NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

C. GORDON FULLERTON
INTERVIEWED BY REBECCA WRIGHT
NASA DRYDEN FLIGHT RESEARCH CENTER, CALIFORNIA – 6 MAY 2002

WRIGHT: Today is May 6, 2002. This oral history with Gordon Fullerton is being conducted by Rebecca Wright for the Johnson Space Center Oral History Project at the Dryden Flight Research Center in California, where Colonel Fullerton serves as the Center's chief pilot.

We're going to thank you again for taking time from your very busy schedule to discuss your career. You have spent the vast part of your life in aviation. Could you tell us how your interest began?

FULLERTON: Well, it began when I was in the first three years of grade school. I lived in Butler, Pennsylvania, and my father was off in the Army Air Corps. So we heard what he was up to, where he was being based, and what airplanes he was flying, so the interest was natural there. I remember specifically, for a Christmas present he sent me an aircraft instrument panel—"toy" is not the word—an educational kind of toy that you could set up on a table, that had cardboard rudder pedals and a stick to fly with and a book that said how to fly, and I devoured—I wore that thing out.

So that's about as early as I can remember, and remember also building with a peach basket and a two-by-four and some skate wheels and wagon wheels, an airplane I could roll on the sidewalk, with some help from my grandfather and uncle. Pretty cool little airplane, I thought. Still, I have a picture of it.

So that interest in airplanes was pretty firmly established as I proceeded on.

WRIGHT: And this was in grade school. Your interest continued on, of course, through high school and then you went on into college.

FULLERTON: Yes. We moved when the war, World War II, was over, and my father was discharged. We moved to Portland [Oregon] at the time, when I went into the fourth grade. So he never flew again, except he rented an airplane for my tenth birthday. He rented a little two-place Aeronca and took me for an airplane ride, which he was getting back in the swing of it himself, but it was exciting for both of us. And that's the last time I really flew an airplane. My interests were clearly on the mathematics—scientific, technical, that's where my interests and abilities were. The idea that I would be an engineer was formed real early in high school, and so that's the kind of courses I took, and it led to going to engineering school after high school.

I always wondered about would I be good as a pilot, would I like it, would I have any ability. There were no opportunities for me to actually go take flying lessons or fly anything, so that was all a question in my mind. I figured I can always get a job as an engineer from a good engineer, and so my first flying lesson really was when I went into the Air Force and went to pilot training.

WRIGHT: You had finished your degrees at Caltech [California Institute of Technology, Pasadena, California] before you went into the Air Force?

FULLERTON: Right. I was in ROTC [Reserve Officer Training Corps], Air Force ROTC at Caltech. I knew that this idea, I'd like to fly, was there, and so that was certainly an obvious

opportunity to take, and I did have a chance to get some flights with the instructors at Caltech. The ones who were rated and on flying status hauled me along when they would go out to Norton Air Force Base in San Bernardino [California], and so I got a chance to ride in several airplanes. Very exciting. In fact, my first jet ride was one of those times, in a T-33, and all that convinced me, at least didn't deter me from the idea that I ought to pursue that.

The ROTC unit was very small; only seven of us graduated. It was optional in the upper grades. Seven of us were commissioned. I was the only one to go to flying school in my senior class. But as it turned out, that was the right choice, because I'd rather fly than do anything, and so I've had a tremendous chance to do a wide variety of it over many years and still am, way beyond the point where I have any right to be flying, probably.

WRIGHT: Did you aspire to stay in the Air Force, make it a career?

FULLERTON: The career probably was, again, another unknown. I didn't know whether military life would be for me. I had a commitment to get accepted into flying school, where you had to sign a commitment to stay three years after flying school. It seemed like a long time. Now the commitments are ten years or more. But I thought that's worth it to see, and, well, I enjoyed it very much, and so pursued staying in, and without a longstanding commitment to go military, I ended up thirty years in the Air Force.

WRIGHT: Right after your basic flight training, you trained on the [F-86L] *Sabre Jet* Interceptor and a Stratojet [B-47 *Stratojet*]. Were these your requests, to be part of those programs, or did the Air Force transfer to go to do those programs?

FULLERTON: Well, yes and no. Assignments out of flying school were based on your class rank. I had a high class rank and had my choice of any. The fighters were the ones desirable, and I picked the F-86 over the F-100, because at the time the guys who were going to the F-100 training school were getting shunted into bombers, and so, why, while the F-100 is a newer airplane than the 86, the 86 were pretty secure in getting fighter assignments. Well, wouldn't you know, it reversed in the time I was there.

So my whole class out of F-86s were sent to bombers and transports, and, in my case, I went to B-47s. In looking back, though, it was probably, while it seemed like a terrible thing at the time—some of my classmates almost wanted to slit their wrists, you know, or quit, but they were committed, I went on with it and decided to be the best B-47 pilot the Air Force had, and in the long term it paid off, because of having had both small-fighter-type and bomber multi-engine experience, I ended up probably getting the assignment that was a factor in me getting to fly the Approach and Landing Tests [ALT] on the Shuttle many years later.

WRIGHT: Between 1960 and '64, you belonged to the 303rd Bomb Wing of the Strategic Air Command. These were incredibly tense times in terms of the cold war activity. What were your thoughts, and did you have many experiences during those times with these events?

FULLERTON: Well, our wing had a nuclear mission and a big bomb in the bomb bay of every airplane on alert. We were on alert, ready to go to war, a large percentage of the time. Probably a third of your time, you were on alert. The other two-thirds you were either off or flying training flights. I was at Davis Monthan [Air Force Base, Arizona] for four years, and during

that time we also pulled alert up in Alaska, both at Fairbanks and Elmendorf. Again, it was an everyday thing, so it wasn't like, while we were target-studying targets in Russia and checking the weather in Russia in case the bell went off, again, it becomes a routine. So it wasn't like you felt like you were on the verge of World War III every minute.

The only period that approached that, though, was the Cuban Missile Crisis, when all of SAC [Strategic Air Command] went on the highest level of alert, and our airplanes were disbursed from Davis Monthan in Tucson to several bases. I went to Hill Air Force Base near Salt Lake [Utah]. I remember when we got there and landed and parked our airplane to get it ready to go to war, the quarters we were given to stay in had concertina wire all around them. So they started to look like, hey, this is more than just routine.

Most of the time, though, it was doing your job, and the job involved training flights that simulated real close what you'd be doing going to war, but sitting on alert, kind of like being in jail, you're restricted to a facility near the airplanes. No freedom to even rove around the base. And so in Alaska, we were in a hangar and stayed in that hangar day and night. It wasn't particularly fun, but it wasn't stressful either. But it was a war in the cold war sense, and we won it.

WRIGHT: At this time there was that threat of war, but also a war in Vietnam that was starting to pick up some escalation. Did you ever have a thought that you might be sent to war that direction?

FULLERTON: I certainly would have been, except what intervened, I applied and was accepted to the test pilot school, and then graduation from test pilot school was in 1965. Space flight was

just sort of becoming a possibility. The word "astronaut" I hadn't heard of prior to this, until it started showing up in the papers.

And so that sounded pretty cool, and I applied for, both with NASA and the Air Force Manned Orbiting Laboratory [MOL] Program, so that I'd take either one. There were selection boards convened for both. I happened to be in the Air Force ones and then after a lot of long involved process, selected for in the second group of crew members for Manned Orbiting Lab.

What does that have to do with Vietnam? Well, it was a highly classified program, and once we got enmeshed in it, our classification level was high enough that we were not permitted to go out of the country. And so, in effect, that kind of saved me, you know. I have many friends who went to Vietnam, lost some there, and I feel slightly guilty about not doing my part, but also very lucky that I didn't have people shooting at me. So Vietnam passed me by, even though I was active duty Air Force.

WRIGHT: You were becoming part of this aerospace research pilot school. How hard was that?

FULLERTON: To get into?

WRIGHT: Yes.

