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ORAL HISTORY TRANSCRIPT

N. WAYNE HALE, JR.
INTERVIEWED BY SANDRA JOHNSON
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JOHNSON: Today is April 23, 2014. This oral history session is being conducted with Wayne Hale, in Houston, Texas, for the NASA Headquarters Oral History Project. The interviewer is Sandra Johnson, assisted by Rebecca Wright. I want to thank you again for coming in to visit with us today. We really appreciate it.

HALE: My pleasure.

JOHNSON: As I mentioned before, I want to start today talking about maybe the first 10 years of your career with NASA. You graduated from Purdue University [West Lafayette, Indiana] in 1978, and soon after, you began your career with NASA Johnson Space Center, in flight control, in the propulsion systems area. Talk to us for a little bit about what brought you to Houston, and why you chose to come to JSC, and what some of your expectations were, coming in to flight control.

HALE: That's a long story, so I'll get started and see if I can't bring the salient points out pretty quickly. I have always been interested in working in the space program. I was three years old when Sputnik [Russian satellite] went up and influenced my early days. Grew up watching Mercury, Gemini, Apollo, and was all excited about it, and from the very early age, knew I wanted to be involved in the space program. Growing up in New Mexico, which is my native

state, a lot of what happened was in Houston, which is not that far. I conned my parents, at a fairly young age, into coming to Houston to go to the visitors' center at Johnson Space Center—in those days, I guess it was the Manned Spacecraft Center—and found out that Rice University [Houston, Texas] was closely related to Johnson Space Center, had close ties. I set my sights on going to Rice University to get a degree in aerospace engineering. Much to my chagrin, found out they don't offer a degree in aerospace engineering. Mechanical engineering's very close, so I took mechanical engineering curriculum, and specialized. They had some elective courses that corresponded to an aerospace degree.

When I graduated in 1976, from Rice, it was a little bit of a low point. The Shuttle design was in work, but still, the employment was down after Apollo. I had an opportunity to do a research fellowship at Purdue, a very nice opportunity, so I went off to Purdue and got my master's degree up there. Frankly, had kind of given up on the option of working in the space program, but the Lewis Research Center [renamed Glenn Research Center], Cleveland, came with an interviewer, and I interviewed with them. They said, "Would you really like to work in Cleveland?"

I said, "Well, I'd really rather work in Houston."

They said, "We'll forward your résumé to Houston." Somehow, the people in flight control, who were staffing up, fortunately, at that time, got hold of my résumé. I got a call out of the blue from Steve [Stephen G.] Bales, one of the heroes of Apollo 11, and Gary [E.] Coen, and they invited me down to work.

Of course, I jumped at it. I had other job offers, and actually, the government pay was the lowest salary offer that I got, but it was the one that I wanted. I have been very pleased ever since. I came to work in Houston. You wanted to talk a little bit about propulsion systems?

JOHNSON: Right, and when you first came, you came into that propulsion area. What were your expectations of what you would be doing?

HALE: They told me that it was in Mission Control [Center], would be supporting training, and then the missions for the Space Shuttle. Just as excited as I could be because everybody's seen Mission Control on television, and knew, in rough terms, what they did in Mission Control. It was just very exciting, and to tell you the truth, I didn't know exactly what to expect. I came in and the group that I joined was growing. There were a number of other young people—Ron [Ronald D.] Dittemore, who was also a Shuttle Program Manager, had come to work about a year before I did in that organization—in our branch, with the GN&C [Guidance, Navigation and Control] folks, DPS [Data Processing System] folks. I met [Brock] Randy Stone, who had been a veteran of Apollo, worked with these Apollo veterans who told war stories about the first Moon landing and how exciting it was, and so on and so forth. It was really just a heady time.

Then, we got these training classes. The training was just starting, and we got a lot of classes. Had to develop procedures, met the astronauts, found out Bob [Robert L.] Crippen knew my name almost before I got in the door. The man is amazing with names. He knows everybody—or at least in those days, before STS-1, he knew everybody, it seemed like, by name, and could tell you what they did and where they were. It was just very exciting for a young person to come in and see all their heroes. I think about a month after I arrived, "The 35 New Guys," the first new astronaut class arrived, right after I did. Went through training with them, in some ways, and then a bunch of the Apollo veterans, I think Al [Alan L.] Bean had retired about two months after I started work, so we got to talk to him. It was just very exciting.

At the same time, it was kind of slow because things were not happening very fast. There was a lot of workbooks to read, and I think that's pretty typical, in those days. They didn't quite have the training up to speed, yet. We started off slow.

JOHNSON: Were there formal training classes?

HALE: Yes, there were all kinds of formal training classes. They had workbooks that you would read and take a little self-paced test, and turn in your, "I read my workbook on Shuttle Reaction Control System," or whatever it was. Then, they had the single-system trainers were just coming online, so you would go upstairs in what's now Building 4-North. It was just Building 4, in those days. The flight controllers were in the first floor. The trainers and the flight planners were on the second floor. The astronauts were on the third floor. We saw everybody in there, and you would go to these single-system trainers and throw the switches. They also had lecture classes where the trainers would come in and give you a lecture. We were still developing the procedures, so we worked very hard with the engineering people, who were finalizing the design.

In those days, in 1978, when I came, they promised me we were going to fly in March of '79. I think that had been the launch date for some time for Shuttle. Of course, didn't fly till April of '81, and believe me, we needed that entire amount of time to work all the procedures and get all the training done. We expected it was going to come a lot quicker than it did. I have a graph somewhere of the launch date as announced by time, and it's a saw tooth—how many months to launch? We'd get closer, and then, bing, they'd delay it. It went on that way for two years.

JOHNSON: As you said, it gave you time to get all the writing that needed to be done, as far as the different procedures.

HALE: We had procedures, we had flight rules, we had console handbooks to develop. We also had teams to develop—you have to go to Mission Control and decide on this little propulsion team, who does what? We got the PROP [propulsion] officer in the front room, and clearly he's in charge of the little team, and he reports to the flight director, but in the back room, you got about three people, and they're doing different things. Back in those days, one person was watching the strip chart recorders, if you can imagine watching the strip chart recorders, to see every thruster firing and how all the jets were doing. Another fellow was in charge of keeping track of how much reaction control system propellant or the maneuvering system propellant gas was left in the tank because the gas gauge did not work. It didn't work very well, anyway. We had to keep track of it manually, which was something they did in all the previous programs, then, project the red lines ahead. We had another systems guy who was looking at the heaters and the valves and all the system parts, to make sure they were all working together.

We had to work out that division of responsibility, set up the procedures—who did what, when?—and then learn how to get along as a team. There was a little bit of inter-team rivalry. The flight directors encouraged that. I remember Neil [B.] Hutchinson was Silver Flight, he had the launch shift that went to the planning team, and then there was Don [Donald R.] Puddy, who was Crimson Flight, and he had the de-orbit entry, also orbit II, I think, and then Chuck [Charles R.] Lewis, who was [Bronze] Team. He did the orbit I phase, and there was a little bit of rivalry because people came and left. I started working on the ascent team, on Neil Hutchinson's Silver Team, and because we had some personnel changes, I got moved to the Entry Team. It was a big

deal, in those days, to change teams. There was inter-team competition. It was all in the name of team-building and trying to get people to perform to their maximum.

JOHNSON: You were preparing for something that had never flown before—the Shuttle that had never flown before. You said you worked closely with engineers that were developing these things. How did that work, as far as writing these procedures, or even malfunctions procedures and those sort of things?

HALE: Now that I look back on it, after a perspective of a long career and having worked in the Program Office and other areas, I can understand their point of view a little bit better. As a young operator, I didn't understand their point of view. They were trying to certify the hardware. They were trying to make sure the design worked. They had a design that had gone through many iterations and was actually being built, and the various parts had to go through testing and qualification analysis. Here are these operator guys, coming out and saying, "Well, should we open this valve 5 seconds or 10 seconds before the engine starts?" They didn't know, so they would have to go off and do a study or pull out some test data, which distracted them, I think, from their primary business.

There was always a little bit of, "What are you guys bothering us for?" We'd go off and write the procedures as we thought they should be, and we'd show it to them and they'd say, "No, you can't do it that way. Why did you think you could do it that way?" We had a good group of folks, but there were a lot of type-A people on both sides of that divide, and there was certainly some good-natured competition going on there, as well. They always considered that they were the real engineers and we were not really engineers because we were operators, which

we took great offense at. It was a good time and it was exciting, and I don't remember any real big frustrations, other than, "When are we going to fly?"

JOHNSON: Coming from an academic engineering background and being in school for six years studying engineering, and then moving to actually hands-on, on-the-job-type engineering, talk about those differences and what you had to learn, and what the differences were, for you.

HALE: What they teach you in engineering school is only peripherally important to somebody that's going to be an operations engineer. I had no courses in systems engineering, which is tremendously important, to understand how the fluid systems and the electrical systems and the computers and the thermal, how they all interact, and how you've got to design and operate all those things, or your system, in light of all of those different parts. We had a very traditional engineering state. We had solid mechanics and fluid mechanics and thermodynamics, and lots and lots of math, which I never used. As an operations engineer, algebra and trigonometry were my friend; calculus, we never used. Every year I was in college, we were required to take higher and higher level mathematics, and graduate school, the ultimate course I had was a course in solving systems of non-linear differential equations. Which may be of some use to somebody, somewhere, but I didn't even keep the textbook.

