NASA Johnson Space Center Oral History Project
Oral History Transcript

Don L. Lind
Interviewed by Rebecca Wright
Houston, Texas – 27 May 2005

WRIGHT: Today is May 27th, 2005. This interview is being conducted with Dr. Don Lind in Houston, Texas, for the NASA Johnson Space Center Oral History Project. The interviewer is Rebecca Wright, assisted by Jennifer Ross-Nazzal.

Thanks for taking time this morning to visit with us for the project.

LIND: Oh, my pleasure. You bet.

WRIGHT: You earned a bachelor of science degree in physics from the University of Utah [Salt Lake City, Utah] in 1953. Then the next year you began service, active service, with the U.S. Navy as an aviator. Tell us how these beginnings evolved into you becoming interested in applying for the space program.

LIND: Well, I started in the space program in 1936. I was six years old. My mother was a schoolteacher, and she was teaching me to read before I entered first grade. I was practicing on the comics in the Sunday funny paper, and I was absolutely fascinated with Buck Rogers and Flash Gordon and one I'm sure you've never heard of, Brick Bradford. I thought that was absolutely the most interesting thing I could imagine.

But even as a six-year-old, I knew that was not the real world. That was make-believe; that was fantasy. But when other children in Midvale, Utah, my home, were playing cops and robbers or cowboys and Indians, my sisters and a cousin and I were playing space games. That was just absolutely wonderful.

Well, in my lifetime, fantasy turned into the real world. By the time I was flying in the Navy in the Korean War, the [President Dwight D.] Eisenhower administration started a space program, which [initially] was to launch scientific satellites into Earth orbit to examine the Earth in what was called the International Geophysical Year, and they intended to go at some [later] time into a manned program.

When I got out of the Navy and was back in the university, the [President John F.] Kennedy administration formalized the manned space program into what was Mercury, Gemini, and Apollo. This was just the logical continuation of Buck Rogers and Flash Gordon and Brick Bradford. So, in a sense, it was a childhood dream, but as a child, it wasn't reality. This wasn't something I was ever going to do; this was just the most exciting thing I could think about.

Now, you mentioned the Navy. My attitude when I was young was that if you're going to do something, you might as well be absolutely in the middle of the most exciting part of it. I had served a mission for the Mormon Church, and when I came home, the draft board was very anxious to get me into the infantry. I talked them into letting me go into the Navy instead, because it still counted on their quota, and I had very strong opinions about the various services. So I talked them into going into the Navy. That was fine.

Then what are you going to do in the Navy? My evaluation was that the two power centers, the two exciting centers of the Navy back at that time, were either atomic submarines or aircraft carriers. At that time, the commanders of atomic submarines were trying to set new records about how long they could stay submerged. And, you know, sealed in a long metal tube underwater for six months just didn't meet the recruiting poster, "Join the Navy and see the world." Because I knew I was going to be junior enough they wouldn't even let me look out of the periscope. So that meant aircraft carriers.

So I applied for flight training. I managed to get into that. [I] Got into jets instead of other things, and spent a very exciting time in the Navy landing jet airplanes on aircraft carriers. That was just what I felt was my obligated service, because, other people had defended America for me, and it was my turn to go help defend America. So when I finished my obligated service, I went back to the university, which had always been my goal, and again, what's the very center—I had decided to go into science. That was my motivation. My dad got me started thinking in terms of science and that sort of thing as a small child.

So what's the most exciting thing happening in science? At that time, they called them *atom smashers*, and the biggest atom smasher in the world was the Bevatron at the University of California Berkeley. So if I was going to be in physics, let's go into high-energy nuclear physics. I managed to get into Berkeley and got my doctor's degree in high-energy nuclear physics. Then by [that] time they were talking seriously about getting astronauts, and so that was [my] childhood dream finally coming into reality.

WRIGHT: Tell us how you ended up at Goddard Space Flight Center [Greenbelt, Maryland].

LIND: When I got my doctor's degree, I wanted to go into space research, and Goddard was the most logical place to go. I didn't think I was going to become an astronaut immediately, but getting into NASA was a stepping-stone. At the university, I was doing particle physics. We were taking particles out of the cyclotron, which was at that time the world's largest cyclotron, or the Bevatron, and we were looking at particle interactions.

When I went to Goddard, we were still using particle interactions, but these were naturally occurring particles coming in from space, doing the same type of interactions of particle physics, but now they were the natural streams of particles in space rather than the man-created streams of particles in big particle accelerators. So it was sort of a logical kind of research to go into. It was the thing I was interested in. And, in the back of my mind, I still had this idea [of it being] a stepping-stone into the space program, into the astronaut program.

WRIGHT: You responded to the call for more astronauts? Is that how you decided to apply, or how did you start your application process?

LIND: As you know, I'm sure—the first group of Mercury astronauts were [invited] by private invitation. The second group of astronauts [was] an open solicitation to apply, but they only would take applications from test pilots, and I had not gone through the Navy Test Pilot School at Patuxent River [Maryland]. I was an operational pilot, but I wasn't a test pilot. So I could not apply for the first two groups.

When the third group call went out, they would accept applications from operational pilots. Ta-da, I can make it. The requirement [was that] you had to have a bachelor's degree, in any subject, but I had a Ph.D. [But] they required a thousand hours of high-performance jet flight time. I had eight hundred and fifty, and in my warped sense of values, I thought, "Well, a Ph.D. is certainly worth a hundred and fifty flight hours."

So I applied, and they turned me down, and I appealed, and they turned me down, and I asked for a waiver, and they turned me down, and I wrote to everybody that I could think of. I had written so many times [that] I was on a first-name basis with Jack [G.] Cairl in the Personnel

Office. After about a year and a half they convinced me they were not going to accept my application. But I had already started a physical fitness program to get ready for what I knew was going to be this absolutely unbelievable physical. But anyway, they wouldn't even accept my application for the third group.

When the fourth group came out, these were the first science astronauts; they were not pilots. They did not require any flight time at all, because they were going to teach them to fly. Of course, by this time, I had my thousand jet flight hours, because I was flying in the Naval Reserve. But they had put [on a new] age limit, and I was seventy-four days too old.

My argument was that what was meaningful was my useful lifetime as an astronaut, and if I gained a whole year on the front because I didn't have to go learn to fly, and even if I turned senile seventy-four days early, that was still nine and a half months longer than other people whose applications they would accept. And again they turned me down, and I wrote letters and appeals and got nowhere. But I was still keeping my physical fitness program going.

Then when the call for the fifth group of astronauts came out, I met all the requirements. They had changed the age requirement. I met all the requirements. I was back at Goddard by that time, and [the announcement] was in the evening newspaper in Washington [D.C.]. I waited until five minutes after eight Houston time to phone the Personnel Office, and the secretary said, "Oh yes, Dr. Lind from Goddard. We were wondering how soon you'd call." [Laughter]

There were thirty-two hundred qualified applications for that [selection], and I knew, because I knew some people down at NASA Headquarters, that they could only select twenty people. So there were three thousand, two hundred applications for twenty slots. They actually chose nineteen. So then they started cutting this [large number] down, first of all by the paperwork you'd sent in, and then by the people that you'd listed as references, and finally they got it down to several hundred, and I was still in.

Then they cut it down [further]; I don't know all the process. They finally got it down to sixty-four that they pulled in for the physical down at Brooks Aeromedical Center at San Antonio [Texas]. So I knew I was a finalist.

They [brought] me in and gave us this absolutely unbelievable physical. I was used to a physical that took an hour and a half. This physical took ten hours on six different days. It took sixty hours to take. It included every medical examination I have ever heard of and some procedures that I'm sure were first developed for the Spanish Inquisition. They put you on spinning chairs and centrifuges and all sorts of extremely unpleasant things.

[We] had three sessions on the padded couch with a psychiatrist, and they told us up front, very frankly, that they were sorting the normal candidates from the screwballs. But they never told us from which group they were selecting astronauts. But whichever group I was in, I was in the right group.

I made it through the physical with rather good numbers. In the Mormon Church we have what we call the Word of Wisdom, which is a health code that suggests no tobacco, no alcohol, this sort of stuff. Then I've had this physical fitness program going for quite a while. So the physical exam went really very well. Then [we] had interviews and all that sort of stuff, and by some miraculous intervention, they decided that I could come down and be an astronaut. [Laughs] So it was an intra-agency transfer from Goddard down to Johnson Space Center.

WRIGHT: What were your goals and your expectations of wanting to finally be at the place where you wanted to be?

LIND: Well, I'm sure there was a tremendous component of this [being] the most exciting adventure of this generation. When I was a child, I realized, to my great distress, that I had clearly been born in the wrong generation, because I would love to have sailed when the great square-rigged sailing vessels were plying the oceans and the whalers were going out and the clipper ships were running back and forth to the Orient. That was real adventure. [These were] the explorers exploring the Earth, and I was obviously a couple of hundred years too late for that.

The year I received my Tenderfoot Boy Scout badge was a very bad year for me because that year Admiral Richard [E.] Byrd took with him to the South Pole two Eagle Scouts, and I thought, "Oh, this is the last spot on the planet to explore, and I am five Scout ranks too junior to go, and there is nothing of any interest left to happen in my lifetime." I asked my mother, "When the war is over, what are they going to have on the newscast? There's nothing to talk about."

I'd decided by this time, that this was the great adventure of our generation, and I have not changed my mind. I think the space program is the most exciting public event in the twentieth century. So to be part of that was a tremendous motivation. Now, that was probably, obviously, the dominant reason—motivation.