FULLERTON: Well, it was hard for bomber pilots, because it built up a tradition here that the only people who could possibly be red-hot test pilots were those flying supersonic fighters, and since the selection board for people to get into that school was basically here at Edwards, their prejudice prevailed and SAC pilots didn't get in. I never made the cut.

I found that out later, the reasons, although I started applying to come here when I had the minimum number of hours. So I must have applied four or five times and gotten turned down each time, until all of a sudden one day I got accepted. It turns out the reason was that people with a broader view on things at Air Force headquarters realized they're never getting any multi-engine test pilots because the only people that people here were selecting were fighter pilots. So they took over the selection from the base here, decided to make it half and half, and then that's when I made the cut.

So I was in a class with six fighter pilots and six bomber pilots. Interestingly, this power struggle was under way, and so the class came under more than usual scrutiny, and they washed out four of the six of us. In the first two weeks, they were gone. And the one other guy and I were the only two bomber pilots left in the twelve total, so we wondered when our cut was coming, but we made it through, and that really broke the ice. Now there's an equitable distribution. From then on, there really were both, properly so.

WRIGHT: And you stayed here a few years before you moved on to Wright-Patterson [Air Force Base, Ohio]?

FULLERTON: Not a few years. The course was a calendar year. My assignment out of here was back to Wright-Pat and the Bomber Test Division there. Appropriate for my background. And so I went back there, and then it was during that time that I applied for the space program. So I stayed there, I think, fourteen months, a good fourteen months for a flyer. I mean, this was during the buildup, really, for Vietnam, where the Air Force had been a nuclear Air Force, really, to that point, and all of a sudden we're in a more conventional war, needing a lot of weapons

improvements, and the test beds to test these improvements were the bigger airplanes at Wright-Pat.

And so I ended up flying a tremendous amount of flying hours. We had twenty-four airplanes, only twelve pilots. Each airplane took two pilots, and we had people coming from administrative jobs to help us be co-pilots. And so I flew all over the world and I was in a dream situation for a young pilot, to build flying time. I was always in the air.

WRIGHT: That's where you wanted to be.

FULLERTON: Yes, right. I think in the fourteen months I was there, I got 1,200 hours, which is, half of that is a big year for normal flying time.

WRIGHT: Then you wanted to move on to be part of the aerospace research pilots on the Manned Orbiting Laboratory down in Houston. You applied to NASA and to the Air Force for the opportunity to go into space.

FULLERTON: Right. The Air Force fielded a call from NASA for applications to compete for astronaut slots, and then the Manned Orbiting Laboratory Program also. So the Air Force took the applications and made a sort of a preliminary cut to crew people for NASA and for MOL. You couldn't go both ways. Then you competed with the Navy people and whoever did, and if you made it, you made it. If not, you were back to your old job.

So I ended up with that first split in the MOL group. I made it in that group, and so after just that fourteen-month period at Wright-Pat doing airplane flight tests, I'm now into the space

business with MOL, which meant coming back here to Edwards at first for about three months. Then we moved down to Los Angeles [California]. El Segundo was where the program office, or down there in the big city.

WRIGHT: What were you told about the mission for the MOL?

FULLERTON: Oh, we were told everything about it. It was classified. I'm not sure I've been really released from some of the classification, so I'm not comfortable talking about the details of it. But it was going to be a two-man vehicle, and you rode into orbit in a Gemini capsule modified for MOL. It was mounted on top of a long cylindrical laboratory, which was all put into orbit on a Titan 3-M booster. So it was miniscule by even Apollo standards and certainly by current standards. You're two guys really crammed into this little Gemini capsule to get and also to get back, and then even the laboratory itself was relatively small volume.

It went along. We had several annual three-years-to-launch parties, because, again, we were fighting the war in Vietnam. That was using lots of the military's discretionary funds to do anything else. So the program kept getting slipped to accommodate budget cuts, until about three years after my assignment, it was cut completely.

I was up flying in one of the airplanes that we had to fly for proficiency out of Los Angeles International [Airport]. I was up here shooting approaches to Palmdale or somewhere and got this radio call, "Come back and land," and then when I got back and landed, someone came out and said, "The program's cancelled," which is a real blow, although not a big surprise. I knew it was struggling, because we just weren't getting closer for the last couple of years.

And, like everything, you never know when there's big changes in the route of your life, whether it's going to be good or bad, just like going from F-86s to bombers seemed awful at the time.

In this case, I was married by now, and we wondered. I found an assignment here at Edwards to test the C-5 transport airplane, work on the test force here, and was ready to come up here. It looked like an interesting, good job. But then all of a sudden, George [E.] Mueller at NASA Headquarters decided we have now fourteen semi-trained astronauts available. NASA should pick up at least some of them, and so they made an arbitrary cut in the middle and took the seven youngest, and that's it. That's how I became an astronaut, is by pure quirk of fate, rather than any intense competition.

WRIGHT: And that decision was a part of what you would like to continue on with. I guess you could tell them you didn't want to do that, but you chose to stay around.

FULLERTON: Oh, yes, they didn't want anybody who didn't volunteer. All seven of us went right on down there without question, but without any fanfare. We just sort of slipped in down there, and at the time they had lots of astronauts. In fact, a lot of them, some of the guys that walked on the Moon, were contemporaries of mine at test pilot school, in fact, were more junior. But they had gone the NASA route and they ended up—guys like Charlie [Charles M.] Duke [Jr.] and Ken [Thomas Kenneth] Mattingly [II], ended up down there, and they were senior. We were the new guys, so we ended up, the seven of us who got there were really the new kids on the block, and it was many years, ten or more, before they picked any more astronauts. So we were the new guys for a long time.

WRIGHT: Did you feel an acceptance and a welcome there as far as the new guys to do some of the work?

FULLERTON: Well, yes and no. As far as anybody coming out and announcing to the press, no. Anybody saying, "Okay, glad to have you here. Here's what we're going to do to indoctrinate you," no, that didn't happen at all. They did find us a desk and an office, and there was absolutely no training program or indoctrination. They said, "Well, just find out what you want to do, or make suggestions," because everybody was so busy with assigned Apollo flights that, really didn't have time. So it was good news and bad news. The good news was that we really were free to find a niche and pursue it.

WRIGHT: And what did you look for? What was your niche that you liked?

FULLERTON: The first thing I wanted to do, because when we got there, it was between Apollo 11 and 12—11 had landed in July, the first flight to the Moon, 12 was just happening as we got there in October or November, right in there. And I said, "I'd like to work on that program. I don't know zilch about it," but I was assigned as a support crew member working for Al [Alan B.] Shepard [Jr.] on Apollo 14.

So I couldn't believe it. I'm right in the middle of it and getting in the command module simulator and the lunar module simulators, and learning the spacecraft and going down to the Cape [Canaveral, Florida] and doing the tests in the spacecraft and helping write the checklists, and then when they flew, talking on the radio while they're stomping around in the lunar soil. So

it was without any real right to be, I was instantly in the middle of it, working with people who had been working it for years prior.

So, it was exciting. It was terrific. It was just a stroke of great good fortune to be into the whole thing right away. Some of the others of the seven were put on Skylab, which was off beyond Apollo 17, kind of programmed, not even sure it was going to go. So they were doing a lot more dog work on this thing. None of us had any chance to fly, because we had so many people ahead of us seniority-wise, and the tradition had been fly everybody in a group before you take the first guy in the next group.

So that was great. I enjoyed that. In fact, I became kind of the booster expert for launch phase. So I did the launch phase for Apollos 14, 15, and 16, and then on 17 I handed over, and then I went down and was the guy that closed the hatch for 17, the last one, because I wanted to see a launch. I was always back in Houston. So that kind of closed out the program.

WRIGHT: And it was very symbolic for you, closing the hatch on the last mission of the Moon.

FULLERTON: Yes, for [Eugene A.] Cernan and [Ronald B.] Evans and Evans and [Harrison H. "Jack"] Schmitt.