What we did in operations was so foreign to the academic study. Universities also, at least in graduate school, were interested in doing research and writing papers from the research, which I found not to be to my liking. I had discussions with my thesis professor about staying for my Ph.D., and all I could think of is, "Let me out. I've done four or five papers, six papers," whatever it was, "and had to write a master's thesis on my research, and that was enough." I

wanted out of the research and paper mill, and into something where there was practical, you could see what you were doing.

The engineering background was necessary. I certainly learned a lot more after I got out. I'm wondering if industrial engineering or something more aligned like that wouldn't be better for an operations unit, but NASA typically doesn't hire industrial engineers. They want the aeronautical or aerospace engineer, mechanical engineer, electrical engineer, and they don't teach those kind of, or at least in those days, didn't teach this kind of system-level things. Again, lots and lots of mathematics that went way beyond what we ever used.

JOHNSON: Going into propulsion, and, like you said, the other engineers looked at you as operators, I would imagine that your main focus was on the propulsion systems, as opposed to system engineering, where you would know how they relate. Was your main focus on the operations engineering, as opposed to systems?

HALE: We were trained early on in flight control that we didn't operate in a vacuum from all the other systems, our system worked in concert with everybody else's system. We all flew or didn't fly together. It became very important to learn about other systems. While you were expected to be an expert in the tremendous depth of knowledge about the propulsion systems because that was what we were asked to be, you had to understand how the electrical power systems work, how the computers work. We spent a lot of time studying the software and how it affected the different aspects of the job. Thermal systems, huge concern to us. Crew interaction displays and controls, checklists, flight rules, it was really operating your system in the context of the larger Space Shuttle system. It was never just enough to know your system.

We always felt like the engineers over in the engineering directorate had the luxury of really digging down deep in all the piece parts of their particular gizmo, and maybe not understanding how it fit into the bigger picture. I think the propulsion systems were particularly intertwined. Some of the other life support systems might have been less interactive across the board. We really had to understand the computer software in great detail, the electrical systems in great detail, and the thermal control. It was a good place to get an overview across the board.

JOHNSON: Speaking of software and computers, Mission Control had to be redesigned from Apollo to Space Shuttle. By ’78, when you got there, was that already done?

HALE: Yes, that was pretty much done. They had used one of the Flight Control Rooms for the approach and landing test, which had a very small team, and then they reconfigured for Shuttle Flight 1. Spent a long time talking about what they should call it—Shuttle 1, SS 1, for a while, I saw on checklists, people didn’t like, that had some connotations people didn’t like, so it became STS, Space Transportation System 1. Mission Control is one of those places where you continually diddle with the configuration and the exact nature of what’s at every console. By the time that we started the simulations in late ’78, early ’79, it was pretty close to what we flew the first Shuttle flight with.

The other thing that we knew was going to happen was we were going to fly classified flights for the National Security payloads. The third floor, they were early in the configuration to do all those things that they had to do to provide the security along with it. We’re going to have international partners flying international payloads on the second floor, and then these classified

flights on the third floor. That got very involved, in separating the systems and making sure there were the requirements for the security.

JOHNSON: I know you started training and simulating, and as you said, you went into those single-system simulators. When did they start, or when did you start, simulating the entire flight?

HALE: They started it in phases, so the Shuttle Mission Simulator in Building 5 came up. It had the capability to do certain mission phases—I believe they could do the orbit phase first, and they could do the entry phase, the orbit burn through landing. Later on, after some months, and then the delivery came when they could do launches, then you could start with the countdown. It sort of built up in capability over some period of time. I'm thinking it was close to a year from the time the first capability came on to the last set of capabilities. Even then, there were upgrades. I remember, we'd been simulating for some time, and we were in Mission Control one day, and the electrical power guy, the EGIL [Electrical Generation and Integrated Lighting systems engineer] sung out and said, "Main-C is down."

We said, "What is that?" We didn't know because we hadn't been paying attention because they could not, in the simulator, put in a malfunction in the electrical system for some period of time. When they did, all of a sudden, a lot of our electrical power valves and heaters and switches stopped working, we realized we didn't understand how we fit into the system. We got step-wise capabilities over a period of more than a year, probably two years, before we could do everything. Then, of course, the simulator kept growing in capabilities. They added the RMS [Remote Manipulator System], the arm, for STS-[2], and then we had different payloads that

were simulated, Spacelab, and so forth. It continued to grow in capabilities and you could do new things, but the basic capabilities, I think, were in place within about a year, 18 months of the first set of what we called integrated simulations, where we had a crew in the cockpit, Building 5, and the full Mission Control team in Building 30, and it began to look like you were really doing a spaceflight.

JOHNSON: You mentioned that the astronaut class came in, the ’78 class came in right after you did. That class looked a little different than the previous astronaut classes. There were women and minorities in those classes. Do you have any memories of them coming in and training, and how smoothly that went?

HALE: I wasn't involved so much in the initial training, the things like the survival classes, and those kinds of things. We would run into them in the hall and we would talk to them. I guess I’m a child of the sixties, and it didn’t really make an impression on me until people started pointing out, this is the first class that has women and people of color involved. I said, “Oh, yes, I guess that’s right.” It just didn’t click with me. Sometimes when you’re young, you don’t recognize these things. I didn’t foresee any real issues. I do remember, after every flight, the training team would put up little cartoons and quips and quotes about the astronauts at their landing. After they’d landed, there would be a welcome back, and there’d be this hall of funny little incidents that they’d put on the wall. That kept up all the way through to the last Shuttle flight, and I think, to some extent, with [International Space] Station.

STS-7, which, of course, was Sally [K.] Ride, first American woman in space, had gotten so much press about Sally Ride that when you came in the door to Building 4, they had a big

banner up that said, "Welcome home Cripp [Bob Crippen], Norm [Normal E. Thagard]," the five guys, "and what's-her-name," which was kind of a dig. But I don't think anybody really got upset about women or minority folks. It just wasn't that kind of place in the late seventies.

JOHNSON: Did you have women in your engineering classes?

HALE: Absolutely, I had women in my engineering classes. We had women in the group that I hired into flight control. Some were very good and some of them were maybe not so good, it was just like everybody else. You evaluated people on the basis of their capability and drive and ability to work with other people. I didn't see any 1950 kind of discrimination things going, and never did.

JOHNSON: Because you came in during Shuttle, you may not remember, but I thought since you mentioned that you worked closely with these Apollo veterans, was there a big difference between the way things were done during Apollo as opposed to the way things were going to be done during Shuttle, in Mission Control?

HALE: I think the computer capabilities had given us much more capability. It's a different mission going to a different place with a different vehicle, so the Shuttle, we all believed—now, I don't want to quibble with folks on what actually was going on—we were going to be flying every two weeks. That's what the popular press had picked up on. It was going to be like an airliner; we'll fly this vehicle every two or three weeks. We had plans where we would have one Mission Control that supported two or three or four Shuttles simultaneously in flight. We were

very excited about all of that, and that, of course, is extremely different. What actually came about was more like Apollo than like that vision, in actuality, where every flight was hand-designed, hand-analyzed, carefully put together, and the flights were months, generally, apart. More like Apollo, Gemini flights than it really was like this airliner kind of a conception.

JOHNSON: I know there were different positions because the Shuttle was a different vehicle, but was the decision process similar to what was going on, in Apollo?

HALE: I don't have any insight into the upper-level decision process. You need to interview Gene [Eugene F.] Kranz or somebody. What they did in Apollo was what they did then, and I think the upper-level, I did get a funny story, which is much later on in my career, when I got to be in charge of reorganizing the Mission Management Team. I asked Glynn [S.] Lunney, who instigated the Mission Management Team for Shuttle, how it all came about. He told me that one morning, he and Gene and Chris—that would be Gene Kranz and Chris [Christopher C.] Kraft—he, the Shuttle Program Manager, the head of Mission Operations, and the Johnson Space Center Director would meet for breakfast in the Building 11 cafeteria and talk about what was going to happen in the Shuttle flight that day. That was the Mission Management Team.

They kept getting bugged by these [NASA] Headquarters people who wanted to know what was going on. They needed to have a place, not to control things, but as an information exchange, to let NASA Headquarters and other folks know what was going on. They established this daily teleconference call, which they called the Mission Management Team, which was really a briefing to all these other people on what the Shuttle was going to do tomorrow or today. It morphed from there, the long history. It's kind of funny to say it all started with, "Well, we

would go check in, in Mission Control, and then we'd have breakfast together in the cafeteria and talk about what we should do." You should get Glynn to tell you about that—he does a better job of telling that story than I do.

JOHNSON: Let's talk about that first flight, and building up to STS-1. Did you work that mission?

