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ORAL HISTORY TRANSCRIPT

CHARLES F. BOLDEN
INTERVIEWED BY SANDRA JOHNSON
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JOHNSON: Today is January 6th, 2004. This oral history interview is being conducted with Charles Bolden in Houston, Texas, for the NASA Johnson Space Center Oral History Project. Interviewer is Sandra Johnson, assisted by Rebecca Wright and Jennifer Ross-Nazzal.

I want to thank you again for joining us today.

BOLDEN: Thank you.

JOHNSON: And I want to begin today by asking you, what made you decide to pursue a career in the military and in aviation?

BOLDEN: The military first, because I never wanted to be an aviator. I saw a program on television called *Men Of Annapolis* when I was in seventh, eighth grade; fell in love with the uniform; fell in love with the fact that they seemed to get all the good-looking girls. And then at the same time, there were other programs on television, *West Point Story*, which was okay. There was a program about the submarine service called *Silent Service*, and then one other one. But they were all Navy or naval oriented.

So I just became infatuated with the Navy, and decided that's what I wanted to do when I went to college. And I wanted to go to the United States Naval Academy [Annapolis, Maryland]. So, over the whole process of my junior high and high school years, everything I did

was focused toward getting a congressional appointment to the Naval Academy; actually getting a Vice Presidential appointment to the Naval Academy. I grew up in Columbia, South Carolina, and at the time, a congressional appointment was out of the question.

So, I wrote my congressman, my senators; yes, my two state senators, my congressman, and the Vice President of the United States, who at the time was Lyndon B. Johnson, every year from ninth grade, saying that I wanted to go to the Naval Academy. I would get letters back, very kindly, from each of them each year, saying, "Well, it's not until your senior year that you're eligible, so just kind of relax and enjoy life." I would write them back and say I just wanted them to know who I was, because I was serious about it.

Finally, in my senior year, President [John F.] Kennedy was assassinated, in the fall of my senior year, which, the impact for me was that this relationship I had been nourishing with the Vice President over four years was out the window, because now I would have to deal with a new Vice President. My father, although he had served in World War II, his service was not such that I was eligible for a Presidential appointment. So my only hope was the Vice President, I thought.

Nonetheless, I applied through the normal procedures. I went to my congressional representative, Albert [William] Watson back then, and my two state senators, [J.] Strom Thurmond and Olin D. Johnston, and wrote a letter to the President and said, "I know I'm not eligible for an appointment from you, but I've been writing for the past three years, and you told me you would help when I became a senior. And I need help, because I can't get an appointment from my state. Is there anything you can do?"

Never heard from him, but about a week or two later, got a knock on the door from a Navy recruiter who said that he had learned that I was interested in going to the United States Naval Academy.

Almost simultaneously, a former federal judge by the name of Judge Bennett came to my school, and he was sent there by President Johnson, sent throughout the South, looking for minority students who were interested in going to the service academies, because they were trying to—this was 1963, actually. They were trying to find young men—no women at the time—but young men of color who were interested in going to the service academies, since there were very few, if any.

I told him that I was very interested in going to the Naval Academy. There was another classmate of mine named Wilson Rorie, his father was a career Army officer, so he was eligible for a Presidential appointment. But he also was interested; he wanted to go to [United States Military Academy at] West Point [West Point, New York]. Then we had a third guy by the name of Coroy Ferguson, who we tried to interest in going to the [United States] Air Force [Academy, Colorado Springs, Colorado], because we thought it would be great to have somebody from one class be at all three service academies. We could never convince him, so he ended up at Bowdoin [College] in [Brunswick] Maine, and Wilson and I both got appointments.

Mine came from Congressman William [Levi] Dawson in Chicago, Illinois, and Wilson's actually came from the President. So we went to West Point and Annapolis, respectively. The only things I knew at the time that I went to Annapolis was, I was not going to be a Marine, because I thought they were a little different, and I was not going to fly airplanes, because that was inherently dangerous. And my mom had always—I tell people, "My mother did not raise a fool."

So I went to the Naval Academy. My intent at the time was to become a [Navy] Frogman, what is now a SEAL [Sea-Air-Land]. When I got there, my first year was typical—bad, horrible. Plebe year is just rough. I cried all the time. I wanted to go home, and my father kept me there. Every time I'd call on the weekends, he'd say, "Stay one more week and then we'll talk about it." And so that's the way I went through plebe year.

My second year, the new superintendent became Admiral Draper [L.] Kaufman, who was the father of UDT [Underwater Demolitions Teams]. He was actually the person who had established the Underwater Demolitions Teams in the United States Navy, and Admiral Kaufman and I became at least communicative. I was on the chapel choir and some other stuff, and I was the president of my class, so I had an opportunity to meet with the Superintendent periodically.

When he found out I was interested in UDT, he broke the news to me that I couldn't do that out of the Naval Academy, because at the time UDT was what they call a restricted line billet, so you had to be in it as an enlisted person, and then be promoted into the officer ranks to become an officer in UDT. So, that kind of broke my heart. I had no idea what I was going to do.

Sort of a difficult time, but I thought then about nuclear power. That kind of turned me on and off. I'd never met anybody at the Naval Academy who was a nuclear power officer that impressed me positively, so that went no way. I thought about aviation, but I really didn't want to do that, because I hadn't changed my mind about aviation.

Over the course of the four years, the one person that kept coming back to me was my first company officer at the Naval Academy, who was a Marine Corps major, an infantry officer, 03 grunt by the name of Major John Riley Love. When it was time for me to decide where I was

going my senior year at the Naval Academy, I said, "I want to be an infantry officer. I want to be like him."

I had no idea what that would mean. I just knew that infantry officers died real quick when they went to Vietnam. This was the height of Vietnam [War]. The Tet Offensive had occurred during my senior year, the end of my junior year, actually, and then into my senior year. And although the life expectancy of a second lieutenant at the time was expressed in months, I've always believed that, you know, it won't happen to me. So I decided I wanted to be an infantry officer.

I got into the Marine Corps and went to Quantico, Virginia, for a six-month course of study that every Marine officer undergoes, called The Basic School. Its intent is to prepare you to be a rifle platoon commander, to be an infantry officer. And then from there, everybody gets sent out to other occupational fields, but the intent is that, as you've heard about the Marine Corps, every Marine's a rifleman, and so every Marine officer has to be a rifle platoon commander, or at least qualify to be one.

So, as I was going through the basic school from July through November, December of 1968, the weather turned brutal in Quantico. It was much worse than today in Houston. It was snowy and frigid, and we had our three-day war toward the end of my time there. We were in the field. And I never have liked the cold. Although I had done very well at the basic school, I really enjoyed infantry and all that, I decided there's no way in the world I could live like this. And so I looked for something else to do, right at the last minute.

I had done well enough at the Naval Academy to get an aviation guarantee, or an aviation option. I was married. I had married right out of the Naval Academy, and my wife was never enamored with me going to Vietnam as an infantry officer. So she kept trying to talk me out of

it. I went in to tell my company officer at the time, that I was going to give up my aviation option. He was an infantry officer and he told me I was crazy. He said, "You're out of your mind. Most people would kill to get an aviation option and be able to go to [Naval Air Station (NAS)] Pensacola [Florida] and fly airplanes, because not very many people get an opportunity to do that. And you want to give it up."

I said, "That's what I really want to do." That was pre our three-day war. I came back in after three-day war and I said, "Colonel McElroy, I've changed my mind. I think I'll take my aviation option and I'll go to Pensacola."

So I went to Pensacola, against my better wishes, my better thoughts, anyway. Went through ground school; did very well. Went to [NAS] Saufley Field [Pensacola, Florida] for my very first flight, and first time I got in an airplane, a [Beechcraft] T-34 [Mentor], and went up with an instructor, it was unbelievable. It was like magic, and I knew that I wanted to fly. So I stumbled into it, to be quite honest.

I did very well in the initial phases of flight training; did well enough to go jets. Went through [NAS] Meridian, Mississippi, back to Pensacola for carrier qualifications in gunnery, and then to [NAS] Kingsville, Texas, where I got my wings in the spring of 1970.

Again, Marines kept having an influence on me, even through flight school, and one of my primary flight instructors in Kingsville was a test pilot, and we talked about it all the time; guy by the name of Pete Field, by the way. He eventually became the Commander of the Marine [Boeing] F-18 [Hornet] Test Detachment at [NAS] Patuxent River, Maryland, when we decided that we were going to purchase the F-18 and go through its development. Ironically, one of my other instructors was a guy who ended up being a general officer in the Marine Corps, and whose son I happened to have in my last command. So it's funny how things happen to you in life.

But anyway, I decided I wanted to fly A-6s, the A-6 Intruder. At that time you went to [NAS] Cherry Point, North Carolina, for training. So I was dispatched from Kingsville, Texas, after I got my wings, to Cherry Point, went through the initial training in the A-6, and then to my first squadron, which was an A-6 squadron stationed at Cherry Point. Stayed there for a couple of years, and then finally got sent to Vietnam.

During those days, everybody went on individual orders. You didn't go as a unit, the way we do today. So I reported to my squadron that at the time had come out of Vietnam. President [Richard M.] Nixon was in office. With everything going the way it was going in Vietnam, he had elected to remove all ground forces, all U.S. ground forces, from Vietnam, and consequently, took the aviation forces that were there and brought them back to different places. But then my squadron was sent right back into Thailand, to continue support for the South Vietnamese, but from outside of Vietnam, so it would look like we weren't there.

So, I got orders to Iwakuni, Japan. I was on my way, and when I got there I called my wife to let her know I was there. She said, "Oh, are you going to have to go to Thailand?"

And I said, "Why would I be going to Thailand?"

She said, "Well, *Time,"* or *Newsweek,* "just had an article about this secret Marine Corps base in the middle of Thailand, that President Nixon has really put aviation units back in there."

And sure enough, I checked in and they said, "Don't unpack. You're going to Thailand." So I went to a place called Nam Phong, Thailand, in the north central portion of the country, about sixty kilometers south of Vientiane, Laos, the capital of Laos. I spent a year there in an A-6 squadron, flying what turned out to be mostly night single-plane missions into North and South Vietnam, and Laos and Cambodia, and then came back from there.

Went back to the West Coast to recruit for two years. Still flew, sort of, in what was called the Flight Proficiency Program, so flew a [North American] T-28 [Trojan], a single-engine prop, big single-engine prop, and then finally got assigned down to El Toro, to the Marine Corps Air Station, El Toro, and went back into the A-6 community, and stayed there for another three years.

I never got out of my mind the fact that I wanted to be a test pilot. And all along, I had been applying to [U.S. Naval] Test Pilot School, and every year the Marine Corps would come back and say, "Forget it. No." And I started applying long before I even had the requisite flight time. I just wanted to go. It was sort of like my desire to go to the Naval Academy. I wanted people to know who I was, so that when I became eligible, people would be acquainted.

About the sixth or seventh year of applying to Test Pilot School, I decided that I'd try it one more time. A couple of things had happened in my life that turned out to be fortuitous. When I got to recruiting duty in Los Angeles [California], I had learned about a master's degree program that the University of Southern California [USC, Los Angeles, California] had, called a master's in systems management. It was sort of a hybrid MBA. [Master of Business Administration] and engineering master's degree. I enrolled in that and I got my degree in 1977 from USC in systems management.

That was also the year that I decided I was going to make my last pitch for Test Pilot School. When my application went in this time, I had a master's degree. And lo and behold, the Marine Corps came back and said, "Okay, we give. You got it. You can go." And they gave me orders to Patuxent River, Maryland. So I packed up with my wife and two babies at the time—well, one small child and a baby—and we moved to Patuxent River, Maryland, and I went through the Navy's Test Pilot School there.

Just before I left I'd learned that NASA was accepting applications for the astronaut program, something I never had any interest in. I knew what astronauts were, but again, because I had grown up in South Carolina and I had seen the things that I had seen, I knew who astronauts were, I knew what they did, but not in my wildest imagination could somebody like me become an astronaut, because they were all white, Anglo-Saxon, Protestant, all test pilots, all about five-feet-ten. They all looked alike. And I was none of those.

So I picked up an application, but I didn't fill it out. I didn't send it in. I said, you know, why waste my time and the Marine Corps' time? So I went to Pax River, did my test pilot training, became a test pilot, and I was assigned there when NASA selected the first group of Space Shuttle astronauts in 1978. That was a very diverse group of thirty-five people. It included [Ronald E.] Ron McNair, Sally [K.] Ride, [Guion S.]Guy Bluford, [Jr.], [Frederick D.] Fred Gregory.

And in the spring of my first year as a test pilot, many of them came back to Pax River, since most of the Navy guys were Patuxent River graduates, and they came back for the Test Pilot School reunion. I met a lot of them. I met [Robert L.] Hoot Gibson, Ron McNair, Guy Bluford, Fred Gregory, and we talked a little bit about their experiences their first year down here. And I got interested and said, you know, "Probably won't be selected, but I'll never know if I don't apply."

So I put an application in through the Marine Corps. The Marine Corps nominated me to NASA for the space program, and then I was fortunate enough to be invited to come to Houston in the winter of 1980. I came down and went through the interview process, went back home and told my wife it was awesome, that no way, it's just not going to happen.

And months passed. I think I interviewed in February, and on the 31st of May, my wife's birthday in 1980, I was on my way out to fly a test-op and got a phone call from Mr. [George W. S.] Abbey, asking me if I was still interested in being an astronaut.

I said, "Sure." I thought it was a joke, really.

And he said, "No, you've been selected to be in this group of astronauts." There were nineteen of us, and two Europeans, Claude Nicollier and Ulf Merbold from Holland. So he said, "If you can be here the first of July, we'd like for you to join this class and start training."

So, packed up my family and we moved to Houston, and that was the beginning of my fourteen years in the Astronaut Office. Initially, I did the same thing as everybody else. You go through the astronaut candidacy for—first six months is all classroom work, and then you get assigned to a senior astronaut, somebody who's got some experience, and they kind of take you under their wing and show you around.

My first officemates, as a matter of fact, were [Joseph P.] Joe Allen and [William E.] Bill Thornton. The two of them, I could not have asked for better officemates, because they were two guys who had really been through the wringer here. They had come down in the Apollo era, had survived without flying, had been through Skylab. Bill Thornton had at least had an opportunity to participate as a surrogate for the Skylab astronauts in—they had a ground test program [Skylab Medical Experiments Altitude Test (SMEAT)], long-duration program that went on, and Bill at least was in that, so he could tell me about that. Joe Allen told me about the things that he had done.

And the good thing was, neither of them were military. Joe was a physicist and Bill Thornton was a doctor. So I got an opportunity to live with two non-military guys and get their perspective on life as an astronaut. They helped me kind of keep myself balanced, and also as it

turned out over the years, helped me keep from being discouraged, because nobody was being assigned to fly. We had not flown yet. We had not flown Shuttle yet.