Anyway, what next? Well, everyone's wondering what next. It was going to be originally up through Apollo 21, but, again, the war was taking the funds. The excitement of lunar travel would die quickly. The public is fickle. The Congress is fickle. So that program was short-cut. Skylab was coming. The guys, while I was working Apollo, did have support roles for Skylab. They had no chance to fly it. That was the next thing.

But the next long-term thing on the horizon was the Shuttle. So, after Apollo 17 flew, I worked on the Shuttle, and I worked cockpits and displays and controls. Always been of interest to me. Beside, I'd run across a lot of really crummy designs in learning to fly certain airplanes, and I thought I could do better. And so as it turned out, that was a real challenge to, with the Shuttle, rather than lying on your back on the end of a rocket riding into space, you had possibility of controlling it, both in the vertical mode and coming back as an airplane pilot at the end. The whole complexity of it is far more complex than the rockets, as far as what the man could do.

So, putting all that together in a cockpit was really intriguing, and I enjoy working with stuff in an engineering sense, so it was perfect, and I became the cockpit design czar, sort of, to go to really organize and set up and go to all the reviews. I had a big foam core cardboard mockup of the entire cockpit built right there in the Astronaut Office, and I cycled all the other guys in there to say, "What can you see? What would you do if this was a checklist? Can you reach it?" So I did a human factor study on all that.

What was great about the assignment was that as the Shuttle was built, the first one, the *Enterprise*, I could see here's really what the drawings I signed off turned out to be.

WRIGHT: Great feeling of accomplishment.

FULLERTON: The other advantage was that to do that, you've got to know all the subsystems very well, to make any kind of intelligent decision about what the meter would say or the light should say, the nomenclature on the switches, all of that. That probably gave me a leg up on getting selected for the early *Enterprise* flights.

WRIGHT: When did you learn, or how did you learn that you were going to be selected to be part of those test flights?

FULLERTON: I should remember it as a stellar moment. It's probably George [W. S.] Abbey calling me up and saying, "Come over," and said, "How would you like to?" Dumb question; of course I'd like to. Generally that's how you found out about selections all through my time there. George Abbey was the head of the Flight Operations Directorate and the one who probably mostly decided and also told you.

WRIGHT: And how did you train for these tests? What was your training before you started actually working with the *Enterprise*? Could you tell us about those experiences?

FULLERTON: Well, if I'd never flown the *Enterprise*, doing the training was challenging and intriguing in its own right. People say, "How do you train?" thinking, well, you go to a school and somebody tells you how to do it. It's not that at all. Somebody's got to write the checklist, so you end up writing the checklist, working with each subsystems person and trying to come up with a pre-launch checklist for the approach and landing tests.

So you're doing the work, that the learning comes from doing jobs that needed to be done. We worried about doing this dead-stick landing, so we had to train for that. I built a gadget to work on the T-38s that would allow you with any given weight to set the power with the speed brakes down to simulate what the data said the Orbiter would fly it at, so that we could

go fly the pattern we intended to fly in T-38s, making steep descents, flaring, and touching down, and we did some of that right out here in the patterns that we flew the first tests.

The Shuttle training airplane, a Gulfstream 2, was built as an airborne trainer, and so the four of us assigned to ALT served as the Shuttle pilots along with a Gulfstream pilot to do many, many dives at the ground to get the STA, the Shuttle Training Aircraft, built and working right. And then the *Enterprise* was being built over here in Palmdale, and so Fred [W.] Haise [Jr.] and I flew many, many trips. I didn't even get out the chart to fly from Houston to El Paso, gas up, and go to Palmdale; I knew all the nav [navigation] aids and all the frequencies by heart. So we spent many hours in Palmdale in the *Enterprise* when they were running ground tests.

WRIGHT: Did you feel that this was a role as an astronaut, or are you back to a role as a test pilot during these days?

FULLERTON: The distinction is kind of blurred. Astronauts now, the Orbiter's a pretty stable configuration, so they go to a school with ground school instructors that know the system, so they are astronauts in the—the pilots have got to learn the system, and the mission specialists have got to learn the payload and the flight plan. For ALT and then subsequently on the *Columbia*, we were clearly test pilots because we were doing stuff that there wasn't a procedure for. We were writing the procedure and then flying it for the first time.

WRIGHT: And in this case, as you described it, you were partly a designer of helping to create those systems.

FULLERTON: Yes, exactly. Very satisfying when you see really—I can go get in an Orbiter right now, you know, and look at the panels, "Oh, yeah, I remember all this." It's a real feeling of personal pride, and the fact that it's still that way. They haven't changed it.

WRIGHT: The simulator that, as you mentioned, the astronauts use to train with now, did you have an effect on how some of the simulations or some of the training equipment was set up for future astronauts as well?

FULLERTON: Oh, yes. Since we were the first ones through the STA, you know, those procedures got developed, how we did it, based on us flying and trying. Still, you know, there have been changes over the years, but they're still doing that regularly. Now everybody, every crew that flies, flies a lot of STA flights in much the same way.

I thought it'd be really interesting—in fact, I kind of have set that up, too—and let's see, when I last flew it was 1985. So it's been sixteen years now, seventeen years since I last make an Orbiter landing, and I'd like to just go get in the STA and grab the stick and try a landing, you know, simulating the interplanetary guy that's been on a sixteen-year voyage to Pluto or somewhere and comes back and has got to land it. I have this feeling I could do it. Of course, it's not like I've not flown a lot of airplanes since, but, you know, I'm going to try that sometime when they're out here.

WRIGHT: Oh, good. I'd like to hear the results of that. That sounds really interesting.

You were going through all these processes and procedures and training and creating all this as you were doing it, but at some point you learned of the day that actual tests were going to

be held. Also, the amount of testing was cut, reduced back to only five of the tests when there was supposed to be many. Tell me about the special landing tests. Tell us about how that affected you, when you thought there might be more testing. Was that a good news that there was going to be less, or did you feel like that was a good decision?

FULLERTON: What we were into at that time, the *Enterprise* and the approach and landing, the *Enterprise* was uniquely built to just do the approach and landing test. The idea, it would be sent back to the factory and all the space necessary, the systems would be put in it. That went by the board, never made that way.

But those initial tests, ALT was a program in itself, and there were a lot of people working on that, and money going into it that were holding up the *Columbia* coming along to do the first space flight. And so there was a constant debate about how many ALTs are enough, because this is holding up doing the real mission.

And so the number of the possibilities—it turned out there were thirteen total flights. There were five captive, inert flights, they call it, where the Orbiter was bolted on, completely inert, nothing moving, nothing running other than some instrumentation, and those flights, Fitz [Fitzhugh L.] Fulton [Jr.] and Tom [Thomas C.] McMurtry and flight engineers flew those five to the point where they said, "Okay, the combination is clear, and we understand what we've got here."

So then they decided to have some *x* number of captive, active flights, where the crew got on board and powered up the APUs [auxiliary power unit] and the electronics and all the subsystems, and those were dress rehearsals up to launch point. They had an open number of those. Turns out after three, they thought they'd learned all they needed to know. The systems

were working. Had a couple of failures on number two, a big APU propellant leak. I was chasing that one.

Anyway, at three, they said, "Okay, it's time to go do it," and they were trying to get to the end as quick as possible, so they could get on with the *Columbia*. When we launched then, I flew on the first, third, and fifth of the tests. We did three with tail cone on, and Fred and I flew one and three, and then we took the tail cone off. It made a dramatic difference in the steepness of the glide slope. Joe [Joseph H.] Engle and Dick [Richard H.] Truly flew the first of those, landing out here on the lakebed.

And then the push was, "Let's have this—." It'd all gone quite well, although we discovered some serious design errors, but they were quickly fixed. So the grand finale then turned out to be free-flight five. Fred Haise and I landed on runway four going toward the lake out here, and we had a kind of an exciting landing there. It pointed up a flaw, really, in the design of the flight control software that led the pilot into a pilot-induced oscillation, and we bounced around and shocked a lot of people, probably more than—it didn't look that bad from inside the cockpit. But, again, that's why you do tests. You find out.

