopters. I responded to the letter and said, "I'm looking for a job anyway and would like to stay in operations, and I'd like to go for the mission manager job on the B-57." He had appointed Charlie [Charles S.] Harlan as Head of the Aircraft Operations Branch. I think that's what they called it. It was a branch they formed under Flight Ops for this aircraft program, and they put Charlie Harlan in charge of it.

They called me one day, Kranz and Harlan, and said, "Come over to my office." So I went over there and they said, "Hey, we want to keep you here. We'd really like you to stay in Operations, and we really think you'd be great in this aircraft program. We only have one problem." Gene told me this, he said, "We only have one problem. The B-57 is a two-person aircraft, it's a tandem cockpit, pressure-suit operations. The mission manager flies in the airplane and is an air crew member, and you don't have any aircraft experience, and that kind of bothers us."

I said, "Well, Gene, people that fly in airplanes weren't born in them." I'll never forget it. Gene just closed the book. He said, "That's it. That's all I wanted to hear," and he says, "You're in." So I went over to the program. Then we had our own training program. We went through Air Force Training Schools. I went to Kirtland Air Force Base in Albuquerque [New Mexico] for FTD [Flight Test Division] school on the airplane itself, and I went through pressure suit school at Tyndall Air Force Base [Panama City, Florida]. I went through arctic survival and water survival, jungle survival at various schools that the military had set up, and we went through all these. Since you're a navigator in the backseat—and I was a backseater, not a pilot—we went to Nav [Navigation] school and learned how to navigate.

WRIGHT: You adapted just fine?

REEVES: Yes, yes. It was great. That was just so much fun I couldn't believe it. We went out to Tyndall and got fitted for suits and went through suit test and suit training, then went out and flew in the airplane.

WRIGHT: Amazing. Well, you have to tell us some details about the differences of arctic survival, tropical survival, water survival. Tell us about some of those events; anything specific about going through those? They sound pretty memorable to me.

REEVES: Well, the FTD school on the airplane at Kirtland, up until that point, the airplane belonged to the Air Force. They only had one airplane. They had a science package that had all the cameras and sensors in it that fit on the bomb bay of the airplane. Whenever they would get ready for a mission, they would call the Air Force, the 58th Weather Squadron, and have an air crew fly the plane to Ellington here and they'd fit the pallet on it, and then they'd go fly the missions.

Well, all of that was changing at that time, where they actually got one of the airplanes transferred to NASA, and then they wanted NASA air crews to fly it. They wanted NASA pilots and they wanted NASA mission managers to fly the backseat. Since Kirtland was the home base for the airplane, they sent us out to Kirtland to learn the airplane, the systems on the airplane and how to fly the airplane and all that. It was interesting.

That airplane had a very bad characteristic called mach tuck. It was severely air speed limited, and if you exceeded critical Mach number on the airplane, you'd lose control of it and it'd go into a dive, and it would go into structural flutter and tear itself apart. An air crew based at Kirtland had just lost one to mach tuck and it had crashed. The day I showed up for FTD school they were bringing the pieces of the airplane into the hangar and had them spread out on the hangar floor, and they were in the middle of the investigation trying to put the airplane back together. It was pretty much of an eye opener and you said, "Hmm." I hadn't even flown in it at that time, and here are just pieces of this thing. It killed the crew; neither one of the crew members got out. They were doing mach tuck testing, and they intentionally put it into tuck and they lost control of it, and it got them.

That school was a several-week school, and you went through all kinds of systems training on the airplane. Then there's a water survival school down at Homestead Air Force

Base in Florida, where all of the Air Force, new air crew members, go through water survival in case you have to eject out over water or something.

WRIGHT: So you just became part of that training?