And so the only people going to the simulator were John [W.] Young and [Robert L.] Bob Crippen. Now, every once in a while, [Thomas Kenneth] T.K. Mattingly [II] and [Henry W.] Hank Hartsfield [Jr.] would go, or Joe [Henry] Engle and [Richard H.] Dick Truly, because they were the first three crews that had been named, and then, eventually, [Robert F.] Bob Overmyer and Jack [R.] Lousma. So, other than those eight guys, nobody went close to the Shuttle Mission Simulator, the SMS. The rest of us just kind of drooled and, you walked by the building; you didn't even go in.

Some guys were—guys and girls—were assigned to support them. I was fortunate in that my very first assignment became tile repair, because at the time, we had flown *Columbia* from its production facility in Palmdale [California] to the Cape [Canaveral, Florida], and on the way over it just shed tile. Stuff just dropped off in flight. So we became very, very concerned about tile damage and tile loss and everything. So we put together a tiger team, tile repair tiger team, which is, in hindsight, considering what happened to *Columbia*, you go, "Okay. What didn't we do right?" Or, "What didn't we learn?" And there are very important lessons we didn't learn.

But that was my first job. I worked for a fellow named [William B.] Bill Lenoir, Dr. Bill Lenoir, another physicist. And Sally Ride, Anna [L.] Fisher, John [M.] Fabian, [William F.] Bill Fisher, a number of us were in the tile repair tiger team. We traveled all over the country. We went to Denver, Colorado. The Air Force and Martin Marietta [Corporation] had a simulator there called the Space Operation Simulator, that you could actually get dressed in the Extravehicular Mobility Unit, EMU, the spacesuit, and you could get on this arm, and it simulated your doing a spacewalk.

So we went through all the scenarios we could imagine for having to repair tiles on the Shuttle. While we were doing that, developing the tactics, techniques and procedures, if you will, there was another part of the team, the materials sciences guys, who were trying to develop the material that we would use to actually repair the tile. Ideally, what we wanted was something that would be like a spray gun or a—shucks, what do you call it—something that you could just squirt and it would go into place, and then you could use a trowel and smooth it out, and you could fly home.

Everything seemed to be going very well initially, but every time we took whatever material was developed into vacuum, it just didn't work. It would do something called outgassing. The gases in the material would just start to bubble out and cause it to crack and pop. And we became seriously concerned that the repair material would probably do as much damage or more, than we had by a missing tile.

We had pretty much determined, or convinced ourselves, that the zipper effect that everybody was afraid of, was not going to happen. The initial problems with the tile were determined to be just inadequate adhesive, so they went back to the drawing board and developed an adhesive that would work very well, and we became satisfied that that would not be a significant problem. But there was still always the remote possibility that you would damage or lose a tile.

We worked on this for almost right up until the first flight of *Columbia*, to no avail. We became discouraged with the procedures, because, again, our most likely prospect was that we'd have damage to the underside of the vehicle. You'd have to put a spacewalk crewman outside, under the vehicle where you could not see them. At the time, NASA was not at all enamored by that. In fact, they would not accept that risk.

We didn't have, at the time, again, the Remote Manipulator System. While we could reach around under the nose of the vehicle, we couldn't get up under the wing to see anything. So it kind of went out the window. Eventually, we walked in to management and under the recommendation from the Astronaut Office, we said, "We're throwing away good money after bad. There are too many reasons not to do this. And also, we have faith that the tile will work," which turned out to be good. It turned out to be a good decision at the time.

Interestingly, never in my memory—and I've been through my notebooks and everything—never did we talk about the reusable carbon-carbon, the RCC, the leading edge of the wing, leading edge of the tail, and the nose cap itself. Nobody ever considered any damage to that because we all thought that it was impenetrable. In fact, it was not until the loss of *Columbia* that I learned how thin it was. I grew up in the space program. I spent fourteen years in the space program flying, thinking that I had this huge mass that was about five or six inches thick on the leading edge of the wing. And, to find after *Columbia* that it was fractions of an inch thick, and that it wasn't as strong as the Fiberglas on your [Chevrolets] Corvette, that was an eye-opener, and I think for all of us.

So, I always say, for all the Monday morning quarterbacks, and for everybody who wants to beat us about the head and shoulders for what we didn't do, the best minds that I know of, in and outside of NASA, never envisioned that as a failure mode. And if they did, they sure didn't say anything about it, because we never looked at that. But that's neither here nor there.

So that was my first job. After we gave up on that, my second job was, I was assigned to T.K. Mattingly of Apollo 13 fame, because he didn't fly. But T.K. had the systems group in the Astronaut Office, and my assignment became Auxiliary Power Units [APU]. So I was to go off and become the duty expert for APUs. Everybody in the office had some field or some area that

was their field of expertise. Hoot was a main engine guy. I was an APU guy. Somebody else had something.

So I was sent off to learn everything you could possibly learn about Auxiliary Power Units, and I tried. It seemed like every time I came back with an answer for T.K., then I got three more questions. And I learned after a couple of years of working for him that, just slow down your answer, and that would slow down the questions. But if you went back in and answered it right away, wanting to impress him, then you were in trouble, because he kept a computer printout long before people used computers for data filing and all that kind of stuff. But he was way ahead of his time, and he would pull out this long computer sheet with all the questions that you had been asked to find out for him.

So I worked APUs for a long time, and then in conjunction with that, started working autoland [automatic landing system] in time for STS-3. The engineering community was really trying to force us to demonstrate an automatic landing of the Shuttle, something that those of us in the office did not want to do, especially the pilots, because we recognized the fact that although many of us had flown automatic-landing aircraft before; some of them had even—I had not, but some people had even flown on autoland to a carrier, to an aircraft carrier, and made an arrested landing.

So, the fact that it could be done was not a question. The question was, did we want to do that on a powerless flying machine. The Shuttle is not an airplane. We had to keep trying to remind the engineers that it was a glider, and we knew of no gliders that utilized an automatic-landing capability. So that became my next project.

I worked with aircraft manufacturers, airlines from all around the world, trying to determine how they went about decisions to implement autoland; how they went about training;

how they went about the decision in the cockpit whether or not to use autoland when the weather got bad. And in every case, it turned out they had multiply redundant systems. They had not only multiple engines on the airplane, but they had air speed indicators, multiple air speed indicators. In the Shuttle, we don't even use air speed. We use energy and energy management.

So the things that commercial airplanes and the Navy use for autoland just didn't exist in the Shuttle Program. And so we tried to talk everybody out of it, but for STS-3 it was determined that, "Okay, we hear you, but we're going to demonstrate it. And we won't go to touchdown, but we're going to go to 500 feet."

So John [E.] Blaha and I—John was working on the Heads-Up Display, HUD, under the leadership of [S. David] Dave Griggs at the time. John Blaha and I would go out to [NASA Ames Research Center] Moffett Field [California] and fly the simulator out there, he primarily looking at the HUD, and I primarily looking at autoland with the engineering community. So we developed the procedures that we would use for autoland for STS-3, how they would manually take over at the very last second, to go ahead and land the vehicle.

And through everything that we did, we came back in and we recommended, "This is not a good thing to do. We should not do this. And if we're going to do it, we should really only take it down to just under—." And I know I'm getting way into the weeds here, but, "We should not allow autoland to fly the vehicle through the final flare," because now you're asking a person who's been in space, their physical gains, their mental gains, their balance, everything's not there, and you want them to take over in this dynamic mode of flight and land the vehicle safely. Not a smart thing to do.

And everything that we had seen at Ames in the simulator, when we were in complete control of our faculties, told us you didn't want to do that. But the decision was made that, "We

really need to demonstrate this, so we're going to do it, and we're only going to go to 500 feet anyway."

And we said, "That's the point. You're going to go to 500 feet." So anyway, we did it. At the time I was actually, for the flight I was working with ABC Radio [Networks]. Back then, the Astronaut Office put astronauts with all of the major networks, both television and radio, so that they would have somebody who'd be able to kind of walk them through from beginning to end, the pre-launch preparations, the launch, the orbit stuff, and then the reentry. So you were teamed with somebody. I was teamed with ABC Radio. So, kind of travel around the country with them from launch to landing and recovery.

My team went to the Cape for STS-3. We got through the launch and everything, and then it came time for them to land. We were at the Cape, and the weather turned bad. They were actually supposed to come into the Kennedy Space Center [Florida] the first time. Weather was bad at Kennedy, so it was decided that they were going to land at Edwards [Air Force Base, Edwards, California], especially since they were going to do autoland.

So we got in an airplane, headed out west, and somewhere between Orlando, Florida, and Houston, they determined that the weather at Edwards was not going to be good for a couple of days, and they were going to land at White Sands [Northrup Strip, White Sands Missile Range, later renamed White Sands Space Harbor, New Mexico]. So we landed at Houston. We were supposed to just land in Houston, change flights, and keep going. So they took us off the airplane and put us on a flight to El Paso [Texas], and then subsequently out to White Sands.

We got up there and it was a horrible dust storm. I don't know if you've ever been out there, but it's gypsum, and it's very fine, like talcum powder. And this dust storm was unlike anything I'd ever seen. So they waved off the first day at White Sands; didn't land. Everything

inside was covered with plastic. The windows were sealed with plastic; didn't make any difference. When we got inside the ABC trailer, everything was covered with gypsum. So that was a hint that this was not a good place to land the Shuttle.

But anyway, second attempt, second day we managed to bring them in, and we brought them into White Sands. Everything seemed to be going well until just seconds before touchdown, when all of a sudden we saw the vehicle kind of pitch up like this [gestures] and then [vocalizes sound] kind of hard nose touchdown and everything. We found out that just as we had thought, just as we had feared, Jack Lousma had trained to do—just move the stick in both the vertical and the side axis, so, pitch and roll, to disengage the autopilot.

Well, you need to move it an appreciable amount. We didn't realize that. Or you could just punch two buttons on the glare shield. The way that he had trained was just to do a manual download with a stick. When he did that, he disengaged the roll axis on the Shuttle, but he didn't disengage the pitch axis. So the computer was still flying the pitch, although he was flying the roll.

And when he realized what—in fact, I think, as the debrief showed—[C.] Gordon Fullerton just happened to look at the eyebrow lights, and he noticed that he was still in auto and pitch. He told Jack, and so Jack just kind of really pulled back on the stick, and it caused the vehicle to pitch up. Then he kind of caught it and put it back down, and we saved the vehicle; he saved the vehicle. But that was my experience with autoland.

We ended up with the vehicle out there for several days. That was *Columbia*. I flew it several flights later, on my first flight, and when we got on orbit there was still gypsum coming out of everything. You know, they thought they had cleaned it, but I think probably some of the

debris from *Columbia* that we gathered probably had gypsum in it. It was just unreal what it had done. But, so that was my very, very, very, very, very early time in the Space Shuttle Program.

It was 1984 that I was finally assigned to a crew. I was assigned to STS-51L, which turned out to be the teacher-in-space flight. My commander was going to be Hoot Gibson. I was the pilot. [Steven A.] Steve Hawley, Franklin [R.] Chang-Diaz, and [George D.] Pinky Nelson were the mission specialists. And as we started training, then we picked up [S.] Christa McAuliffe and [Gregory B.] Greg Jarvis as our payload specialists.

We trained with them for a little while, and then the decision was made—we had flown Jake Garn, Senator Jake Garn, as the first member of Congress to fly in space. And so [C. W.] Bill Nelson, who was the Chairman of the Space Science and Technology Subcommittee in the [U. S.] House [of Representatives], had accepted the invitation from the NASA Administrator to fly, and so they decided he was going to fly. Mr. Abbey, in his infinite wisdom, decided that Hoot Gibson and his crew of merry men could better handle the congressman than most other people out there, so he switched us, and we became STS-61C, with Congressman Nelson. And [Francis R.] Dick Scobee and his crew picked up Christa and Greg Jarvis about six months prior to flight.

So we brought Bill Nelson down from D.C. and he trained with us. We picked up a fellow by the name of [Robert J.] Bob Cenker, who was an engineer with RCA. We actually flew the prototype for a—at the time it was highly classified. It turned out it—I was operating it and I didn't even know what it was, other than the fact that it was an infrared imaging camera. They would let me know that. But Bob Cenker, who was the RCA engineer, knew everything, and he was working this thing with the Air Force. But it was classified enough that I couldn't know about it, so I just operated it.

So we flew Bob to be our technical advisor on the camera, and we flew Bill to be our congressional representative. And contrary to what people will tell you, who don't know about the flight, and don't know about the crew, and don't know Bill Nelson, I thought he did very well. He actually left his congressional position to live here, for the most part. He did not miss a vote, to my knowledge, because he would get on an airplane and fly back to [Washington] D.C. for critical votes. And while he did not have the technical background to fly, he worked really, really hard to understand what was going on. And he became the brunt of a lot of jokes because he was a lawyer who was designated to fly on the Shuttle.

Jake Garn was great. Jake Garn was the ideal candidate to do it, because he was a veteran Navy combat pilot who had more flight time than anybody in the Astronaut Office. Jake had 17,000 hours of flight time flying transports, when he flew in space. So we all grew to accept him being there. I don't think most people in the Astronaut Office ever grew to accept Bill Nelson, but I did. I thought he was great. I really liked his family, and I liked him as an individual, and still do. And I consider him a friend.

But anyway, we trained for the last six months of the flight. Originally, we were scheduled to fly—when we were [STS] 51L, we were scheduled to fly in early 1985. When we got switched to [STS] 61C, we were scheduled to fly in June of '85. That kind of went by the wayside because flights started getting delayed for a variety of reasons.

We ended up slipping to December of '85, and there was even talk, because there was really a lot of pressure to get the teacher-in-space flown—there was even talk that if we didn't get off in December, that we would switch positions; that they would go ahead and fly 51L so that we could get that mission accomplished.

And there were rumors, you know, because the State of the Union address was coming up and all this kind of stuff, and you still hear that. But anyway, we went down to the Cape in December. Our first attempt to launch, I think, was the 8th of December or something like that. I can't remember.

We got down to fourteen seconds, and we were happy as clams, thinking, "We're going to go now." And all of a sudden everything just stopped, and the countdown clock went back to—I guess it goes back to T-minus nine or something, and just kind of ticked there.

We had no idea what had happened, and the ground had no idea what had happened, to be quite honest. As they started looking at the data, they had an indication that we had a problem with the right-hand solid rocket booster, with the hydraulic power unit, which is really an APU. So here I was. I mean, you know, I'm back to, "Gee, my goodness. My APU has bitten me." And as it turned out, when we finally got out of the vehicle and they de-tanked and went in, they determined that there wasn't really a problem, but it took them several days to find that it was a card. It was a computer problem, not a physical problem with the hydraulic power unit at all, and it probably would have functioned perfectly normally, and we'd have had a great flight.

But anyway, we got so close to the Christmas holidays that it was decided that we would wait, and we'd come back after the holidays and try it again. So we went back down to the Cape for a January 3rd launch attempt. That day we got down to thirty-one seconds and the clock stopped. They could not get a valve in the engine, in the propulsion system, the main engine system, to work. I can't remember whether it was an oxidizer valve or a fuel valve. It doesn't make any difference. It was a valve. The ground thought they could make it work right, but they decided, "No, we'd better not do that. We'd better go ahead and check it out and see what's going on."