Then the debate was, should we fix that and test it some more. It was a strong feeling, like, that was a pretty exciting landing, which shouldn't be that exciting, or do we cut it off, fix it by testing and simulators, both airborne and on the ground. Do we know enough to press on? And it turned out that was the decision. You've got to cut the ALT off so we can go on the *Columbia* and get into orbit.

WRIGHT: Could you share with us a few more details about what your roles were during those tests? I'm sure Fred Haise was the commander, and you were the pilot, for instance, on the

landing or any of the other aspects. What exactly were you doing, and what were you having to be responsible for during those testing times?

FULLERTON: Okay. The commander in the left seat primarily had the job of flying the airplane, to take the stick and fly it. There was a stick both places, so on each of the three flights, I got some of the flying time. But the prime role of the co-pilot was to take action when any of the subsystems had problems, monitor the systems. The pilot is busy watching where he's going and how he's doing on the profile, and checking the navigation displays and keeping the airplane on the profile we wanted to fly.

On the very first flight, the instant we pushed the button to blow the bolts and hop off the 747, the shock of that actually dislodged a little solder ball and a transistor on one of the computers, and we had the caution tone go off and the red light—I mean instantly. I'm looking, and we had three CRTs, [Cathode Ray Tubes] and one of those essentially went to halt, the one hooked to one of the four computers that monitored. This is pretty fundamental. All your control of the airplane is through fly-by wire and these computers.

So I had a cue card with a procedure if that happened, that we'd practiced in the simulator, and I had to turn around and pull some circuit breakers and throw a couple of switches to reduce your susceptibility to the next failure. I did that, and by the time I looked around, I realized, hey, this is flying pretty good, you know, because I was really distracted from the fundamental evaluation of the airplane at first.

That's roughly how the Orbiter's set up. The guidance and control and fly on the airplane on a space reentry is designed by the cockpit and what displays are there, given to the left seat. The right seat's the co-pilot, and he's got access to the reaction control jets, the main

engine, computers for space flight, for the auxiliary power units, the power, the hydraulics. All those critical supporting systems are over on the right side. Some are in the middle where both guys can grab.

So all the landings you see, it's the commander's going to land it. He's not going to give that away, because you don't get very many.

WRIGHT: How soon after the completion of the fifth test did you learn that you were going to become part of the STS-3 mission?

FULLERTON: Oh, how soon was it? Now, the others were having a lot of trouble with the tile, the thermal protection system. They'd had fits and starts and failure of tests and delays. So it's a long time. The ALT was '77. The first launch was not till '81, right, four years later.

So what happened? During those four years, I picked some crews. The first crew that I was picked for was with Vance [D.] Brand. So I was his co-pilot, PLT, as we called it. I'm terrible for dates. I can't tell you just exactly how long it was. But then there was a reshuffle of things. No, that's not right. It was Fred Haise and I were on second flight, I think. Golly, I'd have to research this.

For a while I was going to fly with Fred. Then Fred decided he wasn't going to stick it out. He went off to management world with Grumman. So then I ended with Vance for a little while, and then finally with Jack [R.] Lousma, which was great. Jack's a great guy, and he'd flown on Skylab. He's not a test pilot, but very capable guy and a great guy to work with, and so I couldn't have done better to have a partner to fly with.

WRIGHT: During that time period, were you training now in the simulators that you helped process originally?

FULLERTON: Training, again, more engineering job than training job, because there were more details of the cockpit. The cockpit we had in ALT was just only the switches that applied. All the other systems now had to be put in. So I was back into that again. More reviews.

There were lots of changes, and then the software became a huge—the biggest stumbling block. The software that in these central computers not only control where you fly and control the flight path, but almost every other subsystem. And so getting the software wrung out and simulators writing the checklists, writing especially the malfunction procedures, what do you do if this breaks, if this breaks, if this light comes on. It's a book this thick of fine print, and amazingly, it's wrong most—you can get a room of the smartest people and you think we're going to get this right the first time, and then you go in the simulator and find out, whoops, that doesn't work, because it's a waterfall of interrelated effects every failure can be. And so we didn't really have it nailed down by STS-1.

There were lots of unknowns when STS-1 flew. There were lots of unknowns about the effect of a coolant loop failing and the cooling of the aft MDMs [multiplexer/demultiplexer], which was part of the data processing system. You know, a myriad of details. There were theories about what would happen, how the interaction would be, not really tested because there wasn't time. You just finally have to set a launch date and say, "We're going to go." You cannot be 100 percent sure of everything. And just bugs in the software.

When we flew STS-3, we had another book this big called *Program Notes*, which were known flaws in the software. There was one subsystem that when it was turned on, the feedback

on the displays said "Off," because they'd gotten the polarity wrong and the logic, which they knew and they knew how to fix it, but we didn't fix it. We flew it that way, knowing that "Off" meant "On" for this subsystem. The crew had to train and keep all this in mind, because to fix it means you'd have to revalidate the whole software load again, and there wasn't time to do that. They had to call a halt and live with some real things you wouldn't live with if you'd bought a new car. That's all part of the challenge and excitement and satisfaction that comes with being involved with something brand new.

WRIGHT: How was your confidence level in the Orbiter and the whole process when you got ready to launch on STS-3? Did you feel it was ready to go?

FULLERTON: Yes, but with this nagging thing, the thing that says "Off" when it's on, with a lot of cases where if this widget failed, this procedure in the malfunction book doesn't work in the simulator right. It doesn't come out right, and so you're flying knowing if this failed, there's going to be a lot of real-time conversation. There's not going to be a book answer, because it doesn't work in a simulator. It might be because the simulator's wrong. The simulator was a whole parallel development. We'd do an abort procedure and crash and burn, and we didn't know—well, is that because the simulator doesn't cope with this nor not? And the instructors didn't know because they were just as new at it as we were. And so, we, "Well, I hope it's a simulator problem." And so we'd write it and document it, and they'd take it off, and somebody would research it, and sometimes you'd get the answer, and sometimes you' just kind of go by the board because you're just too busy.

And so there's always an element in anything this complex, and that's the thing. It's really a complex vehicle. It really is. Even now I'm sure there's some question marks that exist there. When you're going to the *n*th detail about failures, if everything works like normal, it's all a piece of cake. It's when something breaks that you worry about, and is the big challenge to get to a point where you feel like you've got a handle on it.

So was I ready to not show up on the launch date? No, not at all. Was I quaking in my boots? No. Was I intense about the whole thing? Yes, mostly because I am worried about my part of this. Especially for pilots, it's the launch phase, because while it's short and concentrated, if anything goes wrong, the Orbiter only takes care of the first failure. The second failure is pretty much left to the crew, generally, and so you worry about being ready to recognize a problem and do the right thing. You feel like the whole world's watching you when that failure occurs because of the manual action you've got to take to save the day. So it's that kind of pressure, pressure of performance, rather than fear or anything.

WRIGHT: And you had spent a few minutes up in an Orbiter, but yet you had never launched one. Would you like to share your experiences about the launch?

FULLERTON: From *Enterprise* to *Columbia*? Yes. Well, the launch is a whole different ball game. I remember the first time, even though I'd spent a lot of time in the simulator, the simulators we built were fixed, one, and had the upstairs and the downstairs arranged horizontally, and then we had a two-seat, just the pilots' seats, in a motion base that would tip up and go up and down and shake around to simulate launch and entry. Those were the two Orbiter trainer simulators. But most of the time they were both horizontal.