But there was also a motivation that you can do good science. This was exploring the unknown. This was expanding human understanding of the world, the cosmos in which we live. I'd been doing that. I'd been doing research at Berkeley in particle physics. I had been doing research at Goddard in space science physics. Now this was just an extension of doing experiments in another, wonderfully exciting regime.

WRIGHT: Your group of nineteen were split into those that were going to work on the Command Service Modules and those that were going to work on the Lunar Modules, and that was the area that you got put into.

LIND: Yes. When you first get into the space program, you obviously go back to school. [We] spent, [as I recall, about] eighteen months or so learning all the fundamentals; pressure suits and orbital rendezvous techniques and rocket engines and this sort of stuff, and you read a stack of books that's three feet high. When you finish that fundamental training, back in those days, you were assigned a technical assignment, and since I was in the group of astronauts who were obviously being trained to go to the Moon, that was the area of our assignments. Jack [Harrison H.] Schmitt and I shared the assignment of lunar surface operations.

Now, Jack is a geologist, and so he worried about picking up rocks and the tools to do that. I worried about all the other procedures and hardware that was to be used on the lunar surface. That made me automatically a member of all the design teams that were designing all [of the required] hardware and working out the procedures and writing down the procedures, the flight plan procedures. So I was just automatically a member of all the different teams designing the various pieces of equipment.

Now, obviously, there were electrical engineers that worried about that. There were thermal engineers that worried about that. I was responsible for human factors. Can the astronaut perform the task with the restriction of his pressurized gloves in the pressure suit, which restricts his movements somewhat, in either the zero-G of space or the one-sixth-G on the Moon? So I made hundreds of parabolic flights in the zero-G aircraft or the one-sixth-G aircraft;

same thing, just a slightly different parabola. So I worried about what was going to happen between touchdown and liftoff on the lunar surface.

I don't say this boasting, but I knew more about what Neil [A. Armstrong] and Buzz [Edwin E. Aldrin, Jr.] were supposed to do on the first mission and Pete [Charles Peter Conrad, Jr.] and Al [Alan L. Bean] were supposed to do on the second mission than they did, because at that time we were spending about 80 percent of our time training for malfunctions. Can you complete the rendezvous if the radar goes out? Can you complete the landing if the altimeter goes out? In simulations, things were always breaking. Can you keep going [on with] the mission, completing the mission with the malfunctions thrown in?

Well, it was very correctly decided that if you have some malfunction on the lunar surface, nobody dies. You may lose an experiment. You may not get television, something like this, but nobody's life is endangered. So the crew correctly decided, "We will not train for any malfunction procedures." So if the equipment didn't work exactly as advertised, they had no idea what to do as a backup.

I had spent three and a half years playing these [malfunction] games, so I sat right in the center seat in the front row of the Mission Control Center so that if some piece of equipment broke, I could simply step forward, pick up the microphone, and talk them through the procedures that I had tested that they had not trained for.

It turns out that that was not required. Nothing broke on those two missions. But it gave me an absolutely excellent seat for what I think of as the most exciting part of the space program, the most exciting thing in our generation. So I was intimately involved in the preparations for the first two landings on the Moon, and I still think of those early Apollo landings as the golden age of space. I don't think we've done anything since then that [has] had the sense of destiny, the sense of history, the sense of sheer high adventure that those first landings did.

Now, as I'm sure you know, the original plans were to make ten landings on the Moon, Apollo 11 through Apollo 20, and we were building Command Modules and Saturn Vs and all the equipment for ten landings. Then Washington, in their infinite wisdom, reduced the budget and canceled the last three flights to the Moon, and I did not get to go to the Moon. That was an incredible professional disappointment. But, you simply gird up your loins and press on, since you have no other options.

Then we did the Skylab Program, and Vance [D.] Brand and I and Bill [William B.] Lenoir were going to obviously fly on the second Skylab. We'd been backup for the last two of the Skylab I flights, and Vance and I were the rescue crew, and so it was perfectly obvious to everybody that we would fly on the second Skylab, when again they reduced the budget, canceled the flight, cut the vehicle in half with a welding torch, and it now sits in the aerospace museum [National Air and Space Museum] in Washington. I think it's the most expensive museum display in the world, two and a half billion dollars.

So I spent six and a half years training for two flights that never flew, but it was exciting [anyway]. The training that we were going through was, for me, absolutely wonderful. Those of us who were training to go to the Moon received essentially a master's degree in astrogeology, and it's the kind of training you couldn't go to any university in the world to get. Because of the prestige of the program, they could get anybody they needed to teach any class they needed. So [for] anything that we might see on the Moon, we went to absolutely the best analog on the Earth.

If you're talking about craters, you go to the Barringer [Meteorite] Crater in Winslow, Arizona. You get Gene [Eugene M.] Shoemaker to teach the class, sitting on the edge of the crater. You talk about shield volcanoes. You talk about nuée ardentes, you go up to the Valley of Ten Thousand Smokes in [Katmai] Alaska. You talk about fissure volcanoes, you go to Iceland and get Sigurdur Thorarinsson, who was the national geologist of Iceland, to teach the class, sitting right on the edge of the Vatnajökull [glacier]. You couldn't get that kind of training anywhere [else] in the world.

We did that in geology, physical geology. We did the same thing again in solar physics, because in Skylab [we were] going to have the most sophisticated solar observatory that then existed. I have been to every major solar observatory in the United States. We had classes from all the experts. [It was] absolutely fabulous.

We were going to be in space long enough that you [had] to worry [about] what you are going to do if someone says that he's got this pain right here in his kidneys? What are you going to do if somebody says, "Oh, my wisdom tooth really hurts"? Are you going to abort a multi-hundred-million-dollar mission because some guy has some pain? So they sent us through an absolutely fabulous crash course in medicine. I have operated on people in full operating procedures. I have done dental surgery. You know, the average physicist just doesn't get to do things like that.

That's besides all the water survival training. [For Apollo] you're going to land in the ocean. If you're a little too shallow with the reentry, you're going to end up in the Amazon Basin, so we [went] through a jungle survival training. If you're a little bit more shallow, you end up in the Sahara Desert, so we went through [desert] survival training.

So even though it was incredibly disappointing not to fly on two different missions that [I] had trained for [ten] years, the training and what [I was] doing while [I was] getting ready was, to me, absolutely stimulating, absolutely—it's hard to say whether it was worth it, because of the disappointment, but it was certainly a nice way to spend your time. So I had a wonderful experience early in the space program, even though I lost out on two flights.

WRIGHT: Part of what we learned when we were researching you is that during this time that you were doing all these other things, the late sixties, you helped design and develop experimental gear for an orbital geophysical observatory, one of the satellites.

LIND: Yes. That was when I was back at Goddard, we had some experiments that were going on, OGO [Orbiting Geophysical Observatory]-5. One of the interesting things was that on the first landing, on Apollo 11—you won't believe that there was office politics in this, but one component of the scientific community got General Sam [Samuel C.] Phillips to agree that no science would be done on the first mission that couldn't produce results in ten minutes. Because if you have to abort after you've been there for twenty minutes, and you've started to set up a science station that's going to take ninety minutes to set up, which was ALSEP [Apollo Lunar Surface Experiments Package], which was one of the big projects, you've aborted and got nothing to show for it. So they got this ten-minute rule, which obviously means that the only thing you can do is pick up rocks. Guess who got that rule through?

Well, the rest of the scientific community rose up in righteous indignation, and said, "Hey, that cuts out everything except geology."

General Sam did the logical thing. He said, "Well, if you can come up with any science that you can do in ten minutes, it can go on Apollo 11."

The scientific community decided collectively that the most important single piece of equipment they could send up there was a seismometer, because that's how we understand the interior of the Earth [by detecting] earthquake [generated] seismic waves [as they] pass through the Earth. That's how we understand the interior of the Earth, and [hoped to understand the interior of the Moon]. We did not expect tectonic earthquakes up there, but we did expect meteor impact moonquakes, and so a seismic station was extremely important. This was being built by the Bendix Aerospace Group up in Ann Arbor, Michigan. They had a $6.2 million contract, as I recall.

I was, by definition, part of this team. I was essentially the one that had to decide—can it be done in ten minutes? Operational problems were my part of the responsibility. That was a challenge. A [normal] seismic station is the size of a small room in the basement at some university. They had miniaturized that into a twelve-inch-diameter can sixteen inches high. It was an absolutely magnificent piece of scientific equipment.

But this had to be set up in ten minutes. They'd come up with really a neat design, and I'd go up and try it. My suit tech was living up in the Holiday Inn at Ann Arbor, and they had my pressure suit up there all the time. I'd go up for these tests, and I'd say, "Great design, but it takes twenty-two minutes to deploy. Can't do it."

I had no contractual authority over their contract, but I was the one that had to go into Deke [Donald K.] Slayton's office and say, "Deke, we can do this under the rules."

One of the engineers up there, oh, he would have liked to have beaten me up, because I was the thorn in his side. In one meeting, he said, "Dr. Lind, what do you want?!" [shouting]

I said, "Have you ever heard of Constantine?"

"What does Constantine have to do with this?"

I said, "Constantine had a recurring dream. He saw the sign of the cross in the sky and the words, 'Under this sign conquer.' I have a recurring dream. I see a great red button in the sky that says, 'Push.'" And got up and walked out of the meeting and flew back to Houston.