So that time they went in and found out that—good decision, because they probably could have gotten it to work right, but it just wouldn't have worked the rest of the way up, or something like that. So they fixed whatever the problem was.

We came back; don't remember the date. But came back out, got in, and that time we got down to thirty-one seconds, and one more time things weren't right. So we got out, and it was another main engine valve. This time they found it. There had actually been a probe, a temperature probe that in the de-fueling, they had broken the temperature probe off, and it had lodged inside the valve, keeping the valve from closing fully. So that would have been a bad day. That would have been a catastrophic day, because the engine would have exploded had we launched.

They got the valve changed out, got the probe out, a new probe put in. We went back, got in the vehicle, and this day we stayed out there for hours. We went down to thirty-one seconds and they went into a hold for weather, and it was the worst thunderstorm I'd ever been in. We were really not happy about being there, because you could hear the lightning. You could hear stuff crackling in the headset. You know, you're sitting out there on the top of two million pounds of liquid hydrogen and liquid oxygen and two solid rocket boosters, and they told you about this umbrella that's over the pad, that keeps lightning from getting down there, but we had seen lightning actually hit the lightning-arrester system on STS-8, which was right there on the launch pad. So none of us were enamored with being out there, and we started talking about the fact that we really ought not be out here.

And after several hours, they decided to scrub, and we got out and came back. We were getting loose. We were starting to—I mean, as a crew, we were really starting to relax, though, believe it or not.

And so we went out for our fifth attempt. Steve Hawley had a mask on and some other stuff. I forgot what we did, but we did all kinds of crazy stuff, fully expecting that we wouldn't launch, because I think the weatherman had given us a less than 50 percent chance that the winds were going to be good or something. So we went out and we were about as loose as you could be that morning. And they went through the countdown, came out of the holds and nothing happened. "Ten, nine, eight, seven, six."

And we looked at each other and went, "Holy—we're really going to go. We'd better get ready." And [makes sounds indicating takeoff] the vehicle started shaking and stuff, and we were gone. Had an alarm go off within seconds after lifting off. I looked down at what I could see, with everything shaking and vibrating, and we had an indication that we had a helium leak in the—I think it was the right-hand main engine. That was a bad day, because had it been true, it was going to be a bad day.

Bill Nelson writes about this in his book, *Mission*, which is about his space flight. And contrary to his belief, I didn't save his life. To this day he thinks that Charlie Bolden saved the crew and *Columbia*, and I didn't. We didn't have a problem. We didn't have a real problem. We had a problem, but it was an instrumentation problem. So we got an indication that we had a helium leak, and I told Hoot. Hoot looked. We called the ground and said, "Hey, we think we've got a helium leak. We're going to work the procedure."

The ground didn't see anything. It had happened; it was one of these, again, a card in one of the many computers on the Shuttle, in what's called a multiplexer/demultiplexer, an MDM. The card had glitched and had caused it to look like a helium leak, so we started working the procedure. Tried to isolate the first system, with no luck. Still looked like it had a leak. Tried to isolate the second system; no luck. And then all of a sudden I looked back down and it looked

like we were making helium, so I knew that couldn't be true, because you don't do that. So I told Hoot. I said, "Hey, I think we've got a false indication here. I think we've got a sensor problem."

And Hoot took a look. He said, "I think you're right."

So once again, we called the ground. We said, "Hey, guys." And this is all in the first few seconds. It's inside a minute after we lifted off, and we worked this procedure and talked and all this stuff. So we called the ground. We said, "Hey, we don't think we have a problem. We think it's instrumentation. We're now seeing the engine make helium. We know that can't be true."

The ground called back and said, "Hey, we don't see anything. Press. Go ahead and reconfigure everything back to normal." So I reconfigured the system back to its normal condition, and we went on uphill. And, you know, eight and a half minutes you're in space, so it went by *really* fast, that one did.

And we got on orbit and it was awesome. It was unlike anything I'd expected. Technically, we were fully qualified, fully ready, and everything. Emotionally, I wasn't even close. I started crying. Not bawling or anything, but just kind of tears rolling down my cheek when I looked out the window and saw the continent of Africa coming up. It looked like a big island. Just awesome, unlike anything I'd ever imagined.

We had a great flight. Some of the stuff—we used to call ourselves, we were the end-of-year-clearance flight, because we had picked up just tons of payload, science payloads that [NASA] Marshall [Space Flight Center, Huntsville, Alabama] had been trying to fly for years, and some of the Spacelab experiments and stuff that they couldn't get flown. So we had

Congressman Nelson and every experiment known to man that they couldn't get in. There was nothing spectacular about our mission. It was almost like a year-end-clearance sale.

So we finally launched on the 12th of January, flew for a grand and glorious seven days. Because they were trying to get *Challenger* off with a teacher in space, then they decided they would cut our flight short. So instead of going the scheduled seven days, they decided that we would be a four-day flight. They'd bring us back early so that they could go right into the flow for *Challenger.*

Everything worked except God. God didn't cooperate. We were scheduled to land at the Kennedy Space Center. I think we were going to be the first landing there, but that may not be true. But our flight was scheduled to land at Kennedy. We tried the first couple of days with no luck. Kennedy had bad weather for two days going, so the program decided, "Okay. Let's go to Edwards."

The first attempt at Edwards was waved off because the weather there was bad. And finally, on our fifth attempted landing—so it was five attempts to launch, and then five attempts to land—in the middle of the night on January 18th, we landed at Edwards Air Force Base, which was interesting because with a daytime scheduled landing, you would have thought that we wouldn't have been ready for that. And Hoot, in his infinite wisdom, had decided that half of our landing training was going to be nighttime, because you needed to be prepared for anything. And so we were as ready for a night landing as we could have been for anything.

It was uneventful, other than the fact that it really upset Congressman Nelson, because he really had these visions of landing in Florida and taking a Florida orange or something. And boy, the crew that picked us up was unmerciful, because they came out with a big—it wasn't a bushel basket. It was a peck basket of California oranges and grapefruits. And even having

come from space, he was just not in a good mood. So that was a joke that he really did not appreciate.

But that was the end of my first flight, and we were in heaven. We were celebrating as much as anybody could celebrate. Next to the last day of our debriefs, we took a break to go watch *Challenger* launch, and the weather was really bad at the Cape, so they didn't launch that day. So we went back in and finished our debrief.

And then the next day we kind of finished up real quick, because we were done, for all intents and purposes. We sat in the Astronaut Office, in the conference room with everybody else, to watch *Challenger*. Liftoff seemed—nobody was comfortable because of all the ice on the launch pad and everything. I don't think there were many of us who felt we should be flying that day, but what the heck. Everybody said, "Let's go fly." And so we went and flew.

The launch went without a hiccup, and then about 73 seconds into the flight—just this awful explosion, at least that's what it looked like. And most of us, at least in my case, I really thought it was a premature separation of the solid rocket boosters or something. So, in my case, I just kept thinking we'd see the vehicle fly out of this mist, and they'd do a return to launch site abort, which everybody knew you do not want to do, because we don't even know if that's going to work. But we were looking for something good to come out of this. And nothing came out except these two solid rocket boosters going their own way.

So it took a while, but it finally sunk in that we had really lost the vehicle and crew. We were just all stunned, just didn't know what to do. The good thing was that by the end of the day we knew what had happened. We knew what had caused the accident. We didn't know the details, but the launch photography showed us the puff of smoke coming out of the joint on the right-hand solid rocket booster. And the fact that they had argued about this the night before

meant that there were people from [Morton] Thiokol [Inc.] who could say, "Let me tell you what happened. This is what we predicted would happen."

So, because we knew what had happened, we were able to come back in the next day and really get started in earnest, in getting back flying. I don't think there were many of us who didn't want to just turn around and start flying again. I know there were some who were diametrically opposed to the way I felt, but at the time I felt we should go ahead, knowing what we knew, find a way to repair the problem that we had, but keep flying. Pick and choose the time you fly. Don't fly when the weather's cold like that, since we knew that it was an O-ring that had caused the problem, and we knew that it was temperature-related. So I felt we should go ahead and fly as quickly as we could. Turned out quickly was not quick at all; it was two and a half years.

But anyway, we went through that period of time, post-*Challenger*. I was moved over to the Safety Office to become the Chief of the Safety Office at the Johnson Space Center, because just as after *Columbia*, the safety community just was beat on unmercifully. They were blamed for the accident and blamed for not speaking up, and blamed for this and blamed for that. So it was felt that—I'm not sure what it was felt I could do in the Safety Office, but I went over and took over there.

We did some reorganization and brought some operational people in to go along with the safety professionals who were there. [Charles S.] Charlie Harlan was the Director of SR & QA [Safety, Reliability, and Quality Assurance Office] here at the time, and he did a tremendous job of just trying to get that organization regrouped and everything. So I worked there for a year during the recovery.

And then we were relatively on track to go fly, and then you had to go through the political part of return to flight. And that proved to be forever, which is a good lesson for people who watch what's going on today. I tell people, "Anybody who thinks we're going to fly next fall is crazy." I don't think there's any—not a snowball's chance in hell that we're going to fly prior to the elections, which is going to put us into the winter. And we're not going to do that because of our fears, and because we've got to go to station, and because it's got to be daytime, then the number of launch opportunities you have are just so small. So it'll probably be the spring of 2005 before we fly again, is my prediction.

Anyway, we worked really, really hard to get back. Just prior to my flying my first flight, I had been assigned—I mean, it was awesome, because I had been notified that I was going to fly the Hubble Space Telescope deploy mission. Didn't cause any—I was elated. It was unbelievable, not for the reason you would think. I was elated because I was going to fly Hubble, but the big reason I was elated was because I was going to be John Young's pilot, so I was going to get an opportunity to fly with the legendary John Young. And that was just mind-boggling. So I got really excited.

After the accident, while we continued to train, the decision was made that we were just going to put everything on hold. We broke up most of the crews. For the most part, the nucleus of the Hubble mission stayed together, but the decision was made that John was not going to fly. He was replaced with Loren [J.] Shriver, who ended up being the commander for the mission.

So, long story short, I ended up coming back again in 1990, after we started flying again, and flew the Hubble Space Telescope deploy mission aboard *Discovery*, with Loren Shriver, Steve Hawley, [Kathryn D.] Kathy Sullivan, and Bruce McCandless [II]. And that in itself was another very interesting story, and preparation and expecting the unexpected, and having the

unexpected happen, because could not have had two people—I think the three people at JSC [Johnson Space Center, Houston, Texas], anyway, who had the most extensive knowledge of Hubble, everything, its inner workings, everything about it, were Bruce McCandless, Kathy Sullivan, and Story Musgrave, because they had been with that program, that project, from its very inception, so they knew everything to be known.

I was privileged to have an opportunity to fly with Bruce and Kathy, so I felt very good, because I had the two Hubble experts on my crew, and they were our spacewalk crewmembers. They were our EVA [extravehicular activity] crewmembers. Bruce had flown the first flight with a man-maneuvering unit. Kathy had become America's first woman to do a space walk. Very competent and capable people, very knowledgeable on the Telescope. And so it was fun to get ready to go fly with them.

We finally did fly in 1990, and it was ironic because our very last integrated simulation—and the way we do things here is that the crew trains for about six months, generic training, and that's intended for your benefit. You go into the simulator and you just do stuff by yourself with your training team. It's meant to bring up your knowledge, or refresh your knowledge in some cases, of the Orbiter and its systems, and just to get you working together as a crew. And then the final six months of that last year, you start doing what's called integrated training. That's where you bring in the Mission Control Center and the flight controllers.

And then the crew becomes secondary. They could really care less about the crew. You're just there. You're the training tools. You're the—whatever they call it—training aid for the Flight Control Center, because everybody recognizes that in Shuttle, if the Flight Control Team is doing their job, if they are on top of things, nothing goes wrong, for the most part. That's where they see things days ahead, usually, and they need to be sharp. So the last six

months, you really focus on the Flight Control Team, and you have a team of people who do nothing but dream up diabolical things.

I always tell people, it's catastrophic training, getting ready to go fly in space. You would love to get in the simulator and have everything go right. Never happens. The training team's life is designed to make you miserable all through training, but prepare you for everything that can go wrong. And they generally do. They do a superb job of imagining every conceivable thing that can go wrong, and exposing it to you at least once.

Ironically, our very last integrated simulation session, the failure mode was a failure of a solar array to deploy on Hubble, and it was a failure that went to the point that we could not solve it from the ground, and we had to send Bruce and Kathy out to do a spacewalk and manually wind the solar array out. While it would work and we knew we were very confident it would work, it would spell disaster for the Telescope, because once you did that, it took it out of its automatic mode and it would no longer be able to take care of itself. It was sort of like taking a baby from the womb, putting it on a respirator, and putting it in a position where the rest of its life it would need something. And that was what that would have meant for Hubble, had we had to unwind it, you know, until you send another crew up and put on another set of solar arrays and reset the clock.

But we had been to Bristol, England. The crew had gone over, where British Aerospace designed and built the solar array. So we went over there and we actually—they had this water table. I mean, it was a huge long thing that was filled with water, and the solar array, the actual flight unit, they could let wind out and back in, and we were actually trained to go out and manually wind this thing out. All of us got a chance to do it, so we would know what it was like. Bruce and Kathy became extremely competent on it.

So we launched. Everything went superbly. Got into space on deploy day. Everything started out bad. We were trying to lift the Telescope out of the payload bay, and the remote manipulator system, which in the simulator, it compensates for things rotating, and differences in mass and all that. Steve Hawley was our primary arm operator and I was the backup, and from the moment we started lifting it out, I mean, it started moving and doing things that we didn't expect.

It turned out that there were characteristics of the arm that we didn't know at the time, and so we were making it up as we went along. Finally, what was supposed to take a few minutes took several hours, and we finally got the Space Telescope out of the payload bay, and then up over the vehicle. So now we're well into the time that we're supposed to be deploying the solar arrays and high-gain antenna and all this, and approaching the time we're supposed to let it go.

So we start sending commands, or the ground starts sending commands, and the high-gain antenna start out. One of them has a problem and it kind of burps, but they take a few hours and they figure out what's the problem with it, and they finally get it down. Then the solar array, one of them goes out, no problem. The second one starts out and just stops. And we go, "This is not really happening." So they reeled it back in and they started out, and it stopped. We went, "You've got to be kidding."

Bruce says, "It's a tension monitoring module, I'll bet." He says, "We put the software module into the system so that if it sensed that there was unusual strain on the solar array, that to keep from destroying it, to keep from ripping it, tearing it, since it was fabric with all these solar cells on it, the tension monitoring module would just stop the deployment, and we'd be able to

go out and fix it and manually put it out. So that's what we ought to do." Bruce said that at the beginning of the day.