When I went to the Cape, I remember the first time when it's on the pad, and crawled in the hatch after being in my old cardboard, all these, and I was just flabbergasted how when you just rotated ninety degrees, how it becomes an entirely different outlook. I was lost. Wait a minute. Where's upstairs? Upstairs is this way. And so it's a huge psychological, physiological difference when you get on the pad and that whole part of it. You get over it, of course. You find yourself, "Wait a minute. I'm standing on an instrument panel. I'm not supposed to be standing on it." But that's the way it is. We knew we were going to do that. We built the switches recessed so you could stand on it. But that's a whole different thing.

Then, of course, the launch phase is like nothing, but your landing test is the last part of entry. So there was a familiarity there from ALT that certainly helped. But the eight days prior to entry was just a whole different world.

WRIGHT: And while you were in orbit, one of the tasks that you had was to test the Remote Manipulator System [RMS]. Did you have a lot of training in that as well?

FULLERTON: Yes, that was built by Spar Corporation, or whatever, Canadian firm. That was Canada's contribution, was the manipulator arm. So I went a couple of times up to Toronto to work with them on and to basically train, see how it worked. And then we had a full-size mockup at Houston with a 1G-capable arm driven by hydraulics. We had an electronic version of the arm, looking at screens in the windows and the simulator.

So there were a lot of tools to get the hang of working the arm. So that was pretty cool. I was prime on the STS-3. They had taken it out of the locks and waved it around a little on STS-2. Three, we actually grabbed something and picked it up and moved it around and put it back.

Later, on [STS] 51-F, that same package we picked up and let go off of it and then went back and grabbed it. But Tony [Anthony W.] England did most of the arm work on 51-F.

WRIGHT: Did you feel like the training and the actual tasks were close hand in hand?

FULLERTON: Yes, we had good replication, so there were very few surprises. The nice thing about space flight, it's pretty pure. Airplanes fly through the air, and you've got air that does funny things and goes around corners differently, depending on the speed and all that. So simulations of airplane characteristics are much harder to do than when you're up there in a vacuum, where strictly Newton's laws are pretty pure up here and the predictions are very good.

WRIGHT: While you were on that mission, you experienced a loss of appetite and some difficulty sleeping. Had you expected to have that kind of adjustment, or what were your expectations, being able to live in space?

FULLERTON: On STS-3, that was, of course, my first look at it. STS-2, actually, they had some problems. They had a raw deal because they had a fuel cell—that was Engle and Truly—they had a fuel cell quit on them, and their planned five-day flight was axed to two and a half.

Of course, everybody has their acclimation problems. That's pretty consistent through the population. It takes about twenty-four hours to get to feel normal, at varying levels of discomfort. Most everybody can hang in there and do their stuff, even though they don't feel good. A few are pretty well debilitated. But they had not time, you know, in a two-and-a-half-day flight, they were cut short. By the time they got on orbit and traced down the problem and

the decision was made to come back early, they were getting ready to come back. So they had no time other than to kind of respond, do things, that the ground was coming up, and they had some dizziness and orientation problems on entry that we learned about, and Jack and I worried about it a lot.

One thing that we did do, that I don't think they did, is we had a G-suit, like they wear in the F-18, except that for entry you could pump up the G-suit and just keep it that way, and so that helped you keep your blood flow up near your head, or assisted that. So we decided we're going to wear the G-suits. There was some controversy about whether you ought to pump them up or not, among individuals. We said, "We're going to pump them up."

The other thing about the motion sickness, we're not sure there's a direct correlation to flying airplanes and sickness. I know if you go up and do a lot of aerobatics day after day, you get to be much more tolerant of it. So Jack and I, we scheduled T-38 every chance we got in the last couple of weeks before we went down there, and I flew literally hundreds of aileron rolls. I know that's what would do it to me. If I did roll after roll after roll, I could make myself sick, and I did that, and I got to the point where it took hundreds of them to make me sick. But I did that figuring I don't know if this helps, but I had the opportunity, I'll do it, and the results were pretty much the same on both flights.

For the first day or so, I didn't ever throw up or anything. I never got disoriented, but I felt kind of fifty-fifty, you know. You're pretty happy to just—a malaise—you're happy to float around and relax rather than keep charging. And into the second day, this is really fun and great, and you feel 100 percent. That was my—so whether the aileron rolls helped or not, I'm not sure, but it was relatively easy.

WRIGHT: Where Engle and Truly's flight got cut, you had an extra day added on to yours because of the weather.

FULLERTON: Right, so we had eight days, had seven scheduled and an extra one.

WRIGHT: What were your thoughts when you heard mission control said—

FULLERTON: "Wow!" We cheered. "Great!" Because we really had a busy time with just two people. This was an engineering test flight, and we had a flight plan full of stuff, and people fighting over, sticking in their stuff. So there was always something that you were watching the clock on. You had to do this coming up. We did have sleep periods, which we would use for window gazing, some part of it, because you don't need as much sleep as they were scheduling. But when they said, "Wave off," I remembered getting in the recycle book, going through the pages, shutting down some of the computers, opening the doors again, and I got all the way down, all of the sudden, I turned the page, and there was nothing on it, and there was this realization, hey, this is free time, and it was terrific.

We got out of the suits, and then we got something to eat and watched the world, and I wouldn't have had it any other way, if it had been my choice. In fact, we flew right over White Sands, where our landing site was. Just happened to be in the reentry attitude and we stayed in it. So we went half way around the world. The nose was pointing straight down, and as I looked up, I could see this monster dust storm going on there. It looked like it was all headed for Texas, the dust in the valley there. It was a clearly good decision. It looked really bad down there.

WRIGHT: Yes, while you guys were having a, as you mentioned, free day, they were very busy down at White Sands preparing for your arrival.

FULLERTON: Yes. Well, they were ready for us because we knew we were going there. This [Edwards AFB] was underwater out here. That's why they gave up on that.

WRIGHT: Can you tell us about the landing? Was there anything different or any test procedures that you were working on with the landing that came in for STS-3? Anything different that you—

FULLERTON: Well, where we planned to go, the main thing was this really fierce jet stream, fairly low altitude at 20,000 feet. The winds were over 100 knots out of the west, which is unusually high. John [W.] Young, I think, had flown some approaches in the STA ahead of time and decided if we made our normal left turn around to the southbound landing, coming from the west, we'd never make it back because of this wind blowing us away. So they changed to a single right turn, which put me on the inside of the turn, not Jack. It was clearly the right thing to do. So that was a wrinkle.

FULLERTON: I could see the turn. He was asking me, "How's it look? How's it look?" because he was flying blind over there. I was saying, "Oh, it looks good. Keep it coming." So that was different. But we had lots of help figuring that out ahead of time.

The entry was pretty cool because it was an early morning landing, meaning that the main part of the reentry is at night, so we could see this glow from the ionization really bright out

there. In fact, we had lost a couple of tiles on launch. We knew that because we'd looked out and had seen the holes in front of the windshield, and we looked at it with an arm camera. They said, "Not to worry. It's cool up on top there." We didn't know how many we'd lost from the bottom, but wasn't any use worrying about that. And then to see all this glow right there where the missing tiles were, gave us pause to think about it. Again, there was no point in worrying about it, nothing you can do.

The spectacular light show through entry. Then the sun came up, which washes all that out, as it's dying out anyway. We went whistling by—and I spent four years at Davis Monthan [AFB] in Tucson—and as we did a roll reversal back to the right, I was looking down at Tucson going by and knew exactly what I was looking at. We were at about Mach 10. So it was a tour of the area of the country I knew. So, entry is really a great time for the pilots. You're flying. You're really flying. You're seeing where you're going. You're not just along for the ride at all.

WRIGHT: And then you touched down without a problem.

FULLERTON: Yes, the only problem there was a kind of a wheelie that Jack did. Again, it pointed out another flaw or room for improvement in the software. The gains between the stick and the elevons, that were good for flying up in the air, are away, were not good when the main wheels were on the ground, and he thought he had ballooned. He kind of planted it down but then came back on the stick, and the nose came up. So what? It didn't take off again, and we came down and rolled to a stop. A lot of people thought this is a terrible thing. I mean, we improved the software, and so people don't do that anymore, but we discovered a susceptibility. But other than that, we rolled to a stop, and we're out there surrounded by white gypsum.