Two or three days later, one of the Vice Presidents called me up and said, "Would you accept a handle that says 'Squeeze'?" [Laughter]

I said, "Well, I can be airborne in twenty minutes. I'll see you in two hours." So I jumped in a plane and flew up there, and they really did have an excellent design. I got my pressure suit on, and they had a little simulated lunar surface. [There were] 105 engineers standing behind [a] rope, [watching expectantly]. [I] did the deployment, and it worked just fine, and I said, "Sold," and everybody cheered.

This was so late in the procedures that Buzz, who was [going] to deploy this, had never seen a deployment. So I flew down to the Cape [Kennedy, now Canaveral, Florida]. I said, "Level it with a bubble level; you know what they look like. Line it up with a gnomon. You know what they look like. And then there's a handle that looks like a cane. Reach under the handle and squeeze the trigger. It's going to start doing things. Now, don't move, because if you move, you'll bust it. It's going to start deploying solar cells all the way around you, and when it quits moving, then just back out slowly and go away."

When he got back, he said, "Oh, Lind, that was fantastic. I wish we'd had the television set up to see that."

This [instrument was] deployed about thirty feet from the Lunar Module, and during the first night on the Moon, the crew had gone back [into the LM]. They were sleeping before the takeoff the next morning. And the seismic station picked up something. They didn't think it was a meteor impact at a distance. It was something really close. So the science team called the Mission Control Room and said, "Did some relief valve just go off, or did some mechanical [operation] go on in the Lunar Module?"

They went down the line and quizzed every single [controller.] The last one on these surveys was always the flight surgeon. When they got to him, he said, "Oh yes. Exactly at that moment, Neil turned over in the hammock." That was registered on the seismometer thirty feet away out on the lunar surface. [That's how sensitive it was.] That was very satisfying.

The other experiment they wanted to put up is called an LR^3 [pronounced LR-cubed], which stands for Laser Ranging Retro Reflector. There's a certain kind of optics where you can do an internal reflection off three surfaces, and the light beam will come back in exactly the same direction that it approached. They wanted to put some of these retroreflectors on the Moon and then beam lasers up to the Moon and measure the distance to the Moon within an accuracy of two inches. This was to check on general relativity; [that is] to check to see if the gravitational constant was slowly decreasing because of the expansion of the universe. So this is a big deal scientifically.

Since it had to be deployed in ten minutes, I was automatically a member of the [LR^3] team. And that was easy, because all you had to do is open it up and set it down on the Moon. There was no [time] problem with this one.

But since I was a scientist, I was interested in the science that could be accomplished. There were two proposals. One was from the Geophysical Institute at Hanscom Field [Bedford, Massachusetts] with the Air Force. The other one was a university consortium led by the University of Maryland [College Park, Maryland]. They were using different lasers, and so the optics requirements were a little bit different. One was more expensive than the other, [however]. But the one that was the more expensive had the potential to grow; if they got better lasers in the future, then they could do more accurate measurements. The other one couldn't grow.

General Sam's procedure, when you had to make a choice between two groups like that, was you have a meeting, and it went on all day. One team would make their presentation, and the other team couldn't make any rebuttal. [Then the] second team would make their presentation; [and the] first team couldn't make any rebuttal. Members of NASA who had operational questions, about orbits or crew involvement or something, could ask amplifying questions. Then General Sam, with the wisdom of Solomon, would just say, "Cut the baby in half."

He was the most reasonable leader I have ever seen, and I have never disagreed with [any] of his decisions. I was very impressed. But I had done enough research [that I felt] that one of the experiments was scientifically superior to the other. So when they got around to questions, I asked my three well-thought-out, [pre-planned] questions—and I knew what the answers were going to be, and it would show that one experiment had a better growth potential than the other. And that's the one that General Sam chose.

Al [Alan B.] Shepard [Jr.] and I were the two representatives from the Astronaut Office, and as we walked out of the room, Al said, "Lind, do you know what you just did?"

"No, sir. What did I do?"

"You just spent an extra $300,000 of the taxpayers' money."

I said, "Oh, sir, it was worth it." As I think back on this, [as a] flippant little thirty-six-year-old kid, who happens to be at just exactly the right spot, at the right location at the right time, [I] could influence a decision like that in the space program. I don't know how decisions are made nowadays, but in those days, you could have a big impact.

I find a personal satisfaction in that, because [right] now there are two experiments that are using those same retro reflectors, and they're trying to measure the distance to the Moon to [an accuracy of only] two millimeters. Because they have this incredibly improved laser system, [they likely can do this. These are the verifications] that they're doing on general relativity right now, which could never have been done if we'd gone with the cheaper of the two experiments. So these were very heady times. These were exciting times, because they were impacting not only adventure, but they were impacting the very front edge of scientific research.

WRIGHT: You mentioned that you had a front-row seat for the Apollo 11 and Apollo 12 missions. At what point did your duties start moving from those missions into Skylab and the Apollo Applications Program?

LIND: Probably about [the time] they committed to [Apollo] 14, I guess. They called in a group of us, and said, "Now, we want you to start working on the Skylab Program." Well, as soon as they [said] that, you [knew] that you just lost a trip to the Moon. So as I recall, it was about the time that 14 was flying, so there were still two or three flights to go, but we were now working on the Skylab Program.

WRIGHT: Were you involved in the Apollo 13 recovery at all?

LIND: Well, in a sense, no, and in a sense, yes. Because I had been so intimately involved in 11 and 12, [in] the normal sequence I didn't have any support assignments for 13. I kind of got to rest a little bit and then would pick up support assignments for the next mission or two. So I was not on the support team until the explosion took place.

As soon as the explosion took place, then everybody was working in the simulators to try to get things worked out, so everybody plunged back in. We were doing simulations, of course, around the clock at that time, figuring out a way to bring them home with the Lunar Module engine, because they were afraid that the Service Module engine would explode, because the damage was back in that area.

WRIGHT: Could you share with us what it was like for the personnel at MSC [Manned Spacecraft Center, now Johnson Space Center] when they found out that the Apollo missions were going to be reduced? For instance, you mentioned the disappointment of knowing that your chance to land on the Moon was gone.

LIND: Well, there were different feelings. There were a very large, influential group of engineers who were anxious to design and test and verify machines, launch vehicles or Command Modules or what have you. Once Apollo had shown that their equipment worked, now the motivation was to jump on to the next big mission. They didn't want to just run an airline back and forth to the Moon.

So those people, I think, were quite satisfied that, "Yes, we have proved that [this] system of hardware works. Now let's go design something new and better." So I don't think they were distressed. I'm not sure they were gleeful, but they were certainly not distressed by the canceling of those flights.

Those of us who were involved in the operational world or those of us, an even smaller group, who were excited about the science you could do, were devastated. So depending on what your motivations were, there were different feelings.

WRIGHT: But you felt encouraged enough to take on your new role in Skylab and move on to that?

LIND: Sure. You bet. That's your job.

WRIGHT: Tell us how this program was different for you than the one that you had just come from, and, of course, how it was similar.

LIND: We were going to use the leftover Apollo hardware to essentially put in space the first temporary Space Station, so this was another big step forward. We were going to have some very sophisticated science on board. The solar physics observatory, the telescope to see the sun, was going, [and] it turned out [the things we learned] rewrote every chapter in every astronomy book on solar physics. This was a big deal.

There were some very sophisticated medical experiments that were going to be run, [what would be the] long-term effects of weightlessness on the human body. These [experiments] were going to be very significant for moving on into longer trips into space.

There were some very sensitive instruments for Earth resources, [with which] you could look down at the Earth and measure crop densities or see what the water content in the soil was and predict harvest rates and this sort of thing. So there were some very sophisticate Earth resources experiments. All of which [was] very exciting, so, you got over one disappointment and pressed on to the next big challenge.

WRIGHT: Tell us what some of your first roles and responsibilities were when you got moved over to start working with Skylab.

LIND: My assignment was the Earth resources equipment, and so I helped design—excuse me—I observed the design and put [in] the crew [requirements]. Again, I'm not an electrical engineer. I'm not an optics engineer. There were people doing that. But the crew interface, the human factors, the operational questions again were my responsibility, so I worked for quite some time on the Earth resources package of equipment that was going to go up.

WRIGHT: I think you mentioned earlier you were named as a backup for Skylab III and IV. Did your role start to change then, and what kind of training did you receive?

LIND: By this time the equipment was designed, and now we started in training to fly the mission. [That included] all the operational training that goes on for any mission. Vance [Brand] and Bill Lenoir and I were on the backup crew for the last two missions, [so] we were backing up the other [two] crews. I was backing up two of the most depressingly healthy people you can imagine. [We] weren't hoping for anything serious to happen to them; nothing more serious than a compound fracture. [Laughs] But they used to joke that the prime crew would never walk ahead of us down the stairs. [Laughter]

WRIGHT: Smart men.

In [19]'73 NASA began talking about a space rescue mission team, and you were a part of that. Can you share with us how that came about and all of the rationale behind that?

LIND: Yes. The question [was one of hardware reliability. We were] going to take a Command Module and fly up to the Space Station—the Skylab and shut it down; shut down the Command Module. Then two or three months later, you're going to try to start it up again, and this has never been done. The Command Module was designed to come up to power with all sorts of ground support equipment. So the logical question [was] what do you do if you can't get the Command Module to work.