Many hours later, I mean after we've tried everything and the vehicle's going all over the place, a young engineer—as we were told—a young engineer at the [NASA] Goddard Space Flight Center [Greenbelt, Maryland] said, "Only thing I can figure—." In the meantime we had been told to put Bruce and Kathy in the airlock and we're going to send them out and do a spacewalk, and we're going to manually deploy this thing.

They were happy; I was terrified. Because I was what was called the intervehicular [IV] crew member. And it didn't occur to me until that time what the significance of that really was. You're the person that's going to go down here and put these people in a spacesuit and send them out into space, and that's pretty significant. Other people had done it and didn't have any problem with it, and I don't know why it affected me. But I just—I'm going down here, "Boy, whatever you do, don't do anything wrong, because if you screw up, these guys are going to die." And so that really just bothered me.

But we went through the hours of pre-deployment preparation and everything, finally got them in the suits, started depressurizing the airlock, and we were about five minutes away. We finally got the airlock depressurized, got a "Go" to send them out, and we were about five minutes away from having them open the hatch, when the ground called and said, "Hey, time out. Hold on just a minute. Don't open the hatch yet. We've got an idea."

And we found out post-flight that a young engineer at Goddard had decided, "This can't be real. It's got to be software, and I think it's the tension monitoring module. And if you all will give me permission to send a signal up and noop [no operation] that module, just take it out of the loop, I think the solar array will start to open."

[William D.] Bill Reeves was the lead flight director, and he and I talk about this all the time, even to this day, because it was a superb Flight Control Team, both in Goddard and here. They talked about it long and hard, and they decided, "Okay. We're going to do it. If we're wrong, all we do is destroy the Space Telescope. If we're right, everything will work right." I mean, these are the kinds of things that they had to deal with down on the ground. We're fat, dumb, and happy up there. We're having a good time. Bruce and Kathy are happy as pigs in slop, because they're going to go get to do a second spacewalk each, and they're going to go down in the history books because they saved the Hubble Space Telescope. And I'm scared to death because these guys are getting ready to go outside. I don't know what Loren and Steve are thinking about up on the flight deck, but we're all tired because it's been a whole day.

And finally they decide, "Okay. Here's what we're going to do. We want you to put the vehicle in position for a deploy, because we're going to noop the tension-monitoring module, and if it works, the solar array is probably going to start moving right away, and we want to be able to release it as quickly as we can."

So we said, "All right." We got the vehicle in position and we said, "Okay. We've done all we can do."

And they said, "Okay. Stand by." And we looked, and all of a sudden we saw the solar array start to go out.

And we went, "Holy jeez."

I said, "Bruce, how did you know that?"

He said, "That's what we put it in that for." He said, "We knew it all along." He was now upset because he and Kathy both knew that we're going to have to repressurize the airlock,

and they weren't going anywhere. But they did get some EVA time, because when you depressurize the airlock, when it gets down to zero, then that starts counting as EVA time.

But anyway, so we repressurized the—well, we left them in the airlock. We deployed the Telescope. So they're down there in the airlock by themselves, wondering, and they can't even see it. So now you've got the two people onboard who had devoted all of their adult life to this thing, and they don't get to see the deployment.

So we deploy Hubble coming off the Pacific Ocean, across the west coast of South America, and it's just the most beautiful thing you can imagine. It comes off the end of the arm and down. We're looking at the Andes Mountains, and it goes right across the coast between Bolivia and—somebody will tell me I'm wrong, because my geography is not all that great, but I think it was Venezuela. But anyway, whatever. So it goes zipping by and we watch it for a while. And then what we did was we took the Shuttle up to a higher orbit, which caused it to fall behind Hubble, so that's the way we let the Space Telescope get out in front of us.

While we're doing all this, we're just oohing and aahing, and Bruce and Kathy are going crazy, because now they've lost their EVA, they don't get to see their telescope. And finally, when everything's okay and the ground is satisfied that we can go back to normal, then they us repressurize the airlock and we bring Bruce and Kathy out, and we go to sleep; that's the end of that day.

And then the rest of the time on orbit, we're doing experiments inside, student experiments. We had something that was a fire experiment. A young man, as a high school student, had designed this experiment, and to show you how long it took to fly student experiments in those days, he was graduating from medical school on the day that we activated his experiment. That's how long it had taken to get this student experiment onboard. The kid

had gone all the way through college and medical school, eight years, in the time that we got around to flying his experiment. Can't remember his name, but we celebrated his birthday onboard and wished him the best, and all that kind of stuff. So we did those kinds of things.

And finally the folk at the Space Telescope Science Institute [Baltimore, Maryland] said, "Okay. We've done all we can do. Everything seems to be working properly." We didn't have any images from Hubble yet, but we knew that physically the solar arrays could be controlled, the door could be opened and closed and all that, and it was okay for us to come home. So we deorbited and came back home.

A couple of weeks later, a week or so later, we learned that Hubble had a problem, that it had this thing called a spherical aberration. The mirror was perfectly ground, but the dimensions on the outside were a little bit off from what they should be. So, like you or I with a problem in our vision, the Hubble had a problem with vision. It still gave spectacular images, but to the trained eye, they weren't what they were supposed to be.

And so some of the experiments for which it would be needed in the early phase, they were put on hold. They brought a lot of optical telescope stuff up into the forward end of the timeline, so they could do that, because the telescope was good enough to do that, stuff like photographing Mars and Saturn and some of the early stuff you saw from Hubble. But even as bad as it was, the first Hubble image was one that showed us what turned out to be a binary star, two stars that are very close together; so close together that they appear to be one star. You find them every once in a while, but not very often, because we just don't have the instruments that are capable of doing that, I understand. I'm out of my league here.

But it was ironic that Hubble's first image was a binary star, one that astronomers had been studying for probably hundreds of years without knowing it. That was the very first image

that came to Earth from Hubble, and it foretold of what Hubble would do the rest of its life, and continues to do today. The rest of the story is that we went up and put some optical instruments on Hubble that made it even better than it was ever designed to be, and now we have upgraded a lot of the scientific instruments on it and everything. It does phenomenal stuff.

But that was the end of my second flight. After that, I got tasked to go off and do a variety of things. Worked for Mr. Abbey as his technical assistant. I worked for [Jesse W. Moore, who] didn't stay very long [as Center Director]. Worked as the [Technical Assistant] to the Center Director [Gerald D. Griffin], and did all kinds of stuff. And then I was assigned to command my first mission.

And I've been talking. You had another question. I've been talking for an hour and a half here.

JOHNSON: No, that's fine.

BOLDEN: That was just in answer to your first question. Want to go to question two?

JOHNSON: [Laughs] No, that's fine. I've been making notes as you've been going on, and we'll go back and talk about them. You're on a roll, if you want to just continue on.

BOLDEN: Okay. Well, we can go back to question two if you want, since that's a good break point there, at the end of the first, because now I start talking about being a commander, which is different.

JOHNSON: Right. It is different.

BOLDEN: Jeez. Question two, an hour and a half into this session.

JOHNSON: That's okay. What we'll do is we'll kind of start talking about the 31 mission and work backwards.

BOLDEN: Okay.

JOHNSON: One of the things that Steve Hawley told us was while Bruce and Kathy were in the airlock and he was up there, they were the ones that were actually supposed to take the photographs also.

BOLDEN: Absolutely right. I forgot about that. That was a nightmare.

JOHNSON: But he said that you turned on the IMAX camera. Do you have any other memories about that incident?

BOLDEN: I do. As a matter of fact, that was my one moment of fame. We had all trained for IMAX, and we had an in-cabin camera as well as an IMAX payload-bay camera. So we were ambidextrous; we could all do what needed to be done. As it turned out, it was fortuitous, because the two primary camera operators were locked in the airlock.

Steve, he's flying the arm. Loren's flying the vehicle. I'm down trying to watch them. So the three of us were playing musical chairs, trying to get the cameras set up and document everything we did. And among the three of us, we managed to capture everything that there was to catch, I think, on the deploy, to include getting the payload bay camera turned on, which got some absolutely spectacular footage of Hubble that you see on *Blue Planet* [1990] and there's another IMAX movie that featured stuff about Hubble [*Destiny in Space* (1994)].

But my crowning moment was post that. It was when we did have Bruce and Kathy out of the airlock and back in. But I did a shot of interior with IMAX. They had trained us to do this thing that was—I forget what the technical name for it is, but it's a transition from interior to exterior, where you have to—because IMAX is all manual. It doesn't have an automatic bone in its body, the one that we flew. So when you change the F-stop and the lens setting and the focus and everything, it's got to be all manual. You have nothing to gauge whether you've done the right thing, because it's also not like a normal camera, that you're looking through and you can see what's going through the lens.

So I did this shot coming up from the mid-deck. I floated up from the mid-deck with a camera, took Loren at the controls, flying the vehicle, and then transitioned to the outside, where you could see Hubble. And it stayed in focus the whole time, and everybody said that was absolutely phenomenal. And I didn't have a clue what I was doing. It was just luck. But that was my one moment of fleeting fame. But it was tricky getting everything coordinated and done real-time; not at all what we had trained to do.

JOHNSON: Quite an amazing mission, from all sides. We can continue to go backwards if we want to.

BOLDEN: Okay.

JOHNSON: In between your first and second flight, you mentioned some of the duties that you had, and, of course, one of them was the Chief of the Safety Division. What exactly did that entail on a day-to-day basis?

BOLDEN: The way that Safety, Reliability, Quality Assurance was made up back then—it's now Safety and Mission Assurance, I think is the way they've changed the name. But we had three divisions in the SR & QA Department. We had the Safety Division; I had that. The Quality Division, I think was a guy named—forget his first name, but it was [Duane L.] Duston. We used to call him Dusty. And then the Reliability Division was headed up by another guy.

Safety was responsible for the boards that were held, meetings to determine what issues potentially had safety impacts on the crew, the vehicle, anything that had to do with anything involving human space flight. We didn't do unmanned stuff, but we did everything that had to do with human space flight. So that meant we essentially controlled, or had oversight over every safety issue dealing with Shuttle, solid rocket boosters, external tank, crew training, you name it. And it was all headed up out of JSC.

Now, we had other safety offices around NASA, but they all came and reported, essentially, to the [NASA Systems Safety Review Panel (SSRP)]. And as the Chief of the Safety Department at JSC, I chaired that panel. So, my responsibility was twofold. It was to Charlie Harlan as the head of SR & QA. It was to the Center Director, who had overall oversight of everything that was going on, and then it was to the Shuttle Program Manager, to make sure that

we did everything that they needed done to ensure that flights were going to proceed safely and all that.

I also coordinated with the SR & QA folk up at Marshall, and down at [NASA] Stennis Space Center, Mississippi] and Kennedy. All the contractor safety folk reported in to us. Boeing [Company] was my prime contractor at the time, so they really had the corporate knowledge, and they did all the legwork for safety analyses. All the analysis that had to be performed, we did; hazard analysis. Back then we learned about something called FMEACIL, Failure Modes Effects Analysis and Critical Items List, building the Critical Items List.

If I remember correctly, the Quality Division actually performed the FMEACILs, or the FMEA, the Failure Modes Effects Analysis. And then it all came together where we and the Safety Department kind of helped the Program Office put together the Critical Items List. These were the thousands of things, pieces, parts, on the Orbiter, the ET [External Tank] and the SRBs [Solid Rocket Boosters], that we could not fly without having them work properly. For something to get on the Critical Items List, it meant that if it failed, you lost the vehicle and/or crew, and there were thousands of them.

So my principal job was oversight of the safety effort, not just for the Johnson Space Center. That was industrial safety and hygiene, as well as operational safety for the Shuttle Program. And then gradually we started taking on Space Station, as Station took on a life of its own. I also had the coordinating responsibility for overseeing the other safety organizations within NASA. So that's what I did.

I forget how many contractors, but there were almost 200 or so JSC NASA safety employees who were housed in Building 45. That's where our offices were. And as I said, again, I worked directly for Charlie Harlan in the SR & QA Department. And if there was

something we didn't think was right, we said it. The good thing that we did, the thing that I remember the most, was again we took—the Safety Division at the time had very competent and capable people, but they were mostly industrial safety and hygiene people. They were safety professionals.

They knew their job, but some of them wouldn't know the front end of the Orbiter from the back end. So we were asking them to be responsible for critical decisions or critical advice on operational issues concerning Shuttle and Station. The one thing that I was able to do was go out and recruit people from within NASA and the contractor community, and some from academia, who came in with the requisite operational background and technical expertise to fill out the Safety Division.

So instead of being all safety professionals, there were some operators that we taught safety, because we figured that we didn't have enough time to teach the safety professionals operational things. And it worked pretty well, I thought.

JOHNSON: You also were the lead astronaut for the vehicle test and checkout at Kennedy.

BOLDEN: Yes, I did that. In fact, I think I went to VIT [Vehicle Integration Test]—I want to say I became a Cape Crusader after—I became the lead, I think, after my second flight; actually after Hubble, if I remember it correctly, because that's what I was doing when I was named to be the commander for STS-45, because I spent a couple of years down at KSC [Kennedy Space Center, Florida], and that was great.

Two jobs, two outstanding jobs in the Astronaut Office, in my opinion—everybody has an opinion—the two outstanding jobs were being a Cape Crusader, flying to the Cape on

Mondays and coming home on Friday night, but being around the vehicle all day long, every day, working hand in hand with the engineers and the logisticians and everybody that physically put the vehicles together, physically integrated the payloads. Just a totally different life from being here. It was real.

Here is, it's okay. Being at JSC is good; nothing at all like being at the Cape, where the hardware is. And so I did that for two years. And as the lead Cape Crusader, your job was to be the person responsible for tying KSC and the operational world together with the rest of the world, with people at JSC and Marshall, primarily, and also at Stennis.

During that time I also worked part-time as Alex—Alex [A.] McCool [Jr.] had Safety, Reliability and Quality Assurance at Marshall, and so I became his Astronaut Office liaison. So I would fly up to Marshall for a couple of days sometimes, and spend time with them to try to make sure that the integration was working right, that they felt comfortable that they were getting word from the Astronaut Office of concerns, and that the Astronaut Office was getting word back from Marshall. So those were two jobs that I really enjoyed.

The other job is being a CapCom, Capsule Communicator. That's the way it used to be. I'm not sure whether it is now or not, but that was the other thing that everybody wanted to be. The third job that I thought was outstanding, and I did for most of the time I was here, off and on, that nobody wanted to do, but two of us loved—three of us, Story Musgrave, Claude Nicollier, and I, we fell in love with it—that was being in SAIL, in the Shuttle Avionics Integrations Laboratory. And there you essentially just flew the test rig.

That's where, in Building 16, every piece of software that ever goes on the Orbiter goes through stress testing at SAIL. They run it through all kinds of scenarios. When I say *stress* it, they make the vehicle have to do things; make the software have to perform in stressful

environments. They'll fail an engine on liftoff, or fail something else to see if the software then says—tells everything the right thing to do.

I talked about RTLS [Return to Launch Site]. While a lot of us flew a lot of them in SAIL, I'm not sure any of us ever believed that that's something you really wanted to, because this was a maneuver in which something goes wrong shortly after liftoff, and you decide you're going to turn the vehicle around and fly it back to the Kennedy Space Center. And the computer's got to do that, so the software really has to work.

