NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY 2 TRANSCRIPT

VANCE D. BRAND
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is April 12, 2002. This oral history is being conducted with Vance Brand in Houston, Texas, for the NASA Johnson Space Center Oral History Project. The interviewer is Rebecca Wright, assisted by Sandra Johnson. This session is part two of Mr. Brand's oral history. The first part was conducted on July 25, 2000, and focused on his involvement with the Apollo-Soyuz Test Project. Today's session reflects his efforts with the Shuttle Program, his additional roles during the Apollo era, and his current service for the nation as Deputy Director of Aerospace Projects at the Dryden Flight Research Center [Edwards, California].

We thank you, again, for taking time with us, and we would like to note that we are visiting on the twenty-first anniversary of the first STS [Space Transportation System] launch. So may we start by remembering that time and ask where were you during the first launch?

BRAND: The first STS launch, I went over to Goddard [Space Flight Center, Greenbelt, Maryland] to be sort of an astronaut rep [representative] during the launch and early part of the flight. They have a center there that handles the communications, the so-called Shuttle network. So worldwide communications were coming through there.

WRIGHT: Your first flight for NASA was as the command module pilot for Apollo-Soyuz Test Project in July of 1975, which was also the final flight of the Apollo era. Would you share with

us about the transition that you went through from being part of the Apollo era to becoming part of the new age of NASA?

BRAND: Sure. I, of course, finished with the Apollo-Soyuz mission in July of 1975. After that, we wrote our report and we talked to all the engineers, as we customarily did after a mission, and the physicians and everyone to debrief the mission, the experiments, basically how it [all] went. That took probably about two weeks. … Up to the time of the mission when you're first up to bat, as we used to say, everyone will pay attention to you, and if there's something that you think might help the mission, why, there are people eagerly waiting to get your ideas and bounce them against other people's ideas. So, anyhow, you feel like you're working with [many] people and you're sort of on top of the world.

Well, after you come back from a mission, whereas before you had a parking place, why, when you come back, you lose your parking place. That's the first thing that happens, and you suddenly realize that everyone's interested to hear what happened and all, but after about two weeks post-mission, why, their interest starts to wane because they're thinking of the next mission.

So at that time, while on Apollo-Soyuz, about a couple of months after we got back, it was in what would be known as Indian summer in Russia. It's after summer, but it's before the fierce winter winds [and cold that] come in. We went to Russia and we had a tour around Russia, and it was just fantastic. We started in Moscow and we went to what was then called Leningrad, and down to Kiev [Ukraine] and to Sochi [Russia] and out to Novosibersk [Russia] and to Stalingrad [now Volgograd, Russia], [and other] places. The mission received a lot of publicity in the Soviet Union, what was then called the Soviet Union, [or] just as it had around

the world and [in] the United States. So there were crowds and they were friendly. It was a marvelous experience. We met a lot of people. We took our immediate families on that trip.

After that trip, we went to the Winter Olympics [in Austria and with] just our crew, not both crews, [then] our crew had a tour of the Mideast and met many rulers and [in] Egypt, Saudi Arabia, Qatar, [Algeria], Abu Dhabi, Kuwait, [Israel]--so there was a lot of PR [Public Relations] afterwards. The Soviets came to our country and we took them all around the United States.

After that, it was time to get back to work. The Shuttle had been in development for a few years in late 1975, and I got busy in the Astronaut Office. As I recall, there were only about twenty-six of us back then. I did a lot of simulation, mostly in the area of launch, launch aborts, launch guidance, reentry guidance, [and] things like that. So it was a technical job after [Apollo-Soyuz].

We were all enthusiastic about the Shuttle coming up. It was to fly a few years later. It seemed like it would be impossible back then to get [so much] ready so it would actually fly. But we worked with marvelous engineers at NASA and the companies involved. So I was doing a lot of flying, a lot of simulating. We were practicing Shuttle-type approaches out at Edwards [Air Force Base, California] and at White Sands [Test Facility, Las Cruces, New Mexico] with T-38s and that sort of thing. Those were busy days, and everybody wanted to be the first to fly. I was lined up for the third flight for a while, and then I ended up on the fifth flight. That was in 1982, November.

WRIGHT: How did the training differ as you were preparing for the Shuttle flights that you remember as you were trained for the Apollo flights? Were there a lot of differences?

BRAND: Well, it seemed to me there were a lot [of differences]. Some things were similar, like science training, oceanography, things like that. But when it came to how the vehicles actually flew, why, all the systems were different. Although we had a computer in Apollo, we had much more capable computers in the Shuttle. The ascent was different. How you would abort the Shuttle is completely different, because this was a vehicle that could land on land at an airport as opposed to something that splashed down in the ocean. The entry was different, too, because the Shuttle was a winged vehicle, so it had more capability to deviate right or left to land at [an out-of plane] place.

We were worrying about, [things like] what if we would overshoot the airfield or … what if [the] flight control [system] didn't act like the simulators said it would. What backup plans would we have? So there were all kinds of differences regard[ing] to the way the vehicles flew.

WRIGHT: Did you have specific duties as NASA was preparing for the orbital test flight?

BRAND: Yes. At that time I was mainly, as I mentioned, sort of the office representative for guidance, [that is] ascent and entry guidance. You know, in the Astronaut Office [at one time] we all probably [had] three or four duties. That was my primary duty. But we would all have three or four duties, and then there were [additional] firefighter duties that would come in, … had to be done real fast. So we were all [as] busy as heck.

WRIGHT: When you learned that you were going to be the commander for STS-5, was that at the same time that they had announced you as also doing the orbital test flight, or did you learn you

were going to be the commander of the first operational flight after the flights had already begun?

BRAND: Let's see. I'm fairly sure that I knew [just after] the flights had begun, but I can't remember the exact time when I realized I would be commander of STS-5.

WRIGHT: What types of specific training did you have for that mission? Because now you weren't just doing overall training for the Shuttle; you were actually doing training specific to that mission. Could you share with us some of those training specifics?

BRAND: Our job was to be the first to deploy satellites, which would go into geosynchronous orbit. We were the first, quote unquote, "commercial mission." These were Hughes [Hughes Global Services, Inc.] satellites, and the boosters to send them from low orbit up to geosynchronous orbit were built back then by McDonnell Douglas, which now is a part of Boeing [Company].

We had a Canadian customer for one of the satellites and an American customer for the other. As it turned out, a lot of our training that was really mission-specific dealt with those two satellites. But, in addition, we were to be the first Shuttle mission that was to send someone out on EVA [Extravehicular Activity], and so there was a lot of EVA training.

We had a crew of four. Bob [Robert F.] Overmyer, who, unfortunately, [was killed on an airplane test flight] a few years ago, was the pilot, and Joe [Joseph P.] Allen and Bill [William B.] Lenoir were the two mission specialists who would do the EVAs and who were really

responsible for knowing the deployment and the satellite systems backwards and forwards. So there was that kind of specific training.

Other specific training … had to do with get-away specials. We had some of those on board. I think you know what they are. We had our own specific Earth viewing and Earth photography objectives, so we had geology and geography and oceanography training to help us be able to identify what we should photograph and comment on. [We were training out first to make the first fully automated Shuttle landing, but those preparations later were cancelled in favor of a manual landing.]

WRIGHT: This spacecraft was very different from the one you had been in in 1975. For instance, the launch was somewhat different. But tell us was it a lot different or was it similar to the launching on the Shuttle, as it was when you launched on the Saturn?

BRAND: I thought the launch and going up into orbit was fairly similar in many ways. For example, you know, with the old Apollo Saturn 1-B you had staging after two minutes, and then you continued up … into orbit. [It was] similar with the Shuttle. It's just that with Apollo, the first stage was something that came off the back end and fell back. With the Shuttle, you had solid rocket boosters on the side that peeled off. So the staging, even though it was a little bit different between the two missions, when you actually were sitting there going into orbit, it seemed about the same, because the first stage was rough, noisy, and there was all this shaking, which smoothed out after staging in both cases, [then] it seemed like you were sort of in overdrive going the rest of the way into orbit.

The Shuttle and Apollo, in going to orbit, took about the same amount of time. There was [only] a minute or two difference. Once you got into orbit and the engines cut off, you had the same feeling on each vehicle, because … whereas you had been pressed [firmly] back into your seat or coach, suddenly you were free-floating, [and just] hanging in your straps.

I think [most] of the differences came, actually, when you got into orbit and when you returned. You want me to mention the differences in the return?

WRIGHT: Please.

BRAND: On the return, of course, if you're landing [near Hawaii or] in the United States, whether it be Apollo or Shuttle, you would do a deorbit burn to slow down a little bit when you're over the Indian Ocean. The big difference comes after you're hitting the atmosphere. In each case, it takes about a half hour to coast before [approaching] Hawaii [where] you hit the top of the atmosphere, whatever you define that to be. In Shuttle, for example, we define it at 400,000-foot altitude.

… From then on there was a big difference after you hit the atmosphere, because with Apollo you were seated in a couch with your back pointing into the wind, so to speak, and you could look out tiny windows and … see a donut of fire behind you. … The speed of the vehicle and the friction [from] hitting the atmosphere was ionizing the atmosphere, and the ions [formed] a plasma ring behind you. It was about fifteen feet behind the spacecraft, I would guess, and you had the feeling that if you could step outside, you could … almost go back and touch it.

As you were flying … [seated] backwards in Apollo you would control your trajectory by rolling the vehicle. … Of course, eventually you were on parachutes and you landed … in the water and there [was] a splashdown and little bit of shock.