The answer was you get another Command Module and go up and rescue the crew. Vance and I were the rescue crew, and we again had to work out the operational procedures of how are you going to handle [such a flight]. [We were] trained for the rendezvous, just like the original crew did.

But then you had to decide several other things. You're going to have five crew members in the Command Module instead of three, and this brought in a lot of operational questions. How do you fit them in? What happens if you get into an inverted position? If you land in the water and the Command Module flips over, it's stable either floating point down or point up. If you are point down and inside the Command Module, it's a very disorienting situation.

So Vance and I had gone through some training on this out in the Gulf with a real Command Module. Then we were going to take one of the crews out and show them how this was going to work. I said to one of the other crewmen, who I'd better not mention his name, "Now, if we get in 'stable two,' [upside down] remember you're on the top of the vehicle, and so when you unstrap, make sure you have a hold of a stanchion someplace."

He looked at me like, "Lind, how dumb do you think I am?"

Well, we got in "stable two." The radio called for this guy to unstrap. It was hard to realize that you were now strapped [to] the ceiling, because it was bouncing around in the water. He released his seatbelt and wham, [he fell several feet.] Then he looked at me like, "If you say one word, I'll kill you." [Laughter]

So there were all those kind of operational questions. Another big question was [concerning] all [the] scientific data up there. [This] could be in the form of samples. [It] could be in the form of film. What are you going to bring back? That was an operational question that you could not decide ahead of time.

Vance was the commander, and he said, "Okay, Lind, you're the cargo master. When we get up there, you have to make the decision [as to] what we can bring back, [and] what we can't." So I had to inventory all the possible decisions to maximize the scientific return with the limited capability we had to return all that data. So we had to go through all those kind of questions. We were not needed, but it was a well-thought-out emergency operation.

WRIGHT: I think for a short time they thought you might have to go up and rescue Skylab III crew.

LIND: Yes.

WRIGHT: Could you give us the situation and how you began to prepare for that and then the length of time we're talking about?

LIND: Well, we were also the backup crew, so we immediately jumped in the simulators to see whether there was a reliable way that we could bring them back with the one set of thrusters not working properly. Basically Vance was the lead on that and came up with a wonderful procedure that management [said was] totally safe to do. So we were so clever as the backup crew that we worked ourselves out of a flight as the rescue crew. You really didn't want to have to go rescue them. You really wanted to bring them back safely with all their equipment, so that was the right choice.

WRIGHT: At what point in the program, your involvement in the Skylab Program, did you realize that your opportunity to be able to fly as part of an Apollo crew was gone?

LIND: Well, as part of the Apollo crew, it was when we were assigned to Skylab.

WRIGHT: I'm sorry. I meant Skylab.

LIND: In Skylab, [we had another great disappointment.] Washington makes these incredibly "wise" decisions—they decided never to launch the second Skylab. We were at a social gathering. I had a chance to talk to the Administrator and say, "You can't do this. You can't waste a two-and-a-half-billion-dollar piece of equipment and not go up and do the follow-on science that you can get with these incredible solar observatories." The telescopes that we were using to observe the sun were absolutely rewriting the whole textbook on solar physics.

Totally emotionless, he said, "That would delay the Shuttle by a year," at which point I just sort of smiled and walked away. They had their criteria, and in their set of values, they made the right decision. In my set of values, they wasted a wonderful opportunity, but Headquarters being what Headquarters is, they make the decisions. You salute smartly and press on.

WRIGHT: Did you have any involvement with bringing the Skylab down when they started to deorbit it?

LIND: Originally Vance and I were going to go up and push it down into any twenty-mile circle on the Pacific Ocean they decided. We were trained to do that. There were some complications. I had to, hard-suited, release the latches if the latches didn't work [normally]. So there was some risk in that, but we were prepared to go. Then they elected not to do that, [and just] to let it [reenter uncontrolled].

Because we were involved in the preparation for the deorbit mission, I was in the Control Room all during reentry. When the trajectory came up on reentry, if it had made one more orbit, it would have gone right straight across Washington, D.C., and I said, "Aha, there is some justice in the system."

Everybody looked at me like, "You traitor. You traitor."

Charlie [Charles S.] Harlan, I think, was the Director at the moment, and when they saw [that the trajectory was going to cross Canada], he looked at Chris [Christopher C.] Kraft [Jr.] and said, "Dr. Kraft, you really have to call the White House."

Just like a whipped little puppy, he walked into the room and picked up the phone and said, "Mr. President, we suggest you call the Canadian Prime Minister and tell him that we may drop some pieces on Canada." [Laughs]

What happened was that the footprint, that is, the area in which you're going to dribble in debris, was so long that it actually went up onto part of Nova Scotia. [The main component was] supposedly going to impact in the middle of the Atlantic Ocean just off Dakar, Senegal. Then the Air Force, who was doing the tracking, called up and said, "No, oh, we're sorry. Our prediction—we're going to go down range by another twelve minutes or something." That moved the [main] impact area down south of Johannesburg, South Africa, which saved the Canadians, but now put the [furthest part of the] impact area up over Australia.

If you're going to have to go over a land area, that was the most unpopulated area in the entire world, so, you know, the Lord was really watching out for us. But that did mean that we dribbled pieces onto Australia.

The people in the Control Room, were absolutely tremendous. We got a call from an Air Force tracking system that gave either the moment of impact or the moment of impacting the Earth's atmosphere or the moment of breakup, and I forget which it was.

Chris Kraft said to Charlie, "Call them back for more data."

Charlie said, "I can't, sir. That's the mission we don't know about."

But that meant that things had gone up across Australia. Then we waited. And then we got a call from the tower operator at Perth, Australia, [who said] that a commercial airliner at

40,000 feet up northeast of them [reported], "Something just passed me that looked like a freight train with its brakes locked. It was throwing sparks all over the place." Oh! Goodbye, Port Moresby.

It was really tense as to whether or not there was going to be human life damage as well as property damage. There was one rancher that got a piece on his roof, but I think that's the only [piece that came close to anyone.] That's the closest to a human being impact that we had. So the Lord was really watching over us on that one. This was not human planning that controlled that. That was totally in the Lord's hands.

WRIGHT: Did you have involvement with ASTP [Apollo-Soyuz Test Project]? Your buddy Vance Brand went on to fly on that mission.

LIND: No, I didn't really have anything to do with that mission, because by that time, we were involved in Shuttle.

WRIGHT: How did they transition you over to the Shuttle area? Did they give you specific responsibilities at the beginning?

LIND: I can't remember just exactly what the very early responsibilities were. They just announced in a pilots' meeting, "The following group of people will now be working on the Shuttle Project." So, you get assignments accordingly.

WRIGHT: Before we move on to the Shuttle, I meant to ask, there's a couple of things that you did I thought were of interest that you might want to talk about. One was that you were with fourteen other astronauts when you participated in the food compatibility test for Skylab missions. You got to test the foods that were going up.

LIND: Oh yes, yes.

WRIGHT: Can you share with us what that was like and how they put that together for you?

LIND: Well, I can't remember just exactly when a man named Clayton [S.] Huber came into the program. The first Mercury, Gemini, and very early Apollo food program [was before he arrived. For those mission] they worried about nutrition and shelf life and stability and all that sort of stuff, and they never worried at all about taste. Some of the early Gemini food [was strange], if you can imagine puréed plum and peanut butter in a toothpaste tube, [things like that]. We actually tried it out in the jungle, and on the third day you [could] take it, but [on] the first two days, you'd rather not.

Then a man by the name of Clayton Huber came in and took over as the lead food scientist in preparing the food, and he was the first one that talked about taste and palatability and "Do you like it?" So we had all sorts of things [to eat] that we would test. They did a marvelous job. He and the ladies that prepared the food were great. Every so often you'd have lunch in the Briefing Room over in Building 4, and you'd try out different menus and then you'd write your little comments and they really did improve the food tremendously. By the time we flew in the Shuttle Program, the food was really great.

On the ground, the chicken teriyaki [tasted] absolutely fabulous, and so I [chose to have] chicken teriyaki once a day [on orbit]. You set up your own menu, and I had chicken teriyaki once a day. I did not particularly like the spaghetti, because it was more spicy than I like. So I never had any spaghetti in my menu. [But] when you get up on orbit—and I don't think we've ever really tested this, at least they hadn't when I left the program, because it had no operational [impact]—you have a difference in your appetite. Man, I got up on orbit, and the spaghetti was great. [I would say,] "I'll trade you two chicken teriyakis for a spaghetti."

The food was really very good. The only thing that changed for me was I suddenly loved the spaghetti. [They had] a very nice way of testing out all the flavors of the drinks. Do you like cherry better than strawberry? It was very, very well done. I think most astronauts back in that day would consider Clayton Huber as one of the heroes of the space program.

WRIGHT: You mentioned the tubes, so were you also trying out the containers that you would be using? Did they have—

LIND: Oh yes. Most of the food—well, [about] 85 percent is freeze-dried. You literally pull the water out of it. Because [on orbit] when you create electricity, you're going to take liquid hydrogen and liquid oxygen and run it through a power cell, and you create electricity and absolutely pure water. That's a by-product from the power cells. So there's no use hauling the water [component of the food into orbit], because it makes the food so much heavier. Most of it is freeze-dried.

It looks like something you swept up off the garage floor. It looks absolutely terrible, in its little plastic container with a [thin] film over the top, like saran wrap. You add water, and in nine minutes or eleven minutes, it turns into salmon salad or [spaghetti, or], you know, everything.