HALE: I did. I was on the entry team. We had the pre-launch shift, so we came in during the tanking operations. Mission Control would come in roughly 12, 14 hours before launch. We had the pre-launch team that was there to watch the system activation, watch them load the external tank, chill down the engines, get everything ready to go. Then, about three or four hours before launch, we'd hand over to the ascent team, who was there for the final countdown, watch the weather, and then performed the ascent through the first few hours of flight. We had about an eight-hour shift. As I recall, we were launching not early morning, but mid-morning. I'd have to go back and look the time up. The pre-launch team, of course, had the overnight shift. We were there till 4:00 in the morning or 5:00 in the morning, we worked all night.

It was exciting from the standpoint that this was a real flight. After we'd done simulation, after simulation after simulation, had sat in the chair and watched the data, then we'd watched all of these pre-launch tests where the Shuttle was on the launch pad and they'd done a wet countdown and dry countdown and all these other tests, we felt like we knew what we were doing. There was just a tremendously different feeling in the air, that this is now for keeps, this is for real.

I think one of the things that was interesting is everybody dressed up. We would come to work and it was not terribly casual, but we didn't wear coat and tie. But, when we got to the real countdown on the real day, everybody came in like their Sunday best, and we're all dressed up. There was a lot more food, I think, in Mission Control, for some strange reason, than there had been before, and this air of, "This is real, we're going to really do this. This is exciting, this is the first time." I don't remember being scared—I think, looking back on it, I should have been because things could have gone not well. We were excited that we're really going to actually get to do this, and this feeling like, "I'm going to do my part and I want to make sure I get my part right. I want to do my work without an issue." Then, of course, the first countdown, went home, went to bed. My wife woke me up—I told her to wake me up to watch the launch—she said, "They scrubbed." They had the issue where the backup flight system didn't track, when they brought it up at T-20 minutes, brought up the computer systems to the launch sequencing, the backup flight system didn't track.

There was a bug. It took them a couple of days to fix that, and they uploaded a patch, and we'd try it again. It was kind of like that was a good rehearsal. We got all the way down to 20 minutes, and then didn't go, so we get to put people in, take people off. They had all the steps down, but that last 20 minutes. I remember I did the pre-launch thing, said to the folks on the ascent team, "Good luck." Went home, went to bed, then my wife woke me up and I watched the launch on TV. It was like, "Wow, I didn't know the solid rocket boosters would be that bright."

I think we'd all seen these—well, they weren't computer animations in those days—they were artist concept cartoon kind of drawings. It just didn't do the real launch justice. In a few hours, I had to get up and go take my shift in Mission Control. Things were not—I don't want to

say they weren't working right, but we found out that there were little signatures that the simulator didn't do exactly right. Things looked a little peculiar. We had some things going on that we hadn't really thought about. There was no show-stoppers or problems to speak of, but it was a huge learning experience on the first flight. I think that was true for people all throughout Mission Control, and the engineers. No matter how much ground testing you do, being in space is different. Doing that combined environment operation is different, and things don't always work exactly like you thought they would.

The flight was largely uneventful, and landed. The thing that you've got to remember about the early Shuttle flights is we did not have the TDRSS [Tracking and Data Relay Satellite System] network, so very much like Gemini more than Apollo, we were out of touch with the crew much of the time. We had the Worldwide Tracking Network, and we practiced really hard in the simulations. We'd be coming up on a tracking pass—what are we going to tell the crew? What's important to get on the telemetry, what kind of analysis? We've got 8 ½ minutes, and then it may be 15 minutes or an hour-and-a-half before we get to talk to them again, depending on where the orbital track falls.

We really worked very hard. "Okay, CapCom [Capsule Communicator], we've got this first, that second, this thing third, ask the crew this question. Let's get their report on what they've been doing." Very highly orchestrated. When we got the TDRSS satellites up—and we have virtually continuously comm [communication]—all of that, I don't want to say discipline, but all of the need for that discipline went away, and it became somewhat more casual because you had virtually continuous communication. Very little outage. The real question became, "How can I last till the little bit of loss of signal that I have with TDRSS, so I can go to the coffeepot or to my other business? Go to the refrigerator and get my lunch out because I've only

got three minutes out of the next three hours that we're not supposed to be glued to the data, watching the data."

We would dump the recorders, or the INCOs [Instrumentation and Communication Officers] I would say, would dump the data recorders over those ground sites in those early days. Then, between ground sites, they would play this data back. You always wanted to be watching that data to see if something happened. Maybe it didn't rise to an alarm value, but you're looking for trends in the data and how systems functioned. That took a lot of our time during the loss of signal. It was a little bit of a downtime, too.

JOHNSON: That first flight, though, went relatively smooth as far as what you were responsible for?

HALE: It did, it did. The most surprising thing that happened, I'll tell you this story, is I got a call. Ron Dittemore was on the launch shift. He was in the back room, we were all in the back room. I was on the entry shift, so I had the shift before him, if you want to think about it. I got a call from his wife—she called the console phone number. Nobody had cell phones, this is before cell phones. Even if you were allowed to use them in Mission Control, which we didn't, for a long time. They called the black phone number and said, "Can you come downstairs? It's Ron's birthday, I baked him a cake. Would you take it up so it'll be there? He doesn't know I'm bringing this in."

You had to have all kinds badging to get into Mission Control, but I went downstairs and met her in the parking lot, and we got this cake and brought it in. We had a birthday cake for Ron on his birthday, on April 13, in the middle of the mission. I think about that, we have the

anniversary every year, April 12 was the launch, and we landed on the 14th. On the 13th, I think, "Whoa! It's Ron's birthday, we should get him cake." It's a cute story.

JOHNSON: One way to remember.

HALE: Yes, I won't forget that. There's a lot of those little human element things that went on, too.

JOHNSON: In the entry, I know because they've had some issues with the tiles and everything, and that was always a concern, but that first entry, just talk about the atmosphere, what was going on.

HALE: That was probably the only time that I got concerned because we were busy. We were very busy in planning the de-orbit burn, making sure that the rocket systems operated properly, being prepared for anything that might go wrong, having all our checklists ready and back-up plans and calculations for if the orbital maneuvering system engine failed, we could back this burn up by doing with the reaction control system jets, and how would we configure this heat? We were very, very busy, right up through the de-orbit burn, which happened between the Australia Station and the Guam Station. We saw the first part of the de-orbit burn, they came over the Guam, and they reported, "Good burn, everything's normal." We got the data and we could look at the data.

Then, it was LOS, and they were into blackout. Loss of Signal, no telemetry, no communication with the crew. We were done because the flight was over and we didn't have

much to plan for. I remember thinking, "Oh, I hope those tiles work." This was the first time, and that was the only time that I would say my personal anxiety level over the success of the mission came up. Before that, it was all about, "Am I going to perform? How is my team going to do? How are we going to support it? Are we going to do a good job or not?" Then, we're effectively done, and you just got another half-hour, 40 minutes, to wait before they come to acquisition of signal off California coast—"Oh, gosh, I hope it all works right." There was a lot going on in that 40 minutes. Later on, when I was a flight director, we had the TDRSS satellites, we would maintain continuous comm, and you could see every little thing happening and what was going on. This was just, okay, they're on their own.

I remember that Crippen and [John W.] Young trained very hard to be able to recognize what part of the California coast they were coming ashore at because there were concerns about the navigation—would we be able to navigate, would they actually arrive where they were supposed to be? They spent a lot of airplane time, T-38 [training jet aircraft] time, flying along the California coast, memorizing landmarks, so if they came in north or south or something other than they planned to, how could they correct manually and get back to where they needed to be? They practiced a lot of landings at some of the other little airfields in California. If we couldn't make Edwards [Air Force Base] and we were 20 miles short, where do you land? We looked at every little airstrip. Not me, personally, but the planners did, every little airstrip that's out there in Southern California, could we land a Shuttle on it? Wouldn't that be a surprise, if you were out getting ready to take off in your Cessna and somebody said, "Clear the runway because the Shuttle is landing on our little strip out here?" It would have been really interesting. Of course, none of that ever happened, but they were ready for it.

JOHNSON: Talk about those first four flights before the Shuttle was considered operational. It was those test flights. Any other instances or memories you have of those?

HALE: Gosh, yes, a million because I was young and we were doing new things. In particular, I got moved up to train to be in the front room on the second Shuttle flight. We had enough mobility that people kind of bubbled up in the system pretty quick. I was sitting with Gary Coen and we had a couple of anomalies happen on that flight. I was OJT [on-the-job training]—they let me sit in the chair, but the senior guy was right there at my shoulder. We had some valve issues. No huge problems, but there were issues in our system that had to be solved. It was a very exciting time. STS-3 was the first long mission, more than a couple of days. The first two flights were 54-ish hours long, and STS-3 was going to be a week. "Oh my goodness! How are we going to stay in orbit for a week and do everything we need to do?" It was a thermal test, so we'd turn one side toward the Sun and leave it there for a day, and let that side get hot and the other side get cold, and then flip around and do the other side. We were watching all our heaters and the temperatures and all of these things.

I remember the thermal folks, we had the ECLSS [Environmental Control and Life Support System] folks who monitored the thermal environment. They had made a stick figure—these guys must have been from Louisiana—and they had a little alligator showing how hot they were getting. It was the "thermagator," and so for the flight director to look down, the thermagator would be going up or down, depending. It's silly stuff.