… After you hit the atmosphere, [all of this] changed for the Shuttle, because, first of all, you had the feeling that you were … sitting like a pilot and a co-pilot in an airliner.… In the early part of entry the vehicle had a [large] angle of attack [as it] was pitched up roughly forty degrees with respect to the velocity vector. [There were] very large windows, and you weren't looking backwards at a donut of fire [as with Apollo]. You were able to see the fire all around you, … [and] you could look out the front.

First the sky was black [during entry], because you were on the dark side of the Earth, but as this ion sheet began to heat up, why, you saw a rust color outside, then that rust color turned a little yellowish. … [Eventually, around Mach 20] you could see white beams or shockwaves coming off the nose. If you had a mirror—and I did on one of my flights—you could look up through the top window, which was a little behind the crew's station, and … see … a pattern and the fire going over the top of the vehicle, vortices and that sort of thing. So it was really awesome.

At Mach 18, or eighteen times the speed of sound, I had a manual control task, which was to take over [manual control] from the auto pilot and do a … [flight test maneuver]. First I pushed down from forty degrees to thirty-five degrees angle of attack, then up to forty-five and then back. That's just a few degrees, but when I did that, Joe Allen, who was sitting in the center seat … [as] flight engineer, … was watching what was coming off the nose, the shockwaves, and he said a shockwave came from the nose and it came up and attached to the window right in front of us. That was a little worrisome, because he knew it was hot. The shockwave was very

hot. But then about as soon as it got there, why, I was on my way then to a higher angle of attack, so it walked back to the nose. So there were interesting things like that, that happened.

Eventually we were coming over the coast of the United States. … You [are] pitch[ing] down to more of a [normal] airplane angle of attack. [Then] you can see out the front and see the countryside. I guess when we first landed at Edwards, it was dawn, but you could see the sun lighting the [desert] way up ahead.

When you get down to about Mach 3 to 2 you're getting into thick atmosphere and it's rumbling outside. You can hear it rumble, and you're decelerating such that it's pushing you into your [seat] straps. At Mach 1, you … feel … [a lurch, an] increase [and decrease] in deceleration and a decrease as you go through.

Eventually you're over the field. On STS-5 we went through a very thin cloud deck. I was on instruments flying and circled down and landed at Edwards. [We] had an [intentional] max braking test and completely ruined the brakes. I had to stomp on them as hard as I could during the rollout, which points out that we had a lot of flight test[ing] on that mission. Even though it was [billed as] the first commercial flight,I think we had roughly fifty flight test objectives. That breaking test was just one of them. We ruined the brakes, completely ruined them, but it was a test to see how well they would hold together if you did that.

WRIGHT: Can you share some more experiences about handling the Orbiter while you're in space? This is your first operational flight and your first time to fly. Tell us about those times.

BRAND: [The crew] used the autopilot a lot. You have the capability to maneuver the ship in rotation—roll, pitch, yaw—with a hand controller, but more often than not, you just punch

something into the computer and set up the digital autopilot such that you'll get an automatic maneuver. That saves fuel. … [As you can maneuver] at very slow rates.

We were [tested] out the [reaction control] jets on orbit, those that are used for translation up or down, [sideways], or forward, back. On the night side of the Earth, when we translate[ed] the ship down…. The [large] upward-firing RCS [Reaction Control System] jets were used to do that. At night it looked like a Fourth of July display, because you could look out over the nose and you could see these tubes of fire going up [from the RCS jets]. There were fantastic visual effects.

[As mentioned, orbit] maneuvering was … [done] with a computer. We had to set up the correct attitude to enable … essentially automatic deployment of the satellites at the right time, the right place, [and] at the right speed, and that all worked just famously. Joe Allen coined the term "Ace Moving Company," because we moved stuff to space. We put up a sign, "Ace Moving Company," that [Joe had] made out ahead of time. He was just a wonderful guy to have on the mission because he has such a sense of humor and [was very innovative and capable]. Of course, [each] guy on the crew was very dedicated, trained and did a great job.

WRIGHT: You had a little more room in this spacecraft to have some environment to share.

BRAND: Yes [it was enough room although] we didn't have sleep [compartments], because we all went to bed and got up at about the same time. … [We had a] choice of what we would use for sleeping. Since we didn't have a sleep station[s], why, … I just would take a string and tie it to my belt …, and tied the other end, perhaps a string that long, to the wall. [Tethered by the string] I'd put on a jacket and just fall asleep. It was great [in weightlessness and I] slept [well].

Bob Overmyer had the only sleeping bag, and he would string that up down in the lower deck of the Space Shuttle. So he looked like he was in a sleeping bag that was tied [at the ends] to two pieces of structure. Bill Lenoir [jammed] himself into a corner [of the upper deck] with his jacket on, and would … [sleep] there. I don't know how he did it, but he didn't float [out of the corner], and he would sleep that way.

Joe Allen was the funniest. He would just free-float through the spacecraft the whole night, or what we called night. He [moved] gently, and the air currents would move him around. He might gently bump into a switch or something, but they were [covered] and he was hitting them so gently that there wasn't really any [concern about] moving the switches. So that was really humorous, seeing that.

It was an early flight [in the Shuttle program] and we had, as I said earlier, a lot of Detailed Test Objectives (DTOs) [or flight tests]…. For example we were soaking the vehicle [thermally] with one side into the sun and the other side in the shadow for a long time. [Design engineers] wanted to see how much the ship would warp, the thermal effects. Sometimes after [spending] many tens of hours in one attitude …, the shady side of the ship would get real cold. Dew would … form on the inside of the ship on the cool side. We had a treadmill [in the middeck], and when people [ran] on the treadmill, it [shook] that dew loose and it would sort of rain inside the spacecraft. So there were many things that were happening on orbit that weren't dangerous, but … were interesting…. Some of those [effects] we had anticipated and some we hadn't.

WRIGHT: As you mentioned, the commercial satellites were deployed without a problem, but the EVAs had to be cancelled. Did those cancellations, although they were disappointments, how

did it affect the rest of the flight and the crew, the fact that you aren't going to be able to do those?

BRAND: Well, I guess I was the bad guy. As much as I hated to, I recommended to the ground that we … [cancel] the EVAs, because we had a unit in each spacesuit fail in the same way. As I remember, it was a little pump [and] one of its [functions] was to be a cooling pump. So it looked like we had … a generic failure there. It was [to be] the first time out of the ship. We didn't want to get two guys or even one guy outside and then have … [another failure]. We could have taken a chance and … could have done it, [the EVA], but we didn't. I'm not sure [that] Bill Lenoir was ever very happy about that, because he and Joe, of course, wanted to go out and have that first EVA….

WRIGHT: Of course, as you mention, that was part of your responsibility for the safety of your crew.

BRAND: Yes. You just don't want to do anything dumb. Well, if you [can] say something [is] a little less than perfectly safe that's one thing, but if you [get] up there and [get] into a lot of trouble you'd really regret it.

WRIGHT: On your next mission in 1984, you had almost the opposite. You had spectacular EVAs that set the stage for many more to come. Tell us about STS-41B and what your experiences were with that.

BRAND: Whereas on STS-5 we had a crew of four, 41B was about five missions later, this time not in *Columbia*, but in *Challenger*. This was the fourth flight of *Challenger*. I might say that somewhere in there they got a new numbering system for Shuttles or Shuttle missions. I think John [W.] Young did STS-9 as commander, and we did what was either STS-10 or 41B, and 41B was a neat new way of designating missions that confused almost everyone.

[Yes, the new numbering system was logical yet confusing.] But, anyway, [on STS 41-B] we had a crew of five. The EVA guys were Bob [Robert L.] Stewart and Ron [Ronald E.] McNair. Ron was, unfortunately, killed later in *Challenger*, in the *Challenger* accident. [Robert L.] "Hoot" Gibson was the pilot. Anyhow, we had a [strange] flight. We had a lot to do, and, as you mentioned, the EVAs went just famously. It was the first time that people had flown with the Martin backpack [Manned Maneuvering Unit (MMU) developed by the Martin Marietta Corporation]. … It was supposed to be an early-day Buck Rogers flying belt, if you know what I mean, except it didn't have the person zooming … real fast. It was a huge device on your back that was very well designed [and] redundant so that it was very safe, but [it] move[d] along at about one to two or three miles per hour. It used cold nitrogen gas coming out in spurts to thrust you around and everything.

Anyway, [Bruce] McCandless [II] and [Bob] Stewart went out about a hundred yards [away from *Challenger*] and came back, and they weren't tethered to anything. So we were tracking them with [the ship's] radar, [and] something similar to a Surveyor's laser rangefinder. The trick was not to let [the EVA crewmen] get too far out such that orbital mechanics would take over and separate us. We didn't want them lost in space. We didn't want to come back and face their wives if we lost either one of them up there.

Anyway, [the EVAs] worked very well. We'd [simulated the EVAs] a lot, and we thought [that] if somebody did start to get away from us, … we would chase after them with the Orbiter and just fly the payload bay into them and have them grab onto something. We had… contingency procedures, things like that [as backups].

… The [satellite] deployments didn't work out so well. Here we were deploying … two satellites that were [similar] to what were so successfully deployed on STS-5. One, the PALAPA [PALAPA-B2], was for Indonesia, and … the other one was [for] Western Union [WESTAR-6]. Anyway, it turned out that [their booster rockets] had similar failures. The deployments [from the payload bay] went flawlessly. Everybody check[ed] that backwards and forwards. But what … happen[ed]… about a half hour after each of the satellites left us, was [it started] its burn, which was to sent the satellite up to an orbit … 23,000 miles out away from the Earth, called geosynchronous orbit. The engine burns, which were solid rocket burns, [each] started, and then [after about 20 seconds unexpectedly] stopped. We had the underside of our vehicle pointed in the direction of the burning satellite[s] so that if any speeding particles from the burn would… just hit the underside and wouldn't do any harm. We were observing with a TV camera … on the end of the RMS [Remote Maneuvering System]. [It] [looked] around the side of the ship, … [to see] what happened and that was recorded.