REEVES: Yes, they just got us slots into a class down there, and we went down there and joined right up with them and went through water survival. I'd pay to go see that stuff. It was so much fun. They'd take you out and drag you through the water behind a boat, then they'd put you on a parasail and take you up real high and you'd get to fall in the ocean and a helicopter would come pick you up, after you bobbed around in the ocean a while in a rubber raft. Then you'd go through jungle survival in Panama, which was the same survival school the astronauts went through, in case you ever went down in the jungle, you'd know how to survive until somebody found you. Then one of our missions was flying way up north of the Arctic Circle out of Alaska, and we were way out over the pack ice so we had to go through arctic survival training in case you ever went down up there.

Then I came back here and got a flight in the airplane. The first couple of flights were what they call non-pressure flights where you didn't wear the pressure suit, you just wore a flight suit. You'd stay low altitude and you'd just fly around the area. You'd get used to the airplane. I flew a few of those. Then you suited up and went for the pressure flight.

I remember the first pressure flight because your depth perception, your whole perception of distances is screwed up. I can't imagine how much trouble astronauts have, because we were flying over 60,000 feet. We'd get high enough to where the sky is black and you could see the curvature of the Earth, and you can see the horizon. You can see about 400 miles in any direction. We took off out of Ellington, we climbed up to altitude, and we were flying across this area and I was looking out the window thinking, "Where's Houston?" I'm looking out, "Where's Houston?" Then, "Oh, there it is!" There's Houston, there's Galveston, and everything is real close together and right underneath you because you're so high. It just changes the way you think about things.

When I first got in it was at the same time that they actually moved one of the planes here and we had one here. Then later, we added another one. So NASA had two of them here, and then the 58th Weather Squadron was still doing a mission for what used to be the Atomic Energy Commission and later became ERDA [United States Energy Research and Development Administration] and then several other agencies. Some of the work they were doing was black work or secret work, and some of it was the first theories about Freons depleting the ozone layer and all that stuff. There was a group out at Sandia [National Laboratories, Albuquerque, New Mexico] that had come up with these theories, and so they were sampling air to try to verify these theories. They were using an airplane out of the 58th Weather Squadron to do that, then the DoD [Department of Defense] decommissioned the airplanes and did away with all of them and sent them all to The Boneyard [aircraft storage and maintenance facility], and the 58th went out of business.

Well, these agencies came to NASA and they said, "Hey, you guys have air crews and maintenance crews and pressure suit people and everything, and you fly out of two of these airplanes that belong to you. Could you all pick up this mission for us?" They had the budget for it and everything. They said, "Could you all continue to do this mission for us?" We said, "Sure, but if you'll give us another airplane that's got the right equipment on it."

They did, and they gave us a third airplane that had all of the sensors on it that they maintained. So we would fly that plane. There was a regularly scheduled mission that was a 14-day mission where we would sample the air at 50,000, 55,000, 60,000, and 63,000 feet, between seventy-five degrees north latitude and ten degrees south latitude. We'd do the southern part out of Howard Air Force Base in Panama Canal Zone. We'd do part of it out of Ellington. We'd do the northern end out of Anchorage, Alaska, out of Elmendorf [Air Force Base], then we would do a couple legs on our way to Elmendorf. We'd spend one night in McChord [Air Force Base], in Seattle [Washington]. They'd want you to fly that mission and finish the mission as fast as you could from the time of the first flight to the last flight, and they'd do that three times a year. The whole purpose of it was to provide a database, cross-sectional air sampling of the atmosphere at three distinct times through the year so they could track the ozone and Freons and all this other stuff.

Then we also went to some other training that I can't talk about that was part of DoD, for the black, secret work. We picked up that mission too, and we did that for them. We had three airplanes going. Then when Skylab flew, we had the same camera systems on the airplane that Skylab had onboard, and so whenever Skylab would make a pass over the US, we would be underneath it and we would take data from the same area that Skylab was looking at. Then we would have several of the other airplanes below us taking data. We did what they call multistage sampling, where you would have imagery of the same spot from many different altitudes so you could calibrate the sensors on Skylab from our data. Then we got into all kinds of Earth resources work, doing crop surveys. We would put missions together where you'd stage the airplane out of some Air Force base somewhere in the country, you'd get a whole bunch of test sites in one area, you'd go move the airplane there for a week or two, fly out, fly all your sites, and come back.