It's crazy, because you're going upside-down outbound, and all of a sudden you decide you're going to go back to Kennedy. And while you're still flying downrange, you take this vehicle and you pitch it back over so that it's flying backwards through its own fire for several minutes. What has to happen is the computer has to calculate everything precisely, because it's got to flip it over, have it pointing back to the Cape while it's flying backwards, so that just before the solid rocket boosters burn out, it stops the backwards downrange travel and starts it flying back to the Cape.

And then once that happens, then the solids cut off. They separate; they go their way, and then you fly back for a few minutes, for another six minutes, and the main engines cut off and you separate from the external tank. And that became a very tricky maneuver, because what you're worried about was re-impacting with the tank, and if you did that, you were dead. So it's a maneuver that we still have and we still train for, and nobody ever wants to fly it, because just, it's like, boy, this is really bad if you have to do this.

Anyway, so I spent many of my fourteen years over in Building 16 in the SAIL. Made a lot of friends over there, because the good thing about it was you got to fly. You didn't fly physically all the time, but you sat through the ascents and the entries and the on-orbit stuff, and

everything that was going to be done on any flight was done in SAIL. So that was the third really good job, and I did everything except CapCom.

JOHNSON: Are there any other positions during that time that—

BOLDEN: That I liked? No. [Laughter]

JOHNSON: Those were the ones, huh?

BOLDEN: Those were the two choice ones. And the Cape one, for the reasons I gave, and also for the fact that you—boy, you flew a lot. It was not unusual to go to the Monday morning meeting, go out to Ellington [Field], get in your airplane and go to the Cape. And you might take a couple of just training flights while you were down there. If the STA came down, the Shuttle Training Aircraft, because you were already there, then you generally were always available to fill in if somebody who was scheduled to come down couldn't get there because of the weather or something. So you got to fly the Shuttle Training Aircraft a lot.

JOHNSON: Why don't you go ahead and talk about the STA.

BOLDEN: Oh, the STA, it's awesome. The Shuttle Training Aircraft is actually an old airplane. It's a Grumman Gulfstream G II. It's a twin-engine business jet that I have no idea how NASA happened to pick it, but they chose this to be the airborne Shuttle simulator. And although we used the Shuttle Mission Simulator, the SMS, which is a regular simulator inside a building, it

too is awesome because it visually and a lot of other ways, it perfectly prepares you to go into space. The visuals are awesome, very realistic and everything, and you can do everything in it.

There is nothing like being in a real airplane, hurling your body at the ground at 300 knots, and pulling up and seeing yourself go to this elevated touchdown on a real runway, and that's what we used the Shuttle Training Aircraft for. It's a highly modified Grumman Gulfstream II. Although it looks like a normal one from the outside, the wing is different than a normal G II. We send it to Gulfstream in Savannah, Georgia.

Grumman built a special wing for the airplane. It's a beefier wing. It's capable of taking a lot different forces than a normal airplane would have to take. The flaps on it not only go down to create lift, but in flight, in simulation, they come up and act as spoilers, to spoil lift so that it flies like a brick. That's what you want it to do. It has an in-flight computer that sits in the back. It's separate and distinct from the airplane's computer, and this is the Shuttle simulator computer, and it causes all this stuff to happen, and causes it to fly like the Shuttle.

When you get into simulation, the instructor pilot's sitting in the right-hand seat. The person under instruction, the astronaut-pilot, is sitting in the left-hand seat. You have what we call masking. There are pieces of thick cardboard material that go into the windows to block the view, such that it's a small restricted view like you have in the Shuttle. The whole part of the left-hand side of the cockpit has instrumentation and displays that look just like the Shuttle. It has a heads-up display just like the Shuttle. It has, actually, an Apollo hand controller, which is what we use in Shuttle. It's the same hand controller they used in the Apollo era, and that's still what we use in Shuttle.

It has a speed-brake throttle controller on the side, so when the command or the instructor pilot puts it into simulation, you're flying it like you would the Shuttle. The visual image is the

same. The sensation is the same. You know, you're kind of hanging in your seat, coming down at anywhere from an 18- to 21-degree glide slope, a little bit more than 300 miles an hour, hurtling your body at the ground.

They put the main landing gear down, the engines in reverse thrust, and the spoilers up, and that just causes it to go [demonstrates] like a brick. It goes from having a normal glide ratio of a normal Gulfstream that's, jeez, I don't know, probably twenty-to-one, which means that for every mile you're in the air, the airplane can glide twenty miles. When we put it into the Shuttle-simulator mode, the glide ratio is three-to-one, which means that if you're a mile up in the air, you're going to glide about three miles and crash. So it's not very good flying. It's not a very good glider.

But the pilot puts you into simulation. You start flying and you get to 2,000 feet above the ground, and you initiate a very gradual what we call a pre-flare. You just start to pull the nose up gradually enough, and the primary purpose for this is just to start bleeding the air speed off, to lose the energy that you have, because you've got too much to land and stop on the runway. And you lose a knot per second, one nautical mile per hour per second. It's just [demonstrates] clicking off.

Going through about 400 feet, you put the gear down, the landing gear, in the real Orbiter. So in the STA, the Shuttle Training Aircraft, either you can do it or you can have the instructor pilot simulate being your pilot and do it. You put the gear down and what that does is it takes the nose gear and it now puts it down, along with the main landing gear that were down all the time. So now you've got three down and locked, and you go to about a twenty-foot elevated touchdown over the runway.

That gives you the same what they call seated-eye position to the runway that you are going to have when you land the Shuttle. Shuttle's a big vehicle, so when you're sitting on the runway in the Shuttle after landing, you're at the same height above the runway as you are at a twenty-foot elevated touchdown in the Shuttle Training Aircraft. You go through thousands of simulated landings in the Shuttle Training Aircraft before you fly your first flight.

I think the rule is you have to have 750 simulated landings in the Shuttle Training Aircraft, plus the thousands of simulated landings you've had in the SMS, before you're qualified to fly as the pilot, the co-pilot, really. Before I flew as a mission commander, I think I had 2,500, 3,000 simulated landings in the STA, prior to the first time I flew the Shuttle. But the thing is, first time you fly the Shuttle is the first time you fly the Shuttle, you know. Contrary to what people think, you don't go out and get in the Shuttle on top of the 747 and they let you go and let you go land it. You don't do that.

We do essentially the same way that commercial airliners do nowadays. Commercial airline pilots go in the simulator. A guy flying for Continental [Airlines] goes up here on [John F.] Kennedy Boulevard [In-Flight Training Center, Houston, Texas] and spends months in the simulator and accumulates hundreds of hours of simulated flight time, and then they send him out to a real airplane and he's got passengers in the back. He flies as a co-pilot; doesn't do the first landing, you know, but that's the first time he flies a [Boeing] 747 or whatever it is, is the first time he flies it. But it's because of the sophistication of simulators today. They are just that good.

So that's what we use the Shuttle Training Aircraft for. Every flight, it's very much like the SMS, because the instructor pilot is a diabolical person, and on every approach they put in some off-nominal situation. Either they start you out too high, so that you have too much

energy, or they start you out too low, so that you have too little energy, or they start you off way to the right or left of the runway, so that you've got to figure out how to get there.

And because it's a glider, then the only thing you can do to change energy is either pull the nose up, push the nose down. You can't push it down too far, because in the Orbiter you start shedding stuff. So it's superb training. It just teaches you how to think real-time, recognize, first of all, that you're in an off-nominal situation. You depend a lot on your eyes, but you also depend on the instruments. Where are you altitude-wise versus air speed, versus proximity to the center line of the runway? You have to integrate all that stuff and tell yourself like this, "Okay. I'm not where I need to be. How do I get there quickly, safely?" So that's what you do in the Shuttle Training Aircraft.

JOHNSON: So how did it compare, the first time you flew?

BOLDEN: First time I flew the Shuttle, it was like I'd been there before, from both sides. When I was Hoot's pilot, sitting in the right-hand side, calling off air speeds backwards, air speed and altitude, putting the landing gear down, it was just like being in the STA, flying it. And that's a bad way to say it, because being in the STA, in hindsight, was exactly like it was in the Shuttle. Combine that with the SMS. It was just as if I had been there before. So, the world of simulation, even back then when it wasn't as good as it is today, was awesome.

JOHNSON: I think we're going to take a break and let Rebecca change out the tape.

[Tape change]

JOHNSON: When we stopped, we were kind of working backwards through there. I think what I'd like to talk about just for a moment is to go back to the *Challenger* accident. Did you have any specific duties immediately following? You said that you immediately started getting ready to go, but as far as the memorial service or any of the tributes?

BOLDEN: I was a family escort for the [Ronald E.] McNairs, and so I spent the next, well, lifetime, actually, because I don't think you ever finish being a family escort. We're still very good friends and, you know, still try to stay in touch with Cheryl [McNair] and the kids. But I was their family escort for the post-flight, post-disaster stuff.

So I sort of became a surrogate, if you will, for Joy and Reggie, and just trying to make sure that Cheryl had whatever she needed, and got places when she was supposed to be there, because for them it was an interminable amount of time, I mean years, that they went through the post-flight grieving process and memorial services and that kind of stuff. So I spent the bulk of the year after the accident doing that.

JOHNSON: Let's go back to your first flight on [STS] 61-C. Since this was your first flight, when you said you learned about it in [19]'84, you knew you were going—

BOLDEN: I think that's when we were assigned.

JOHNSON: Okay. What was it like when you got that phone call, if you can describe—

BOLDEN: Oh, it wasn't a phone call. You got—I'm trying to remember exactly how it happened. I think, again, I was told to report to Mr. Abbey's office at two o'clock or something like that. And we were all there, the whole crew. He brought the whole crew in. I think Hoot, as the commander, had been notified ahead that they wanted him to—that's generally the way they did it, I think. Since I've never had any part in picking crews, I don't know how they did it.

But I think the commander was notified that, "Okay, our intent is to give you this—." That's what they did for me, anyway, for my two flights. "Our intent is to make you the commander of this flight. Here is the crew that we've put together for you. Have you got any objections?" or anything like this.

So we all met in Mr. Abbey's office and he told us we were going to be the crew of STS-51L, and we went off, happy, excited, ecstatic, and all that kind of stuff. And started getting crew assignments in terms of who was going to do what with the flight, who was going to do which experiments and what your responsibilities were going to be; who the EVA crewmen were going to be; who was going to be responsible for earth obs [observations]; who was going to be responsible for this and that and everything else. So that's kind of the way I remember it happening.

Franklin and I were the rookies on the crew. Steve, Pinky, and Hoot had flown prior to that, had had their first flights. So Franklin Chang-Diaz and I were classmates, and so we were beside ourselves. We were like two little kids.

JOHNSON: Did the other crewmembers that had flown before take you under their wing, as far as making you aware of what was going to happen?

BOLDEN: Yes. Hoot was unbelievable, especially as a pilot. He and John Young were two guys that to this day continue to boggle my imagination in terms of their piloting ability. I've met a lot of people in my life in aviation, over thirty-five years; never met two people like them. Everybody else gets in an airplane; John and Hoot wear their airplane. They're just awesome.

You know, you get with them in the simulator and things start happening. Their mind just takes over, and they instinctively know the right thing to do. It's like that in a normal airplane. It's like that in a simulator. With Hoot, it was like that in the Orbiter. You're sitting there thinking about something, trying to figure out, "Okay. What the heck's going on?" And he's got it.

And the two of them, really, they're two phenomenal aerodynamicists. These guys are engineers at heart, to be quite honest. They're both aeronautical engineers, real aeronautical engineers. I'm not, by any stretch of the imagination. My major at the Naval Academy was electrical science. I didn't even get a major in electrical engineering. I just did get out of the Naval Academy.

But these guys are not only smart, but they can really apply their smarts. So Hoot took me under his wing. As a matter of fact, I had a very difficult time getting ready for my first flight. There is so much stuff to learn. There's an overwhelming amount of knowledge that one has to grasp if you really want to understand the Orbiter and fly it well, or execute the mission well; not fly it, because you don't do a lot of flying, physical. But there's so much stuff to commit to memory, so much stuff to know when to apply.

And because the way that I was trained with Hoot was you don't ever wing anything. I credit him with my technique as a commander. He preached from day one, "We don't ever do anything from memory. We don't ever wing it. If something's going to happen, there is a

procedure for it. And if there's not a procedure for it, then we're going to ask somebody, because somebody should have thought about it."

And so what we did was we trained ourselves just to know where to go in the book. And hopefully, crews still train like that, although I always flew with people who would invariably want to wing it, because they prided themselves in having photographic memories or stuff like that. The Orbiter and just space flight is too critical to rely on memory, when you've got all of these procedures that you can use, and the ground to talk to.

Hoot taught me a bunch of things. He taught me Hoot's law. Hoot's law says—in fact, let me tell you how he taught me Hoot's law. We were in the simulator one day, in the SMS, and I was still struggling. It was in my struggling phase. And I really wanted to impress everybody on the crew and the training team. We had an engine go out, boom, like that, right on liftoff. So we worked through the procedure and everything, and as the training team is wont to do, they just start piling things on top. And really what they're trying to do is just get you distracted.

There is probably one critical thing that you really need to focus on, and the rest of it doesn't make any difference. If you don't work on it, you get to orbit and you don't even know it was there. But if you notice it and start thinking about it or start working on it, you can get yourself in all kinds of trouble. They love doing that with electrical systems, so they would give you an electrical failure of some type.

And that's what happened that day. We lost an engine, worked the safeing procedure, because you had to safe an engine when you got it down. And in the middle of doing this procedure, I got a minor electrical problem, just really one of these super, super sub-buses, something that I should have ignored. I started working the procedure for this minor bus. Wrong bus, in the first place. And this was my nemesis throughout my training.

There are three of everything in the Orbiter; sometimes there are four. I picked the wrong sub-bus to start working the procedure for. And it just so happened—everybody knew this was going to happen, because it's happened to everybody else. The training team intended it this way. You learn a lesson from it. So I started working this procedure and what I did in safeing the bus was I shut down the bus for an operating engine. When I did that, the engine lost power and [demonstrates] it got real quiet.

So we went from having one engine down in the Orbiter, which we could have gotten out of, to having two engines down, and we were in the water, dead. I just—here I went from I was going to feel real good about myself because I'd impress my crew, to feeling just horrible because I had killed us all. And Hoot kind of reached over and patted me on the shoulder. He said [imitating Gibson's voice], "Charles, let me tell you about Hoot's law." That's the way he used to do stuff sometimes.

And I said, "What's Hoot's law?"

And he said, "No matter how bad things get, you can always make them worse." And I remembered Hoot's law from that day. That was probably 1984, or 1985 at the latest, early in my training. But I remembered Hoot's law every day. I have remembered Hoot's law every day of my life since then. And I've had some bad things go wrong with me in airplanes and other places, but Hoot's law has always caused me to take a deep breath and wait and think about it, and then make sure that somebody else sees the same thing I did. And that's the way I trained my crews, but that was because of that experience I had with Hoot. And he did that throughout.