I'm not sure even today that it's well understood why those rocket[s] burned out prematurely, but each left its satellite stranded in an inappropriate orbit. Of course, one of the satellites was later rescued by a follow-on [EVA] mission that Joe Allen was on, [Joe] had been a member of [the STS-5] crew. At least one of [the satellites] was retrieved … and later reused.

Also, we had some failures in the RMS system. … In the early days of Shuttle, we had [a lot] of anomalies and, of course, now after a mission [typically there are] just a very few….

[Effects from most anomalies] weren't Earth-shaking, because we had so much redundancy [built into Shuttle system], but some [failures] would, although they weren't safety-related, … would spoil mission results a little bit.

WRIGHT: One of the other maneuvers or objectives was the inflation of the rendezvous balloon.

BRAND: Oh, yes. Yes, we had a lot of objectives on that flight, as we did on STS-5. One of the objectives was to test out the rendezvous software in the computers for the first time. To do that, we had a [mylar] balloon in the payload bay, [a radar target], which would be released. As I recall it, it was shot out [of a tube by] a spring. … Spring energy [shot it] away from the Space Shuttle. … When it got out a little ways, it timed out and it filled with gas. We were watching it go [away from the spacecraft], and all of a sudden it exploded. Not that it was any danger to us, because it was … away from the ship, … [and] after all, it was only a balloon. It wasn't like a stick of dynamite…. But when this balloon … exploded, I said, "It blew up." [Laughs] And on the ground they were wondering, "Does that mean it exploded, or does that mean it filled with gas [that is] blew up?" Well, it exploded. We, fortunately, salvaged that test by tracking the biggest fragment with radar, and … exercised our computer programs….

So it was fun to do those early things. Many things [that] are done on the Shuttle today as very [routine] things … back then had to be checked out.… [The] rendezvous [system] was one of them.

WRIGHT: An unplanned opportunity that I know happened during that mission was that you practiced some rescue procedures when one of the foot restraints floated away. Tell us about your decision to go after that and the impact of the results of that.

BRAND: Well, Bruce McCandless was on an EVA, and he was in the payload bay. I don't recall now whether it was before or after he went out with the backpack. But he was … trying to reposition his foot restraint so that he could get in it to do work. You know, [EVA equipment] generally [was] tethered, but it somehow got away from him. I looked back and I saw it floating away. I thought about it for a [second] or two, and I decided that the ground wouldn't have time to come up with a decision whether we ought to chase it … and go after it. It was going to get away from us very quickly, so I couldn't see anything wrong with going after it. So I [used] the translation controller. We … chased it. Bruce caught it, and we didn't have to worry about [encountering] that as space junk the next time we came around the world.

WRIGHT: Were you very satisfied on how the Orbiter handled when you had to do that?

BRAND: Oh, yes. Yes. I had one switch that was out of position when I … first [thrusted], which had the thrusters aligned to an axis system that was ninety degrees from what I needed at that time. After the first thrusting, I had to [reposition] the switch to get the proper orientation, … so that the right thrusters would come on and I could accurately chase [the foot restraint].

WRIGHT: Fifteen months earlier, you had landed the *Columbia* at Edwards at the end of STS-5, but for STS-10 or STS-41B you were going to land the *Challenger* on the landing strip at [John

F.] Kennedy Space Center [KSC] [Florida] and this was going to be the first time that this was going to occur. Tell us about that accomplishment as well as if you had to do any other specific training or any other maneuvers it took to prepare you for that.

BRAND: The main thing we had to do different was fly the STA [Shuttle Training Aircraft] and T-38s on practice approaches at the Cape to … have a feel for what the terrain was like, where the checkpoints were and things like that. We … made a big thing out of it back then, that it was going to be the first [landing] at the Cape. [The Orbiter] landed once at White Sands, but most of our landings had been … at Edwards. When it came time to do it, it was sort of a no-brainer, you know, it's just landing at another place. You saw greenery going by at the Cape instead of [the] desert plants at Edwards and that sort of thing. The Cape was a beautiful place to land, and we were very happy to get to be the first guys to do it.

… Since you're touching on landing here, way back when we were talking about STS-5, … we trained to make [a] fully automatic, landing, and we would have been the first crew to make a hands-off landing [all the way] to touch down with the Space Shuttle. The software [that is] the approach and landing program guidance … was quite good. I think we could have done that. But we found out on [the White Sands landing] that if you have to take over at the last minute for any reason, … there's a transient in there that [can] mess you up. … Even though the programs for landing were good, but we didn't have all of the redundancy that you'd … like to have to do [a] hands off [automatic landing] with your arms folded. So [before flight] our plans were changed. We didn't make a completely automatic landing. I took over at [around] 50,000 feet, as was sort of the new [tradition], and felt the plane out, got used to it, then landed it manually.

WRIGHT: You did two landings in two different Orbiters. Did you have any differences in one handled compared to the other?

BRAND: No, they're essentially identical.

WRIGHT: Before you could take another mission as a commander once again, *Challenger* [STS-51L] accident happened, and you lost, as you mentioned, on your former crewmembers on that. What was your role at that time? Were you preparing for your next flight, or had you been assigned some other duties? Were you doing some other duties when you learned about the *Challenger* explosion?

BRAND: After the 41-B mission, I was reassigned and I got a crew for a life sciences mission. It was the first life sciences mission. So we started training for that. Then, for some reason, because of restructuring of the missions—and I kind of forget all of the details, but I ended up with another mission, which was [called] Atlas. … So … I had another crew, and we were training. … That's what I was doing when along came *Challenger*, and that [unfortunate disaster] changed life for everybody for a while.

WRIGHT: Were your duties changed after?

BRAND: … [I thought to myself,] "… We have to really fix the Space Shuttle so [that] this isn't likely to happen again. We've got to strengthen the whole [system] so that [another] accident

that might be somewhat probable could never happen." So we all got into a mode of … fixing the Space Shuttle.

At that time I had … really interesting [assignments]. For one thing, I [led] the Development Branch in the Astronaut Office. … There were about thirty astronauts that I was working with at that time, and they were all … looking at different [Shuttle] systems. There'd be one [person] on escape systems, and somebody else following what was being done to the solid rocket boosters, and another on main engines, etc. … We were all working with engineers and managers [to correct problems], and there was a big effort under way to assess … the critical [failure points] were in the Space Shuttle and to prioritize the fixes.

… Jay Green and I co-chaired a committee that [reassessed] ascent and aborts and [emergency] landing fields around the world. [The committee looked] at the [whole] ascent and landing picture.…

Eventually, I was on a board that [looked] at the system safety of the Shuttle when changes were being implemented after … the groundwork [was laid] that I just mentioned. … I spent a year sitting on this board, and we were [looked] at all the hazards that … had [been] identified for the Space Shuttle [including] the solid rocket boosters and the ground facilities.… So it was somewhat tedious just marching through all of that, but it was interesting [and necessary].

WRIGHT: Do you believe some of the concerns or issues that you might have had got addressed during this time period, as far as the safety for the Shuttle?

BRAND: Oh, yes. [The] Astronaut Office just had scads of concerns, and this was an opportunity to maybe not get everything fixed, but certainly to get everything looked at and to have a lot of competent people decide whether or not these things needed to be fixed.

WRIGHT: At what point were you contacted or told that you were going to be commanding the STS-35 mission, which was in 1990?

BRAND: [Donald R.] Puddy told me. He was the head of [Flight Crew Operations Directorate, which included] the Astronaut Office and the organization[s] that trained astronauts.… I got a phone call from him. I was in my office. Beyond that, I don't remember … [many details of the conversation.]

WRIGHT: It's your third mission, but yet it was again going to be so different, because this was an astrophysics mission and a very large crew of seven, of all of you, with four Ph.D.'s. Did you, again, have different training so that you could be prepared to do what you needed to do for this observatory?

BRAND: Sure. You know, the Hubble Telescope is a satellite telescope that goes up and stays up, [however, on STS-35] we had some telescopes that scientists wanted taken up for a [few days at a time]. They were ultraviolet and X-ray telescopes. There were experimenters from all around the United States [sponsoring] these.

… We had about thirteen tons [of] telescopes in the back of the Shuttle, and they were not to be deployed. They were to be taken up, used for eight or nine days, and brought back….

It was another use of the Shuttle. People used to say [the Space Shuttle is like] a truck or it's a platform, and it can be used for many different things. So it was important to engage with the scientists….

We had four Ph.D. scientists on our crew: [Robert A.] Parker, [Jeffrey A.] Hoffman, [Ronald A.] Parise, and [Samuel T.] Durrance. They all had Ph.D.'s, they were professional astronomers and they really knew the equipment. [In the beginning] Parise and Durrance really knew all of the telescopes very well and later the two NASA guys, the mission specialists, did, too. It's just that … Durrance and Parise, being payload specialists, had the advantage of earlier involvement [in the mission preparations]. … When we flew, everybody was really up to speed on the objects that had to be viewed, [the] astronomical objects, which were largely hot spots in the universe, places where cataclysmic events had occurred … [such as an] exploding star…. So it was very interesting.

As crewmen, three of us … were to run the ship, [so] we didn't get involved in the astronomy too much. It was our job to make sure that our side of it would work … running the ship.

