NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

EMERY E. SMITH
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is February 28th, 2006. This oral history with Emery E. Smith is being conducted for the Johnson Space Center Oral History Project in [Sunrise Beach], Texas. Jennifer Ross-Nazzal is the interviewer, and she is assisted by Rebecca Wright.

Thanks again for joining us this morning and having us to your house.

SMITH: You're welcome.

ROSS-NAZZAL: I'd like to begin by asking you how closely you followed the fledgling space program in the late 1950s and early '60s.

SMITH: Well, not really very close. In the late '50s, I was basically working on the Mississippi River for the Corps of Engineers as a part of a river revetment team, and I was working as a clerk at that time. I wasn't in school or anything else.

And then in 1960, I decided to go back and go to college, and I didn't follow the space program directly very much until my senior year when I was looking around for employment post graduation.

ROSS-NAZZAL: How did your college studies prepare you for your eventual career at MSC [Manned Spacecraft Center]?

SMITH: Very well. I spent four years at Christian Brothers College in Memphis [Tennessee], and it was primarily at that time an engineering school, and I had a very good background in theoretical engineering from an electrical engineering standpoint with specialties in automatic control systems. And that, in fact, is what I spent the first part of my career at NASA doing is working with automated control systems for the onboard Apollo and, later on, Shuttle.

ROSS-NAZZAL: Could you describe what automatic controls are in a general sense?

SMITH: Basically, automatic controls are set up and they are not necessarily there to entirely replace a crew, but they are there to enhance their capability. They basically pick up signals from sensors on the vehicle and feed those through processing to make sure that the vehicle is stable and moving where you want it to move. And so they pick up signals and through their processing, give you control commands to take the craft wherever you want to do it. They are not just for spacecraft. They are for any kind of craft. You have automatic controls in your cars these days that do things.

I'm more of an egghead theoretical type of guy from a math standpoint, so my interests were in design, and as I matured, I got into the hardware development and hardware testing.

ROSS-NAZZAL: How did you find out about the job opportunity at the Manned Spacecraft Center?

SMITH: A guy named Burney Goodwin came to our school to interview is how I got originally acquainted with the, at that time, Manned Spacecraft Center, and I interviewed with him, and then he went on back to Houston [Texas], and I got a call from a guy named David [A.] Beckman, who ultimately offered me a position, and I accepted, to go to work in June of 1964.

ROSS-NAZZAL: What was the position you were offered?

SMITH: The position that I was offered was basically an electronic systems planning guy over in what was at that time the Flight Control Division in the Operations Directorate. After I got there, I found out that wasn't my cup of tea. They were taking systems that were already developed and tested and defining their use in the operations, and I was more interested in theoretical. So after I was there for about six months, I transferred into the Engineering Directorate to get involved with the basic design and development activities.

ROSS-NAZZAL: Where did you first live when you first came to Houston?

SMITH: I lived over off of Navigation and 75th Street in a boardinghouse.

ROSS-NAZZAL: Did a lot of people live in boardinghouses when they first came to Houston?

SMITH: Oh, they lived almost anywhere they could get. Getting an apartment at that time was tough because there weren't enough apartments around. So I lived in a boardinghouse for a

couple of months, and then I got an apartment at the [Glenview] Apartments just south of Gulfgate on the Gulf Freeway, and I stayed there for, oh, about two and a half years.

ROSS-NAZZAL: When you came down, was the Center open? Was the Engineering Directorate onsite at that point, or still offsite?

SMITH: When I got there, I went to work down at Wayside Drive in what was then an Oshman's building, which was across the street from the Houston Petroleum Center, and I went to work there one week, and the next week I ended up moving into Building 30 onsite. At that time, I was in the Flight Control Division.

When I arrived in Houston, I reported to work at what was then Building 2, is now Building 1, in Room 960. It was full of people, and everybody got signed up and basically were sent out to report to where they would work. So I ended up going back in to Houston and working for about a week at the HPC Oshman's warehouse complex there at Wayside Drive. Then I moved into Building 30, and I stayed in Building 30 until I moved over into Building 16, which was the engineering building at that time, the Guidance and Control Division.

ROSS-NAZZAL: When you moved over to the Engineering Directorate, who was your boss at that point?

SMITH: My immediate supervisor at that point was Tom [Thomas P.] Lins, and my Branch Chief at that time was Kenneth [J.] Cox, and that basically was my chain of command for quite a while.