The texture did not reconstitute properly on three foods, but the flavor was great. Apples and strawberries tasted like apples and strawberries, but they chewed like rubber bands, and the potatoes tasted like potatoes, but they chewed like Styrofoam. It was like eating a Dixie cup.

But the flavor was great. The [other 15 percent of the food was] really in the liquid state, like canned peaches or fruit salad or something, then there was a pop-top lid, [and] a film [under the lid]. You sliced [the film] with a knife, like a great big buttonhole, and if you were careful, you could get the spoon in, and the surface tension of the liquid was enough to hold one peach slice and its liquid [in the spoon long enough] to get it into your mouth, if you were very careful.

If you jiggled your hand, a drop of liquid would float off and you had to chase it down and get it into your mouth, because the air flow would carry it right straight into the electronic system. So letting liquids get away in space was a problem. The drinks—and many of them were powdered, and you'd add water, and they'd reconstitute—came in a sealed container with a little straw to drink out of.

So you had to be careful not to let food float away. Most of the food that was reconstituted was sticky enough that if you got it on the end of a fork, it would stay there until you got it in your mouth. But the food, by the time I flew, was very good.

WRIGHT: I have, I think, one more question at the moment about Skylab, and this is when you were part of a team that went to Huntington Beach [California] to work with McDonnell Douglas for preflight verification tests. Share with us about the importance of these teams going down and verifying everything that needed to be there and what kind of—

LIND: Well, this was a twofold thing. When they would do the tests, you had to go through simulated counts and power up and power down and all the operational things you're going to do with a piece of hardware. It was a good training exercise for us, but it was also a good verification of the design, because we were intimately involved in what the requirements [were], either because of time pressure or because of the weightlessness or something, so that we could verify that the design was correct.

I don't know that we made any major inputs into the design of the Command Module, but I was on the same assignment one time for the camera that we were going to use. I was talking to the engineer who had designed the camera. "Okay, how do you change the film?"

"Well, like you'd change it on the ground."

I said, "Well, that means that you're holding the camera in one hand, and you're holding the film container in the other hand, and you're taking the film in a third hand and inserting it into the camera, but the cover is floating away."

He said, "Oh, that's right."

They had to do [only] simple little things; put Velcro tabs so that you could literally do it with two hands. Because there's no such thing as setting two pieces on the table until you need them, and he just had not thought about that. So that was just a simple little thing on a camera, but it was the same type of verification for the Command Module System. It was training for us and verification for them.

WRIGHT: You left for about a year to go do some postdoc [post doctorate] work.

LIND: Yes. When there was a long delay, they suggested that the scientist-astronauts, if they wanted, could take a sabbatical leave to maintain their scientific capability. When we first came in, the scientists were told, "We will not fund a laboratory for you here. If you can maintain an operational connection with some other research group, we will give you a limited time to maintain your scientific capability and currency, but with other laboratories around the area."

So then when we had the long delay when Shuttle was getting ready, they said, "If you want to take a sabbatical leave, fine." So I jumped at the chance.

I had been doing work—and this is a follow-on to some work I had originally started at Goddard—with the Aurora, and I thought, "If you're going to study the Aurora and particularly the particles coming in to create the Aurora, [choose a laboratory where you can continue this work]."

I had had a collaboration with the University of Bern, Switzerland, and Johannes Geiss. Herr Doctor Professor Johannes Geiss and I had an experiment on Skylab [in which] we had detected some of the particles coming down to create the Aurora. The assumption had always been that these were particles that originated in the sun, but this was not [absolutely certain], because [this assumption was based only on] energy arguments. We actually collected some of these particles and [measured] the isotopic ratio numbers and proved that they were solar particles, which verified that section of the auroral theory.

Well, [I thought,] if I'm going to [continue working on] auroral science, [I] might as well do it at the very best spot on the entire Earth for studying the Aurora, which is the Geophysical Institute in Fairbanks, Alaska. That's why they put it there. So we took a year's leave of absence and went up to the Geophysical Institute and spent a year there doing some [preparatory] work. When we actually flew, we did some studies of the aurora which were, again, rather significant because of these connections that I had made while we were up in Alaska.

So it was simply a way—since we'd be treading water waiting for the Shuttle to come along—it was a very useful way to maintain our scientific currency. This was at the suggestion and approval of NASA Headquarters, so I jumped at the chance.

WRIGHT: It worked out well.

We've been talking about an hour, and we're moving into that Shuttle phase. Want to take a break? We'll switch out the tapes, and we'll come back and talk about Shuttle.

LIND: Yes. That would be very nice.

[pause]

WRIGHT: Before we ended and took a break, we mentioned about you becoming involved in the Shuttle era and being involved in some of the responsibilities there. We know that you worked in the development group that was responsible for developing the payloads for the early orbital flight test.

LIND: Yes. I guess the first significant assignment I had was in developing the control system for the remote manipulator system, the RMS. In the hinge line of the cargo bay doors, there is an arm that's articulated pretty much like the human arm. It's about as long as two telephone poles, and it's designed for deploying and retrieving satellites. Again, somebody had to worry about the operational considerations of that arm. It was built by the Canadians with the agreement through the [U.S.] State Department, and I was assigned to work on that. So I made a lot of trips into Canada to work with those people. The people who were actually building the hardware were very, very compatible, very easy to work with, and we had a very nice working relationship.

There were several things that I had to input. One was the [different] coordinate systems that [they] were going to build into the software. One coordinate system, obviously, [applied when] you're looking out of the window into the cargo bay, and so you want to work in that coordinate system. If you wanted the arm to move away from you, you pushed the hand controller away from you.

Also, if you're trying to grasp a satellite [that is] up over your head and you're looking [with the TV camera] down the fingers [at the end of the arm, which is called] the end effector, and you want to move straight along the direction the fingers are pointing, you don't want to have to try to figure out which way you [should] go, so you shift to a totally different coordinate system. So if you're looking in the TV picture with the camera that's mounted right above the end effector, you want to push the hand controller straightforward. You want it to move straight forward in the television picture. [Actually] there were three different coordinate systems, and I helped them decide what those should be.

Then there's the question of how are the hand controllers supposed to be configured. We wanted hand controllers [where] the translation [motion] would be done by one hand controller, which we decided would be the left hand, and the rotational [motion controlled by a] hand controller [which] would be [handled with] the right hand. We decided, as a joint decision, that the hand controller for translation should be a square knob.

Then I said, "Now, remember you're floating. You're floating, so you've got to hang on to something while you're translating, and you don't want your bobbing around to [affect] the hand controller. So you need to put a square bracket around it so you can [hold onto the bracket] with your little finger and can use the hand controller."

"Oh yeah, we hadn't thought of that. Well, how big do you want it to be?"

Wwe actually measured my hand, and designed [the controller and bracket] to the physical dimensions of my hand. Obviously, when you make a decision like that, then you have five other astronauts check it out, and they say, "Yeah, that was a really good decision."

[Also] I didn't want the hand controller for the right hand to be mounted square on the bulkhead, because the relaxed position of your arm is not at a square angle; it's drooping down to the side. And I wanted that position to be the no-rotation position. We [set up] a simulation, and I stood up there, and they measured the angle of my arm and then built a bracket to mount that hand controller just exactly the way my arm relaxed. And again, we had several other astronauts check it, and they said yes, that was a fine thing.

So the hand controllers were literally fine-tuned to my design. Now, other people were worrying about the software, how to implement these coordinate systems. Other people were doing all the very sophisticated engineering. But the human factors was my responsibility, and basically it was a very pleasant experience to work with the Canadians, with one exception.

The arm has two joints like the elbow, [and] like the shoulder; one degree of freedom in the elbow [two in the shoulder,] and three degrees of freedom in the wrist, so there are three literal components to the wrist junction. They had mounted the camera on the middle one. As you maneuver in certain ways, the wrist has to [compensate for] the rotations of the other joints, and every once in a while the TV picture would simply rotate. Not that anything had [actually] rotated, but the wrist was compensating. I said, "That's unacceptable."

They said, "No, no, no, no, it has to be there. That's the cheapest place to put it."

The engineers were all in agreement that this was a mistake, because you could lose a satellite when suddenly the picture rotates and nothing really has happened. But the management people said, "This meets our letter of intent with the State Department. We're not going to change it."

So in one meeting, I had to be very unpleasant. I said, "Now, gentlemen, if we ever lose a satellite because of this unnatural rotation, I will personally hold a press conference and say that you had been warned, and it's the Canadians' fault."

They looked at me like, "Ooh, you're nasty." At the next meeting, they said, "Well, we'll change it, and it doesn't cost as much as we thought in the first place."

Usually you could get good cooperation, but occasionally, particularly with people up in the bureaucratic levels, you had to be a little bit pushy. I try not to be pushy, but that's one time I did.

[Eventually the RMS control system] worked out very nicely. We had several simulators down [at JSC], and we had [large fabric] balloons that would simulate either the LDEF [Long Duration Exposure Facility] satellite or the Hubble satellite, the Hubble Space Telescope. We did simulations both in Canada and [at JSC]. I think the RMS worked out very nicely. That was a very satisfying assignment.

Another thing that [I] did during this time period, was [to maintain] science [proficiency] on the side. When we were first getting ready for Apollo, I had been assigned to go over to Switzerland to work with [the] team that was going to put out what was called a solar wind experiment. It looked like a little window blind of aluminum foil on a pole that you stuck in the ground and then rolled up and brought home. All of the official isotopic numbers on the solar wind come from this experiment.