WRIGHT: Were you always assigned with the same pilot, or did you work with different ones?

REEVES: No. We had about six or eight pilots that were checked out in the airplane, and so you'd draw a different pilot. There was no telling who you'd be with that day. There were five of us that flew the backseat, that shared the duties. You'd stay at altitude about five to five and a half hours. There was a rule that we inherited from the military that if you fly over five and a half hours in the pressure suits, you can't fly again for thirty hours. It's a physiological thing. Whenever we'd go on deployments, we'd take two crews and we'd alternate flying days. If you flew one day, you couldn't fly the next day. You'd have to stay down. We found out you couldn't even do that for very many cycles. You could fly about three cycles in a row, where you'd fly every other day for three times, then you were just shot. You'd have to stand down. Never did really know why.

WRIGHT: Did you fly often during that time period that you were working there?

REEVES: Yes, we flew a lot. I was in the program from '73 to '79, and I flew over 1,200 hours in the airplane. So you got a lot of good flying in.

WRIGHT: Is there a mission or two that's more memorable than the others?

REEVES: Well, later in the program there were seven or eight federal agencies in Alaska that pooled their budgets, and they were trying to photo-document the state of Alaska before it started getting all messed up with civilization. They wanted a baseline of what was there, and so we would go up there six weeks every summer and stage out of Elmendorf. We had the NASA U-2 staging out of Fairbanks and we were staging out of Elmendorf in Anchorage, and we were photo mapping the entire state of Alaska. We'd fly wherever the weather would let us fly. We did that every summer. That was fun.

WRIGHT: Did you find a lot of changes every time you went back, or was it a lot the same?

REEVES: Nothing that we could notice from the airplane. They were looking at detail stuff. The scientists, or what we call the principle investigators, would put together the projects that they wanted, and we would help them write the projects. We knew the capability of the airplane, and they knew what they wanted to do scientifically, and we'd get together and we'd figure out how to do it. This was all very valuable training because it paid off when we got to Shuttle.

We were learning how to outfit sensors on an airplane and adapt it to multiple missions, which is what you do with the Shuttle. We were learning how to work with scientists and put the operational end of it to get with the science people and learn how to work together. It really paid off. We did a lot of the pioneering stuff that people don't even think about anymore today. We did all the original development work for the theories for Landsat satellite that eventually replaced what we were doing with the satellite. That came later.

We did a bunch of early tests on communication via laser from the airplane to the ground. We did all of this pioneering work on ozone depletion because of Freons. We were the only ones in the world providing that data and verifying what was going on. Some of the other black work was fascinating.

I enjoyed going down to Panama and flying out of there, enjoyed going to Alaska. Out of Panama, we'd fly the southern leg. We'd fly out of Howard and go down the west coast of South America and fly straight down, we'd make our turn back to the north and our climb at Lima, Peru, and then we'd come back north. That was beautiful. You'd be flying right straight down the coast of South America, and you'd see as you were going south the Andes Mountain Range on your left and the ocean on your right. It was beautiful.

WRIGHT: You helped manage and implement a major redesign of the sensor systems, of the universal power system.

REEVES: Yes. When we first got the airplane, it was fitted with just a pallet that would go on the bottom of the airplane that was just one big pallet that had fixed camera positions and a scanner in it, so you were limited in what you could do. We designed and developed what's called a universal pallet system, where we segmented the bomb bay into four sections and we had four pallets. You could get a blank pallet, and a scientist could develop his own sensor and put it in that pallet, and then we could roll any combination of pallets under the airplane and just hook them up and raise them up and fasten them to the bottom of the airplane. We could vary the sensor complement for any mission based on what the scientists were trying to get. It gave the airplane a lot more flexibility, and the people that we could do missions for, and it turned out to be a great thing. Again, it's very similar to what we do in Shuttle. You get this big payload bay and you just put different sensors in it, and we learned a lot from what we were doing in those days and how to do all of that.

WRIGHT: It's kind of a long way from Jonesboro, Arkansas, wasn't it?