ROSS-NAZZAL: What was your first assignment when you started working in the Directorate?

SMITH: I guess my first assignment was to help a guy put together a simulation of the lunar landing module, a guy named, and another name for you, Clarke [T.] Hackler was the guy that I was assisting.

ROSS-NAZZAL: What did that entail, creating this simulation?

SMITH: Well, basically, the simulation was already created, and my job was to help him run it. At that time, I didn't have enough experience to put together a simulation. This was a learning experience, and basically at that time, contrary to what you've got now, we were working with analog computers and learning to put the equations of motion and the hardware simulations on those type of elements. That all evolved to the point where eventually we tied some digitals into the analog systems, and that's basically where we were with some few exceptions when we landed on the Moon. That was our technology base for the Moon's lunar landing, was analog and hybrid simulations. We didn't have digital simulations with high-speed computers like they do today.

ROSS-NAZZAL: You mentioned actually in the previous interview that you did in '99 that you helped develop the techniques for building the digital simulators.

SMITH: Yes.

ROSS-NAZZAL: Can you tell us what was involved in that?

SMITH: Well, basically at that time and technology, there had been very little work done in simulation of digital systems. Digital systems are unique from analog systems in the sense that you have a continuous flow of data with an analog system, but with a digital system, you've just got samples and the amount of data you get into the system is how fast can you sample it. And with the Apollo computers, we were limited to a certain sample rate on the onboard computers because of the way the computers themselves were built. So we had to learn to develop our designs in the digital world such that they were compatible with that computer system.

There's a phenomena that happens when you're sampling. If you're not sampling fast enough, the higher frequency occurrences are missed, and when you actually sample a peak of one of those higher frequency signals, you end up getting positive feedback into your system. And we had to learn to do all of that stuff.

So at that time, the Apollo systems, the analog systems on Apollo, and we did have analog control systems that weren't digital, were developed by the company that's now North American Rockwell, but the digital systems were developed by MIT [Massachusetts Institute of Technology] in Cambridge [Massachusetts]. And so we worked very closely with both the analog systems and the digital systems to make sure that they were compatible, and they performed similarly for making sure that the crew didn't have to learn to operate two different systems in drastically different ways.

Actually, I did my master's thesis at the University of Houston [Houston, Texas] on design of digital systems and documented some of that, and it was documented in a JSC Internal

Note at the time. But it was a new technique, a new development, there was a lot of people working on it across the country, and we were working on it there. Although I did some design work, my job was not to design the system. My job was to make sure that the guys that had the responsibility for designing the system did their job well. To do that, I had to do some development activity, which I coordinated with them, and we all had this as a learning experience. The final designs were done by the contractors that was responsible for them, and we basically verified those designs.

ROSS-NAZZAL: How much time, if any, did you spend going out to California or going up to Massachusetts working with these contractors?

SMITH: Very little going to the East. Those guys always came to Houston, and we worked with them directly down there. We went quite a bit to California, because they had the responsibility not only for the systems but development of the spacecrafts, and we had to make sure of compatibility with of all of that. So we did like once a month type thing to California for review and exchange of information.

ROSS-NAZZAL: What do you think were some of the biggest challenges while working on this development activity of these simulators?

SMITH: Well, one of the biggest challenges were developing the techniques to put them together. For instance, one of the simulators that we worked with was the crew-training simulator over in the crew area. Their sample rate on their system were different than what the onboard computers

were. So we had to go back in and transform the digital equations that were on the onboard system into a compatible set of digital equations that were on their simulators, and that was a learning experience for them and us, is learning how to do that. Their sample rate was twice what the sample rate on the onboard computers were so it made a significant difference in the equations that you put into the digital systems.

ROSS-NAZZAL: Besides the crew-training simulator, what were some of the other simulators that you worked with?

SMITH: Oh, goodness. I can't even remember. We had simulators at Downey [California], which were associated with the engineering and development. There were also crew-training simulators at Downey, California, and there was simulators at the MIT. There were ground-based simulators with no crew interface at both [and] in Building 16, with which were the hybrid, the analog/digital interface type of computers. And then we had all digital simulations that we did just from an engineering analysis and development. Those simulators were in 16, and some of them were over in, I guess it was Building [12], which was the computer center for the Center at that time. And then some of the simulators that were used in the Mission Control Center for Operations, we helped with the verification on those.