The family was there. It felt like I had been a long ways away. When I got down, we were on the ground, I'm feeling the gravity, it's all feeling normal, and I remember remarking to Marie, my wife Marie, "You know, it was a terrific adventure. I'm here, but it feels like I've returned from somewhere a long way from here," you know, compared to flying in on an airplane. I guess it's true in a way, although you're going over all the time. But it's a great feeling, both space flights, too. I think it's a combination of—it's mostly a feeling not of relief that you're back. In a way, it's kind of crummy I'm down here slogging around in this gravity field, not nearly as much fun as floating. But the relief is that you got this huge team of people that are helping you through, and you're back, and it was a success, and you didn't screw up, do something to mess it up. That's a combination of good feelings, I remember, right out here on Runway 23 on 51-F.

WRIGHT: Let's talk about 51-F. Three years later you were scheduled to be a commander of a mission. Did you again find that out sometime soon after STS-3?

FULLERTON: It must have been a year or so. Three years between, maybe a year and a half. There was some shuffling around on who would fly what and all that, all happening at levels above me. Somebody would write a book about crew selection some day, maybe. Not me, I want no part of it.

But, anyway, the word came out, 51-F would be my flight, and the crew was seven people. We had two payload specialists, plus two others were backups to them, with Roy [D.] Bridges [Jr.], a great guy—he's the director of KSC [Kennedy Space Center, Florida] now. He

was making his first flight, was the other pilot, and then we had Tony England, Karl [G.] Henize, and [F.] Story Musgrave, who's a character in his right. I don't know if you've interviewed him.

WRIGHT: Not yet.

FULLERTON: So it was a good team that was really good, and it was a great mission. It really was. Some of the missions were just going up and punching out a satellite, and then they had three days with nothing to do and came back. Ours was the first time we've flown around the clock. We had somebody up and working. We had a payload bay absolutely stuffed with telescopes, instruments. We had, again, the first two-shift operation to run all these things. We had the instrument-pointing system that had never been flown. We had the idea of letting a satellite go and then flying this precise orbit around it and then going back and getting it. So, all kinds of new things, which took a lot of work to write the checklists for, write the flight plan, and so we spent a year and a half doing that.

Then it worked out to be we had a scare on the engine failure on launch. We were worried then, is this going to squarewave the whole flight plan and mess everything up? It did to some extent, but the ground worked overtime, because everything was sequenced by time because it's an astronomy thing. Whether we're on the dark side or the light side, all that had to be rewritten. And it all worked out great. We even made up for the fuel we'd had to dump on the way up because of the engine failure, and eked out an extra day on it. We were scheduled for seven and made it eight.

WRIGHT: When you mentioned the team effort, part of being the commander, you could choose when you needed to work, because you really weren't on each of those shifts. How did you decide when your duties were? Did you find yourself working—

FULLERTON: Well that was all working out with the flight plan. It was just pioneering, I guess, because nobody had done it in the Shuttle. So it basically had twelve-hour shifts. We had a red team and a blue team, with three guys, an MS [Mission Specialist], a PS [Payload Specialist], and between Story and Roy, they were the other crew member on each team. So, during your twelve hours on, you ran all these instruments. During the shifts twelve hours off, you had dinner, slept, had breakfast, and then went to work for twelve. So you sandwiched everything else you did, hygiene and whatever, in your twelve-hour-off period, and two weeks before launch we set that up.

I anchored my schedule to overlap transitions, so if something came up on one shift, I could learn about it and carry it over to the next shift, hopefully. But I also had to stagger things so I got on the right shift for entry, so I was in some kind of reasonable shape at the end of the mission.

At the beginning, too, I didn't want to be—we had the red team sleeping right up till launch time so that once we got on orbit, the red team was the first one up, and they'd go for it for twelve hours. So it was all that kind of thing, juggling around so that the right people that had to be alert for launch and entry were. We got into that circadian cycle prior to launch. So the last week we didn't see the other team, or I only saw part of one and part of the other myself.

WRIGHT: Once again, you found yourself in a role of creating procedures and studying the cycle and doing something you hadn't done before.

FULLERTON: Not so much the Orbiter procedures, except for the manipulator arm and the unique stuff.

WRIGHT: This time when you started the entry procedures, you were the commander. So when you got ready to land the *Challenger*, you were totally in control. So how was this landing different from your other for you?

FULLERTON: I knew that I was going to get the landing ahead of time. It was different because I had the commander-type systems on my side. Roy had the other system. But we also had a flight engineer with Story, which we didn't have on—so it was really a three-man launch and entry crew, with Story as the flight engineer on both up and down, which made a lot of difference in how we could do a better job responding to emergencies and trained that way. The pressure is higher when you're commander, the pressure of making sure that not only you, but somebody else doesn't throw the wrong switch.

With Jack and I, it was just the two of us. He only had to worry about me, and I him. We could double-check each other. With seven people, there are many opportunities for somebody to blow it, not to say instant disaster, but to use too much fuel or to overheat some system or not have the right ones on and blow the chance to get this data. All that, you're dependent on other people checking, with seven people. That's a lot of other people throwing switches, too.

During the entry, there was the pressure, you know, it's your fault if this doesn't come out right. When you're in the right seat, it's not all your fault. The commander bears culpability even if you make a mistake. I'm dwelling on this pressure thing because that really is a strong part of the challenge. I mean, you're really tired after space flight. I think you're tired mostly because of the mental, you elevate yourself to this mental, high level of awareness that you're maintaining. Even when you're trying to sleep, you're worried about this and that. So it's not like you're just lollygagging around and having a good time. You're always thinking about what's next and mostly clock-watching. Flying in orbit is watching a clock. Everything's keyed to time, and so you're worried about missing something, being late.

We had 270 maneuvers or something like that. Every sunrise and every sunset we had to go to a different attitude to put the right telescopes at the right stars or sun or whatever, the sunny side we're pointing at the sun. So those are all typing exercises, typing long strings of numbers into the computer and the time to start to maneuver so it goes to the right attitude. Well, you mess up one number and you're going to go to wrong attitude. Then you're going to miss that data. Every forty minutes, you've got a new one.

WRIGHT: Constantly something to do, wasn't it?

FULLERTON: Yes. Well, that's what you're paid for, though.

WRIGHT: And getting the crew home on time. At least when you were going to do the landing, you were landing at some place where you felt was home. You were coming back to Edwards.

FULLERTON: Yes, that was definitely—and I was real familiar with White Sands, too, because we did most of our STA training there. So it wasn't like a strange place at all. But we did more dives at the ground there than here or anywhere else.

How are we doing on time?

WRIGHT: Well, let me just stop this for a second. [Tape recorder turned off.]

FULLERTON: —yes, I think pretty well I've talked about the great feeling when we got down, and we'd endured our engine loss and takeoff and wrapped it all up, came back here with a great feeling of accomplishment. We knew we'd also face challenges with getting the instrument-pointing system operating. It didn't work worth a hoot to start. So the whole crew had a hand in recovering from what could have been a real bust, to a great flight.

WRIGHT: The times before when you had been in the Orbiter landing, there had been a couple of issues that attributed to some needed-to-be adjustments to the software. When you landed, did you feel like everything was in place to have a smooth landing when you brought that Orbiter home?

FULLERTON: Yes, I thought the Orbiter handled great, and it had some refinements since the Approach and Landing Tests. And so I made a landing I was proud of, very smooth and a nice touch-down, and right where I wanted it. We worried about the center of gravity [CG] was further forward than it had ever been because all of our gear was still in the payload bay. So we

were heavy, forward CG, but we got the nose down smoothly and rolled to a stop out here. So I had no suggestions for flight control improvements.

WRIGHT: Wow. Maybe somebody was surprised to hear that. [Laughs]

After you landed, was there a difference of your adjustment back to Earth than it was for your first mission, or did you feel like your body and your physical being had adjusted well each time?