We had a really interesting interpersonal relationship thing happen on the third Shuttle flight. Flight directors are competitive—they're like astronauts—so there's a lot of competition. The orbit ii team was run by Don Puddy, and there was a great deal of rivalry between Neil and

Don. Saw this all the time; not always as polite as one would have wanted. There was an issue during the flight, they had to re-do the flight plan, which is something that we learned you almost always wound up doing. Early on, we kind of thought, "We have a plan and we're going to stick to it." They had a real issue with the plan.

I was on the planning team, and the first thing that went wrong, I think Don Puddy's team changed the plan and Neil Hutchinson's team came in, and he did not like the way they had changed the plan. There were words. The lead flight director, among his other duties, controls the shift handover schedule, so if you're changing the plan, you'd have the shift handover schedule, which is on a phone that you call in on the recorded phone number. "When am I supposed to come in," and it could change, and maybe you'd need to be there half an hour early, maybe you'd be there an hour late, from the pre-flight published plan.

He put a plan on the recorder that never had Don Puddy's team on console. For like four days, it was the orbit I team, Neil Hutchinson's team, and the planning team, which was Tommy [W.] Holloway's team that I was on. We would work 14-hour days or something. He would come in and they would do all the stuff while the crew was execute, and our team would come in and we'd watch the crew sleep, and maybe wake up in the morning.

This went on for several days. There's probably a sociological study in here. At the end, we put a big sign up in the back of Mission Control. They had the cameras, you could see Mission Control, there's a blind spot in the back where you could put things where the cameras could not see, very important to know that. We put a big sign up, "Welcome back, entry team," after three or four days that they had not had a shift. They were literally off the flight.

During that time—I'm going to get in so much trouble from this—there's always food in Mission Control, and on the night shift, the orbital mechanics works out that frequently, you only

have one pass in orbit, so we would have a five or six, seven-minute data pass at Santiago, Chile, and then it would be an hour and a half with no comm with the crew until they came back to Santiago again. The AGO to AGO passes, and it was very quiet. Think about it: middle of the night, no data coming in, it's kind of like, what do we do now? One of the big activities in Mission Control is food, it always has been.

One night, the team got together and talked Tommy Holloway, the flight director, into having an ice cream social. We cleared off all the consoles down in the front row, the FDO [Flight Dynamics Officer] and all those consoles, and they brought in all these gallons of ice cream and syrup and chocolate and strawberries and bananas, and we had an ice cream social. It was a big deal. When we got all done, there's this huge mess. Took us quite a bit of time to clean this mess, sticky stuff all over. I can't believe we did this.

In the morning, then, when Neil Hutchinson's team was coming back, the only thing we really had to do all night, watch the data, make sure everything's okay, but put together the next day's plan, minute by minute plan, that the crew is going to execute. We failed to get that plan complete before the lead flight director's team came in. We heard about that, so that was the last ice cream social, ever, that I know of. There may have been others—there's always food—but we never did that again. That's one of those things that as the planning team, you always want to make sure that the plan is done and complete before the lead flight director comes in, and he always comes in early.

George [W. S.] Abbey was notorious for showing up at about 2:15 in the morning. He would come in, and you could almost set your clock by him. He would come into Mission Control about 2:15 every morning, and sit with the flight director. Later on, when I became a flight director, it was, "Good morning, Mr. Abbey, how are you? Everything's quiet here. What

would you like to know?" You could almost set your watch by him, it was very interesting. The rest of the Management Team would start showing up 6:30-ish and it would get really busy. The planning team flight director, planning team, had complete control of the nation's space program for about seven hours. Nobody was there in the middle of the night to tell you, "Don't do something." When the first manager showed up, you were done, and it was, "You did what in the plan?" "Okay, let me explain." It's a great job. I loved it.

JOHNSON: Do you have any idea why George Abbey chose 2:15 in the morning?

HALE: There are some rumors, but I'm not going to go into them. I think you can correlate them with other sociological data in the area and what might be going on, but yes, he would show up in the wee hours. First, when he was the head of Flight Crew Operations, and then when he was Center Director. It's the same pattern.

JOHNSON: There were a lot of firsts going on during this time, of course, after the first flight. STS-3 landed at White Sands [New Mexico]. There were several others, and as you mentioned, STS-7. STS-6 was the first [Space Shuttle] *Challenger* flight. Talk about some of those firsts, bringing the newer Shuttles on.

HALE: I would go back just a second to STS-4 because I think that was a really critical flight. It was the first time that we're going to land on a concrete runway, we're going to go to Edwards Air Force Base, and it's the only flight that I know of that the schedule was dictated by politics. There's a lot of discussion about different flight schedules, and maybe there were things that I

was unaware of. Harold [M.] Draughon, who was the flight director, was very open about the fact that he told us that the number-one flight rule is we would land on the Fourth of July at Edwards Air Force Base, and no matter how long the flight was, we would land on the Fourth of July at Edwards Air Force Base because the President [Ronald Reagan] was coming. The widespread expectation is the President would announce that NASA is going to build a Space Station, July 4, 198[2], that we would be allowed to build a Space Station.

Sure enough, flight launched on time. We did the fully planned mission, we landed July Fourth at Edwards Air Force Base, and rolled to a stop. President Reagan and Nancy [Reagan] were there to greet the astronauts when they got off, and there was a nice ceremony. We all sat in Mission Control. Usually, after the crew gets out of the Shuttle, Mission Control is done, and we clear out. People were tired, you'd take your books back to the office, your documents that you would analyze the next work day, and we'd go home. This time, we all sat and watched on the big screen. The President made a very nice speech and did not announce the Space Station. We were all sorely disappointed, so that was a huge thing.

STS-4 also marked the first time that we worked with National Security Space [Johns Hopkins Applied Physics Laboratory] because they had a payload complement that was on board that was, at some level, considered security. It was a milestone in that regard, and got much tighter. It was a real silver lining on the black cloud, I guess, that after *Challenger,* [accident, STS-51L] the National Securities payloads went away. NASA is not set up, not physically, emotionally, or culturally set up, to do National Security operations. We do, and we do it about as well as it probably should be done. Folks tried really hard, but it just wasn't natural for us to do that. We did get a lot of good people.

We worked very closely with the Air Force. They sent a whole cadre of flight controllers—detailees, they called them—the Manned Spacecraft Detachment. We got some very, very good people and they helped us out a lot. I know General Willie [William] Shelton, who's currently the commander of U.S. Space Command, four-star general, he and I worked together in Mission Control on early Shuttle flights. Great guy, and other people, we really got a lot of help from, but I wouldn't go back to those days. It was just very odd, very difficult for us to fit in that environment.

JOHNSON: The training or getting ready for those DoD [Department of Defense] flights and those type of flights was completely different.

HALE: Right, and learning how to keep classified documents in secure locations, and who you could invite to meetings, and having guards at the door, is just very, very odd. For most of our work, it was very open and the public's invited, and we tell everything about everything that we know. Then, here we go, we can't say anything about anything. It was just a real cultural problem for us, and STS-4 marked the first one of those. I, personally, didn't get real excited about the new Orbiter. That also happened when STS-4 landed, as [*Challenger*] was at Edwards and was taking off on the Shuttle Carrier Aircraft. That was part of the whole show on that Fourth of July, was that yet another Orbiter, having come out of the factory, was headed toward a launch site.

Discovery, from my systems point of view, *Challenger*, *Columbia*, were virtually identical in the propulsion systems. They had different weight, they had some new this and that, but they weren't different in the propulsion systems. We were very worried about our small

thrusters. We had, on the reaction control system, 38 large thrusters and 6 small thrusters, the vernier thrusters. The original design intent for the verniers is that they would only be used for fine-pointing exercises, for short periods of time. It was less gas consumption and less propellant consumption to use them for attitude control all the time because the big thrusters were actually oversized for that, and so they were somewhat inefficient. You would bing back and forth, and they were loud and they'd keep the crew awake, and various things, when they were trying to sleep.

We started using the vernier thrusters all the time, and we literally were wearing those things out. The engineering team had to figure out how to redesign the coatings on the rocket engine throats and install those, and we had to keep track of lifetime on those thrusters, and total number of pulses, which is hard to do. Those little thrusters were working all the time. We had a number of issues in those days to work through.

JOHNSON: Any issues with any of your systems from landing at White Sands, on STS-3?

HALE: Everybody talks about how terrible White Sands was—I actually read a report, we carried an experiment called an IECM, Induced Environment Contamination Monitor, in the payload bay of the Shuttle for the first four flights. The payload bay that was the cleanest was STS-3, in spite of the sandstorm that happened after landing and all the tales you hear about the gypsum dust and so forth, the payload bay was the cleanest. Even more than STS-4, that landed on a concrete runway on a perfectly calm day. I don't know how that happens, but that is the technical fact.

I grew up in New Mexico. I knew that landing in New Mexico in the spring was going to be a challenge because it is a very windy time of year, there. That's just when the winds kick up, March and April. It was no surprise when we had to waive off the first landing because the wind was so high. We had a good day, we landed, and we all went home.