… We had a very congenial crew. In addition to the four scientists, [there was John M.] Mike Lounge, who was flight engineer, and … the pilot, Guy [S.] Gardner. These guys were … all very intelligent, capable guys, and they did a great job.

… The whole crew was put to the test … on this mission. You know, I'd said earlier that [there are] anomalies. Well, [there weren't] very many anomalies with the spacecraft itself, but this telescope system, and particularly the mount that held and pointed the ultraviolet telescopes, acted up on us. It had been tested … on the ground thoroughly, but there are things about being in space that couldn't be [duplicated in] the ground [tests]. … For example, the mount itself is

rather weak [structurally], and you can't [do an end-to end test] on the ground [with] it pointing at … stars, because it's not strong enough. [On orbit in] weightlessness, … it's plenty strong enough to do its job. … [On orbit] we found out that there were some things about the automatic pointing system that didn't work right.

So there was a very commendable effort between the [STS-35] crew and two [NASA] Centers, Johnson and [George C.] Marshall [Space Flight Center (MSFC), Huntsville, Alabama] Centers, to coordinate manual maneuvers [and workarounds so] that we could get most of the data, anyway. It took about a day to get this all [working]…. In a typical viewing sequence the telescope would be pointed by first [rotating] the spacecraft to an attitude, and then having one of our four [astronomers] onboard manually point the … ultraviolet telescopes…. The fine-[pointing] that was a coordinated exercise between the [astronomers] and Marshall [scientists]. Anyhow, … [the coordinated contingency operations saved the mission.]

The other [major anomally] during the mission [was that] the wastewater system plug up. Wastewater's kind of dirty stuff, and [normally must be dumped into space.] There had to be some rerouting of the lines. Our two [trained repair men] were Guy Gardner and Mike Lounge. I don't think they enjoyed the job very much, but they were able to successfully reroute the lines.

WRIGHT: Became plumbers in space.

BRAND: Yes.

WRIGHT: Before you could even leave on your mission, you had a delay, almost a seven-month delay from the original launch date to the time that you got up. Could you share with us the tests

and patience that you had to go through in order to get the mission ready before you could even get into space?

BRAND: … These [Space Shuttle's] main engines are fed by huge plumbing lines. They're oxygen and hydrogen lines, … covered with insulation and [located in] … a little compartment … [in front] of where the [main] engines are. There was a leak [somewhere] in there, a hydrogen leak. Hydrogen leaks [cannot] be tolerated, because hydrogen is very explosive. And even though [the system is designed to] overpower a leak with a nitrogen purge in there, it still [isn't] considered … safe, and [ground crews] had to understand [and correct] the leak. It just was driving the engineers at the Cape [Canaveral, Florida—KSC] crazy trying to find the source of the leak.

Finally, I think they [assigned] a guy from Marshall, a senior engineer named Bob Schwinghammer, to go down to the Cape with a team, …[to] start from square one [to] find out where the leak was.

… [Before that] though, we'd had several launch attempts. It was very frustrating. It took a lot of patience on the part of [management,] the ground crews and the flight crew…. We would get up [ready] to fly and … get to a certain point in the count and they'd say, "Sorry, we don't fly today. We still have a leak." It took seven months to fix it. Schwinghammer and his team worked their way through a hazard tree on paper….

… When they found a place that was a likely [leak] location on the hazard tree on paper, they would go to [*Columbia*] and strip the insulation off the pipe, … valve or whatever it was, and … troubleshoot…. It was through that … very commendable effort, that … [the team] found not one leak, but three or four small leaks that added up to one big leak. They fixed it … [then

we] flew. [After that] *Columbia*, with regard to … hydrogen plumbing … was [said to be] the tightest ship in the fleet.

… [Before we hadn't ever] had a vehicle down for that kind of troubleshooting … that long. And [the problem] was a surprise to me, because on my three previous missions we … always got off on the second that [liftoff] was planned. Sometimes [launch time] was planned for several months ahead of time. So [STS-35] was bitten, … by that [hardware problem].

WRIGHT: This is the time when the two Orbiters were passing each other. You had one that was coming to the launch pad and then another one trying to reschedule and to do that.

BRAND: Yes. We got passed up by a mission that was supposed to be behind us. [Richard O.] Covey was the commander [of STS-38]…. I forget the designation of the mission. It was STS-36, -37 or –38….

WRIGHT: And when you left it was a night launch. So that was, again, something different that you had.

BRAND: That was a [great] thing for us … to experience a night launch and a night landing. In the early days of the Shuttle Program, Dick [Richard H.] Truly demonstrated the first night landing, so it wasn't the first. There'd been a few. But it was [quite] different. There was [of training involved].

… We sat on the pad waiting to launch, and … saw the Moon going across slowly, … [lying in our seats] there for an hour or two. … [During] … [launch], you … had the feeling you

were lighting up all of that part of Florida. Well, it was … like night flying in an airplane. You had to really have your lights adjusted … [and] pay attention to your gauges. … You couldn't really tell much about what was going on outside. You couldn't see the horizon very well….

But coming back to land[ing] at night, I found … that whereas when you're landing the Shuttle in the daytime, you sort of land it like an airplane … [and] you see all [the visual] cues as you're coming in. If you're landing at Edwards [AFB] in the daytime, out of the corner of your eye [you see] the sagebrush and it's giving you an impression of how high you are above the ground, but at night you're really relying [special guiding] light patterns that you see. Like from about 15,000 feet down to 2,000 feet, you're on what's called the steep glide slope, and the light patterns are used to keep you on the correct [steep] angle going down. Then after [that] you're [into] pre-flare and settling on to the rather [shallow] glide slope, [and] looking at what's called a BALL-BAR. It's a string of lights that [you keep] centered in [certain] way. …You fly the vehicle so as to keep the lights centered correctly. …[This] should have you on the right glide slope to land. Of course, you have the floodlights lighting up the first third of the runway…. Anyhow, light cues [are] indispensable, and the whole environment [is devoid of other visual cues.]

WRIGHT: Plus, you had a heavier Orbiter, because you were bringing back your payload, like you mentioned didn't deploy. Did that affect your landing?

BRAND: … It made our angle on outer glide slope … two degrees [less] and it made our landing speed maybe a [a few knots] higher…. So it … [only had a small] effect.

What did have an effect, though, was … we landed in a tail wind, and the differences there were really noticeable. It changes your trajectory just a … bit, and you're actually [having to decelerate faster and land at a higher ground speed]. Your groundspeed is higher than normal. … I noticed those differences more.

WRIGHT: Also, during your mission, I guess because you had so many Ph.D.'s that had been teachers at some point, you had some instructions for students. You had some classroom activities that came out of your mission. What were your thoughts as you were watching your crewmembers not be crewmembers at the moment, but be instructors in space?

BRAND: … We thought it was a good and natural thing. It didn't really interfere with our viewing or anything. We always had somebody on the job [at the telescopes] up there. But … these Ph.D. astronomers did a great job [as teachers too]. They were … enthused about it. They wanted to tell students … about the problems [of] viewing … stars and phenomenon in the universe and that sort of thing. … It was great. Of course, at the time I … [was glad they were] teaching it and not I. Of course, they … [were very knowledgeable]. They [obviously] had a … lot of background … [in astronomy].…

WRIGHT: You were so busy with those duties. Did you ever have a chance to look through the telescopes and have maybe a one-on-one from the astronomers of showing you what they were looking at?

BRAND: We would look over their shoulder. A funny thing about the telescopes was, it wasn't like a telescope that you would buy … [with an] eyepiece. What you [looked at] was … a CRT, on a TV-type display. So we could watch them use a hand controller that you might liken sort of to a Nintendo controller … [to] move the telescopes … manually. We [could] look over their shoulder [to] see … [them] put the crosshair on the star or whatever.

WRIGHT: This is your last Shuttle mission. After you landed, what were your new duties?

BRAND: … After I got back, I had the feeling that the early flights had really been sensational, and now we were getting into, as demonstrated by an astronomy mission, … a more operational phase. …At some point I thought, well, …the early missions were most exciting and … [it's time for me to get] on and try something else. … It would have been some time … before I could have picked up my next flight, so I decided to move on.

At that time, I thought … there [were] two things that would really be fun to be involved with: … development work that could lead to a Mars mission … [and the] National Aerospace Plane (NASP), … a hypersonic plane. I thought… "That [could] be a replacement for the Shuttle." Looking at the two programs [of interest], there was a big effort to look at going to Mars. Then … [the NASA Mars initiative was cancelled]. The agency decided … not [to pursue] sending … people … to Mars in the near future, [but to] send … automatic unpiloted probes [instead].

[I decided to be part of the NASP Program.] …NASP, it was such a tough technical [problem]. I went … to Wright-Patterson [Air Force Base, Ohio] for a [two] years and worked … there in the Joint Program Office. It was joint because it was [an] Air Force and NASA

[partnership]. But NASP, technically [was difficult and,] couldn't achieve[d] [on] the time schedule … [and funding] given. [There were] a lot of very difficult problems to solve…. So it eventually [was] dropped because it was lagging in achievement … [and lacked sufficient] funding. So what I thought [were the] most interesting [concepts] didn't really materialize. …[I believe that] some [later] generation will … send people to Mars [and construct an airbreathing, single-stage-to-orbit (SSTO) vehicle].

WRIGHT: After you were at Wright-Pat for a couple of years, then where did your career lead you? Were you still working with the flight operations people as well?