I can remember going to him—boy. We had already gotten Bill Nelson onboard, so we were inside six months of our flight, and electrical stuff was just killing me, which was ironic because that's what I really liked. That was going to be my major in college until I flunked a

course, which is another story we can tell. But I just had a difficult time grasping all this stuff. Finally, one day I said, "You know, I don't know that I'm going to get all this stuff."

And he said, "Hey, relax. Forget about it. We all get there. Some learn quicker than others, and it'll come to you."

And a couple of days after that it was like—bing!—like a light bulb went off, because all of a sudden things really did start to gel. I have no idea what it was, but I really started to understand and comprehend what was going on. After that, the training became really enjoyable. It didn't become a piece of cake, by any stretch of the imagination. I don't think it ever does. But from that point on, things seemed to go well, seemed to go right.

JOHNSON: So you felt prepared when you finally—

BOLDEN: Oh, I felt fully prepared when we launched. However, as fully prepared as I felt—kids ask you, "Were you afraid?" I can't ever remember being afraid, ever. When we had the alarm go off on my first flight, it was just that's what you train for. You do it. We had some other things happen on other flights. I just don't remember being afraid.

Apprehensive is something different. Before every single flight—and I flew four times—before every single flight I would lay there in my seat, just with stuff in your stomach, because there was so much to do that you just didn't want to do something wrong and put the crew in jeopardy. So, that bothered me. You work your way through it, but to say that it was a piece of cake—for some people it was, or for some people it may have been, but never for me. I worked really hard every flight.

JOHNSON: And with the delays on that one, I imagine the apprehension grew.

BOLDEN: It actually turned out to be good.

JOHNSON: That was because you were more relaxed.

BOLDEN: That was probably a blessing, because I was really uptight the first time we went to the pad. First time you—I went over every procedure in there. I mean there's stuff taped all over the—stuck all over the cabin—procedures. And what worried me, because you'd had it happen to you in training, what worried me was that in the excitement of the moment, with stuff vibrating all over the place, which I had no idea it was going to vibrate the way it vibrates, by the way. That was the only thing that was a surprise to me. In the simulator, stuff shakes around and all that. Nothing shakes like the vehicle when you lift off. When the solids ignite it just goes [demonstrates], and here everything starts to shake and vibrate, and you go, "I don't remember this. This wasn't in there." And that's the one thing that was a surprise to me, was just the volume, the extent of the vibration on the vehicle. Everything's shaking and vibrating, and you can't read anything. And so you've been training for years to read these procedures. You've got to reach out and grab stuff.

Like when the alarm went off for the helium leak, I literally had to reach out and grab the procedure, take it off its Velcro and hold it in front of me so that it wouldn't be doing like this [demonstrates], because the vehicle's just going like this and you couldn't read anything. So I was very, very apprehensive about picking the wrong procedure. I'd had it happen to me before and put everybody in the water, and I just did not want to have that happen in flight.

So, that was something that I had to deal with. That was just me. I imagine most other people never had that. But, boy, I'll tell you, like I said, every single flight of my four, you lay there beforehand saying, "Okay. If something goes wrong, make sure you get the right procedure." And there I go back to Hoot's law. What I did was every single crew I commanded, there was a rule that said, "Okay. Nobody does anything. Don't you touch a switch until at least one other person has verified that what you think is wrong, is really wrong. There is nothing we can do right away, no matter how bad you think it is. Let's at least make sure there are two of us that agree on the procedure, and then we're going to start working it. And we're going to work it as a team."

And the training crew, they'd always try to divide and conquer. What they really liked to do, and it worked a lot of times with people who were typical pilots, arrogant, cocky, very confident, it was real easy to get us to split up. You know, "I got this one. You get that one." And before you knew it, all hell broke loose, because you guys weren't communicating and you're working something over here that was in opposition to what was being worked over there.

So eventually you learn that, okay, this is a team effort. This time to star, to be an all-star, is over. But that was one of the things that the training team tried to do. They tried to give you something that would split the crew. So what I did was, we always worked in pairs. Usually, MS 2 [Mission Specialist 2], who sat in the center seat—Steve Hawley and me, for example, would work certain systems together. Steve and Hoot would work certain systems together. And if it was anything that was on Hoot's side of the cockpit—DPS, the Data Processing System, the computers, the environmental control system—Hoot could see it. I couldn't, so he and Steve worked that. Anything that had to do with electrical, hydraulics,

APUs, Pinky, who sat behind me but could peek around, and he could see the console pretty well, so he and I worked those procedures together.

And then periodically we would go back and forth and say, "Okay. Here's where we are in this procedure." If you were on orbit, where you were in a book and you're working a page, you say, "Okay, I'm on page so-and-so." And you would call the ground and say, "Okay. We're working step three on page 2.5 of the on-orbit checklist in this procedure." And it worked very well for me, so that was just the way I got used to working with Hoot, and that was the way I trained everybody I flew with.

JOHNSON: Part of your training, also, was in the KC-135. How did training in that vehicle compare with your first experience with weightlessness?

BOLDEN: The training in the 135, for a pilot the primary focus was landing. It was actually rollout. So while we went on, when our mission specialists went to do their EVA training, for us it was just fun, because you had about twenty to thirty seconds of weightlessness at a time. It usually made people sick, more than anything else. It was just because you went from weightlessness for about twenty or thirty seconds, to 2 Gs while they would pull the airplane back up to get it where they could go weightless again. And that constant zero-G, 2 Gs, zero-G, 2 Gs, for most people just after a while—you did 200 parabolas over a course of two hours, and for most people, sooner or later your stomach just said, okay, I've had it. I don't ever remember getting sick, but I can remember not feeling comfortable sometimes, just depending on whether you had something to eat or that kind of stuff.

But for the pilots, you flew two of what we call heavy aircraft training flights prior, within—once you got within about six months of flying, then you would go out, the commander and the pilot, and you would fly two heavy aircraft training missions. What they did was you'd go out and fly touch-and-go's; a couple of practice approaches and some real touch-and-go's, and what they call stop-and-go, where you would land, roll the vehicle out and stop it on the runway, and then turn around and go back and take off and do it again, in the KC-135.

The reason we did that was because it was the simulator for the Shuttle on the runway. Shuttle's a huge vehicle. It's the size of a [Boeing] 727. And most of us came from tactical jet communities. Like I was used to the A-6, which was a pretty big airplane, but nothing like a 727, or nothing like a Shuttle. So, just the fact that you're sitting thirty feet above the runway means your view is different, your sensation of speed is different, the way you handle the vehicle in coming to a halt is different. And it just kind of lumbers down the runway. It's a big vehicle.

So we used the KC-135 to get you on the runway, learn how to apply the brakes, how to get this vehicle smoothly stopped without going off the side of the runway or something, which you could do if you panicked, or if you didn't do it right. The good thing about the KC-135 was it was generally nominal. Unlike everything else in training, they didn't try to put in any failure. It was hard enough to fly. It was just a hard airplane to fly, for me, anyway. You end up flying it with your right hand sometimes, but then when you want to do power, you had to fly it with your left. It has a yoke. Almost all jet pilots are right-handed, flying. The airplane configuration is such that the power level for the engines is on the left side, so you're flying the stick in your center. And that's the way you grew up.

All of a sudden you get in this airplane and the power levers are in the middle, so you're moving that with your right hand, and you're trying to fly this thing with your left. And it's big,

and it wants to do this [gestures with tight circular hand motion] all the time. It has something called a Dutch roll that makes the nose just wander like this. People who fly them for a living, piece of cake. They don't even notice it, because they know you've got to do this, then it won't do that.

Flying the KC-135 for somebody like me, the nose starts doing this [gestures with tight circular hand motion] and you're going, "Oh, man, what am I going to do?" And you're like this with the stick [rapid up and down motion with left hand] and like this with the power [motion of pulling back on power level with right hand]. So it was always fun. The crew chief would laugh and the instructor pilot would laugh, and then finally you'd get it down. And you got pretty good after a while. But, whew. But they were fun.

JOHNSON: So what was the first experience, when you first felt weightlessness for the first time and you got to look out the window?

BOLDEN: The very first long-term weightlessness was on orbit, because as I said, in the zero-G, in the [KC] 135 it was just twenty or thirty seconds at a time. One of the things that had done a superb job of preparing me, however, was the water tank, the Weightless Environment Training Facility, the WETF. Now I forget what we call it, now that it's out in the Sonny Carter [Training] Center [Neutral Buoyancy Laboratory, JSC, Houston, Texas].

But I found that when I went to the tank with my EV crewmembers—I never got in a suit; I was always in scuba. But I would spend most of my time upside down, in odd positions, so that things didn't look the way they looked down here. I think that benefited me better than

anything. It's not the feeling of weightlessness, in my case. It wasn't the feeling of weightlessness that bothered me at all. That was good and I got used to it instantly.

It was just the disorientation of being—you thought you were upright, but the writing wasn't. Because you were literally upside down in the cabin, then the writing didn't look right. And so by being in the water tank a lot, I got accustomed to the feeling of—because when you got upside down in the water tank, gravity pulled blood into your head. I didn't know it at the time, but that was good, because weightlessness is exactly like being upside down in the water tank. It's not this euphoric feeling, or stuff. I don't know how people describe it to you, but it hurts, initially. Weightlessness initially is somewhat painful in your head, because your fluids in your body seek equilibrium. They want to fill every void the same way. So the fluid inside your body—your blood, your body fluids, everything—wants to have the same relative amount in your big toe that it has in the top of your head, and it goes [demonstrates], and you end up with this pressure in your head that, unless you've been in the water tank upside down, you've not had before. And it's just uncomfortable.

You've got this feeling of fullness, like a really bad head cold. You take care of it by going to the bathroom, and over the first couple of days you just pee to beat the band. You're trying to get rid of the fluid you don't need, and you end up eliminating about two liters of fluid from your body that way. And then you're perfectly comfortable, because the balance of fluid is just where it ought to be.

You really want to stay hydrated, and it's really easy to know when you're properly hydrated because you drink until you get this feeling that, "Okay, I'm getting ready to have too much fluid in my head." It just triggers something down in here, barrel receptors in your neck. When the barrel receptors say, "Okay, I've had enough," then you quit drinking, and you've got

enough fluid in your body. You can do that in space. You can't do it here, because you'd have to drink *a lot* of fluid. You'd probably pop before you got the barrel receptors down here on Earth to say, "I've had enough."

So the feeling of weightlessness initially is pain. That, however, does not detract from the sensation of weightlessness, which is awesome. Just seeing the world from that vantage point, recognizing the fact that it doesn't make any difference what position you're in; it's all relative, and it doesn't make any difference, depending on who it is. In my case, Hoot again had told me, he said, "Hey, just go easy. The first few minutes, first few hours, I'd recommend, don't move your head without moving your body. If you want to look left or look right, move your body and keep your head locked straight ahead in relation to your chest." Worked great. Didn't need it, but it worked great.

I never sensed any sensation of stomach awareness, or never felt I was going to be sick or anything. I was doing somersaults and stuff within a couple of hours after being on orbit. But again, Hoot prepared me that way, and said, "If you get sick, no big deal. Happens to a lot of people. Just don't do anything to hurt yourself." And so that was basically what I did. And you learn, again from being in the water tank, how to reevaluate where you are and how to get yourself oriented pretty quickly when you're not in a normal attitude. So that part I was ready for.

JOHNSON: As you said earlier, there were several delays on the landing, so you actually had more time up there than you were expecting.

BOLDEN: Well, we actually got back to the original time. We were supposed to be a seven-day mission. I think we were supposed to be a six-day mission, and we ended up being a seven-day mission.

JOHNSON: Was there time you had to fill?

BOLDEN: No. We went back and we filled the time with the experiments that were originally scheduled to be done. They were really trying to figure out how to chop stuff out of our schedule to get us back in four days. So it didn't affect us in terms of activity onboard, other than the fact—well, I take that back—other than the fact that we had to pack up and unpack every day, from Day Four, which we not ordinarily have done. That took a huge chunk of time out of the on-orbit availability of experiment time.

So, some of the experiments that we would have ordinarily done, we didn't get to do, or we didn't get to do them for the length of time that the ground would have liked for us to have done them, because when you started buttoning up the vehicle for landing, then you stopped doing experiments. Everything went into their drawers or into their lockers, and that was it.

Even after we waved off and it was decided we were going to stay on orbit for another day, you didn't go back in and pull everything out wholesale, because some experiments you'd already fixed, if you will. If you had something live, you'd already put the death fluid in there, and so it wasn't going to come back. It was dead, and it was fixed in perpetuity, or whatever it is. So, some things you just couldn't reactivate.

JOHNSON: One of the things that you were supposed to do on that flight was observing spiral eddies.

BOLDEN: Yes. How do you know that?

JOHNSON: [Laughs] We've talked to other people. Actually, I've read a couple of different things. I think Steve Hawley's interview, and also [Robert E.] Stevenson—

BOLDEN: Bob Stevenson taught us about spiral eddies, bless his soul. I was okay at it. I wasn't the world's best. But, it's amazing, again, what you can see from the vantage point of space when you have—there's a feature called sun glint, and probably they've talked to you about it. But it's taking advantage of the relative angle of the sun to the ocean, and when it's low on the horizon, you can see tremendous features in the ocean, on the ocean surface and sometimes many tens of feet below the surface of the ocean, that you couldn't see ordinarily.

Spiral eddies become very visible in sun glint. In fact, that's the only time you can see them. The other thing is, they're called internal waves. The ocean is full of underwater turbulence and waves. Everybody knows what waves are like on the surface of the ocean. That same activity goes on under the surface of the ocean. What we found out—we didn't do it, but the early space flyers found that, after they came back and looked at some of the images they had taken, "What is that?" Didn't make any sense, because they didn't remember seeing anything. They didn't remember seeing any waves or anything. What they were doing is they were looking at as much as thirty, forty, fifty feet beneath the surface of the ocean, and they were seeing this phenomena of internal waves. Internal waves can be very violent, because sometimes

they're seismically caused, maybe a mild earthquake under the ocean, and you get these waves going. They're destructive. They can damage ships; they can do all kinds of stuff.

And it was our first clue to damage that had occurred to underwater facilities or underwater things that we just didn't know about. That was something that was discovered just from the vantage point of space, by happenstance. But I don't know anything else about spiral eddies.

JOHNSON: I think you ran out of film on that flight. You ended up drawing pictures of it.