REEVES: That's a long way from Jonesboro, Arkansas. A long way. I still am amazed.

WRIGHT: Yes, that's a lot to be able to see from up there, from down to the tip of South America. Did you go further east or west?

REEVES: No, no. The only other really far off place, we went to the Azores once, which is a little island about 600 miles off the coast of Spain. The principal investigators were studying weather, and they wanted to go to the Azores in February. We kept telling them, "You don't want to go to the Azores in February; it's the worst weather in the world." They said, "No, that's what we want to study." So we told them, "Well, this airplane is kind of fragile. It's long wings and kind of gangly on the ground, but it's a beautiful flying airplane. But it can't take a lot of weather."

So we flew from Houston to Langley Air Force Base in [Hampton] Virginia because we couldn't make it to the Azores from Houston. We didn't have enough gas, and we only had one-way gas, to get from Langley to the Azores. We couldn't make it to Spain. We had to get to this 10 by 20-mile island, and we had to fly at pressure, at altitude, in order to be able to even get there with the gas we had. It doesn't take as much gas when you're up high. So we said, "We'll go to Langley. We're going to stay at Langley until we get a good weather forecast so we can go, and if we can't get any good weather, we're not going." They said okay, so we flew to Langley.

The very next day, we got up and checked the weather and they said, "Go, good weather!" We took off and we flew to the Azores. Of course, by the time we got there, the weather had changed and the winds were way out of limits, and we landed in horrible winds. We rolled the airplane straight into the hangar, shut the doors, and we were stranded there for 10 days. The weather got so bad we couldn't fly. After about six or seven days, I told them, "The first good weather day we get where we can get that airplane out of the hangar and take off, we're going home." We were there for 10 days before we got a break in the weather, and we rolled it out and we headed back. We never flew the mission. It was pretty nasty weather.

WRIGHT: Yes, that's a long way from home to be stuck with the weather, that's for sure. You shared with us earlier that your first encounter with that type of plane was the one that came back in pieces. Did you have any close calls while you were working on these assignments?

REEVES: I just had one. We had two or three in the airplane while I was in there with other crews, but I had one and that was down over South America. We were going south, and we were at altitude. We were at 60,000 feet. We had made a maneuver. The air is so thin at that altitude that you can't make quick maneuvers, it causes problems, and we made a maneuver and we lost control of the airplane. It went into this tuck, it was on its way into tuck, and the air speed was building up and we were losing altitude. It was out of control for a little bit, and I had cleared my lap in the back and I was getting real close to getting ready to eject. Because in training, they had told us from the onset of tuck until the airplane starts coming apart is 13 seconds, so you get 13 seconds to make a decision.

When you're in the airplane, you're in pressure suits and you're hot miked to each other, and you can hear each other breathing and you can talk. I could hear the pilot had his hands full; in fact, he was hollering that the thing was running away, and I could hear him huffing and puffing and fighting the airplane. You don't have any controls in the backseat. I was just about to the point of asking the pilot, "Are you getting control of this airplane?" and if he didn't give me the right answer, I was gone. I was leaving.

About the time I was about to ask him, I started feeling the airplane squat. I could feel G's [gravity] building up and I could tell that he was starting to recover. We had lost, I don't know how much altitude—I don't remember, but 10,000 or 15,000 feet we lost in just a matter of seconds. It squatted, and then he overcorrected and it lofted and it did kind of a zero G thing and it went into another squat. We went through about three or four of those and he finally got it leveled off and got control of it again. I remember the Air Traffic Control Center came on and was hollering in the radio, "Do you have a problem? Are you in trouble?" Because we didn't have clearance to come down, and he saw us on radar, saw us descend and saw us descend rapidly. They were saying, "Are you okay, do you have a problem, do we need to notify anybody or anything?" We said no, we'd got it now, so we climbed back up and went ahead and finished the mission, then came back.