FULLERTON: I think it went well. I don't remember a lot of differences. Two aspects to acclimation from a one-week flight. Different ball game than if you've up there for six months, I'm sure. One is this heavy feeling. It feels like you've got a big heavy pack on your back, and you're kind of wooden-legged. That goes away relatively quickly, in a matter of hours. You've acclimated to your weight and moving it around.

The part that takes longer is your equilibrium. Surprisingly, if you don't have to balance yourself when you don't have any weight in orbit. And so I found that when you're walking down a hall and make an eighty-degree turn into a doorway, I would tip over and bump into the jamb or something, surprise yourself at how unstable you were, even after you felt normal from a strength standpoint. That maybe lasts—you can feel the effects the next day or so. But you're pretty quickly over it, all of it, for a one-week stay.

WRIGHT: We talked just a moment about the Orbiter and how it handled. There had fifteen missions between the first time that you flew on STS-3 to the STS51-F, and, of course, there

were two Orbiters, the *Challenger* and the *Columbia*. Were there a lot of differences, or did you see a lot of changes that had been made to improve how the Orbiter flew?

FULLERTON: Probably at the time I was aware of what changes—I remember flying simulation loads, and I think even in the Calspan TIFS airplane, Total In-Flight Simulator aircraft, I participated in studies on some of the recommended changes. Certainly I did that at least between ALT and STS-1.

Again, between the two space flights, I can't remember any major things that struck me as different. I didn't fly too much on the STS-3 reentry. They were pushing at that time to go full auto land, and so that it was a bad decision, really, but even Jack Lousma was—we stayed in automatic all the way down through the pullout of the dive, and then he only got the feel of the airplane the last couple of seconds before touch-down, which, in retrospect, everybody agreed was dumb, and now people fly from the time they go to subsonic as a minimum to get the feel of the airplane all the way down. He only got the last second, and then we landed a bit fast and ended up doing that pitch maneuver on the wheels in large part to poorly planned, too much pressure to push toward automatic landing, which they'd really never done. Kind of gave up on that now.

WRIGHT: It was five months after you landed on STS-51-F, that NASA and the nation experienced its tragedy with the *Challenger* [STS 51-L]. Where were you when you heard the news?

FULLERTON: I was flying a zero-G airplane. That's one thing I did back before ALT and all that, because I had flown at Wright-Pat zero-G. I had kind of started the program at JSC. When we first got a KC-135, I was the initial pilot that checked out the other staff pilots. I had been up flying zero-G, came back. Trying to remember whether they told us to come back early or not. Anyway, when we got back in January, I walked back in the ops [operations] room, and everybody was down in the mouth, and I learned right away what had happened.

WRIGHT: What were your duties assigned during that period when all the crews were—

FULLERTON: I was working the Space Station. I came back after 51-F. They were in a period of trying to finalize requirements and design for Station. It hadn't been built yet. It took some time after to build it. I was the Astronaut Office representative, so I was going to lots of meetings and helping write lots of thick requirements books and trying to go the users' conferences and disagreeing with a lot of the concepts that were being embraced as far as what the Station would—how it would be built.

That's what led me to look for work elsewhere, not the *Challenger* disaster. I could see it being a long time. I could also see the cycle time to fly in space. It was going to be at least three years more of going to meetings and simulators.

My first love still is flying regularly in airplanes, and I thought, well, I'm going to look for a flying job before I'm too old to get one, which I did, and I had offers with Douglas Aircraft in Long Beach and here. I'd actually looked into going back in the Air Force full-time, too. Didn't take me too long to rule out. The possibility they offered was in a third sub-basement of the Pentagon, a good job by name, but by the duty—I went back there, dusted off my uniform,

met the three-star I'd be working for, and that was not for me. Best decision I ever made was to not take that one.

So, anyway, I had done a lot of airplane flying, much more than the average astronaut did. I flew the zero-G airplane regularly, all through the years I was working on Shuttle. I also then, after STS-3, checked out on the Shuttle carrier 747. So I was able to keep my hand in and managed to get the job here.

WRIGHT: And you're back as a test pilot.

FULLERTON: Yes. You have to fly a variety, which is a test pilot's dream, fly a variety of airplanes, do new things, not radically new things. I'm not flying F-22s or anything, but I'm flying experiments that haven't been done before. The challenge of organizing it, the same kind of thing we've been talking about—write the test card, write the checklist, fly it, and get the data or whatever the purpose is, and that's a good feeling. It's a challenge and one of real satisfaction when you do it right.

WRIGHT: I wanted to take a few minutes before we end today and just mention a few of those aircraft that you have done and get your comments on your experiences with them, one of them being the CV-990 that you did some tests with, that eventually helped the Shuttle.

FULLERTON: Yes, that was really interesting, truly in the realm of not having been done before. That modification we made to it was tremendously complex, big time, 60,000 pounds of hydraulic system in there to operate the apparatus that tested the Shuttle tire. I just saw that

airplane this morning. It's parked out at Mojave. We were over in the T-34 with another guy shooting landings at Mojave, and it's sitting by the front gate over there now. Looks better from the air than it does close up. It's full of birds' nests and dust and dirt right now.

But it was, again, challenging to get the thing built. So I spent a lot of time with the engineers designing the system. Challenging to fly, too, because we ended up making really high-speed landings to full stops, way beyond anything you ever do in a normal airplane, and speed, and we worked up to it, and we had procedures that would be as safe as it could be.

For instance, at the Cape, when they decided the runway's too rough down there and it was tearing up the tires and we were getting much less tire capability than had been assumed, we blew out lots of tires, big-time bang. A big Shuttle tire at 300, 400 psi inside letting go is a big bang. But then they decided that we needed to grind the runway off smoother so it wasn't so tough on the tires, and they ground a strip off eight feet wide down the center of the runway, which now the challenge for the guy flying is to land very close to the end and at very high speed and stay on that eight-foot strip all the way so that the tire doesn't see the rough part.

That's neat, fun to do, and I was reasonably successful in doing that. Again, it adds to self-satisfaction in being able to—not too often do you get a flight test that challenges your stick and rudder skills right to the limit.

WRIGHT: How was your flight in 1998 with the Russian supersonic transport? Tell us how you had an opportunity to do that.

FULLERTON: Yes. We had a Headquarters high-speed aircraft program within Dryden and Langley and other Centers looking at technology that would lead to an economical, viable

supersonic airliner. Part of that was sending money to the Russians to resurrect the last built Tu-144. We had some ten or twelve experiments on it, as I recall, of various kinds.

And then toward the end, the idea came out, we ought to let some American fly it. So Rob Rivers at Langley and I went over it with some engineers from both places to get our chance to fly it. I flew two flights. He had one. We both went to Mach 2 in the airplane. It would take me a long time to describe the differences of that airplane, Russian design, compared with, say, the Concorde or a normal western design.

Probably as interesting as the technical aspects and the flight aspects was the seeing how—well, frankly, how bad a shape their aerospace industry is in, but also just their philosophy and how they did business in designing, building, and flying airplanes. Really different than us. So here we have Xerox machines and computers and we overkill. We have lots of paper, reams of paper. So everything we do, we share with lots of people, communicate. In Russia, totally the opposite. The hydraulic system guy that taught us about the hydraulics—we were over there for two weeks going to ground school. This is before we were even allowed to get in the airplane and get aboard. But the hydraulic guy came in with a notebook that he had when he designed the thing in the first place, his own hand-drawn drawings, and that was it. We were never given a picture of the hydraulic system or anything else.

We had to cry and whine to get a copy of the flight manual, which we had translated, and it didn't say much anyway. It didn't have checklist, how to start the engine. You'd think that would be in there, right? The engine-start checklist, not in there. Everybody has their own notes. The pilot we flew with for the flight test has a knee board with a five-by-eight card written in teensy, tiny print, every little aspect what he's going to do. He writes it. He keeps it. Nobody else gets it. He does it. It's just a whole different way of approaching things.