Then, the next day, before they could get the Shuttle undercover, as it were, they had this big sandstorm. They hadn't brought the right equipment to protect the Orbiter, so they got a lot of fine gypsum, talcum-powder-like dust in all the little crevices. They had thrusters that had to be removed because the very small passageways in the injector of those engines got clogged. There was a lot of clean-up work.

I know, learning from that experience, the folks out at White Sands, which we carried as a third-level backup planning site for the duration of the program, always made sure they had the protective covers in hand, which they didn't for STS-3. They poured a concrete pad that was off of this gypsum lake that they could tow the Orbiter to, to get it out of the wind and out of the gypsum dust. I always thought that if we ever needed to land at White Sands again, it wouldn't be as huge a deal as it was that first time because we didn't prepare properly for it.

We only made one landing out there. White Sands was a challenge because of the altitude of the landing site. It's the highest, it's about 4,000 feet above sea level, and California's Edwards Air Force Base, 2,400, if memory serves right. Of course, the Shuttle Landing Facility [Florida] is sea level. Gliders fly better when they have thicker air, so White Sands did represent a challenge, but it was a perfectly fine place to land.

STS-9 was the first Spacelab flight. That was a very important flight. We had a very long flight, it was an eventful flight. We had a fire in the back end of the Orbiter, post-landing, when the auxiliary power units [APUs] had some problems. The hydrazine-powered turbines

that pumped the hydraulic, we learned a lot about that. We had two computer failures in flight just before de-orbit, and we had to deal with that. There was more excitement on that flight than we should ever really have again, and we learned a number of lessons in how to prepare the vehicle.

I think there's a KSC [Kennedy Space Center] Orbiter project, how do we prepare the vehicle better? They had some issues where little pieces of solder—some of the electronic boxes, if you look at the circuit boards, there are all these little soldered connections—some of these little pieces of solder had broken off and floated around in zero gravity and caused short-circuits and caused two computers to fail out of the five. One, we recovered, one, we didn't. That was high risk. Then, these auxiliary power unit problems that really was quite scary.

We didn't realize what was happening, I don't think, at the time—at least, I didn't—post-landing, we were done, the propulsion system was turned off, all the valves were closed, we were safed, and all of a sudden, the MMACS [Mechanical, Maintenance, Arm and Crew Systems] guy, the APU hydraulics guy, was saying, "We've had some problems." Just at the time the crew was just about to turn them off, they detected that there was fire going on back there because hydrazine was coming out. We had to redesign after that.

STS-8, the mission before, was the first night landing. That was a huge deal, trained very hard for the night landing. Dick [Richard H.] Truly was the commander, and the thing I remember most about the landing for STS-8 was it was the middle of the night. It was 2:00 or 3:00 in the morning when we landed. Whenever we had landed a Shuttle flight before, it was always middle of the day, and you've seen the pictures from Apollo, where they had a splashdown, immediately Mission Control is filled and there's this huge crowd of people. I

wouldn't exactly say party atmosphere, but along those lines. We'd have not just the people who had been working in Mission Control in the shift, but all the management.

When we landed STS-8, it was 2:00 in the morning. We got all done and they said, "Okay, unlock the Mission Control Center doors and let people in," and nobody came. It was like, here we are. We all put our stuff away and went home, and the party didn't happen till during normal people time. All of that worked the entry were kind of, "Where is everyone? What did we do wrong? Where's the party?" That was something that changed. Those post-landing celebrations decreased over time, just as a natural course of events, I think. The real shocker was on the eighth flight, nobody came. Everybody stayed on and watched it on TV.

JOHNSON: [STS-]41-B was the spacewalks, and the first landing at Kennedy.

HALE: 41-B I remember because that's when we had the MMU [Manned Maneuvering Unit] flight, and that was very famous. We tried to do a spacewalk on STS-5, I believe, and the spacesuits did not work. We found out some things about the EMUs [Extravehicular Mobility Units (spacesuits)] on that flight that was unfortunate. The first time the EVA [Extravehicular Activity] guys actually sat on console in Mission Control and they didn't get out the door. They were very disheartened. I think we did a demonstration on [STS-] 6, and the suits actually worked, and that was good. Then, we had the Manned Maneuvering Unit checkout flight, on 41-B, which was going to be STS-[10]. We changed the numbering system because people didn't like STS-13, which is a whole other story.

It all came about because we were beginning to publish flight rules and other documents that said "STS-13," and all of a sudden, it came down on high that we were to have this new

numbering system. It would start with STS-[10] being STS-41-B, and so the numbering scheme was really strange, if you think about it. The first digit is the fiscal year, in the eighties, in which the flight was originally manifested to fly. Not necessarily when it actually flew, but when it was originally manifested to fly—it was going to fly in ’84—1 for Kennedy Space Center, we actually did some training for 62-A, 2 being Vandenberg [Air Force Base, California], we were going to fly out in Vandenberg in those days. The second digit was the launch site. The third digit was the order in which, again, it was originally manifested in the fiscal year, so, A, B, C, D, E, F, G, whatever.

I keep thinking, what would have happened if we had kept going into the nineties with that numbering scheme? We would have the same designator show up again. It was just nuts, and people never understood it. After *Challenger*, of course, we went back to good old STS-whatever number. They didn’t always fly in order because flights change around. I really do believe that it was because people didn’t want to see STS-13. Apollo 13, of course, had some interesting things happen. I’m not superstitious, but somebody must have been. That’s a digression.

STS-41-B was notable because it was the first landing at the Kennedy Space Center on the Shuttle Landing Facility, which was really important for the program. We had this MMU flight, which was the Bruce McCandless picture and the MMU was a classic, always will be. I always felt sorry for the second guy, Bob [Robert L.] Stewart, who also flew out. Nobody looks at his picture.

We learned some things about the Manned Maneuvering Unit. We really only used them for about three flights, and then decided that there was more risk inherent in those devices than we really cared for. They were retired, and a second generation, if you will, that’s for emergency

use only, the SAFER [Simplified Aid for EVA Rescue] units, were developed when we got to the Space Station. If the MMU failed, ran out of gas, whatever, the theory was, well, the Shuttle could fly over and pick the guy up, which we could, until you were docked to something like the Space Station and you could just go get somebody. The MMU had a number of single-point failures in it, which was very risky. As a PROP guy, we had to always budget in enough propellant. We have to give a go or no-go for MMU free flight. If we did not have the requisite amount of propellant to go rescue somebody and then safely come home, to de-orbit the Shuttle after that, we would give a no-go.

We never did—the Shuttle always had propellant—but 41-C, when we went after the Solar Max [Maximum]Satellite and the device that Pinky Nelson, George [D.] Nelson, had to latch on to that flight didn't work, and tumbled the spacecraft and tumbled him, and all of a sudden, we were off to the races. That was really a scary time. We could have run out of gas. Bob Crippen did a masterful job of keeping him in view, and of course, he was able to break off and fly back to the Shuttle and we recovered him. That was very scary, on a flight that had gone so perfectly normal and everything was working just exactly as we'd planned, and we sent George Nelson out with this capture bar, and he gets close to the Solar Max. All we had to do is latch on and life will be good, and then, boom, things just changed in an instant.

We were hosing out propellant, gas gauge was going down, visibly, and we didn't know where he was. It was really chaos, almost chaos, and that was scary. That, I think, was not the last time we flew the MMUs, but I think that signaled to everybody how dangerous that particular device was, and how we needed to be more careful. I think we only had one more flight, 51-A, that we used the MMUs. As a PROP guy, I was happy, because we were always worried about it.

JOHNSON: That's something that the Shuttle did more frequently. They released satellites, but they also did those service calls.

HALE: The Shuttle was going to do everything for everybody. Originally, they were going to retire all their U.S. launch vehicles and launch all satellites—science, for NASA, commercial telecommunications satellites, and National Security Space payloads—from the Shuttle. It was going to replace everything. After *Challenger*, of course, the President decided that that was not a good plan. I think the National Security Space people were actually pleased because they like to control their own destiny more than having to deal with NASA. The commercial guys, I think, it's not clear how we were charging the commercial guys. I wasn't involved with them, but frankly, they were getting a subsidized ride, and if they were charged full cost, they would have never flown on the Shuttle because it was just too expensive.

It fell back to just the science, really, that NASA wanted to do. Build the Space Station, very important payloads like the Hubble [Space Telescope], Compton Gamma Ray Observatory, Chandra X-Ray Observatory, and so forth. It was going to be everything for everybody. We were going to not just launch the satellites, we're going to retrieve satellites and service them.

The Solar Max mission, [41]-C was the first demonstrator of servicing a satellite. It was very successful. There are certain things you can do for satellites in Low-Earth Orbit. I remember the Intelsat rescue [STS-49], where they had suffered an upper-stage failure, Intelsat [VI]. While it wasn't our primary mission, it became the star of the mission. The primary mission was another payload, and we took care of our business first, and then went to Intelsat and hooked them up with a new rocket stage. That whole story is a very interesting story as well

because, again, we had a capture device that didn't work, and we had to re-plan on the fly to retrieve that satellite. Our only three-person EVA, ever.