BRAND: … [After it was clear] that [NASP] couldn't make it, … [I relocated to] the [NASA] Dryden Flight Research Center at Edwards Air Force Base in California. [There are] scads of projects … there involving airplanes and … space vehicles. I started as … Assistant Director for [Flight] Operations then later … [became] Deputy Director for Aerospace Projects. … In earlier days I was a [test] pilot, [and astronaut]. Although I had education in both engineering and business management, I had never used the business management part very much. So this gave me an opportunity to see a bigger picture and … help the Center to [achieve] important [flight] research projects …. …I'm really enjoying … [the work as it involves both technical and business management aspects of flight testing and technology integration.]

WRIGHT: Are there some projects that you can talk to us about, that you feel that your expertise and skills have been able to help move along and progress?

BRAND: Sure. We [have] had quite an evolution [at Dryden]. … In the time that I've been out there, unpiloted planes have come into the forefront. …Examples are Predator … which [is] used [by the military] as a reconnaissance airplane, [Helios, UCAV, and Global Hawk.] These … airplanes have … come … to the forefront, because … [there are] computers now … capable that we can make [unpiloted planes] work [well].

Twenty years ago, … [there were] remotely controlled airplanes like you'd see a kid flying …, but [not] airplanes … [with an onboard] computer … programmed … to start the airplane … then … [make it] taxi out, take off … [and] do a [complete] mission. …It [can even] respond to certain emergencies. Eventually, … [without human intervention the computer guides the plane] back, land[s] it, taxi[s] it in. It's … a new world out there [in aviation]. …I'm a pilot … [but I'm starting to believe that] pilots have their niche and these autonomous machines have their niche, too. …[This is an] example of new sorts of things that we're getting into at Dryden.

We're … [assisting in the flight test of] a UCAV, that's the Unpiloted Combat Air Vehicle. …We're … helping the contractor … as they wring [the vehicle] out at our place, and eventually it will go … to the Air Force. … [UCAV is military. Some unpiloted] airplanes [can] have dual use, a military use and a potential civilian scientific use. …

[Dryden has] a thrust in intelligence systems, which … [involves] finding out how we can use computers to make airplanes better. For example, neural-net-type software, which most people haven't heard of, … mimics [the] nervous system in your body a little bit. It's software that's used for adaptive flight controls, that is, flight control systems on airplanes that can respond to unexpected things without really being programmed for that specific thing. …For example, [should] a rudder … freeze or fall off an airplane, this kind of a control system will

recognize … and … adjust all the other surfaces to compensate…. That's an example of … [an] intelligent system.

[There are unpiloted aerial vehicles (UAVs)]. We have … access-to-space-type activities out there, [including] X airplanes, [like the] X-43, which is testing … a scram jet engine, and [the] X-37, … which will eventually be a vehicle that comes in … [from space to] can test new thermal protection coatings and all sorts of things.

We have our old standard piloted airplane platforms, [the] B-52s, that can drop things … like the X-43 and the X-37, [that is] carry them up to a certain altitude and drop them off, [and there are] F-15 platforms of various kinds. So that's just a taste of some of the things we're into … [at Dryden]. It's sort of 21st century aeronautics. We're almost through one century of flight, and we've done amazingly well. Now what's coming up in the next [100 years]?

WRIGHT: It sounds like you're in the right place at the right time to get to witness so much of that, just as you already have in the space area.

What we'd like to do right now is to take a break and then we'll come back and visit some more.

BRAND: Okay.

WRIGHT: What I'd like to start with at this point is if you could tell us how you first became interested in aviation.

BRAND: Okay. … I'm not one of these guys that got his pilot's license when he first turned sixteen … or something like that. I was raised in a small town in Colorado, and I knew one or two of the aviation pioneers around that part of the country, … [for example] Raymond Bullock, who'd been number three pilot on Western Airlines, and who was a friend of the family. Western Airlines has gone by the way now, of course, but [it] was one of the very old airlines in that region.

I always [had been] interested in airplanes and space. I used to draw a lot when I was a kid, and I would try to design spacecraft, even though … they didn't exist yet. The astronaut profession wasn't invented yet, so to speak. But when I was a kid, they still had [science fiction] movies, *Buck Rogers* and *Flash Gordon*, things like that [which were an inspiration].

So I think … [I had] a latent interest … in aviation and space, but I went through college not knowing really what I wanted to do. …I got a business degree in finance and went into the Marine Corps as a lieutenant to be an infantry platoon leader around Korean War days. At one point I was assigned to [the] Cherry Point, [North Carolina], Marine Base for a short time, and … used to sit at breakfast and watch the FJ Furies, early jets, take off. It was … purely an emotional thing. I thought, "I've just got to do that," you know, because [the jets] were so beautiful. So it was not with any logic that I got into this field. It was all emotion.

I went to flying training, …flew the old F-9F Panthers for the Marines at [Marine Corps Air Station] El Toro [California] then later went to Japan, [flying] in a fighter squadron there. [We had] FJ-2 and then FJ-4 Furies, which were Navy and Marine Corps adaptations of the F-86, which was [made] famous in the Korean War.

After a four-year [of] active duty, I got out and I thought, "Well, airplanes are really interesting. I'd really like to understand them better." So I went to University of Colorado,

[Boulder, Colorado] [and] got an aeronautical engineering degree there. I was just fascinated with airplanes, [including] what made them do what they did, and … the theoretical underpinning[s]…. … [In one of the design classes] we drew up plans, each of us, for an airplane, did some analyses, [and conceived] something that we thought would work.

So I [graduated in 1960 and] went to work for Lockheed in Burbank after [the second tour at] the University of Colorado…. I started with Lockheed as a trainee, then [became] a flight test engineer … on the P-3 program, which was an … antisubmarine airplane development. [I worked] on the [structural] test airplane, and learned … about flight [testing].

…[Later Lockheed] sent me to the Navy test pilot school … at Naval Air Station Patuxent River, Maryland. [I] spent a little less than a year there and just loved it. [Were] flew about seven or eight different kinds of airplanes concurrently. …[Before that when] they closed Marine Corps and Naval air stations, I switched [from Marine Researve] to the Air Guard. So I was flying [with] the Air [National] Guard in Ontario, California, … at [around] the same time. [After] flying a lot of different kinds of airplanes, learning a lot, [I] eventually became … an engineering test pilot on the F-104 Starfighter. [The airplane] had gone through its early development as F-104A and B, and we were testing the [Canadian and West German] export versions, which were more capable. …[My] work [was at] Palmdale, California.

Eventually … [Lockheed assigned me] to Europe, [where I] worked with the Germans at [their] test base … in southern France. There were about six of us Lockheed people, and I eventually was [leader] of the group [as well as] test pilot. We were teaching the Germans how to test airplanes again. They had stopped testing airplanes in 1945 [after] they lost the war, and [there was] a hiatus [as] they didn't do very much [flying] until 1958 when their Air Force was started up again.

…My family went over with me. We had our kids … [in] the French schools… [that is 3 of the 4]. We loved living in [the Provence of Southern] France and spent two years there. … [I was] flight testing and flying all over France, the Mediterranean and … Germany … in the 104 and other airplanes like the G-91, F-86, (Canadian version) and T-Bird….

… I took *Aviation Week,* a periodical …, and there was a little article on, "NASA's looking for astronauts. There [will be] selection…." So I applied and made a couple of trips … to Houston [for a] physical exam and … the other testing and interviews…. [I] lucked out and came in with a pilot class in 1966, the fifth group of astronauts. … These were the people that would eventually fly in Apollo, Skylab, Apollo-Soyuz, [and Space Shuttle].

I loved astronaut training. We did a lot of geology field trips and other field trips. It was kind of a standard thing for … then, …[and] somewhat similar to what astronauts do now in training. …Eventually three of us [were] assigned to … a ground test on the early command module, … in a thermal-vacuum chamber … at Johnson. [It was] a huge thermal vacuum chamber, and we were in there for a week, testing mainly environmental … and electrical systems…. The spacecraft in a vacuum … [was] alternately being cooled by nitrogen panels … and heated with arc lamps….

I got Cape assignments. I was … ["Stony"] on Apollo 8, which was the first [manned Apollo]. "Stony" was the guy that calls out the "10, 9, 8, 7," … the astronaut who worked with the [launch] control room.… [And] I monitored the development of the command module and its testing at the Cape before it went [to the] region of the Moon.

[Next] I got assigned to Apollo 13, the mission that had the explosion, … [to] do testing at the Cape and later to be a CapCom. There were three CapComs: Joe [Joseph P.] Kerwin, Jack [R.] Lousma, and myself. That was a bit of excitement that we all wished we could have

avoided. A lot [happened] in that week, and it was [such] a very impressive undertaking by the Johnson Space Center, to figure out the best they could what went wrong and how to … work with the [crew to get the] spacecraft to get it back and reenter. I … [read] up … the [contingency] entry procedures. All in all, it was kind of a scary week, and everybody was … very relieved when the spacecraft came back … okay and the [crew] stepped out of the spacecraft.

WRIGHT: How did you learn that there was a problem aboard Apollo 13?

BRAND: Well, I had just come back from the launch at the Cape. …Probably … somebody [telephoned] me at home, because when it exploded, Jack Lousma … was on shift as CapCom…. …Through the rest of the mission, … Joe Kerwin, Jack Lousma, and I alternated [as CapComs]. … The word got around very quickly, you know, as soon as that happened.

…The *Apollo 13* movie, I think [did] very well in capturing the feeling that people had back then. The movie is based on a book. Naturally, the movie simplifies a lot of things. In reality, they didn't have just one … [Flight Director] like they seem to have in the movie, but they had several. I think maybe there were four. One was Gene [Eugene F.] Kranz…. He … [had one team] trying to figure out how [to] save the mission, and the other teams were running [Houston] mission [control]. Anyway, the book is quite good, I think, [and] it's a lot more realistic on … some of the details of the mission.