BOLDEN: Oh, no. Taking spiral—yes. You all did get that. In fact, Bob Stevenson—I just drew what it looked like. As a matter of fact, the one that Bob was talking about—now I remember. The picture we drew, "It could not have been," was the claim, because it was a wrong-handed eddy. Just like in the northern hemisphere—I've got to get this right—I think eddies go counterclockwise. He'd kill me, you know, if—and in the southern hemisphere, because of Coriolus Effect, things go clockwise. If you want to see it, you just look at your toilet. When you flush the toilet up here, the water goes out of the toilet counterclockwise because of the Coriolus Effect. In the southern hemisphere, because it's just the opposite, the water goes out spinning to the right, or spinning clockwise. And the eddy we saw and drew for them, it didn't faze us because we knew that you'd see them going both ways. But the Shuttle's theoretical position, or the position we thought we were in when we drew this eddy, you shouldn't be able to see one that was going clockwise.

What they determined, I think what Bob Stevenson and the experts determined, I think, was that there's a transition zone around the equator, and although you shouldn't see it, then in

this transition zone you might see southern hemispheric-acting eddies in the northern hemisphere. I don't know whether that's what he told you or not. But I had drawn it, and so I had my proof.

JOHNSON: That's right.

BOLDEN: I didn't have a picture to show for it.

JOHNSON: You mentioned earlier that this was sort of the end-of-the-year-clearance flight.

BOLDEN: It was.

JOHNSON: Were there any specific challenges that you remember on that flight that you'd like to share with us?

BOLDEN: Yes. The big challenge was arguing with the ground about how we should do some of the experiments. There were some that we could see were not going exactly right. I didn't have the problem as much as Pinky. Pinky was the big person working a lot of the material sciences experiments. And while we had very little insight into what was going on inside the box, we could tell that because of the data that we were seeing onboard, we could tell that if we were just given an opportunity to reenergize an experiment, or to turn the Orbiter a different way, or do something, we might be able to get some more data for the principal investigators.

The principal investigators agreed, but the flight control crew on the ground, that wasn't in the plan. They weren't interested in ad libbing. They had a flight to fly and a plan to fly, and so forget about these doggone experiments. And that generally represents the pull and tug that you see all the time.

You have the Flight Control Team that's responsible for the conduct of the mission and the safety of the vehicle. You have the crew onboard—and I can talk about this a little bit now or later. But there's always a pull and tug between the Flight Director, who is in charge—nobody argues that point—and the Crew Commander, who, by the General Prudential Rule of Seamanship, of navigation at sea, has ultimate responsibility for the safety of the crew and vessel. And so if there's a disagreement between the Commander and the Flight Director—and that's happened on very, very few occasions, but every once in a while it happens. If there's a disagreement, the Commander can do what he or she thinks is the right thing to do, and is justified in doing that by the General Prudential Rule. And even NASA recognizes that.

Now, you could be in deep yogurt when you come back, if something goes wrong. But you have the right to countermand the direction of the Flight Director. Almost never happens. For my two flights, I had two superb—I had a bunch of awesome Flight Directors. But I can remember the guy that I had this discussion with probably more than anybody was [Charles W.] Chuck Shaw. Chuck was an Air Force colonel at the time. He's now retired from the Air Force, but still working in the space program. I think Chuck is still here, working with NASA as a contractor.

But my discussion with him came up in terms of landing. I had watched over time the ground use computers to determine whether you should use the close or the nominal aim point. The way we land the Orbiter, because it's a glider, is you've got two points on the ground, two

schemes of lights on the ground. One's called the nominal aim point, that's 7,500 feet off the end of the runway. The other, the close aim point for high wind conditions, is at 6,500 feet off the end of the runway. You know, you say, well, what difference does a thousand feet make? It makes making the runway or not. That's the difference it can make.

We had seen a couple of flights where, due only to the superb airmanship of the Commander onboard at the time, that we were able to get the vehicle to the runway. I remember that happening twice, but where the computers on the ground took the winds and everything else and said, "Okay. We know what they think, but you ought to go to the nominal aim point, because if you don't—."

The engineers on the ground were always worried about running off the other end of the runway. With a 15,000-foot runway, there's no pilot in his right mind who ever had any concerns about running off the other end of the runway. But it was a bad day if you didn't make it to the runway. So, just to begin with, we were in opposition in terms of what our goal was. Granted, they wanted to get you on the runway, and 2,500 feet down the runway, which was your target landing position, but they always had in the back of their minds, early in the game, that, "Boy, if we do this wrong, we're going to run the vehicle off the other end, and we can't survive that."

We just wanted to get to the runway. We could stop it. We had confidence that the brakes were good, from the first time John Young said, "Boy, we've got some good brakes." And so we believed it. And so we never worried about running off the other end of the runway.

So Chuck Shaw and I sat down a couple of times before my first flight, and I said, "Chuck, a couple of things we need to talk about. One is, aim-point selection on landing. If

there's 5 knots of wind reported or greater, I'm going to the close-aim point. I don't care what you guys say."

He said, "But that's not the rule."

I said, "Well, the rule's screwed up, or it's screwed up for me, because I know how I've trained. I know what I can handle, and I'm not worried about running off the other end of the runway. I do know what 5 knots of wind will do if it's a bad day, and so you may as well recognize the fact now. Don't put me in a situation where you and I are going to argue about it, or your Entry Flight Director and I are going to argue about it over the net, because the media's going to pick up on it and it's going to be real ugly. So, let's figure out a code or something. I can tell you what's going to happen. No matter what you tell me to do, I'm going to put the close-aim point in if the wind is 5 knots or more." And we had that agreement, and nothing happened.

But if a Commander and a Flight Director kind of have at least an idea that you're going to have egos involved, and that should not impact anything, then I think you can work anything out, and that's what we generally did.

JOHNSON: One of the things I read about you is that you were the first one to get in the basket on the escape.

BOLDEN: Yes.

JOHNSON: Can you talk about that for a moment?

BOLDEN: Yes. At the Cape, on the pad, as I mentioned, for everything, we go through hundreds of hours of simulation of everything that can go wrong. One of the many things that can go wrong on the launch pad before you launch is a fire, a leak, or something else that necessitates an emergency evacuation of the crew from the vehicle. And the very last thing that you do when you go down for your—we go down about two weeks prior to your scheduled launch, and we go through a dry run of the launch, from waking up that morning all the way to an emergency egress and going down into the bunker, and then driving the tank and all that kind of stuff.

But for years we had always said, "We always come to the basket, jump in it, hit the little paddle here and the basket goes two feet, but you don't go down the wire. How do we know that things are going to work when you get down at the bottom? How do we know we're going to do the right things? How do we know the wire's going to work?"

"Well, we put sandbags in."

I said, "Yeah, but that's sandbags. That's not people." But nobody wanted to put a person at risk, especially an astronaut. They figured, "Holy G, if we do that."

Ironically, after *Challenger*, we went back to the very beginning of the space program. The good thing about being here after *Challenger*, as horrible as that experience was, the good thing about being here was, we went back to the very beginning of the Shuttle Program. We redesigned the vehicle. We went back over the design of the vehicle. We completely reviewed every decision that had been made. Why are there no air-breathing engines? Why do we not have a crew escape pod? Why did we choose individual tiles instead of something else? Why did we do this? Why don't we do this?

And the question that kept coming up out of the Astronaut Office, and me as one of the prime questioners, since I was a Cape Crusader, was why have we never tested the basket? Why have we never trained a crew by letting them get in the basket? "No, we don't want to do that."

And so we said, "Well, then we can't say it's certified, if you've never done it." Putting a sandbag in there is one thing, but having a human being go down there and say, "Yeah, it's okay. I didn't break my neck when I struck the bottom and came to this rapid stop, and I still had my faculties and could jump over the side or let the thing down and get into the bunker." Until you've actually done that, you can't guarantee that that's going to happen. We're just counting on getting a crew safely out of the vehicle, and then we lose them at the bottom because they're disoriented due to impact or something else, and the thing blows up and they're lost.

And so I finally convinced them that we ought to do that. So, the scheme we came up with was that eventually there would be three of us who would ride the basket—an astronaut, a fire rescue guy, and a closeout crew member, one of the Kennedy personnel who actually is in the vehicle when the crew gets in there, because if you have to use the slide wire, it's going to be in the pre-launch phase, and the only people around are going to be the fire and rescue guys and the closeout crew.

Because I didn't want to put anybody else at risk before I knew everything was okay, then I said I wanted to go first. If I didn't get hurt, then we could put other people in there. And so we came out and it was very choreographed and everything. Everybody held their breath, and I hit the paddle [demonstrates] and the thing went down and stopped. I jumped out and kind of fell in the sand, and then ran to the bunker and said, "Okay, it's okay."

And we talked about some of the things, just—the reason I was able to do it first was because of my background. As a test pilot I had been trained to be observant, and I tried to look

at everything. I tried to look at the attitude you needed to be in in the basket, what it sounded like, what it looked like, what it felt like when you came to a screeching halt, because it was an abrupt stop. You went into this net, and although it looked like it played out pretty smoothly, you hit the net and you just [demonstrates] stopped.

So, determining whether or not you could get your faculties real quick, because you had to pull these pins and let the side of it drop down, and then you had to swing yourself out. And as people started getting out, one of the things we didn't anticipate, as you start getting weight out of the basket, this wire coming from the top of the launch pad is a couple of thousand feet long, a big old guide wire like this. And if it's got five hundred pounds down here at the bottom pulling it down, every time you take a hundred pounds out, the wire's going to want to straighten out more and more.

What we found was when the third guy came out, I mean the basket was way back up in the air. And so that person, you couldn't just jump out, because you're going to break your leg. And that we discovered by virtue of the fact that we put human beings in it and had it go. The first one to go out just kind of rolled off the side and the basket was almost sitting in the dirt, because you've got a fireman in all the silvers; you've got an astronaut in eighty-five pounds worth of flight gear, which was what we had after *Challenger*; and then you've got the closeout crew guy who's got an oxygen bottle and all this stuff.

So you've got a lot of weight in that basket, and every time you throw somebody over the side, the basket gets lighter and lighter and goes higher and higher. So I did that. That was my claim to fame. And it was awesome; it really was. It's one of those things that you—and it was never done again, for some reason. We did it; we got away with it, and everybody said, "Okay. We hope you're satisfied. We're never going to do it again."

So, what I wanted to do was get people confident that it worked, so that we could then begin to train the crews. But to my knowledge, we still don't do it. And they're asking the same question now. "Why don't we do it?"

"We don't want to put anybody at risk."

JOHNSON: I'm going to go back to the beginning again. When you said that you first heard that you had been chosen, and it was on your wife's birthday, how did you—

BOLDEN: May 31st, 1980.

JOHNSON: How did your family react to the news?

BOLDEN: Hard to say. I can only tell you—well, my wife was the only one that knew at first, because Mr. Abbey said, "Do not tell anybody until—." He said, "You'll know you can tell people because it'll be on the news." And the leak happened [snaps fingers] instantly, because I didn't—I went out and flew. And it was an unbelievable flight. It was what we call an accelerated—I remember it very well, because it was an accelerated service test on an A-7, single-engine jet, and my job was to go out [demonstrates] and try to get the engine to quit. We did those all the time. And so I went out and flew my flight, and I was all over the place. I was as giddy as you could be. And everybody kept asking, "Okay, what was that phone call? Anything wrong?"

I said, "No, no, no. Nothing wrong." Went out and flew my flight; came back went home. Told Jackie [Bolden]. She was sworn to secrecy, couldn't tell anybody. And the phone

started ringing off the hook that night—NBC from Washington, and other people had heard. And I said, "You've got me. It's the first I've heard about it. You need to call Johnson Space Center."

"Yes, we're waiting for word."

"Shucks, I interviewed in February, and I haven't heard anything." That was my story and I was sticking to it.

And the next morning, NASA came out with the press release. And so they did give me an opportunity to call my mom and dad; no, my mom. My dad had died. My father never got an opportunity to see me do this, because he died in October of [19]'79, the year prior to my—in fact, I was in the process of putting my application in when he died. So he never got a chance to see it physically.

But I didn't want my mom to get the word on the news, so I called her and she was, as she always is; she was just beside herself. Here I was going off and doing another crazy thing. She did not like the fact that I was a test pilot. She did not like the fact that I was flying airplanes. Every day of her life until she died two years ago, last year, she asked, "When are you going to quit? When are you going to retire and get a real job?"

But she was very proud, unbelievably proud, but just afraid, and wanted me out of everything I did. She was a very highly educated woman. She had a master's in library science. I grew up as a son of—one of two kids, but our parents—mine and my wife's—parents were educated. My mother was a career librarian from the elementary, middle school, high school level until she retired, and then died a number of years later. My father was a career teacher, and he was my high school football coach.

JOHNSON: That's interesting. Well, of course, you said your wife, you got to tell her, and then, of course, then you had to move to Houston.

BOLDEN: Yes.

JOHNSON: Was that ever an issue—

BOLDEN: No.

JOHNSON: —or was that something you've enjoyed?

BOLDEN: We loved it. We had no qualms whatsoever about—although it was funny, my wife cried going into Patuxent River. When I told her I'd been selected for Test Pilot School, she was excited. She had never heard of Patuxent River, Maryland. She had no idea where we were going. I knew, because I had been back there, and I knew it was the sticks. It's South St. Mary's County, Maryland. Nowadays it's a big place, because the Naval Air Systems Command migrated from Crystal City, Virginia, to Patuxent River, and it is built up now, unbelievably.

When we moved to Patuxent River, it was tobacco country. When you crossed the county line, all you saw for miles around were fields of tobacco; families that were inbred. You name it about the country. It was like—and people will kill me for saying this, but it was like going to the Beverly Hillbillies or something like that. These were country people, and they were happy. But a number of my engineers and people had grown up down there, so they bore

the brunt of all the jokes about where they lived and everything. When you went to Pax River, you were going to Pax River. There was nothing.

There was one thing south of Pax River. I don't know if you're familiar with the State of Maryland and how it's shaped, but it's got the bulk over here, western Maryland and all that, and then it has this little appendage that goes down. That's South St. Mary's County, and the very tip end of it is Point Lookout, I think. Fishermen go down there. Nobody else goes there. Nobody comes into the finger of the State of Maryland unless you're going to Pax River or unless you're going to fish. So you don't pass through Patuxent River.

And when I took Jackie there, we just kept seeing trees and tobacco fields, and she cried, wanted to know where I was taking her and her kids. Our son, I think—that was 1978, so he was seven years old, and our daughter was two. And Jackie cried for days. The two years we were there, she fell in love with the place and the people. She crabbed every day, so, when she wanted crab, she went out and caught it. It was just phenomenal living there. We got to know the watermen and all that, the people that do oystering and crabbing and everything.

And when we left to come to Houston, she cried on the way out of town, not because she was sad to go to Houston, but because of the friends she was leaving. So, she cried on both ends. We drove through South Carolina, stopped and spent some time with my mom, and then drove on into Houston.

We got down here Fourth of July weekend, as a matter of fact, and that was our introduction to the Astronaut Office, because they had one of these outings planned. They were all going up to Canyon Lake [Texas], up around north of San Antonio [Texas], and were going to go tubing for the Fourth of July. So that was our introduction to tubing. It was miserable for

Jackie, because we got in late, so all the cabins were gone. We borrowed a tent from somebody. Jackie hates—there is nothing that she hates worse than the great outdoors.