Interesting to see, along with all the social, the vodka-drinking and everything else, it's different, too. The culture that we learned was as significant as the airplane aspects.

WRIGHT: Did you find it ironic that thirty years before you had been preparing to your missions and your flights—

FULLERTON: To drop bombs on them? Well, they were, too, and on that line, Sergi Borisev was the man to pull off. He was the pilot for all the tests, flew all the flights. He flew with me when I flew.

We invited him over here, and I gave him a ride in an F-18, and he was here for a week, which he was just jazzed about, naturally, and he's a former fighter pilot. It turned out we were flying the SR-71 that day, and so I was able, when it was coming smoking back, he was out there by the Colorado River at Mach 2, coming back for a landing. We got him on radar and intercepted and pulled up alongside, let him fly it, you know, SR-71, as mysterious an airplane to the Russians. As a matter of fact, Borisev had been flying MiG-23s up near the Baltic [Sea], an interceptor aircraft, making passes at SRs flying by, trying to intercept it, which he didn't succeed much because it was smoking at Mach 3 when it went by. And here he is now in an American airplane, we're pulling up on the wing of it. So that's kind of cool, really.

WRIGHT: Surreal for him, wasn't it?

FULLERTON: Yes, both sides, and we talked about it that way. He's a good guy, you know. It's not surprising they've got all the same interests we do. We're on opposite sides by a fluke, not by any basic inherent difference, just personally.

WRIGHT: Just people and pilots.

FULLERTON: Yes.

WRIGHT: You also worked on the development of the propulsion-controlled aircraft systems. Would you like to talk with us about—

FULLERTON: Yes, that was unique and different, not been done before. Bill Burcham is the guy that came up with pursuing this concept, of being able to fly an airplane that's lost all its hydraulics and, therefore, its ability to move its flight controls, and by just nudging the thrust carefully, get the airplane back on the ground, which is what the crew of United 232 did in Sioux City [Iowa] with some success, although a lot of people were killed.

We took it beyond that, making an autopilot basically, that uses the engines as control effectors, rather than the normal controls, and had tremendous success, really, with an F-15 and a MD-11, all the way to touch-down in both cases, without having moved the controls. Locked up the controls, not that I couldn't have taken over, should it be necessary. But without cheating, got the airplanes on the ground. A great example of why working here is so much fun. You get to do something new and different.

WRIGHT: Well, another thing that you did that was new and different was you launched a satellite into orbit with Pegasus [launch vehicle]. Tell us about that experience.

FULLERTON: Yes, flying 008 B-52, B model, which I'd read about that when I was in high school, launching lifting bodies. The X-15s were flying—the last few of them were flying when I was at test pilot school here. So I saw that airplane. When I got here, it was sitting right out there in the corner, been parked for four years. Then another program came up, and both guys that had been flying it both retired. So I became the B-52 pilot, and that's how I got into it. A little of OJT [on-the-job training], self-taught there, though I'd flown B-47s earlier.

Pegasus is big. It's 45,000 pounds, a lot of weight to drop off the wing. We knew the airplane would carry it because it had dropped heavier things, not much heavier. Got in on that from the beginning. I remember going to a meeting in Denver where the Orbital Sciences guys were proposing it. So we got to work with them—good group—to make sure that we did this properly and safely, and we didn't have a lot of last-minute changes to insist on. We were in there from the beginning of their design. So it worked well.

We flew with it inert flights, that is, with an inert rocket. Then we put a live rocket on, a dress rehearsal, then finally we threw the switch and let her go, and the airplane responded as I had expected. The surprise was, I expected to see kind of like you see a missile shot, where the missile is zipping out in front of you, looking at the tailpipe. Instead, it looked like it was going straight up in front of us. It was only three-quarters of a mile in front of the cockpit, but it had rotated at a point where the visual image was of a Shuttle launch straight up in the air. Spectacular. So we did six of the six launches, first launches. Now they're on ten, eleven.

WRIGHT: When you were working on these projects, was there a lot going on at one time, or are you able to concentrate and focus on one of these projects at a time?

FULLERTON: No, I had more than one, usually. They would phase along, and you'd just see how they came out. I got a chance to fly the F-111 that we had there, a cambering wing, automatic wing shaping internally, that was real interesting. That had been flown, so I got on for the last phase of that. I got a chance to fly the X-29. I'd have to look in my log book. We had an F-14 that I flew quite a bit. So these were all going along, not all at the same time. It's a good job when you're having trouble working in all these good assignments. There have been dead periods, too.

WRIGHT: What about your involvement with the X-38?

FULLERTON: The involvement there is with basically as a mother ship pilot to get it in the air. I've worked with John Muratore on the initial figuring out how high we could get it and where they wanted to launch each successive, also planning how we chase it because some of the documentation's done from video from the chase planes. So I'm sorry to see that sort of fizzling out on us here, because I think it's a basically good concept and one that's needed for the Station, but higher levels have decided we can't afford it, I guess.

WRIGHT: Well, I know we have a time limit this afternoon. So before we close, I have a couple of other questions for you, and one being, what do you consider in your career to have been the most challenging time or the most challenging aspect that you have found?

FULLERTON: Well, for a sustained challenge, it was 51-F, taking on the responsibility of making that flight work, through all the development of the procedures. We were working with Marshall Space Flight Center [(MSFC) Huntsville, Alabama]. It wasn't just working with the guys I knew at JSC. Working with a couple of payload specialist slots for individuals that had never been in space, integrating them in. They just weren't along for the ride, either; they were essential people. They were the people that had led and built the instruments, a lot of them. But they were not aviators at all, never been in a jet plane.

Then the lead-up, we had a launch pad abort, when the engine started and quit, and we were left there. Karl Henize was pounding on his leg, really mad because he didn't get to go. I turned around to Karl and said, "We don't want to go, Karl. There's something wrong out there, you know."

We then had engine failure on launch, and there were lots of things you could point to that said this wasn't a piece of cake. We got up there, the IPS [Instrument Pointing System] wouldn't work at all, and they had to completely reload, rebuild the software, real time. We had to redo the whole flight plan. Lots of challenges. So, spread over that entire period, as an event in itself, was certainly the most sustained challenge.

WRIGHT: What do you feel is the greatest accomplishment that you've been able to have—

FULLERTON: I don't know if I'd—it'd be hard for me to write it, again, because that's protracted over all that time and came out so good, and the war stories that go along with it, hard to beat that one. But I wouldn't do the whole career any different. I've really been lucky to come here

and at my advanced stage still fly in F-18s and other airplanes. It's just like I've always dreamed of, and I'm still getting paid for it.

WRIGHT: So let's end it on that one. I have heard several times in our conversations today, as well as read, that the thing you love to do most is fly planes. Do you have a favorite of all the ones that you fly?

FULLERTON: I'm often asked that. I've had favorites as they go along that have been impressive. If I had to go back and pick one, it's hard. It's hard to beat the F-18 for pure kick to fly, pilot-friendly airplane. But flying the bigger airplanes is more of a challenge, really. Fighters are easy to fly. Big ones are really different from one to the next, and flying them with engine failures and that sort of thing are a bigger challenges. So there's some maybe more higher level of satisfaction of mastering such a beast, like a B-52. And so my favorite one is the one I happen to be in.

WRIGHT: The perfect answer.

Is there anything else you'd like to add today before we close?

FULLERTON: I think not. With every incident I've described, in the back of my mind, there are six others I could talk about. I'd hate to be the person that has to listen to all this, or much less type it up, but I'm happy to share what I have and hope it's of some use to somebody sometime somewhere.

WRIGHT: It will be, and it was extremely interesting hearing all the things that we had time for you to share. So I thank you again for your time today.

FULLERTON: It's all right. Well, you do a nice job of preparing and leading on with it.

WRIGHT: Well, thank you. I appreciate that.

[End of Interview]