WRIGHT: In that book, *Lost Moon*, by Jim [James A.] Lovell [Jr.] [Apollo 13 Commander], he mentions how well you handled yourself all through the times that he talked to you as the

CapCom. I believe he even mentioned something about when everything settled down, he was going to buy you a beer. Did you ever get that beer from Jim Lovell? Have you ever had a chance to talk to him since the mission has been over?

BRAND: Yes, [but] not very much, because he had a lot of people to talk to after that mission. I guess I don't remember the beer part.

WRIGHT: It was kind of those when you read it it just kind of threw it in, but he did mention how well that you'd handled yourself. I know that you were on the CapCom during the time that he asked the question about the flowers blooming in Houston. Was this a code that you had worked with him regarding whether Ken [Thomas K.] Mattingly [II] had encountered the measles?

BRAND: You know, I don't remember who talked to him about that. I hadn't worked it out with him. It was somebody else. And I, frankly, don't remember now who reported that to him. Did it say I did?

WRIGHT: I believe so, yes.

BRAND: Well, that was a long time ago.

WRIGHT: It was, yes.

BRAND: You forget some of those details. … It was one of the great moments of the space program or great events, bringing those guys back.

WRIGHT: And a great team effort. Were you there most of those four or five days continually at the Johnson Space Center?

BRAND: After I got back from the launch at the Cape, why, yes. Like most other astronauts, I was around that whole time taking shift duties, and there were other things going on, too. So I mean, everybody was pitching in any way they could to try to help out. It was, like you say, a great team effort. Mission control just did an outstanding job. [Kranz and other flight directors showed great leadership.]

WRIGHT: For a couple of the missions, Apollo 8 and Apollo 15, you were a backup crewmember. Could you tell us what it was like to train as the backup member for the Apollo crews?

BRAND: Well, for 8 and 13, I was sort of a third crewman, so to speak, not a backup, and it was our job to help with the mission planning, the spacecraft testing and things like that. [I was backup Command Module Pilot on Apollo 15]. So the backup role … [was] a much better role.… The backup crew trained in parallel with the prime crew so that they could take over at the last minute, if need be, as a crew or as an individual. And you'll recall, that actually happened on Apollo 13 when [they thought] Ken Mattingly … had the measles, …I forget, but it

seems like it was only a day or two before launch [that] and [John L.] Swigert [Jr.] substituted in. [It was] that late.

As third crewmen, … support crewmen is what we were called. … We were with the crews all the time down at the Cape or wherever they were, but helping out. … About twenty-four to thirty-six hours before Apollo 8, we were all working checklists down at the Cape, and … looking at the places on the lunar surface where they were going to take a picture or try to observe what was there.

[There were] big scientific questions at that time [about was it] like [on] the Moon. [For example] is it deep in … dust? The surface-is it volcanic or was it formed from impacts from meteoroids and meteorites? Things like that. So we were putting notes in checklists, and [the crew was] getting ready to go. It was a very exciting time, because that mission was the first where anybody [was leaving] the planet…. …[Apollo 8] went out 250,000 miles to the region of the Moon, [orbited] the Moon and came back.

WRIGHT: And what a good time for you. You'd only been part of the astronaut corps for two years when Apollo 8 launched. Seems like you were in a good place at the right time to be a part of that whole effort.

BRAND: Well, I learned a lot, yes. Apollo 13 taught a lot of things, too. That's one great thing about the space program. … They … log the lessons learned. I remember after every mission I …[kept] notes. When I came in, they had one or two Gemini missions yet to go, and I would just listen with my mouth open and my eyes real wide when John Young would describe a Gemini mission and how the rendezvous worked and … things like that. So it was a great period

of learning for those of us in my 1966 group, which was called the Original Nineteen. And that was because everybody talked of the Original Seven, and there were nineteen of us. So we'd thought it would be a funny thing to say, … [we] called [ourselves] the Original Nineteen.

WRIGHT: You were selected to be a backup for the command module pilot for Apollo 15.

BRAND: Yes.

WRIGHT: And so your role changed.

BRAND: Yes.

WRIGHT: Tell us about how that did change your life and what duties you had being a backup member.

BRAND: I was backing up Al [Alfred M.] Worden, who was command module pilot, the guy who would sit in lunar orbit while the other two went down in the LM [Lunar Module] and landed on the surface and then came back. We both got the same science training [which] often [was] together, [that is], visual observations, photography, geography of the Moon and geology…. A lot of the rest of the time, though, in our simulation and all, I would simulate what we had to do, … and try to [devise contingency procedures-that is], how you would handle contingencies…. But the bulk of the time was [spent] getting identical training to … the prime crew[']s]….

We had jokes about how we would try to trick the prime crewmen into diving off a … diving board or something so we could go [on the mission]. No one wanted them really to break their legs. … As it turned out, Al [stayed] very healthy, so I didn't get to go.

… [Apollo 15] had a great mission. I thought it was … great … to learn how you did each step and going to the Moon and coming back and what the spacecraft capabilities were. I really learned a lot about the spacecraft, which was good for me later on when I … [was to become] a backup for Skylab, [for] two of the Skylab crews.

I was backup commander for the second and third Skylab missions, commanded by Al [Alan L.] Bean and Gerry [Gerald P.] Carr. …[Along with training] I did do a lot of contingency work figuring out, for example, how you could complete a rendezvous if you lost your inertial navigation unit … by gauging things, using charts, using the equipment, the spacecraft guidance navigation and control equipment in ways that it was never, ever designed to be used. So I thought I could almost fly the spacecraft without thinking at the time, because I had so much exposure to that [type of] Apollo … training.

An interesting thing … came up on the Al Bean-led mission, which was the second Skylab mission. They lost two … two service module … reaction control system [RCS] thrusters, which said that if they lost another, they were really in deep trouble. There was some question as to whether they could reenter, even as it was, safely, because they couldn't sustain any more problems in the RCS system without risking … going out of control.…

… Don [L.] Lind and I were assigned to be a rescue crew. … We spent one month figuring out how to rendezvous with them, where we would dock, outfitting our command module so that it had … padding on the aft bulkhead where people could lie … [to] get five people in the spacecraft. We worked on that very hard with all of the other people here at

Johnson that were involved in mission planning and engineering and stuff to figure out how to do … [the rescue]. We came out with special rendezvous documents and everything needed.

Then Chris [Christopher C.] Kraft [Jr.], who was in charge [of Johnson] at that time, said, "Well, now why don't you see if we can figure out how we can get them down safely without sending up a rescue flight." … [There was an Apollo rescue] vehicle in position at the Cape that was ready to go, and we were ready to go. But, of course, it would have been a big expense. If there was a way to get … [Al Bean's crew] back without going through all … trouble and the risk of another mission …, it would be good to work out how to bring them back.

So I worked with [people] from the simulator area and … from guidance and control and … [to find] a way …[to] bring the spacecraft home safely by … [using RCS] jets in different ways than they're normally used…. …If they had further troubles with the service module engines that prevented that [system] from working, we had a way [to deorbit by] … [using] the Command Module alone. … It had its own separate set of thrusters, and … by going through a very unorthodox procedure you could make it deorbit and bring it in land.

So we kept working those procedures. The crew [on orbit naturally] was very impatient. I think that crew stayed up for … two months…. So the first month that they were up there, we were trying to figure out how to rescue them. The second month then we were trying to get them procedures … [to safely bring themselves home]. We kept simulating the procedures … to make sure we hadn't made a mistake anywhere, and the whole Center was geared to … [support] this. So finally we called the procedures up—and I was the CapCom at that time—and they all worked.

…Draper Labs [Massachusetts Institute of Technology, Cambridge, Massachusetts] helped us a lot [in the GNC area] … I just happened to be walking down the hallway [one day]

and I met a Draper guy that I knew. He said, "Oh, by the way. Our simulation [showed] … that Al Bean will have to … hold his translation controller full over in the … [left], and that if he doesn't know this, … it might surprise him and the spacecraft might go out of control when he starts the deorbit burn."

Man, I thought, "We really have to get that information up [to the crew]." We had a system that normally would surface information like that, but this was [done] in such a hurry … that I often wondered if we hadn't of gotten that piece of information up, if [Bean] might have had a problem [during deorbit burn]. So [success] depended a lot on human interaction as well as technical knowledge. … You were trying to get all the knowledge you could before they deorbited to give them the best chance that everything would work correct.

[After that] the third crew, … Gerry Carr and Bill [William R.] Pogue and Ed [Edward G.] Gibson, stayed up for three months. That was really a long time [to stay on orbit] back then. They ran into some of the first problems that [long duration] crews encounter. The ground was working them very hard, and [the Carr crew was] about to burn out, … from being worked so hard. It's easy for the ground to do that, because there are probably hundreds of people trying to put together ideas of what they ought to be doing up there and a few people writing it all down. People on the ground don't picture how much work sometimes they're laying on a crew. So we had a few issues like that.

It seemed like we were fixing things all the time. Skylab was getting pretty old by that time, and all through the mission there had been repairs, like [during boost into orbit] there was actually an explosion on Skylab 1 that caused them to have to use a [makeshift] parasol and special procedures to save Skylab itself. …Through[out] the mission things would wear out, or

you'd get a leak in …, some fluid system, and you'd have to figure out how they could [repair and] recharge that.

So there were all sorts of interesting engineering problems [during] those missions. On the ground, as a member of the backup crew, there was a lot to do coordinating with engineers and getting information up. So you felt fairly useful, and it was … exciting, just as it's exciting for my daughter [Susan] now working in the mission planning and development for Space Station. I'm sure [that while] assembling the Space Station [today] they're … having to [modify and] fix little things all the time like we had to do then.