ROSS-NAZZAL: Did you work at all with some of SimSups [Simulation Supervisors], working out some of the simulations for the flight crews?

SMITH: Not really so much in the Apollo days. I did in the Shuttle days, but not in the Apollo days.

When I got there, a lot of the Apollo work had already begun, because I got there in '64 and the operations guys were already putting together a lot of that stuff then, so not too closely with those. I worked with some of those guys fairly closely after we got into flight of the Apollo and putting flight back data back in through the systems kind of thing, but not too much prior to that.

ROSS-NAZZAL: What about the flight crews, did you have any contact with them while working on this project?

SMITH: Yes, we did. My mind, I try to remember who. [Laughs] We went through so many flight crews. The only ones that I can remember that we worked fairly closely with in Apollo was Ken [Thomas K.] Mattingly [II] and John [W.] Young. But my memory of them is good because they were the first guys that we worked with on the Shuttle Program too.

And one reason it's hard to differentiate is I started work on the winged vehicle, it wasn't called a Shuttle at this time, the winged vehicle, and I started work on that in 1969 before we ever landed on the Moon. So my memory of the astronauts and who did what to who is kind of blurred.

ROSS-NAZZAL: Okay. Well, understandably, that was over thirty years ago. [Laughter]

Let me ask you about working on the automatic controls that you mentioned you worked on for Apollo. Could you describe those systems?

SMITH: Well, basically, their systems are fairly simple. Well, I will say they are guidance, navigation, and control systems. And basically the navigation is a system that, number one, defines through instrumentation where you are and targets where you would like to go. A guidance system is a system that will fly you from where you are to where you want to go. And the flight control system is the maneuvering of the vehicle to accomplish that guidance and targeting. And my primary activity was in the controls themselves, and that was the system that would sense through the instrumentation where the forcing devices were and move them in the direction that they needed to be to accomplish the maneuver, and that's basically what an automatic system does.

ROSS-NAZZAL: Can you walk us through the design of these controls, or were they already designed by the time you started working in the Directorate?

SMITH: Some of them were already designed, but the problems that we had where we had to go redesign were caused by the fact that between the time that they started the design of the Apollo vehicles and where we ended up, they went from an Apollo vehicle that would land directly on the Moon and take off, to the rendezvous system where you ended up landing the Lunar Module [LM]. Because of that early design, you had a very large forcing engine on the back end of that CSM [Command and Service Module]. So when you docked that with the LM, you had a very unique problem of forcing the system with a larger force than you necessarily wanted, but you had to manage it because that engine was built.

So it caused the body to flex, and because it flexed, you had to go in and define what those flexible modes or vibration modes looked like so that you could manage the system and not cause it to be unstable at that frequency, but to be stable at that frequency.

So where I came into the picture at that point was helping with that definition. I had to work with the structures and mechanics guys over in Structures and Mechanics Division. They had the responsibility for understanding and defining what those vibration modes were and what it took to force them. And once they defined that, we had the responsibility for finding an automatic system that would dampen those vibrations under the kinds of loads that it got out of the Command Service Module engines. So that's where it was when I got there.

There were lots of debates over how to approach that problem, and there were two schools of thoughts because you had the one school of thought on the West Coast and one school of thought on the East Coast. And that's strictly an education issue, because people were trained to do different ways. So we had to coordinate that activity. So the way that problem was approached on the West Coast was different than it was on the East Coast, and we actually ended up with two different designs, one implemented in the analog system, one implemented in the digital system, both of which are viable techniques but were different.

So that's kind of where I got into the picture. I was the point man for talking with those and coordinating that community, and while I did some personal design work myself, their activity was the primary activity.

ROSS-NAZZAL: Can you tell us the difference between the West Coast and East Coast models, if you recall?

SMITH: Yeah. Basically, the West Coast model was a technique where if you knew the frequency, you would design what's called a shaping filter that would filter out that frequency in the feedback system. The problem with that technique is that you have to know the frequency within a certain bandwidth or you have a very difficult problem of filtering out that signal. On the East Coast, the technique was, okay, I can't know the frequency that well, but I know the damping characteristics of this, I know how it's phased, so I won't try to eliminate that frequency, but I'll try to actively control that frequency. And that was basically the two different techniques. One tried to wipe out the signal out of the feedback system; the other one took that signal and reshaped it so that it didn't feed back.

ROSS-NAZZAL: Can you tell us about the verification testing and quality control testing of these automatic controls?