Then I was in Alaska once, and we had an explosion onboard the airplane. We knew something blew, but we didn't know what it was. Everything was working. The pilot and I talked about it, and we were doing what's called a vertical profile, where you're sampling air every 10,000 feet, started at 10 and you sample every 10,000 feet up to 63,000 feet. We had just finished 30,000 feet, I think, and we were in the climb to 40,000 when something blew up on the airplane, because we felt the whole airplane shake and we heard this big, "Whoomp!" We thought, "What in the world was that?" We put it through all kinds of maneuvers and tested the airplane. Everything worked fine, all the systems were working. We couldn't figure out what in the world that was.

So we talked it over, and I told him, I said, "Well, let's go ahead and fly the 40,000, 50,000 foot samples, and that'll keep us from needing the pressure suits and getting over 50,000, and it'll also shorten the mission to where we can get back and land while it's still daylight, so we don't have to land in the dark." I said, "Because if we had something like a tire blow up or something like that, in the wheel well out there, I don't want to trip over something in the dark running away from this thing at night." He said, "That sounds like a good plan. We'll do that." So we did that.

We went back and landed, an uneventful landing, and pulled the bomb bay off of the airplane. Ball bearings went rolling everywhere, and there was a big environmental canister in the payload bay that kept a sensor warm, and it had a big door on the side of it and it was pressurized and heated from the engines. The regulator had failed on this canister, and it over-pressurized it and it blew the door open on the side of it, and the door swung up and it hit a bunch of stuff and knocked a bunch of ball bearings off of things, and broke a bunch of stuff, but it didn't affect the airplane's flying ability. We were grounded for several days while they flew parts up and got us going again.

WRIGHT: Good to be on the ground though, wasn't it?

REEVES: Yes, yes. But that, it was just one fun flight after another. It was always something different.

WRIGHT: Did you leave the program or did the program close down?

REEVES: I left the program. Like I said earlier, you do something five to seven years—and I used to sit there in that airplane, especially when you'd gone out on a mission and you had finished the data take, and you were then just ferrying back to the base, a couple hours ferry flight where you're just boring a hole through the sky. I can remember sitting there in the airplane, looking at the instrument panels, thinking, "Reeves, what are you doing? You can't do this the rest of your life. As much fun as it is, you just cannot keep doing this. This is the same instrument panel you've been looking at for the last five or six years, and you've just got to go do something different."

I was already in that frame of mind, and Shuttle was getting closer, and I was sitting in the office one day at Ellington and the phone rang, and it was George [W. S.] Abbey. I knew George real well, and he said that they were coming up on the first flights of the Shuttle, and it was getting closer, and he said, "You've been out there having fun for all these years, flying airplanes and stuff," and he said, "We need some help back in operations on the RMS, the Remote Manipulator System," which is the robotic arm on the Shuttle, which wasn't supposed to fly until the second flight. But he said, "We're having some problems getting a team pulled together and getting set up to support that system," and he said, "How would you like to come back and go back into flight control and help get that set up?"

I told him, "You know, it's funny you should mention that. I've just been sitting here scratching my head, wondering what I was going to do when I grew up, and that sounds really interesting." I took him up on it, and I came back and that's when I left the Aircraft Program. They're still flying the airplane out at Ellington. There's two of them still out there; it's the only two left in the world that are still flying, but they're still flying missions and still doing it.

WRIGHT: Haven't gone and volunteered to take another ride?

REEVES: No, I'd do it in a heartbeat, but I've hung it up. That's behind me. You finally get to that point where you get over it.

WRIGHT: I guess maybe you look at maps a different way now, because you've seen so much from above compared to what you see.

REEVES: Yes, you look at everything differently. I've often thought, to me, astronauts must have a hard time, because once you've flown in space, it's how do you top this? For the rest of their lives, there's nothing that'll top it, I don't think, and that is such a unique experience. We weren't astronauts by any stretch. We got close, but we didn't get there. We didn't get zero G, but we did get high enough where you look out the window and it's sort of the same view you see out the Shuttle.

WRIGHT: That's amazing. It might be a good time to stop, and we can pick up with Shuttle when you come back again. [End of interview]