WRIGHT: Had you hoped to be part of a long-duration flight? Would you have liked to have been up for several months?

BRAND: You know, that's not my thing. The Russians always made a big thing about long-duration flight. When they send a team of people to Antarctica, they like to keep them there a year, partly because it's hard to get in and out over much of the winter period down there. So they … like to qualify a crew for a year down there. It was a very big thing with the Russians to have extended flight in space, … using the same logic, [some said], as they do with Antarctica. They were building up and qualifying [people] and trying to do what they could to keep [them] physically and psychologically fit up there….

But I like to fly high and fast, and I [like] to be up there for [some] time, but I don't have any … desire inside of me to break an endurance record, because … you know, it's just one workday piled on …[another] doing experiments and things like that. [It is being a medical

subject. The important thing is the objective. For the long endurance space flight I would have gladly committed to three years in space to be on the first manned mission to Mars.]

WRIGHT: Before Skylab, when you were a backup for the Apollo 15, at that time backup crews normally were in a rotation to become a prime crew, and you were going to be part of Apollo 18 lunar landing mission. But, of course, circumstances got changed. Can you tell us your thoughts about that time when you learned that your mission to the Moon was not going to occur?

BRAND: Well, it was a tremendous disappointment. …Back in those days, "Deke" [Donald K.] Slayton and Al [Alan B.] Shepard [Jr.] would tell you when you were assigned to a crew, and I was never really told that I was assigned to the 18 crew by them. I think Dick [Richard F.] Gordon [Jr.], who was my backup crew boss, probably talked to [one of them]. I don't know if you've talked to Dick or not, but he probably was holding any information like that. …I expected there was a good chance I'd be on 18 because of the normal rotation, and we all expected to do that. When I heard that those later [Apollo] missions were cancelled, it was a big disappointment, because going to the Moon is something I really would have liked to have done….

WRIGHT: As you mentioned, you went on to be chosen for the Apollo-Soyuz Test Project that we have talked about before. Are there other moments or occasions that you can remember during your Apollo time that you would like to share with us now before we move on to another part?

BRAND: When we were in training, and none of the nineteen [new guys] were assigned, we were all good friends and had a lot of fun and had great experiences together. We went out on survival trips [to] Panama and Washington State in the desert …, and geology trips all over the world, including Hawaii and Iceland and [Mexico]. But what was [interesting] was when the first crew, or the first people out of the original nineteen were assigned, everything changed. It was now competitive, you know. It wasn't everybody together enjoying their training. All of a sudden there …[was] a different feeling about the whole thing…

…For most people in the Astronaut Office it was a little bit like being on a roller coaster. You'd have these [peaks]--tremendous, exciting… news … that you get to do this or you get to do that, then occasionally, if there's something you had your heart set on and somebody else got it, well, then you were down in a trough. So it was a pretty competitive situation.

WRIGHT: As changes continued to occur, Apollo again phased out, in 1978 a new class of astronauts joined the ranks, and that was the first class that they had chosen in a long time, which included females and minorities. How did that, if any, affect what you were doing at the time, to have a new class move in?

BRAND: I was on the Astronaut Selection Board … for the [1978) and the 1980 class[es]. We were glad to get more people…. …I think there were thirty-five people … in '78. So we thought, "Boy, what a big increase." But we really needed the help, and we were glad to get them. They looked like very good people to us, both in '78 and '80, and we were impressed with [their] credentials….

…The whole [Astronaut] Office … tended to mentor the new classes, … unofficially, but they would be given [on-the-job training] assignments at the Cape, … at JSC, [or elsewhere].… I remember Ken Mattingly was a … [good] mentor. He would talk with some of the new [people about astronaut topics] for hours, and I always thought that was very commendable.

WRIGHT: Being on the selection board at a time when changes were being made in the criteria to include other than just male scientists and male pilots, did you find that to be challenging? Was that whole time period one of constant change, or were you able to work through that new criteria with the feeling that this was part of what was going on in today's world?

BRAND: Oh, there wasn't any problem. There wasn't … anything to work through, that I remember. …The Shuttle would have … [pilots], mission specialists and payload specialists. I always thought they ought to go out and get the most qualified people, no matter what. So when we got mixed crews, [that is with] both male, female [members] on the crews and we got minorities, that just seemed good and … to me [assuming that all selectees would be well qualified].

WRIGHT: As you mentioned, there was plenty of work for everybody with all the new tasks, especially with the Shuttle. Were there meetings or specific ways that as you learned more about the Shuttle, especially during the testing period of the Shuttle, that you could pass that information on? For instance, when you did your first flight of the operational flight of the Shuttle, had you had a chance to talk a lot with the pilots and the commanders of the first four missions that you learned from them and had those lessons that you could apply?

BRAND: Yes, the system was set up to bring out lessons learned and pass them along. Every crew would probably write a [detailed report] on the things people should know that were learned out of their mission … [including] things went, how things worked and what to look out for. Then they would debrief the whole Astronaut Office. Then they would go around and debrief various groups around the Center. …You had a chance to ask questions….

You learned [interesting] things. Like when Apollo 8 came back, I think it was Bill [William A.] Anders … [who reported that he] heard strange noises …[on the lunar trip] and … [he thought] it was something [from] the communications system. That crew … [reported that one could] close … [one's] eyes and see flashes. And …[scientists thought] that was … [from heavy particles,] radiation. …Particles coming in from outer space, going right through the spacecraft and through the people. They're miniscule [high-speed] atomic… particles.… And it was [reported] that it would take a long time for them to do enough damage to hurt a person. Anyway, I've been told that these flashes are what you see when one of these particles hits your optic nerve. So, you know, who would have guessed? Well, you found out [about] things like that, you know.

WRIGHT: Do you remember some things that you shared with the rest of the astronaut corps that maybe they didn't know before they had heard it from you?

BRAND: In a post-flight fashion?

WRIGHT: Yes.

BRAND: Yes. Getting away from the technical or scientific and going to the human, we broke ground in the whole area of how [to] work with the … [Soviets]. And ours was the first [international space] docking … and the first time that the two [competing] space programs tried to work together….

We found, for example, that although it might not be the only way to work with a foreign group like the Russians, that it was helpful to have co-chairmen of certain technical committees that worked out how to do things, like the docking committee or the public relations… committee. … It seemed to work, and we'd have meetings to identify issues … [both] in Moscow and [Houston]. I think that, in a way, [it] might have set a pattern for how we worked with the Russians [later] on Mir and perhaps Space Station. I don't know.

WRIGHT: How about the internal communications and the internal procedures that were set up before you got there in 1966? Did you see a lot of the same procedures as you stayed with the astronaut corps or did those evolve as well? How did the corps and the way that it communicated with each other and even with other divisions and departments within the Center change during those years that you were there? So many changes had happened to the program. We had gone from Gemini to Apollo, Skylab, and then on to the Shuttle. Did the way that the astronaut corps communicate internally and externally have a lot of changes as well?

BRAND: I don't think they changed so much. Some things that had been traditional went by the wayside and new things came on. For example, I mentioned earlier the "Stony" position, … the astronaut in the control center at the Cape. That had been a tradition through, I believe, Mercury,

Gemini, and Apollo. And it started out in Mercury, because you actually didn't have something like a TDRS [Tracking and Data Relay Satellite] satellite that allowed you to centralize all of your communications here. But you had the astronauts spread out all over the world at tracking stations, and you had one right at the launch center at the Cape. You had probably a lot of new people that didn't know a lot about manned space flight. So it was important for astronauts to have a presence in a lot of places and to help [understanding and communications].

…Finally on Apollo-Soyuz we got a communications satellite. That [new capability] did away with a lot of ground stations. …[Also NASA] found out that [it] weren't needing this Stony guy at KSC like they had before. So we haven't had "Stony"…on Space Shuttle. Still, that [is an example of] an old tradition that … evolved away because of new circumstances.

I think the thing that [made the] most different through the various eras of the space program … [was differences in leadership], that is, [each] Center directors and each … leader of the Flight Crew Operations … [Directorate], … had a different [leadership philosophy and] style, and so I think … leaders molded, to a large extent, how things would be done during their reign.

For example, "Deke" Slayton had sort of a laid-back style, but he was very effective. …He was followed … as Flight Crew Operations Director, by [Kenny Kleinknecht] … George [W. S.] Abbey, [Don] Puddy, [David C.] Leestma and others. …Each person … put his imprints on things. Early … [in Apollo] [Robert R.] Gilruth, … George [M.] Low, and Chris Kraft had leadership roles. Each of these people … [made a profound] impact, but they had their own [values and strengths].

Gilruth … [was] the George Washington … of what was then [called] the Manned Space Flight Center and now … [the] Johnson Space Center. …He was a very stabilizing influence,

and … had … qualities [such as technical understanding and inner strength] that were really good for those early times….

Chris Kraft … kept people moving and getting things done. He was good in his own way, in a different way. …Some of the biggest things in space [manned space exploration] happened with him at the helm.

…I think now… we need a hero to find out just how [NASA] should continue … with [the International] Space Station. I don't know what sort of [qualities] this hero will have, but we sure[ly] need [someone to lead NASA to continued success.]

WRIGHT: Through your almost forty years of service, you've seen so many changes and you've participated in making a lot of those changes. In the reality, could you possibly share with us what you think maybe is the most challenging part of your career that you've had, or even maybe your greatest accomplishments?