SMITH: Well, okay, that went all the way from basically hand analysis to digital computer analysis to simulation analysis to actually buying and implementing the hardware and putting it together in a facility and making it operate. So it was very extensive. It was not just a few people. It was a lot of people involved.

ROSS-NAZZAL: How many people worked with you on the automatic controls?

SMITH: I have no idea. I had interfaces through MIT and through basically what was then North American, and then North American's contractor was Honeywell. So I had interfaces with those people, and I might interface with a half dozen people, but there were lots of people involved.

We're talking hundreds of people involved in the small element that I was dealing with. But I didn't direct them or interface with them directly, just a few.

NASA's job, as it is today, was primarily coordinating these activities, not doing them.

ROSS-NAZZAL: How large were these automatic controls? Can you give us a sense of what size we're talking about?

SMITH: Physical size?

ROSS-NAZZAL: Yes.

SMITH: No. You know, the sensors vary all the way from the onboard IMU [Inertial Measurement Unit], which was about a one-[foot] diameter sphere kind of thing, with all kinds of instrumentation inside it, to very small sensor size. I don't really have much to talk about because the hardware itself wasn't something that I had a hands-on activity with.

ROSS-NAZZAL: What were your workdays like? You mentioned working with all these various contractors. Did you do a lot of traveling? How much time were you in the office?

SMITH: Well, basically, we were in the office quite a bit, depending on what was going on, but most of our work was done onsite. At the level that I was operating, I didn't travel but like maybe once a month, and guys that were above me and had greater responsibilities were

traveling more than that, but we basically stayed in-house and worked on the projects that we had to work on. So eight-hour day, ten-hour day was not unusual kind of thing.

ROSS-NAZZAL: Did you ever work on the weekends?

SMITH: Oh, yeah, yeah. Back when we were trying to get all this stuff running and there was lots of time to do things, most of us were young and full of energy. Most of us were single at the time, and we had lots of time to spend at it. So we did.

ROSS-NAZZAL: What were some of the facilities that you used while you were working on the Apollo Program?

SMITH: Basically, they were mostly in-house facilities like I had talked about, the Building 16 simulators, the Building [12], the onsite computer facilities kind of thing. They were basically whatever was available that you could get through government procurement at the time. That's basically where we were. At that time you didn't even have any electronic calculators. We're talking about slide rules and adding machines, and what few digital computers you had you had to have approval to get computer time at that time to go make data runs. So we had limited automatic system access.

ROSS-NAZZAL: Did you spent much time at all working on those digital computers?

SMITH: I spent time using them as a user, not as actually working the digital computers themselves, no.

ROSS-NAZZAL: What would you use the computers for?

SMITH: Basically just having built a mathematical equation, going and executing that equation, to make sure that things were validated.

ROSS-NAZZAL: How well did the automatic controls work on the Apollo missions?

SMITH: They worked well. [Laughs] As a matter of fact, as far as I can remember, there was never any concern about how they operated. Back then, the systems that we had were built based on statistical analysis of their quality, and we basically said we built the system with reliability of five nines, .99999, okay, and that's basically the whole technique that was used in Apollo. So everything that was put up in Apollo was expected to never fail, essentially, and as far as I know, the electronics systems on Apollo never had any significant failures in them, period, whether it's controls or not.

ROSS-NAZZAL: Did you have any assignments during the Apollo missions?

SMITH: I did. I was part of the Guidance Control Division's team that supported what was then called the Mission Evaluation Room, which was over in Building 45, third floor, if I remember right. That was basically engineering support for the Mission Control Center. We had data that

we watched continuously and supported them if they had any engineering problems to work kind of thing.

ROSS-NAZZAL: Are there any missions that stand out in your mind where you had to work a certain issue?

SMITH: Yeah, Apollo 13.

ROSS-NAZZAL: Do you want to share with us those details?

SMITH: Well, Apollo 13 was very significant, obviously. There had to be a way to find to manage it both from a life support standpoint, which I didn't work. That was not my problem. My problem again was back in the automated control systems, and basically what we had at that time is we knew we couldn't use the Service Module engine for maneuvering. So the only choice was to use the Lunar Module engines, and the analysis that was done, I helped with. I'll say "helped," because there's a whole bunch of people looking at this, and there were probably more teams than I can count on my hands working at this.