[The Swiss scientists were a] very, very competent group, and I was simply to go over and help them design from the human standpoint, because they didn't know what you could do with the pressurized gloves and this sort of thing. I had a very pleasant experience with these people, and it was absolutely marvelous. Normally if you have a design review in NASA, then you take three months to change things, and you have [to have] another design review.

[With the Swiss], we would sit down and talk about some things, and I'd say, "No, no, no, we've got to make the knob bigger so you can [grasp] it with the gloves," and this sort of thing. About four o'clock in the afternoon, they'd call [up] Herr Wigner, who was the machinist, nd I would draw on the blackboard what we needed to do in changing the design, and then we'd all go home. At ten o'clock the next morning, the new design had been manufactured overnight in the machine shop, and it was lying on the table. This was just a whole new world.

We had such a nice [working] group, and these people were so competent that Herr Doctor Professor Geiss and I then proposed [a] Skylab experiment [in which] we looked at the isotopic ratios of the Aurora particles. [Later] during the Shuttle time period, there was a satellite—I guess it was managed out of Langley [Research Center, Hampton, Virginia]—called LDEF, which stands for Long Duration Exposure Facility. This was basically to test optical surfaces and thermal control surfaces and that sort of thing in the degradations of the space environment, but it was a wonderful opportunity to do other kinds of science.

There is a [thin gas in space] called the interstellar gas, which is essentially the cumulative solar winds from all the other stars. It's a wind that literally [passes] through the galaxy and blows through the solar system. Only the neutral particles [of this gas] can penetrate the heliosphere, but there are literally particles from outside the solar system that are blowing in a very dilute wind through the solar system past the Earth. We proposed an experiment to collect these interstellar gas particles.

So I worked with the Swiss. This group [and] I by now [were] essentially [a] team, and we proposed [an] experiment that flew on LDEF. [But] LDEF had problems. Rather than staying [in space] for nine months, it stayed sixty-nine months, because [NASA] couldn't go back and get it yet. But that was the science I was doing [on] the side while we were getting ready for the Shuttle Program. Then after several delays, I started training for the mission I flew on the Spacelab 3.

WRIGHT: It was nineteen years after you came on board.

LIND: I set a record. No one has waited for a space flight longer than I have. I hope nobody ever has to do that. But with the six and a half years I spent in training for the two flights that didn't fly, and then the delays in getting the Shuttle [program going], and with the [Apollo] fire, there were long delays, and so, yes, it was nineteen years before I got to fly.

WRIGHT: How were you notified that you were going to be part of that crew?

LIND: I guess George [W. S.] Abbey announced in one of the meetings, or maybe John [W.] Young announced in the meeting that the crew for Spacelab 3 was going to be so-and-so. As soon as it was announced, of course, Bob [Robert F.] Overmyer, who was the commander, and I moved into an office together. He was the overall commander. He got us into orbit; he got us back; he had overall command of the ship at all times, in the military sense. [But] once we got on orbit, then I was [in charge of executing the mission.] I was at that time called mission specialist number one; [but] if I flew today, the same position would be called payload commander.

Our mission was the laboratory mission [involving] fifteen very sophisticated experiments that had to be [performed] in weightlessness. I was Laboratory Director. We had five scientists on the crew, myself, two doctors, and two payload specialists [who were] visiting scientists. I think we ran a very significant mission. When the mission was being formalized, I thought, "Now, there are several of those experiments that I will be responsible for that will run in an automatic mode. I will have to check [on] them once an hour, but they may run for two and a half hours in an automatic mode. "So I'm going to have some free time in space," which is hard to come by.

It turns out I didn't have as much time as I thought I was going to have. I thought, however, "Hey, I could have my own experiment." So I proposed [an experiment in collaboration] with the group that I had been with up in Alaska. Tom [Thomas J.] Hallinan and I proposed an experiment to look at the Aurora from space. Before our mission, the Aurora had been photographed [only] by some slow scan photometers, which gives you a blurred picture. [It is] like trying to take a picture of a waterfall. [You] just [get] a white blur. Owen [K.] Garriott in Skylab had taken, I think, six or nine pictures of the Aurora that were way off on the horizon. So there were a few pictures, but not many.

So Tom and I started thinking about how we could do this. [The] first thing we wanted [were] high time resolution pictures of the Aurora [made with a] TV [camera]. So we started looking around. What TV system could [we] get that would be sensitive enough [in [such a] low light level? It turned out that the TV camera that was already on the Space Shuttle was as good as any TV camera we could have bought in the world. [But we had to] take off the color wheel and [photograph in] black and white instead of color. So we asked and got one of the TVs modified.

Because now [we would be photographing only] in black and white, you want to take some [still] photographs in color [to] document what color the [auroral] light is, [since] that will identify what particles are emitting the light. So we started to look around for [an appropriate] camera and camera lens. [It turned out that] the camera that we already had on board and the lens we already had on board were [again] as good as we could have gotten anywhere. NASA [only] had to buy [three] rolls of film, special [sensitive color] film. So this experiment cost NASA $36, and it's the cheapest experiment that has ever gone into space.

It was very satisfying to us that we made some discoveries on $36. [Laughs] We claimed that we could do more science per dollar per pound than anybody else in the space program. We found out that there is a different component to the mechanism that creates the Aurora, involving microwaves, that was not understood before. So the theorists had to add one more element in the equation for the creation of the Aurora light. [This has been] called the *Enhanced Aurora*.

That was very satisfying, and this was the kind of [science] that [I] did on [my] free time, in the middle [of other work in a free moment.] Vance would take the pictures, and I'd run the TV system. It was a very satisfying addition to the [experiments]. So one of the experiments was my own.

WRIGHT: You mentioned that you had two doctors and two visiting scientists, and then, of course, you being the payload commander and the physicist, all these different roles and all these different specifics that you were all working with, how did the crew work together? I know that the shifts were around-the-clock. How did you set all this up that people would have the time that they needed to do what they did, but yet work as a crew when needed?

LIND: Well, the science team on the ground had thought about this for a long time. We worked on two shifts, the silver shift and the gold shift. One would sleep while the other worked. We always had a two-hour overlap when one crew got up and had two hours to converse with the crew that was just coming off of duty on the status [of the experiments]. Lodewijk van den Berg and I ran the crystal-growing experiments, and so we would brief each other on what was going on in the crystal growth experiments. [He'd brief me and] then he'd go to sleep, and when he woke up, I'd brief him on what I'd done during the last shift. That [procedure] was pretty well worked out ahead of time.

We had the first laboratory animals in space, and Bill [William E.] Thornton had to worry about them on one shift, and Norm [Norman E. Thagard] would worry about them on the other shift. That was really nicely worked out. Lodewijk van den Berg and Taylor [G.] Wang had their own experiments. They were principal investigators on two different experiments, and so they were responsible for [them]. But they had had some cross-training on a couple of other experiments, so we had a rather well-thought-out division of labor and who was responsible for each experiment on each shift. That worked out really very nicely.

WRIGHT: That was the first time Spacelab 3 had flown and the first time that live animals had flown. What kind of challenges did you encounter with these firsts?

LIND: We had two cute little squirrel monkeys and twenty-four less-than-cute laboratory rats. The squirrel monkeys adapted very quickly. They had been on centrifuges. They had been on vibration tables. So they knew what the roar and the feeling of space was going to be like. Squirrel monkeys have a very long tail, and if they get excited, they wrap the tail around themselves and hang onto the tip of the tail. If they get really excited, they chew on the end of their own tail.

By the time we got [into] and activated the laboratory, which was about three hours after liftoff, they were now adjusted. They had, during liftoff, apparently chewed off about a quarter of an inch of the end of their tails, but they were adjusted and just having a ball. I kept saying, "Let's let one of them out."

"No, no, can't do that. We'd never catch him again."

The monkeys adapted very, very quickly. The laboratory rats were not quite as savvy as the monkeys. They had also been on vibration tables and acoustical chambers and that sort of thing. But they hadn't learned that this was going to last a while, and when we got [into the laboratory], they were hanging onto the edge of the cage and looking very apprehensive. After about the second day, they finally found out if they'd let go of the screen, they wouldn't fall, and they probably enjoyed the rest of the mission. But they were slower in adapting. No big problem.

WRIGHT: And you felt that Spacelab research facility was—

LIND: Oh, yes, the Spacelab was very well designed. We had had a fair amount of input with the Europeans who built it, and [it] worked out very nicely for us. We had no problems at all.

WRIGHT: Tell us about the differences and the similarities of training for the Apollo flights that you did compared to training for a Shuttle flight.

LIND: By the time we got to Shuttle, things were so much better known, because we knew what the physiological changes would be in the human body. We knew what all the mechanical problems [would be with] zero-G toilets and urinals in space and that sort of tomfoolery. How to handle washing your hands, and wringing out washrags so that water doesn't float around, and food preparation. Many of the housekeeping tasks in Shuttle were well thought out, because we now had [experiences with these matters].

Whereas in Apollo, we had to anticipate what things were going to be like. So the training didn't quite have the glory [of the earlier programs]. Hey, it was exciting. I'm not downgrading it at all. But it didn't have the sense of history, by the time we got to [the] Shuttle, that we had had in Apollo. But space is not routine, by any stretch of the imagination. But it was more manageable, because we had so much more data by that time.