We had a lot of stories like that, where things did not go well and Mission Control had to re-plan them, but not as dramatic, perhaps, as those couple of flights. We really did some broken field running in those days.

We were going to service satellites, and I still have a mixed emotion about servicing satellites. Most of the satellites that need serving are at geosynchronous altitudes, which the Shuttle couldn't reach, so you needed a tug. Early in the program, we were going to build an Orbital Maneuvering Vehicle, OMV, was in the program and it was going to go up and rendezvous. Carried up by the Shuttle, go get the satellite, bring it back to the Shuttle, and then we could service it. That got cut out for budgetary policy reasons and never came about, which is too bad, because that would have been a great capability.

We did a propellant servicing demonstration on STS-41-G. That was Kathy [Kathryn D.] Sullivan, and he was the chief of the Astronaut Office for a while—I'll think of his name in a minute. It's terrible to get old.

WRIGHT: Dave [David C.] Leestma?

HALE: Dave Leestma, thank you very much. Dave Leestma went EVA, and a pallet in the Shuttle payload bay connected up the connections, demonstrated a propellant transfer, and what we called an Orbital Refueling System. Which we kept in bonded storage, I think till the end of the program, on the hopes that we would have the need to go fill satellite propellant tanks with hydrazine. We never used that. I don't know where that wound up. Hopefully, some

appropriate museum's got it displayed. It was a pretty intricate piece of work, the payload that we carried, just for a demonstration. Really, the servicing went down to the Hubble, and of course, we were very successful in fixing the Hubble, updating the Hubble systems. Still up there, going strong. We hope it goes strong for many more years. Returning a huge amount of scientific data.

I keep reading that some of these new, huge telescopes that they're building on the ground are going to exceed the Hubble's capabilities, but they have to see through the atmosphere, and that's a big challenge. We'll see how their adaptive optics really work, and whether they do a better job. James Webb [Space Telescope] will be an infrared telescope, which should have much larger aperture and see many different things, but it won't be the same as the Hubble, which is visible light, like what we'd see if you put your eye to the eyepiece, as it were, at the focal point. I think the Hubble will be unique for a long time, and we did five servicing missions to the Hubble. Immensely successful. Not without their challenges, either—finding doors that don't open on satellites that have been up there for a long time, or you can't get them closed and latched, and parts that wore out sooner than they thought they would, rate gyros and so forth. It's a good demonstration.

Someday, perhaps, we'll do more. Right now, the transportation cost makes it cheaper to just fly a new satellite than to try to service one that's already up there. I know that we're doing work on the International Space Station, in hopes of demonstrating some servicing task. I think DARPA [Defense Advanced Research Projects Agency] has got a project to do, demonstrate satellite servicing. People remain interested in it, but the economics have to prove out.

JOHNSON: As a sideline during that time period, you were also doing some college recruiting. Talk about that for a minute, talk about that experience and when you went to colleges, where you went and what exactly you were looking for.

HALE: We were hiring, in the eighties. I was a first-level supervisor, starting in about ’84, ’85. I’ve got to think about that. I think ’85, I became a first-level supervisor. The human resources team sent recruiters to many colleges, and Rice University, my alma mater right here in Houston, was one of those. When I found out they were sending college recruiters, I volunteered and said I would like to go do that. For a period of, I don’t know, six, eight years, I went every year to Rice, and they would typically have a career fair at Rice. I would gather some of the other Rice graduates that I knew at NASA, and we would go pass out brochures and have a little booth and talk to people about it. Then, I would go and I tried to recruit other people to go, but it was typically just me, going to do interviews.

We would schedule through their placement office, graduating seniors or graduate students who are going to graduate in six months-ish, and we would interview. Get résumés and interview. Frankly, there were several people I interviewed that if we didn’t get to hire them at NASA, we passed their résumés on to some of the big contractors like United Space Alliance, it was Ford and RSOC [Rockwell Space Operations Company] in those days. They were hired on, and some of those people actually got converted from contractor to civil service later on. We did a fair amount of recruiting.

It was a little bit hard because, again, you couldn’t interview foreign nationals. We were restricted to American citizens only. We were only interested in certain engineering degrees, so you’re restricted that way, but I always had a full slate of sign-ups. It was very interesting to talk

to the young people and gather their résumés and write up the interview results. I was always disappointed we couldn't hire more.

We were in the spot at Johnson Space Center of hiring, I would say most of those years, less than 10 new civil servants a year. The first job offers would go to the cooperative education students, and so any college recruiting was very limited. We recruited from a number of schools—Notre Dame [South Bend, Indiana], Purdue, a number of schools, Texas A&M [College Station]—and if you got one civil service hire out of a week's worth of effort, then you considered that as a good accomplishment. It was a good thing to do. We stopped doing it when the hiring freeze went on, at some point in the late eighties, and that was the end of that. I don't know if they've restarted that now. I suspect they probably haven't because the civil service workforce is in a reducing phase rather than an expanding phase right now, at least at Johnson Space Center. We would occasionally have somebody that was interested in another space center, and we'd try to forward the forms appropriately. I never heard how that ever turned out.

JOHNSON: Do you notice any difference over those six to eight years in the students that you were talking to, as far as their expectations for working for NASA?

HALE: A lot of the folks that we talked to had very little understanding about what we did. Again, this goes back to the university environment; they had been taught research, that's what we do in the university environment. We're going to do experiments and write papers and do research. They wanted to come do research, and I would have to explain that Johnson Space Center is not a research institution. If you want to do research, then Ames [Moffett Field, California], Glenn, Langley [Hampton, Virginia] Research Centers might be more what you're

interested in. A lot of them went away a little unhappy that they weren't going to win the Nobel Prize doing research for NASA.

In Houston, recruiting's always tough in the engineering field because the petrochemical business is so big, and their salary offers are so much higher than the civil service salary offers. You really had to find those few people that really, like me, would work for NASA for much less money than they could get if they went to work for Exxon or Shell or somebody like that. Those people recruit very heavily, they were always recruiting. I know when I'd go to the placement office, I'd have one room for two or three days. You would see these other big engineering firms, Bechtel or somebody, come in and they would have 10 recruiting rooms for two weeks, and they would talk to everybody. It's difficult to compete with that.

JOHNSON: I was curious, you mentioned that those flight teams, when you formed them at the beginning, that it was rare to switch. Did that carry on for those first 10 years?

HALE: No, after the first flight, it was kind of fruit basket turnover. Some of the older folks were promoted or retiring or this or that, and there were lots of new slots. People bubbled up, and it became all about filling out your teams, making sure you had the best-qualified team. I know as a first-level supervisor, I worried about the teams that I would field for the PROP [Propulsion Systems] Section, in the sense that I always wanted to have somebody with experience to counterbalance some newer person. We had a good feel for who was a top performer and maybe who was not quite such a stellar performer. You tried to mix and match, so that you didn't have a team that was just totally weak. You'd like to have a team of all

superstars, every position, and then we got into the flights coming so close for a period of time that people couldn't work every flight. You would have to stagger people off.

It was really mix and match, and this whole kind of flight control color team that came out of Apollo, that people had great identification with their team, and there was this inter-team rivalry, I think that just disappeared very quickly, certainly by STS-3, probably by STS-2. People just went wherever there was a vacancy, wherever they were assigned. We always had the continuing tension between the line supervisors, of which I was one for a few years, and the Flight Director's Office, who had to accept these teams. Your line supervisor would say, "Well, your front room operator at position X is going to be so-and-so," and as flight director, you'd say, "Great," or you'd say, "Ugh." Then, you'd go try to negotiate to get the great guy on your team—guy or gal—and "ugh" guys could be on the other flight director's team. People moved around a lot. We started selecting the very best and brightest to the next class of flight directors, or going on up in the management in different positions, branch chief, division chief, what have you. Then, we're bringing new people in.

MOD [Mission Operations Directorate] is interesting because we had this badge-less society, where we had our support contractors. Later on, it was United Space Alliance, but in the early days, it was the various contractors. We actually had a number of contractors—Ford, who's a big one—that supplied people to us. We treated everybody the same. Early on, there was a principle that you could not put a contractor in the front room. You wouldn't put a contractor on the console in the front room because he might be supervising civil servants in the back room. We very quickly had to break that down—we just didn't have the luxury of not doing that. Sometimes, the contractor was the better operator, certainly the more experienced

operator, and we're bringing in new kids into the civil service ranks. We just had to do those kinds of things.

That skirts a little bit around federal HR [Human Resources] rules because technically, a contractor's not supposed to supervise civil servants, but we did what we had to do. I don't know whether there were some things that we had to mind our Ps and Qs on so that we never got in trouble with HR, as far as I know. We didn't want to find out. Everybody was kind of aware that we were on this marginal ground, so we're trying to do our best. The really good thing about a contractor is if they really didn't perform, then they would be gone. As a civil service supervisor, you could go to the contract manager and say, "So-and-so is not performing; I think he needs a new opportunity," and they'd be gone. You didn't do that very often because then you'd get back-filled and you might not get any better on the back-fill, but you did it when you thought it was necessary.