So basically it was to define a way to make that vehicle respond and maneuver and make the trans-earth injection burn to get back and with a stable system, because, again, you had the flexible body problem where the two vehicles were mated, and the same problem that we'd had with designing the system to start with where those flexible body modes could cause you problems had that similar problem with the CSM LM with the LM combination firing. Only it wasn't as great, because the engine forcing function was not as great. So you could not excite

those modes as much with that engine, so you could, in fact, make that burn, and they did and got home.

ROSS-NAZZAL: Were you working in Building 45 when the accident occurred?

SMITH: No, I was home when it actually occurred.

ROSS-NAZZAL: Did you hear about it on the news, or were you called in to work?

SMITH: Oh, I got a phone call. Yeah. I was home and I can't remember if it was on the news. I honestly don't remember.

ROSS-NAZZAL: What was the mood like at the Center when Apollo 13 finally landed?

SMITH: Oh, everybody was elated. They were just absolutely elated that they had managed to get them back.

ROSS-NAZZAL: Let's go back to Apollo 11. Where were you when Apollo 11 landed on the Moon?

SMITH: I was in the Mission Evaluation Room in Building 45 working at the time, so I was there when they landed.

ROSS-NAZZAL: What were your thoughts at that time?

SMITH: Oh, it was just elation at a successful event, and everybody was crazy, waving flags and doing things that people do when they're excited.

ROSS-NAZZAL: I wonder if you can describe the Mission Evaluation Room for us. Give us a sense of how many people were in there, what was contained in that room, what the shifts were like.

SMITH: Well, the Mission Evaluation Room took basically the whole third floor of the Building 45, and it was the Engineering Directorate's team to support the Mission Operations guys. So you had Structures guys in there, you had Propulsion guys in there, you had Guidance and Control Division guys. In terms of at any one time, there was probably on the order of a hundred people on that floor, and people were working basically three shifts a day, kind of thing. So it basically was overhead TV screens to present data. You had clerical support; you had copy support, and basically we had—it was all tables, tables and desks, with calculators and that kind of thing. It was not very modern in today's terms of what you would see in the Control Center or even in the Mission Evaluation Room that's currently there. There is currently a Mission Evaluation Room somewhere onsite. I don't know where it is. It's probably in the Control Center somewhere.

ROSS-NAZZAL: Some of the descriptions that you see of the Control Center in the '60s were that it was smoky and that it was really loud. Was it the same way in the Mission Evaluation Room?

SMITH: Oh, yeah, yeah. Yeah. At that time, as a matter of fact, when they landed on the Moon, they pulled out the cigars. And I'm a culprit also. I was a smoker. I would say the majority of the people were smokers at the time. It was kind of a smoke-filled backroom. The only places you couldn't smoke was basically in the rooms where it was critical from a standpoint of messing up equipment and things like that. In the simulator rooms, you couldn't smoke, and computer rooms, you didn't smoke.

But it was a very significant and traumatic event when they outlawed smoking on the site.

ROSS-NAZZAL: Was it really?

SMITH: Oh, yes.

ROSS-NAZZAL: I had no idea.

SMITH: Yeah. As a matter of fact, I actually quit smoking before it was outlawed on the site. The guy that had the nerve to do it was Aaron Cohen. He may have gotten instructions from somebody else, but he was the one that had the nerve to cut it out entirely. There was no smoking anywhere on the site. Used to, it was when they started out, you couldn't smoke in this room and that room, you could smoke in your office, but with the central systems in those building out there, it didn't make any difference. You were still blowing smoke on everybody.

So it was a traumatic learning experience for everybody, but it was good. By the time I retired, you couldn't tell that there'd ever been any smoke in those buildings out there, which is amazing.

ROSS-NAZZAL: Did you have any assignments after the flights had flown during Apollo?

SMITH: You're talking about post-flight analysis?

ROSS-NAZZAL: Post-flight analysis or—

SMITH: Post-flight analysis, we did some on the early flights, just to make sure that the performance of the systems we were responsible for was what we expected. But on a continuing basis, probably after the work that I did following up on Apollo 13, I actually didn't work any more of the Apollo flights.

As I said earlier, I started working on the winged vehicle prior to the landing on the Moon, and after Apollo 13 my main effort was involved in working on the next program.

ROSS-NAZZAL: You mentioned earlier that you got your master's degree in '68 from the University of Houston.

SMITH: Right.