WRIGHT: How did the simulations compare to your launch?

LIND: Oh, very, very [well]. The simulations in NASA are spectacularly accurate. With the motion-based simulators, you even get some of the visceral sensations, because they can move the machine around and give you the sense of onset of zero-Gs; you can't hold it indefinitely, but we had flown hundreds of parabolas in the zero-G aircraft [KC-135], the so-called "vomit comet," so you were really quite accustomed to those things.

WRIGHT: After waiting so long, did you feel like you adapted to space well and felt like you hung for seven days?

LIND: Yes, thoroughly enjoyed it. Yes, yes, yes. No, it was a wonderful experience.

WRIGHT: Are there some special anecdotes or some special memories of that flight that you'd like to share with us?

LIND: One of the things that I remember very, very specifically was [that] since I was the Laboratory Director, for the first two days of the flight, I did not take one single minute away from the time line to just be a tourist. But on the third day of the mission, I [had] all of [the] experiments for which I was responsible running in the automatic mode, and I had about ten or fifteen minutes with no immediate assignment. So I floated down to the flight deck, just to be a tourist for ten minutes.

We were flying in an orientation with the tail always pointed toward the Earth and one wing always [pointed] forward in the velocity vector. That oriented the windows on the flight deck from the zenith to the nadir and from horizon to the horizon, so it was like a Cinerama presentation. Both my wife and I are amateur oil painters. I got down [to the flight deck], and I looked down.

The sensation in space is that you are always right side up, no matter how you're [positioned]—up and down [are] just meaningless in space. You always feel right side up. Intellectually you know you're moving very fast so that orbital velocity will cancel gravity, but the sensation is that you are stationary, and the world is rotating majestically below you. And I thought, "Could I ever paint that?" The answer is absolutely not. Grumbacher doesn't make a blue that's deep enough for the great ocean trenches.

You look out tangentially through the Earth's horizon, and you see—I was quite surprised—[many] different layers of intense blue colors, about twenty to twenty-two different layers of cobalt and cerulean and ultramarine [and other shades], and then the blackest, blackest space you can imagine. When you go over the archipelagoes and the atolls and [islands] in the Pacific and down in the Bermudas, you [see] the water coming up [toward the shore] from the deep trenches, and it [appears as] hundreds of shades of blue and blue-green up to [a] little white line, which is the surf, and [another] little brown line, which is the beach. Nobody will ever paint that. [It's magnificent.]

I looked down, and I was just overwhelmed with the sense of beauty. It was so impressive that it brought tears to my eyes. Now, in space tears don't trickle down your cheeks; that's caused by gravity. In space the tears stay in the eye socket and get deeper and deeper, and after a minute or two I was looking through a half inch of salt water. I thought, "Ooh, this is like a guppy trying to see out of the top of the aquarium."

Simultaneously with this—there's this sense of incredible beauty. But then I had a spiritual feeling, because several scriptures popped into my mind. You know, the nineteenth psalm, "The heavens declare the glory of God." One of the unique Mormon scriptures is, "If you've seen the corner of heaven, you've seen God moving in his majesty and power." [In the] book of Romans, it says that "the righteous will be coinheritors with Jesus Christ of [all] this."

I thought, you know, "This must be the way the Lord looks down at the Earth." Because from space, you can't see any garbage along the highway. You can't hear any family fights. You [see] just the beauty of how the Lord created this Earth, and that was a very spiritual, moving experience, along with the esthetics, the physical beauty. I'll always remember that [special feeling], besides the technical satisfaction of a successful mission.

WRIGHT: It really all came together for the science part and the—

LIND: You bet. Yes.

WRIGHT: —for you to get to fly.

Well, six months after you completed your mission, you submitted your resignation, to be effective in June of [19]'86.

LIND: Yes. What happened was that when I went to Berkeley, my goal was to join a science faculty someplace. [At] Berkeley, everything is geared toward research, and I got the impression that some of the professors said, "Oh, it's Wednesday. I've got to go talk to those dumb kids again." There were seven Nobel Prize winners [on the faculty]. I had two Nobel Prize winners as teachers. So from a research standpoint, Berkeley was absolutely tremendous, but I knew there were other colleges like Reed College up in Portland, Oregon, where everything is teaching and they don't do any [significant] research.

I thought, "Now, [I will] need to establish the proper balance between research and teaching, and if I go on to a faculty as the junior man, I'm going to have to follow university policy, whereas if I [join] with some personal background, I can establish my own proper balance. So what I'll do is go out and do research for ten years, and then I'll come onto a faculty with a personal background so that I can establish what I consider the proper balance." So that was my life goal.

[However,] in the ten years, I was selected as an astronaut, and ten years stretches out to twenty-two. I always felt like a little boy who had been sent by his mother to the store to get the eggs, but I was off chasing fire engines. I was having a ball, but sooner or later I was going to have to go back to the store and get the eggs.

So when we flew, [I made my decision.] It takes several months to go through [all the] debriefing, and I thought, "I am to the point in my life where if I'm ever going to shift into academia, I better do it now, or I will end up as a NASA manager for the rest of my life." [Now] that's an easy decision to make. So as soon as we essentially finished the debriefing, I put in a resignation. As I recall, I signed it on the twelfth of November '85 to go into effect the first of July '86, so I could start teaching the fall of '86. I was going to spend [the intervening] time choosing the university to go to.

Well, right after that we had the problems [of the STS 51-L, *Challenger* accident]. A number of [astronauts] said to me, "Oh, man, I wish I had done what you did, but if I resign now, it's going to look like cowardice." So I was the first one to leave the program after the big accident, but I had already done the paperwork much [earlier].

Then I started to decide, "Now, where do I want to go teach?" Because a lot of our family's in the West, I decided, "You know, it's either going to be the Rocky Mountain states or the West." My sister thinks I'm the most stupid man in the world for not going to Stanford [University, Stanford, California]. [I considered] either Santa Cruz [University of California], or Tucson [University of Arizona]; there were several places. But both my mother and my mother-in-law were widowed and in fairly poor health in Utah, and so my wife and I said, "You know, why don't we go back to Utah?" So we started looking at the big institutions in Utah.

Utah State [University, Logan, Utah] has put more experiments into space than any other university in the world, and they have a very, very sophisticated infrastructure to support space research. So if [I was] going to [continue to] do space research, which I was still doing, [since] I had experiments on [current] satellites, Utah State was just an absolute obvious choice.

So I went to Utah State, taught for nine years, and when I retired from Utah State, my wife and I had a discussion and said, "You know, the Lord has been so good to us. Why don't we just do volunteer work for our church for the rest of our lives?" So we have been on several church assignments since then, and that's the mode we're in right now.

WRIGHT: When you were still at Utah State, you mentioned about your research projects. So you were able to continue doing some of the ones you were with NASA?

LIND: Oh yes, yes.

WRIGHT: Could you share a couple of those?

LIND: Well, we proposed a follow-on experiment to the one that we did on the LDEF satellite…. We were going to have a satellite up there that would kick out a little package of these very special foils. [They would] come down by parachute, and they'd pick it up in flight over the Utah desert. It was a recovery technique that the Defense Department used to bring back film from spy satellites. NASA did not choose that experiment on the first go-round.

By that time, I decided that if I were to do this kind of an experiment—because this was a major commitment with the Swiss—[it would mean] a ten-year commitment. I thought, "Aah, I don't want to play these games," with all the bureaucracy [that] by this time had built up in NASA. I said, "I don't want to deal with these NASA managers for another ten years." So I decided that I had finished my research by that time, and so the last couple of years at Utah State, I just concentrated on teaching.

WRIGHT: Well, as you said just a few minutes ago that you left right after *Challenger*. Of course, you had put your resignation in before that, but we were looking at some research. I noticed that in 2003 after the *Columbia* accident, you were quoted that your crew had come "within a fraction of a second of the same fate." You found that out after the explosion. Could you elaborate on that statement?

LIND: Yes, what happened was that Bob Overmyer and I had shared an office for three and a half years, getting ready for this mission. Bob, when they first started the *Challenger* investigation, was the senior astronaut on the investigation team. [He] came back from the Cape one day, walked in the office, slumped down in the chair, and said, "Don, shut the door."

Now, in the Astronaut Office, if you shut the door, it's a big deal, because we tried to keep an open office so people could wander in and share [ideas]. If you shut the door, it was either because you were going to be talking about something classified—but everybody in sight was classified for top secret, so it was going to have to be higher than top secret—or it was something so incredibly personal that you just didn't want anybody to hear.

So I shut the door, and Bob said, "The board today found out that on our flight nine months previously we almost had the same explosion. We had [the same] problems with the O-rings on [one of our] boosters." We talked about that for a few minutes, and he said, "The board thinks we [came] within fifteen seconds of an explosion."

Well, shortly after this, I went to Utah State, and those big boosters are built at the Wasatch Division [Morton Thiokol], which is thirty-five miles from the university. I obviously had some connections there, so I called up and I said, "I want to find out exactly what happened on our flight."

They said, "Come on out."

Alan McDonald, who was the head of the Booster Division [sat down with me.] He and [Roger M.] Boisjoly were the two that briefed Congress. [He] got out his original briefing notes for Congress, which I now have, and outlined exactly what had happened. There are three [separate] O-rings to [seal] the big long tubes with the gases flowing down through them at about 5,000 degrees and 120 psi. The first two seals on our flight had been totally destroyed, and the third seal [had] 24 percent of [its] diameter burned away. Sixty-one mils of that [last seal] had been burned away.