Whereas the civil service people, it was much more difficult to have an adverse work action on a civil service person. It could be done and I saw it done, but it took a lot of documentation and it took a lot of time, took a lot of energy in the supervisor's part. Supervisors, if they had a problem child, would always try to get them transferred someplace else, which was not an adverse work action. It was just a transfer. Yes, it really was, so it was kind of interesting.

To be in flight control, you had to have certain skills, certain characteristics. One of those was you had to be able to communicate very well orally, think ahead and communicate very well. We practiced very hard at that. There's some people who are very good in a lot of respects that just don't have that capability, in a pressure situation, to think through, organize their thoughts, and then coherently communicate orally. Huge part of the job. There are some

people that we actually thought very highly of, but we had to outplace them, send them to some different part of the organization, out of flight control, because they couldn't master that skill. Or, they'd get flustered in a time crunch. Somebody might be a very good, great engineer, but can't handle time pressure. Mission Control is all about time pressure, and those people that do well in Mission Control thrive on that. People that don't thrive on it don't do well. It may be a little different in Station, but I don't think it's a lot different.

JOHNSON: Definitely not something that's taught in engineering school, I would think.

HALE: No, no, so when I went recruiting, we would look for those people. I'm thinking I'm recruiting for Johnson Space Center, but in my heart, I'm really recruiting for Mission Ops and Mission Control. I would look for those people that had those extracurricular activities and things that demonstrated they could have leadership abilities and communication skills. That's hard to find sometimes, among engineers.

JOHNSON: Yes, the more well rounded students, sometimes. Those first flights before *Challenger*, you worked, in your résumé it said 15 flights up through *Challenger*?

HALE: I'd have to go back and check, but I think that's about the right number. It started with STS-1 and I did not work 51-L. I got to be a supervisor and I worked in a supervisory role in what Spacecraft Analysis Room, SPAN Room, which was interface between Mission Control and the MER [Mission Evaluation Room], the engineering organizations one flight. I worked as

a PROP officer for a number of flights, and the number 15, before I became a flight director, rings in my hand. I'd have to go back and check, though.

JOHNSON: You also worked that flight right before *Challenger*, just a couple of weeks before *Challenger*.

HALE: That was when I was in the SPAN Room, 61-C. It was Congressman, in those days, [Bill] Nelson was on that flight. Charlie [Charles F.] Bolden was the commander, made a great spacecraft commander. When I say I worked it, I had a shift in Mission Control, and when the operations team would need some detailed analysis or detailed information that they didn't have in hand that the engineering organization could provide, we had a mechanism to write a request—it was done on paper in the early days and it got to be electronic later on—but write a request, "We need some information, can you analyze this situation? Do you have some test data that tells us how things are going to perform under these circumstances?" Send it to the Engineering Team in the MER, which was in Building 45, in those days, and they would go off. They had to budget with their contract vendor supporters that they could go dig through the archives, or maybe run a little quick test, do an analysis, and come back with some data for the flight control team to use.

That was my role in 61-C. I wasn't in the front room, I wasn't directly in the PROP area. I was looking out for all the systems guys. Systems guys, power, thermal, computer, comm, propulsion, as opposed to the trajectory guys, who wouldn't have that kind of interface. They have different interfaces. I did that flight and that was a very interesting flight because it took us a long time to get it off the ground. We had a number of issues on 61-C. Was that the one that

Steve [Steven A.] Hawley was on, where he wore the Groucho Marx mustache and glasses out to the launch pad so the vehicle wouldn't recognize him? I think it was. We just had weather and we had technical issues, and it had got delayed from November/December to January. It flew very early in January, and then 51-L, of course, right after that. I didn't have an assignment on that flight, but I was a supervisor and my people were on that flight. It got delayed a couple or three times, and then we had a very unhappy day.

JOHNSON: Go ahead and talk about *Challenger*. Where you were and what you remember about that.

HALE: My guys worked the pre-launch on the day before when we tried the launch. They had an issue trying to get the hatch closed. The side hatch that the crew boards in, for some reason, they could not get the hatch to latch properly. I don't remember the details of the situation, but I remember they sent for a power tool, a power screwdriver, to actually manipulate the mechanism somehow from the outside. They got the power screwdriver out there and the battery was dead. Of course, you're four miles from where they have the batteries in the launch pad and the elevator, and we ran out of launch window. They had to scrub for the day and get the crew out.

I remember my senior contractor who was on that launch team, in the propulsion area, Mission Control, coming back and saying, "This was the anniversary of the Apollo fire." By the way, the Apollo fire is mythic status, and it's one of the first lessons that new flight controllers are exposed to when they come into Mission Operations. It's, "We don't want to ever to do that again, and here's how we screwed up, and we want to make sure you never make those mistakes." He says, "It's the anniversary of the Apollo fire, and this was so stupid, and this kind

of stupid stuff is going to get somebody killed." That has rung in my memory ever since because the next day—and again, I was a little disconnected, so I knew the weather wasn't good but I wasn't really paying a whole lot of attention—the weather forecast was very cold. They had icicles on the launch pad.

They got ready to go launch the next morning, delayed the launch for some couple of hours to let the sun come up and melt the icicles on the launch pad. I remember thinking in the back of my mind, "This doesn't look real smart. Couldn't we just wait for another day?" Here I am, first-level supervisor, I didn't have any input in the process. Maybe some of us should have joined together to say something. I was in meetings up on the third floor of Building 4 with the astronauts. We're working on flight rules or checklists. We took a break when the countdown resumed at T-9. The corner office had been converted to what they call the astronaut library. It was just an office room, but it had a table and all these bookshelves with all these books in it. It had a television, which we didn't have TVs in everybody's office in those days. They were fewer and far between.

We went in to sit and watch the launch. I was sitting right next to Roy [D.] Bridges. We watched the launch and what happened, and then we all kind of went out and said, "What do we do now?" We knew Mission Control was on lockdown. I had one of the wives of one of my flight controllers call, "I can't talk to my husband, he's diabetic, make sure he's got what he needs."

I said, "I know he's got what he needs because we talk about that before every launch, and he'll call you as soon as they're done." It was several hours, and they all came trailing back across the pond. Building 4 is on the southeast side, and Building 30's on the northwest side of

the central mall there. We walked by the duck pond, and they came really dragging in. It was very emotional. We really did a lot of counseling for which I was not trained.

I don't know how the organization thought through dealing with the tragedy, but we had no training and we didn't have grief counselors and we didn't know what to do. It was just kind of, "Tell us how you're doing. What can we do?" Maybe that's the best you can do; I don't know. Nobody expected it. We'd launched [24] in a row. We'd had a number of close calls, and the 25th one was the one that didn't work. Nobody thought that. We all expected, if we're going to have something bad happen, it would be in the first few, even though we all knew that it was still risky business. It used to irritate me when people would say, "Well, we're operational now," after STS-4, because in my mind, at some level that I probably couldn't have articulated in those days, I knew that we were not operational in the sense that people outside would think we were.

It goes back to that, "We're going to fly every two weeks, it's going to be like an airliner, we're going to carry Walter Cronkite and John Denver and different people, and it'll be just as routine as getting on the plain and flying to Dallas. Anybody in the program knew that was poppycock. It was a nice goal, but somehow that story percolated. I'm not going to speculate on how it percolated, but it got into the public perception, and that certainly was the public perception, that that was going to happen. We didn't know how we were going to get there. I know in 1985, in that 12-month period, we flew 9 flights, which was the most we'd ever flown, and we were working harder than we had ever worked. It was extremely busy, and for 1986, I believe the goal was 15? Might have been 12; I think it was 15, though, that we were going to fly. We did not have a clue how we were going to support that many flights.

I know the training team, the wheels were about to come off because the schedule to get the crews in the simulator and the Mission Control team all tagged up, it just was almost intractable. We needed more resources, we needed more training facilities, we needed more planning tools, which we didn't have. We were so concerned about our little corner of the world in Mission Control that we really couldn't pay much attention to what was happening at the Cape [Canaveral, Florida] or at Downey [California] or at [NASA] Marshall [Space Flight Center, Huntsville, Alabama] or out at Promontory, Utah, for that matter. It was very difficult to image how we're going to fly that flight rate. That was leading up to, I think, 24 or 26 flights a year, we were supposed to get to.

We had real problems with the Vandenberg operation, which we'd started the first training sessions for that, and there were some real technical issues out at Vandenberg. I know the solid rocket motor people were struggling with their filament-wound cases, which they needed for that operation. Everybody knew that we were really going to have to struggle to make this happen, and I guess you could say we should have seen the train wreck coming, but we didn't.

JOHNSON: Right before that, in May of '85, you became head of the Integrated Communications Section, but six months later, you came back to Propulsion, to be the head of that section. You want to just talk about those moves a little bit?

HALE: The people in my class who had come in, in '77, '78, '79, had reached the level of experience that we could be considered for those first-level supervisor jobs. As I said, in the early to mid eighties, there was quite a bit of folks bubbling up through the organization.