BRAND: Well, the big challenge on every mission, seemed to me, is to get the job done [well] and safely, never [to] let down. …[Astronauts joke that], "If you find that you're on a mission and you're feeling satisfied that everything's going very well, then obviously you've overlooked something."

I think job[s] that I enjoyed probably more than any other[s] in my life, … [were] test pilot, … [and Space Shuttle] commander. …[These were challenging], enjoyable and rewarding job[s]. [The assignments] have a beginning and an ending, … have objectives, and if you can … pull … [them] off, you have a great feeling at the end. There will always be things that, of

course, you don't pull off the way you wished, but [hopefully] they're little things, and the big things work out … well. So that's … [a] challenge.

We … [spent] very long hours training and working, especially close into a mission, but I didn't consider that … a [big] challenge, because [I] enjoyed the work. [I] never looked at the clock. It was [exciting and] enjoyable work. [My biggest accomplishments at NASA probably were contributions to Apollo, Skylab and Shuttle development and four challenging space flights.] …

WRIGHT: Looking back over these years that you've spent doing these significant accomplishments for the space program, did you ever believe and did you ever have any idea that when you were a youngster in Colorado drawing those pictures of spacecraft that didn't exist, that you would be flying those and that you would be participating in that?

BRAND: …I had no idea as a kid. Well, the [profession of astronaut] wasn't invented yet. [New] jobs are being invented every day …, and we … may have kids that [will] do jobs that in their lifetime[s] that aren't invented right now. … I really think that science fiction and comic strips like *Buck Rogers* and …*Flash Gordon*, … [are] inspirational to people, … [and can inspire future programs and events.]

I had … heroes in the flight test world…. You know, there's …a link between being a [test] pilot of a spacecraft and an airplane. [I had a lot of admiration for] the Tony LeViers [phonetic] and some of the great test pilots [they were inspirational to me.] But I'm kind of getting off the subject here.

WRIGHT: No, I think that it's very relevant, because I was thinking and even related in the sense that you're out at Dryden, where some of the greater test pilots have been, and then you're being able to spend some of your career there as well. So it's got to be very satisfying for you to be in the midst of those as well.

BRAND: Yes. I think finally I'm at the point where I'm still working, [and] I … may not be right on some things, but I feel an obligation to try to get certain points of view across in today's world. …I discussed with you some of the things we are doing at Dryden. I see that as all real positive for the future, and unpiloted machines will get to be a bigger part of our lives.… But …I'm not sure we'll come up for a good replacement for the Shuttle till maybe 2030.

…Now I'm going into the future and …talking not about who I admired or …about the great people of the past, …but now talking about the future and where we have to go. I think that we've actually peaked out on what we can get out of a chemical rocket engine. To make big advances in the future we've got to get engines that give a lot more thrust and don't burn as much gas. [In other words, the propulsive] specific impulse has to get higher.

The other thing we have to do is … [develop] lighter spacecraft so you don't need [such] big a engines to take them up. Well, it will be very evolutionary making things lighter. We'll make plodding progress. Ten years from now they'll be lighter than they are now. In twenty years a little lighter yet. But the big gain …has to be made in finding new kinds of propulsion that will be so efficient that it will [be] cheaper, easier and more routine to get things into orbit.

[Currently], there are really only a couple of ways to go if you're talking about… [improved propulsion for launch vehicles.] One is nuclear [propulsion] and that doesn't work because we can't contaminate the atmosphere with the …nuclear engine exhaust. But another

way … is to have air-breathing engines. [That way] you don't have to carry your oxygen with you; [as] you get it out of the atmosphere. This would only be for the first stage of … [a launch vehicle]. [Convention rocket propulsion would still be used for the second stage.]

I think we have to make a quantum leap. We're getting world competition now, and [other countries] can build spacecraft that are … cheaper … to [operate] than those we can make. So we've got to somehow make a technological [advance]. There are many [types] of air-breathing engine [concepts] like turbine-based combined cycle, rocket-based combined cycle, [and high-speed] turbo jet accelerators…. We don't know which ones would work, but we need a lot of effort in that direction … [to] make a quantum leap, and then when we replace the Shuttle after developing these things…. We [could for example] have something that would … look like a piggyback airplane, take off from a runway, go up to [four] to [ten] times the speed of sound, [and] release its cargo, which would then [continue] on up into space [using] a conventional chemical rocket engine. Then this air-breathing airplane…, [the first stage], would come back and land. …

There are things like that that probably aren't of much interest to the average person, but one of the big problems [in America] is making it cheaper and easier to get into space. …We're about to spend $5 billion on research to [build a Shuttle replacement] over at the Marshall Space Center on the … [SLI [Space Launch Initiative)] program, and I just think that the focus of it, it can still be at Marshall, still can be the … [SLI] program, I just think the focus ought to be on these innovative new modes of propulsion. So that's kind of a spacey topic that most people wouldn't think much about, but that's something through my career that I've come to believe.

WRIGHT: That's very interesting. I hope that as you continue your career you'll be able to move into that area as well and learn more about that.

BRAND: We're [currently] testing a small-scale version of scramjet engine, which is an air-breathing … [and designed to fly at] seven times the speed of sound.… It's just one small experiment. We need a lot … [more focus at] NASA … on that sort of thing.

WRIGHT: Hopefully we'll hear more about the move that they're moving into. I hope so.

BRAND: Yes. And another thing is, I hope that we have the combination of political, economic, … other factors that can combine to … [enable] or a piloted mission to Mars.… It's like they say, you can send a robot to the top of Everest, but you [will] really never know what it's like unless you get people up there. … My generation won't see it, but I think it's an important thing to do, because we [eventually] need to [explore] the solar system with people as well as robots.

WRIGHT: One of the quotes that I had found that you had said before was part of the STS-35 mission, this was about the situation with the Spacelab failures and the fact that JSC and MSFC and the crew had all come together. And your quote was that, "Once again it proved man in space was a flexible element." And I thought that was a very interesting comment, and again in a way we just talked about that, that it's important.

BRAND: Yes. …You look at the Shuttle Hubble missions, you know, about every week or every month, at least, you read something in a periodical about a new thing they've seen with

Hubble…. It's revolutionized astronomy and cosmology. There are things out there that we can see evidence of with Hubble that [people] just never guessed existed. I personally think that Hubble alone has justified all of the expense that went into Space Shuttle, because [astronauts have] been able to go up repeatedly [to repair] and improve Hubble. …First they saved it, you know, because it had myopic vision. But then they serviced it, replaced components so it could still stabilize itself, and they've improved the optics and the sensors on it.

I just think it's a marvelous telescope, and now they're talking about [a more capable telescope] to follow Hubble that would sit out at a libration point … partway to the Moon. That's a good idea because you get away from the contaminating influences of the Earth for science. However, it would [also] be nice to [still] be able to get people out there so they could, if necessary, save the instrument and keep maintaining it and improving it. [Man in the "flexible element." He or she can adapt to surprises.]

Anyhow, I don't think there's any doubt at all that the Shuttle is more than worth what it cost just for that reason alone, … [plus it has flown over 100 other productive missions.]

WRIGHT: Well, before we close, I was going to ask Sandra [Johnson] if you have any questions that come to mind. We covered as much as I can think of at the moment. Is there any other area that you would like to discuss or share with us before we close today?

BRAND: Well, I think when we're through with assembly of Space Station, somebody should go through all of our [crewed] international missions and … [write down] lessons learned [in] dealing with the Russians.… From our original program in 1975 with them we have had

changing circumstances in each [follow-on program] and probably some for the better and some for the worse. The country ought to learn something from this.

WRIGHT: Yes, it would be quite a study, wouldn't it, from twenty-five years and counting of Russian interaction.

BRAND: Yes, that's right. We've had some outstanding successes. Let me give you an example of a lesson learned…. Seemed to me that when it came to negotiations and things, they didn't change[-out] people as often as we did. We have a tendency … maybe because of our political process, … [to] throw new people into [negotiations], and they may [be at a] disadvantage.… [The Russians have been better negotiators than we, for example, in defining the partnering arrangement for the International Space Station.]

WRIGHT: Well, let me close with this one last question, and I hope it's not an awkward one for you. You mentioned earlier that you felt that being a commander was a very special time in your life. If you had one lesson that you would like to share with your crew or maybe one point of inspiration that you would like to share with others that you learned from being a commander, what is it that you would like to be remembered for?

BRAND: Hmm, boy, that's tough. Well, it's a great job because you get to apply your technical capabilities, but it's always a … human relations challenge, too.

WRIGHT: Do you have a piece of advice for someone else that would be walking into a commander's job, on how to succeed in accomplishing so much in such a little bit of the time?

BRAND: You know, it was never [that] much [of a] problem, because [looking back at] all of [my] crews, everyone was so happy to be on a crew. They could have been with their worst enemy and still pulled it off [the mission], you know. So it's that kind of motivation that's so important. If the space program can just continue to get such good people and keep them motivated that way, [there] just won't be much problem. I guess I don't have any real special thing to say. Just like any other job, you [have] opportunities to plan, [then] everything changes and you …[do the job]day by day the best you can.

WRIGHT: And look back and learn those lessons and continue to go. Well, we wish you the best in all of your new plans and all those projects that you're working on, and hope again we'll be able to sit down at some point and talk about other accomplishments in those.

BRAND: Yes, well, I hope [that] NASA can have a lot of accomplishments in the future. You know, going back to 1958, [NASA'S] record [is] just astounding. It can continue or not. I hope it continues. If it doesn't, why, it would be a little bit sad.

WRIGHT: It would be. Well, we thank you again for spending the afternoon with us.

BRAND: Thank you.

WRIGHT: Thank you.

[End of interview]