[McDonald] said, "All of that destruction happened in 600 milliseconds, and what was left of that last O-ring, if it had not sealed the crack and stopped that outflow of gases, if it had not done that in the next 200 to 300 milliseconds, it would have been gone [all the way.] You'd never have stopped it, and you'd have exploded. So you didn't come within fifteen seconds of dying, you came within three-tenths of one second of dying." That was thought-provoking. [Laughs]

WRIGHT: I guess so.

LIND: We thought that was significant in our family. I painted a picture of our liftoff. Our son [was] is the photo editor of the *Daily Universe*, which is the student newspaper at Brigham Young University [Provo, Utah]. I [had gotten] him press credentials, [and] he took some really professional-type pictures of our liftoff.

So I painted a picture of our liftoff. The steam is rolling up in exactly the right pattern and everything. Then I painted two great celestial hands supporting the Shuttle, and the title of that picture is *Three-tenths of a Second*. Each of our seven children have in their home a copy of that painting, because we wanted the grandchildren to know that we think the Lord really protected Grandpa.

WRIGHT: Looking back over your time with NASA from 1966—I say NASA; the space agency—and until you retired, what part of this time did you find to be the most challenging, and then what do you find to be the most rewarding aspect of your career?

LIND: Well, the most rewarding were clearly the early Apollo flights, because there was such a sense of history, [and a] sense of high adventure. This was exploration at its absolute, marvelous [best]. This was, to me, as exciting and compelling and significant as anything I had read about in history. So that, to me, was the most "rewarding," I guess is the right word; certainly the most dramatic, certainly the most adventuresome.

The biggest challenge, of course, were all the delays. I used to cry every time I read the federal budget, because of the budget cuts. But the long delays and some of the politically driven decisions that I found disappointing, that was, to me, the most challenging aspect of the program.

But overall, it was [really exciting]. Overall, it was wonderful. [There were] dark moments, but it was a delightful way to spend your life.

WRIGHT: Before we end today, I was going to ask Jennifer. I think she's got a couple of questions that she wanted to ask you as well, if that's all right?

ROSS-NAZZAL: Yes, I have some questions for you about the Astronaut Office. When you first came on board as an astronaut, what was the reaction of the rest of the astronaut corps to this new group of astronauts coming in?

LIND: They were very supportive. They really were. It was a tremendous camaraderie. You know, brother pilots exporing the unknown. So [was] the social life, there were parties all the time, and the wives got together for teas. The men were all busy, and we were sharing all the same anxieties about the simulations, so there was a real camaraderie, a real sense of brotherhood. Not [only a] brotherhood, because the wives and children were involved, too, but it was a very congenial, accepting group.

ROSS-NAZZAL: What I find interesting is that you were selected with a group of pilots, but you yourself had a Ph.D. and were also a trained pilot. Did you find in any way that you affiliated with the scientist astronauts or the test pilots, or was that sense of camaraderie just overarching the office?

WRIGHT: Deke Slayton was the head of the crew selection process at that time, and he obviously classed me as a scientist, so my assignments were as a scientist, and that was fine. That was fine. I was selected with a pilot group. I'm sure that the fact that I had a Ph.D. was not a hindrance, but my assignments, once I got in the Astronaut Office, [were mostly science assignments] because we had so many more pilots than we did scientists, [and] that was a very logical decision. Deke obviously thought of me as a scientist.

But when we got ready to get serious about going to the Moon, I went to Al Shepard, and I said, "Now, it's obvious to me that you can't go to the Moon unless you can fly the Lunar Module, and you can't fly the Lunar Module unless you've [had] helicopter training, and I want to go to helicopter school."

He said, "Fine." So he sent me to helicopter school. So they certainly recognized officially my pilot background, but all my internal assignments, like the lunar surface operations, [were] supporting the science component of the mission.

ROSS-NAZZAL: You started working on all these various projects that involved human factors and determining how astronauts might use equipment in space. How did you go from being a scientist doing scientific research in these studies into moving into the operational aspects of space flight?

LIND: That wasn't a difficult transition at all, because first of all, they wanted us as scientists to be generalists. They didn't want to have us on television only [able to talk about] the things that we may have done our dissertation on. So we were encouraged to be knowledgeable in all of the various kinds of science that was going to be [performed]. It was completely obvious that [we could help] to facilitate getting the science done [properly].

So you were working on [many experiments proposed by other scientist—such as the] solar wind experiment. I was never going to get a Nobel Prize for it. That was obvious. But it wasn't going to happen unless I [helped] the Swiss design things so it could be done. You were making a significant contribution in getting the science done, even though somebody else was going to write the scientific paper. And that was fine. That was fine. No problem.

ROSS-NAZZAL: How did the Astronaut Office change in '78 when this new group came in that included women and minorities?

LIND: No way at all. Didn't change at all. I mean, women are human beings. Minorities are human beings. I mean, there [really were] no problems.

ROSS-NAZZAL: I understand that you worked on the CFES [Continuous Flow Electrophoresis System] experiment for a while. Can you talk about that, the Continuous Flow Electrophoresis experiments?

LIND: Oh yes. They needed some help on it; again [with] the human factors. This was a very sophisticated way of separating living cells. It showed great potential. For example, [probably] every hemophiliac—bleeder—in the United States, has hepatitis B, because on Earth you cannot separate the K factor in blood cells from the hepatitis virus, because they're just [to similar]. [But] you can do it in space. [This is] because [in space] you have no turbulence, and therefore the separating of cells by electrostatic forces is much more focused. So it shows great potential. There were things about insulin and all sorts of things [that] I didn't understand.

If we ever get to the point where we can have a guaranteed schedule up and back, so companies can know if they send their samples up on Tuesday, they can get them back in three weeks, there are a number of companies, McDonnell Douglas being only one of them, that have a number of very productive kind of manufacturing or preparation kind of experiments in space. Electrophoresis just happened to be one of the first ones. Charlie [Charles D.] Walker, who was the company representative, was a great guy to work with, and I'm really very almost chagrined that NASA hasn't been able to capitalize on this kind of investment that the companies have made, because that showed great medical promise.

ROSS-NAZZAL: I just have one more question for you. After each flight, the Shuttle crews temporarily go on PR [public relations] trips. Can you tell us about some of the PR trips that you took?

LIND: Yes, we had to run around and talk to all sorts of people. My wife and I went to [Germany,] Bahrain and to Egypt and a number of places that would be hard to [get to] normally. It was an interesting thing, because [we] got to meet very gracious people, and [we were able] to let the public know where their tax dollars were going. The American public pays for this. We owe them a good—firsthand, if we can—a good firsthand explanation of what's happening in space, because space has done some wonderful things.

It's motivated a lot of school kids in science and math that would never have been motivated [this much] before. There's really [significant] potential in what's happening. This is not just a "gee whiz" program. One of the things we used to [do was to] publish *Spinoff* magazines that showed all the technical things that had been designed under NASA contract. By definition, they were now [in the] public domain [and] could not be patented. This [knowledge] was being put into industry, so the investment into NASA was paying off in a standard of living increase, and the public had a right to know that.

This was just part of our way to do that. It's part of the environment, and we enjoyed it. We got to go to interesting places and meet some very delightful people. [I was assigned to fly to Australia to deliver the 3rd annual Hinckler memorial lecture. Burt Hinckler was a celebrated Australian pilot who flew solo from Paris to Bundaberg, Australia just after Charles Lindberg flew across the Atlantic. These assignments were a very pleasant way to tell about the excitement of the space program.]

ROSS-NAZZAL: Those are all the questions I had.

WRIGHT: I just have one. You were talking about going to places. When you came here, of course, you were at Goddard and you transferred. But had you ever spent any time on the Gulf coast, and how well did your family adapt to being here in the Houston area compared to where you'd lived before?

LIND: We thoroughly enjoyed NASA. We thoroughly enjoyed the Houston area. There's the ballet and the—what do you call the amphitheater in the park up there?

WRIGHT: At Hermann Park?

LIND: Yes, the outdoor theater there and, oh—and the opera season here. We thoroughly enjoyed Houston. But it always felt temporary. We were raised in the mountains, and [Houston is] flat. [Laughs] The skiing is not very good in Houston. So we thoroughly enjoyed the twenty years we were here, but we felt that it was temporary, that sometime when you retire, you're going to go back to the mountains where the skiing is.

WRIGHT: Well, we certainly have enjoyed hearing everything from you today. Is there any other aspect or area that you'd like to discuss or any other thoughts?

LIND: I think you have brought up all the different areas. To me, this was as exciting as [Ferdinand de] Magellan's trip around the world. I used to think as a kid, "Wouldn't it have been wonderful to sail with Magellan? Wouldn't it have been wonderful to sail with Captain [James] Cook?" Except in that little unpleasant thing in Hawaii where they [were] killed. And this was, to me, just as exciting as anything that I read about in history.

[I] keep saying, "Oh, why was the Lord so good to get me into this thing?" I [feel] really privileged to be involved in these [exciting] things. I've had a chance to do [special] things, landing on aircraft carriers and flying into space and getting involved, intimately involved, in the preparations for the landing on the Moon. And I look back and think, “Oh, the Lord has been so good to me.” So I’m just grateful to have been involved in this.

WRIGHT: Well, we thank you for sharing all this today.

LIND: Well, thank you.

[End of interview]