So I took them up there the Fourth of July. It was 120 [degrees]. I don't know, it was hot and humid, and as we were setting up our tent, she noticed that—it was [David C.] Dave Leestma, who is over in Engineering now, but Dave and Patty, his wife, were out, and they were putting this chalky-looking stuff around their tent. They were in a nice big tent that had all kinds of stuff. They had planned. But it was stuff to keep the scorpions out. I told Jackie that and then she was—she was fit to be tied then, for sure. "What are we doing?"

And we were in this little dome tent that we had borrowed from somebody, so we've got my wife and two kids in a dome tent with the scorpions outside, and snakes, and it's a hundred-and-who-knows-what. So, I had a great time. We went out, tubed and everything. She was miserable.

She let me do that to her one more time. We drove to the Cape for STS-1, for the launch, and we carpooled with the O'Connors, Bryan [D.] O'Connor and his wife, Susie, and their two kids. The O'Connors had a camper. They had a Volkswagen with one of these convertible tops and everything, so they slept in their camper.

Again, the Boldens had nothing, so we went—I can't remember which car we drove, but it was old, and we had a dome tent. We stopped in Pensacola [Florida], out on the beach at—it's one of these old Confederate forts. So we pitched our tent on the sand. The kids and I loved it, and Jackie was miserable. It was hot and sweaty. It was in July. We were out there on the sand, and you could go shower at the little—because this place was a campground. But by the time you got back to the tent, your feet were full of dirt and stuff. That was it.

So after that, never again was she going to go camping anywhere. Her idea of camping would be a black-and-white TV in a hotel room. And that's exactly what we looked for on the way back. She said, "I'm not stopping to camp. We're going to find a hotel, motel." And so that was the end of our camping experiences, early in our marriage. But that's what we did when I came down.

JOHNSON: Looking at everything we've talked about today and your first two flights, is there anything that we didn't talk about that you'd like to add for today?

BOLDEN: People, but we can talk about people anytime you want to.

JOHNSON: If there's anybody you want to talk about right now—

BOLDEN: I was saying earlier, of all my experiences in the space program—people always ask, "What was your best flight? What was your most exciting flight? What is your most vivid memory?" implying that it's something about some flight. I had four awesome flights. All of them were distinctly different, I mean in every respect. They all had a totally different mission; none connected whatsoever.

Three of them involved international partners, because I went from Hubble to ATLAS 1 [Atmospheric Laboratory for Applications and Science], which was a truly international flight; had a Belgian payload specialist. Ten of our thirteen experiments were non-U.S. And my last flight was the first joint Russian-American mission. We flew STS-60 with—I had Sergei

[Konstantinovich] Krikalev and Vladimir [Georgievich] Titov, who came over from Moscow [Russia]; experienced cosmonauts and their families.

So it was the people that really made our fourteen years here memorable. I always cry when I talk about Franklin, because Franklin is just an awesome individual. [Cries] He is an inspiration to anybody. I interviewed with Franklin Chang-Diaz. We got to Clear Lake Airport. None of you are old enough to even know anything about Clear Lake Airport. But there used to be a little airstrip right there on Highway 3, and they'd fly commuters in and out of there, back up to Ellington [Field] or Hobby [Airport], you could even go.

I must have been one of about five test pilots and flight test engineers, test pilots and test NFO, Naval Flight Officers, backseat guys, who came from Pax River, and a handful of people came from Edwards [Air Force Base], all military. They always brought us down in groups of twenty. My interview groups had—shoot, I don't even remember how many, but it probably was three or four non-test pilots or military people. Franklin was one of them, very quiet and reserved.

I think [Richard N.] Dick Richards—I can't remember who it was, but one of the guys in my interview group, a fighter pilot, decided that since we were all going to be in this group for the week, we needed to get to know each other. So, as a fighter pilot would do, stepped up and said, "Hey, why don't we get to know each other. My name's so-and-so, and I'm a fighter pilot."

We went around the waiting room there while we were waiting on the van, and we all went through, "I'm an attack pilot."

"I'm a this."

"I'm a that."

And it came to Franklin, and Franklin kind of looked up sheepishly. He had come in from MIT [Massachusetts Institute of Technology, Cambridge, Massachusetts], and he said [imitating Chang-Diaz's voice], "My name is Franklin Chang-Diaz. I'm a plasma physicist."

And I kind of—I looked, and I didn't intend for it to be a joke. I wasn't exactly sure what a plasma physicist did, but I knew it didn't have anything to do with blood. But I couldn't resist, and I said, "You work with blood?" And you could see this look on Franklin's face. He's never seen me before in his life. He's here with all these people that he thinks are like him. He thinks they're all really smart, and the first thing he gets is all these assholes who are fighter pilots and that was all they want to talk about, flexing their muscle, and then this other idiot comes up and asks him if plasma physics has anything to do with blood. And he turned pale. And he says, "No, it's not about blood."

And so I said, "Okay. I'm just making a joke." But we got to know each other that week, and it turned out to be a tremendous week.

I gained a tremendous amount of respect for him because I got to know his story. He had grown up in San Jose, Costa Rica, and at the age of seven, after having dreamed of being an astronaut for the first seven years of his life, at the age of seven he went to his father and he said, "I've got to go to the United States." Spoke no English, so this is all in Spanish, by the way.

His father said, "For what?" His dad was actually an American citizen, I think, by birth, but had traveled all over the world as an engineer and had married Franklin's mom, who was a Diaz from Costa Rica. Franklin's father was Chang. And the way it happens—and you all probably know this better than I do—to preserve the mother's name, then her name gets appended, hyphenated on the end of the child's name. So Franklin was Franklin Chang, and he was Franklin Chang when he first came to the space program. But then he legally took his whole

name, and that's what he's used ever since. So he took the Costa Rican name of Franklin Chang-Diaz.

But when Franklin went to his dad, he said, "I've got to go to the United States because I am going to be an astronaut. I am going to be an astronaut, and I have to live in the United States to do that."

And his father said, you know, "Franklin, get real. You haven't even gotten out of elementary school. Go back to school and talk to me when you graduate from high school." And so Franklin said he went back and studied, and he worked real hard and he did real well. And he said the day he graduated from high school he told his dad, "Okay. It's time to go."

His father said, "Time to go where?"

He said, "Well, when we talked ten years ago, you told me to graduate from high school and I could go to the United States."

He says, "Yeah, but I was kidding." He said, "You've got to be out of your mind for me to let you go to the United States because you're going to be an astronaut."

And Franklin, he wouldn't give up. He insisted. And he said his father finally gave in. He gave him $50 in cash and a one-way ticket to Hartford, Connecticut, and a note to some friends that said, "This is my son Franklin. He thinks he wants to be an astronaut. Humor him. And when you're finished, send him home."

And Franklin got on the airplane, came to Hartford, enrolled in the University of Connecticut, almost flunked out because he couldn't speak English; would not let them put him in a remedial program; taught himself English; went on to graduate with honors from the University of Connecticut. Got a graduate scholarship to MIT., got a Ph.D. in plasma physics, and today is one of the world's foremost plasma physicists.

You know, you go, "What am I doing with people like this? What did I do to be here?" And he still goes back to Costa Rica routinely. When we finished my last flight, he took us down to Costa Rica for the inauguration of President [José María] Figueres, who was a childhood friend of his who was elected, one of their early democratically elected Presidents of Costa Rica. And because Franklin knew him, Franklin asked if he could bring his crew down for the inauguration, which he did.

During the two weeks that we were down there, he took us into the jungle, into the Amazon rainforest, to little communities of kids that had no electricity. All of the books and stuff that they—they knew more about the space program than I did, and it was because of all that Franklin had done to get material to them, to go in and talk to them, and just teach them about space and dreaming. And these kids, when we went to the school, they were wearing—because everybody wears uniforms in Costa Rica—this school wore blue bottoms and white tops, and the tops were pressed. And we all asked Franklin, "How can that be? There is no electricity here."

He said, "The moms put an iron on a fire and they iron them. They will not send them out to school unkempt."

We stayed there for a whole day, answering questions from these kids in this little elementary school. And we went to the presidential inauguration. Franklin was in the U.S. delegation. The Costa Ricans had wanted Franklin to head the U.S. delegation. I forget, I can't remember which—1980; must have been [George H.W.] Bush, [Richard M.] Nixon? No, Nixon was gone. It's not important.

But they decided that the Secretary of Commerce was going to head the U.S. delegation, but Franklin would be marching up front with him. And it was unbelievable. It was an outdoor

inauguration in the soccer arena, which is huge. When the U.S. delegation came in and was announced, and they announced, "Franklin Chang-Diaz," the place erupted. It was everybody in Costa Rica knows him, and he is a national hero. The place went wild.

And that night we were driving around. He was driving the car and had us all loaded in there, and we were going to one of the many inaugural balls. We weren't dressed like very much, so we're driving around. Every time we came to a barricade, the policeman would stick his arm out, and then he'd look, and he'd come over to the window and he'd say, "Señor Chang-Diaz! Oh, come through. Come through." And they'd wave Franklin through.

And the next thing we knew, we were at the ball, the principal inaugural ball where President Figueres was entertaining his guests. And we parked right at the front door. The next thing we knew, we're all standing around, and Franklin was just going to see if he could get us in, and just let us look, and all that stuff. The next thing we knew, here comes the President of Costa Rica out the door, President Figueres. "Oh, Franklin! Franklin, I'm so sorry. If I had known you were going to be here, we would have had you at—give me a moment."

He goes back in and he empties a table, clears a table and brings Franklin and his motley crew in. And so there we are, sitting in the inaugural ball for the President of Costa Rica, with this national hero. It was unbelievable. But Franklin is one of the many national heroes that I had an opportunity to meet and associate with here.

When we went to Russia after my last flight, we were there as guests of the Russian government. We had had the first cosmonaut to ever fly on the Shuttle. That was Sergei Krikalev. Sergei was a veteran Russian cosmonaut. He had been in space longer than any of us combined, at the time. His first flight has lasted, I think, five months on Mir [Space Station], and then his second flight on Mir took place when I was flying my first flight as a commander.

When I was flying STS-45 in [19]'92, Sergei was still stranded onboard Mir, because the wall had come down [collapse of the Soviet Union], and the Soviets—now the Russians—just didn't have the wherewithal to get him back yet. He had actually—he ended up up there for ten months because at the four-month point when he was supposed to come back, they were going to end up with a totally inexperienced crew. So they asked if one of the two onboard would mind staying, so they would have somebody experienced and somebody new, and Sergei volunteered.

So he stayed for what was to be an eight-month mission. The eight-month mission turned into ten months, because the Russians couldn't get him back. And then finally he came back. I met him via ham radio while I was on orbit and we did the first communication between Mir and a Shuttle.

And then I was at NASA Headquarters [Washington, D.C.] as the Assistant Deputy Administrator. When [Daniel S.] Dan Goldin had become the NASA Administrator, I'd met him on my back when I landed after STS-45. I looked up because I had agreed that our crew would stay supine and all that for the medical guys, which was heresy. You know, no good crew doesn't walk off and inspect their Orbiter. And I said, "This is stupid. There's nothing we can do. But if they need for us to do it, we'll do it." So we came out on gurneys.

But I was laying there and looked up, and here's this guy I've never seen before. He introduces himself, "My name's Dan Goldin. I'm the new NASA Administrator, and I want you to come work for me."

And I said, "Yeah. I have no desire to go to Washington."

So he said, "Well, when you get finished with your debriefs, come and talk." And I ended up going up, and, like many people, I was unbelievably impressed with him first time you meet him. The guy was a visionary, really was. So he kind of wooed me into agreeing that I

would come to Washington and be the Assistant Deputy Administrator for a while, anyway. So that's what I did.

While I was there, then it was decided that they were going to let me command STS-60. I was really hoping that I would have an opportunity to command the Hubble revisit, because that crew hadn't been assigned yet. So, deep down inside I was kind of keeping my fingers crossed that that would be my next mission. [Richard O.] Dick Covey ended up commanding that. He was STS-61, and I ended up being assigned as the Commander of STS-60.

When they told me what it was going to be, that it was going to be the first joint Russian-American mission, I said, "Forget it. I mean, no way. I have spent my entire life hating these guys. I could give a crap, the significance of this. I don't want to do it." I said, "Pick somebody else."

And they said, "Come on. Just lighten up." They said, "Wait. At least meet them, and then you can say no."

So they brought Sergei and Vladimir through Washington to come down here for some briefs and stuff like that, and I had an opportunity to meet them and have dinner with them and stuff, and immediately, was very impressed.

Sergei, at the time, was a very young engineer, I mean unbelievably sharp guy; had been a Soviet aerobatic champion and now was a Russian aerobatic champion; flew aerobatic airplanes. There wasn't anything he didn't know. Spoke fluent English.

Vladimir spoke none, I mean zero, nada. He couldn't even ask for water if he wanted to. And you grew to really empathize with him. I wouldn't say you felt sorry for him, because you didn't feel sorry for him at all. You just were impressed with his resilience, how he, in spite of the fact that he didn't understand a word, went through the training, struggled for the whole year

we were training and everything, and eventually learned English and became very good. But the decision was made by the Russians that Sergei—the right decision, by the way, was that Sergei would fly with us. But they didn't know until the very last minute, or the last few months, or something like that.

But again, we brought their families over here, moved them into plain old homes. Sergei and his family lived over in what is now—back then it was a newer part of Clear Lake [Texas], around Meadowbrook [Subdivision] or something like that. We moved Vladimir and his family out to Friendswood [Texas]. His son was eight; spoke no English. His daughter, eighteen, Marina, spoke fluent English. His wife, who was gorgeous, a very cosmopolitan woman. Sergei's wife was very Russian—quote, unquote—"Russian," you know, the stereotypical no makeup, quiet, spoke no English. She was an engineer, by the way, in the Mission Control Center.

Volodya [Vladimir Titov] was a colonel in the Russian Air Force, MiG-21 pilot; had been an air attaché in Paris, so Sasha [Aleksandra Titov] spoke fluent French; had been exposed a lot to life outside of Russia; really sharp in every respect. Anyway, within six months their son was speaking cowboy, Texan; wearing his cowboy hat, boots and everything, and speaking fluent English.

Sergei only had one child, Olga. She was two years old when he came over here, and although they were here for almost two years, she learned some English words, but she was just learning to talk. So she never got a chance to learn English for real. Now they're both grown. All three of them are now grown. Marina still works here, and Vladimir is now the Vice President of Boeing-Moscow. Sergei still flies, still with the space program, and his wife is still in the Mission Control Center in Moscow.

But that was a fitting end to my time with NASA. So, when people ask me what is my most memorable occasion or event or whatever it is, it was preparation for my last flight. It was the people I had an opportunity to meet and make friends. And that was my last flight with Franklin. I flew my first flight with him and my last flight with him. So it was a fitting way to leave NASA.

JOHNSON: I think we'll stop for today. We'll come back when we get together again, and talk about those last flights and your time at NASA Headquarters.

BOLDEN: Okay. We can do that.

[End of interview]