Different jobs came over at the first-level supervisory job. We were just [GS] 13s [General Schedule pay scale] and eligible for the job. I and many of my friends put in numerous applications because we thought, "Okay, we've been doing this flight control job, we could be good supervisors and we'll do that." That was not the first job I applied for. There were several positions I applied and interviewed for. In the spring of 1985, Jack Knight, who's the branch chief, selected me to head the Integrated Communications Section.

They were notorious for having had a number of different leaders—it seemed like they would get a new leader, first-level supervisor, and then that guy would get promoted. They'd gone through a number of leaders, so they jokingly called themselves the training ground for section heads. They were a very experienced group, knew what they were doing. I felt very strongly when I came over there that to get their respect—I'm a mechanical engineer, I do not understand radios, I don't understand data systems. The theory—and you'll hear it espoused in many places—is if you're a manager, you can manage anything. At a certain level, that doesn't make sense, and so I thought it was very important for me to establish credibility with these guys, that I would go through the training to work my way up to all the different positions. Start in the back room and work my way up. Sometimes, when someone was selected as a section head for flight control, they would immediately move into the front room position, which is the most expert position. If you're coming from a different technical area, to move into that position just because you're the supervisor, I had concerns about that.

I knew I could not do that, so I started the training in their lowest, entry-level back room position while I was learning to be a supervisor. I made several stupid first-time supervisor mistakes while I was there, but they didn't get too mad at me. There was one memorable day, Ron Dittemore, who I talk about a lot because Ron and I came up together in the PROP Section

and had always been very close, had been named the PROP Section head. He was selected, along with Michele [A.] Brekke, to be a flight director in the fall of 1985. The PROP Section head was vacant, and they were just starting the application. I was thinking, "Well, I could have waited six months and probably would have been in line to get the PROP Section head job," but I'm having a good time learning about stuff I don't understand—radios and coding and telemetry and all these things—which really was really good for my career, to learn a lot of things.

I'm in the back room, had what they called the INST [Instrumentation] position. In the Shuttle world, the INCO [Instrumentation and Communications Officer] does all the commanding. That's not true in other vehicles, but in the Shuttle world, the INCO did all the commanding. I think there were some payload commands later on, but in those days, INCO did all the commanding. He delegated that to his back room to command things, so we did these launch sims [simulations]. I was on the launch team, training, doing generic training to get my certification. The one thing I had to do was send a command to start this auxiliary data recorder onboard the vehicle. On the real Shuttle flight, it started way early, like half an hour before launch. For these training sims, we'd pick up at T-2 minutes, so all these commands had to be sent. The INCO had some commands, and other guys in the back room had commands, and I had to start this data recorder. Manual panel, and you punched buttons, and you had to type in this code and then hit "execute," and the command would go and the recorder would come on, and life is good.

We did, as we did in those days, ascent sims, you'd do five or six. You'd have a six-hour session, from 8:00 a.m. to 2:00 in the afternoon, and you'd probably get five or six runs in. By the end of the day, I was feeling pretty cocky. I'd been doing this job all day long, and I was pretty cocky. We got to this last run and they said, "Okay, you do this, you do that, and INST,

you send the MADS [Modular Auxiliary Data System] recorder on." Tickety-tickety-tickety-tick, and instead of checking what came up on the screen, I punched "execute," and I had mistyped one of the numbers. The guy said, "How come the S-band transmitter just went off? Why did you send the S-band transmitter?" That'll scrub the launch in real life, and so we had to scramble, and in T-2 minutes, the clock is counting right down.

We had to get back on and I hung my head in shame, said, "I did it, screwed up, didn't check." I was feeling really low about that and I came back to my desk in Building 4, and on my desk was this phone note that said, "The division chief wants to see you." I thought, "He's been listening to the squawk box, I am fired, I am out of here."

I went down to see Steve Bales and he said, "We really need you to go back and run the PROP Section." That was all that was on his mind, is, "We're going to transfer you, and I've talked with Jack Knight and Don [Donald J.] Bourque who's the other branch chief. We need you to run the PROP Section. We've got that vacancy, you can do it, we can select somebody else to be the INCO Section head." I was okay, but my story, and I'm sticking to it, is you send one wrong command and you'll be fired. I went back over to run the PROP Section in the fall of '85, and still maintained a warm relationship. John [F.] Muratore, who I worked with for years, was in the INCO Section, and I got to know him really well then and other folks. It really helped me out a lot later on as flight director, having studied those systems in a depth I never would have if I'd strictly been a PROP guy. We did a couple more flights, *Challenger* happened, and we're into examining every thing from square one, every procedure, every rule, every failure mode effects analysis, every critical item list item.

We spent two years doing that, training up new crews, and then we went to fly again. Before we returned to flight, they had the next flight director selection, and I applied. With Bob

[Robert E.] Castle and Rob [Robert M.] Kelso, we styled ourselves the Three Amigos. I was never really wild about that, but that's when the Steve Martin movie had come out, so we were the Three Amigos. We started training, and actually, I remember it was Sadie Hawkins Day, February 29, 1988, that we were selected and started training, and watched the preparation for STS-26 very closely from the Flight Director's Office, as training. We were not allowed to do anything. What was the colorful expression that my boss, [Alan] Lee Briscoe used to do? We were lower than whale stuff on the bottom of the ocean—don't get in the way. Learn and keep your mouth shut. Kind of interesting.

JOHNSON: That might be a good place to stop. We've been going for a couple of hours. I was going to ask Rebecca if she had any questions about what we've talked about today.

WRIGHT: The only one I can think of, and you can think about it and we can talk about it later, if you like, but during those first missions, as you were learning and the debriefings that you might have had after each Shuttle mission, and what lessons or what actions you were able to put in place, and how that exchange of information happened?

HALE: Our debriefings were pretty technical. I would say there's not anything Earth shattering. We would say, "This procedure didn't work exactly the way," or, "it was not clear, these steps were not clear. The crew had difficulty executing this because, well, I don't know why." But we'd go back and look at it again and we'd try to understand. We found out that a piece part of the thruster, the OMS [Orbital Maneuvering System] engine or something, didn't work exactly the way that we thought it did. It was very technical kind of debriefings. I don't think we had a

great, Earth shattering, philosophical changes, but it clearly is the way that you run a safe program. You had the team concentrating on even the minutest detail to see if you can't continuously improve the processes. Every flight, we would go through the flight rules, we'd go through the console handbook procedures. Later on, we'd go through the computer tools that we had on our little off-line computers.

On STS-1, we didn't have anything. They had the Mission Operations computer, which is a big IBM mainframe that punch cards were fed into. We had very little way to interface with the computers. We all came in with pocket calculators because slide rules were passé, and it was all about pocket calculators. We actually got pocket calculators that you could put very rudimentary programming into, and the powers that be, they wanted to know how we were verifying that software that we were coding in these pocket calculators. All of us kids just looked at them, "What do you mean? All I'm doing is basic arithmetic." We went through this kind of learning experiences, and we're always trying to upgrade Mission Control.

I remember during the STS-1 preparation, I kept thinking, "What if we had one of those new Apple II computers that we could get data out of, right here on the console?" Nowadays, it's all distributed and the flight controllers have a process by which they can write their own code and put their own applications in, and it's much, much better. We were very constrained by the computing capabilities of the day. The only thing we didn't do was use our slide rules. It was very much like Apollo.

We learned a lot, but I would say the debriefings with the crew, the debriefings with the flight controller, the debriefings in our group, were very, very thorough. It was always focused on what do we need to iterate on to make things work better next time? We would find something—every flight, we would find something.

WRIGHT: I guess you also found some confidence in knowing what you had done was correct to build on, where sometimes we think we ought to build from mistakes.

HALE: Yes, that's true. We would say, "Okay, how did certain checklists, they worked fine, we don't need to go back and look at those again," that sort of thing. We did concentrate on what needed to be improved, so we're always looking at what didn't work quite—maybe not a failure, but didn't work quite as well as you would like for it to. How could we do the job more efficiently? How could we make sure we took care of all the possible contingencies, prepared for all the eventualities?

There was a feeling in Mission Control that we could handle anything. There really was. It came out of the Apollo 13 kind of experience, and was taught to us, is that we could handle anything—we should be ready to handle anything. Of course, in *Challenger*, there was nothing the flight control team could do. It really shattered that illusion. There are just things that can happen that no matter how good your flight control team is, they are not going to be able to turn that around.

That was a huge, emotional, I think, revelation to a lot of us. We had been in this culture of you'll be ready for anything and you'll make sure, no matter what happens, that you'll be able to save the crew and do what's right. That, again, goes back—Apollo 13, there's this mythos that you get enculturated into. Talk about some of the things that happened in Gemini—Gemini VIII's another good example—Apollo 1 fire, Apollo 13, and on and on. Then, we have *Challenger*, and the flight control team, unless they had stood up and said, "I really don't want to

launch with icicles on the launch pad, let's try the next day," there wasn't anything they could have done once you lifted off the pad.

WRIGHT: When we come back for the next session, we can talk about, as you walked into the flight director position, some of those cultural aspects that you had to deal with that you inherited in the director from there. We look forward to the next time, thank you.

HALE: Very good.

[End of interview]