ROSS-NAZZAL: Can you tell us how you were able to juggle work and going to school at the same time during, you know, a very frenzied environment?

SMITH: Well, actually, going to school was kind of a relaxation from a lot of the other things. One of the reasons I came to NASA and the Manned Spacecraft Center is I had every intention of going on to graduate school, and they provided that opportunity. So I enrolled in the University of Houston and actually started taking classes in the fall of '64, and at that time NASA encouraged people to go take classes kind of thing. So I started in the fall of '64 and between the time that I finished my coursework in the spring of '66, the University of Houston started doing classes onsite. As opposed to us having to go downtown to the main body campus, they brought the professors out to teach the courses that the Engineering needed for the specific degrees that people were working on. So actually most of the coursework I took, I actually took onsite. Some of the courses, I had to go back to the campus for, but probably, oh, 60 percent of them I took onsite, and the rest of them I took downtown. So it made an opportunity. That eventually grew into the University of Houston-Clear Lake [Houston, Texas], that activity. But my degree is from the main campus because the Clear Lake campus was not there at the time.

After I finished my coursework, I got lazy and didn't finish my dissertation or my thesis. I had done all the work prior to that, and I finally—let's see. I got married in February of 1968, and my wife and two of her girlfriends sat down and typed my thesis for me after I got married in February of '68. I had done all the work, but I had never written the thesis. So I finally wrote it and I finally got my degree in June of 1968. So that's the history of that activity.

ROSS-NAZZAL: Isn't that nice of your wife?

SMITH: And then to get it published, I reviewed it in-house, and my thesis is published as a NASA Internal Note, and that was as opposed to publishing it in a magazine somewhere, in a technical magazine, it was published as a NASA Internal Note, and the University of Houston accepted that as publication, which was a requirement for it to be accepted.

ROSS-NAZZAL: Great.

SMITH: So I got free help typing it, and I got NASA to publish it, so it worked out.

ROSS-NAZZAL: That's great.

You were working in the Guidance and Control Division for a number of years. I'm wondering if you can talk about how that division evolved and changed over time as you worked in that division.

SMITH: Well, the Guidance and Navigation and Control Division basically remained intact functionally over the years that I'm familiar with it, including probably even today. It may be operating at a lower level, but it's still there. Basically, it was responsible for, at the time—there were two sides of the house. There was the analysis and development side of the house that I worked on, and then there was the program management and procurement who worked for the project office side of that house. The Division Chief was Clifford [Robert C.] Duncan, the Deputy Division Chief was Robert [G.] Chilton, and the two Assistants was Bob [Robert A.]

Gardiner, who had the program office and hardware procurement side of that house, and Don [Donald C.] Cheatham, who had the analysis and development side of that house.

That organizational structure remained intact for a long time, and through several Division Chiefs, and over the years it functionally remained in that capacity, even through the Shuttle days that it was responsible for guidance navigation and control on the Shuttle. And while the program office function dwindled and went into Building 1 as a part of the Shuttle procurement activity, the analysis and development and tests and verification side of that activity stayed in Building 16 for that. And that remained so up until, I know, until I left there. I left that organization in 1980. I think that's right, yes, 1980. And even after I left that organization, as far as I know, it remained intact until basically the Shuttle Program was finished with development and they started the new programs that they have now.

I honestly have been gone there for a long time, so I don't know what their structure is right now, but I suspect that it's still that, because it's still that kind of function.

ROSS-NAZZAL: Before we talk about Space Shuttle, I had a couple of other questions for you. Did you ever go to any splashdown parties?

SMITH: Yes.

ROSS-NAZZAL: Can you share with us any stories about that?

SMITH: Basically, the splashdown parties was just what it said, it was a party to celebrate a positive mission completion, although we celebrated a lot of negative things, too. We celebrated getting people back on 13, which was a positive result.

But we were all young. When I went to work, I was twenty-four years old, and most people were between twenty-two and thirty at that time. I think the average age at the Center was like in the late twenties when I went to work there. When I retired, I think it was forty-something. So it was younger people, and they had a lot of partying on their mind. A lot of them were single, and I'm not sure that that made that much difference. But it was fun. We had a good time.

ROSS-NAZZAL: You mentioned you had started working on the Shuttle Program before the Apollo Program had ended. What's your sense of the mood at the Center once the Apollo Program did officially end in '72?

SMITH: Well, where I was it was still very positive, because I was in the development of a new activity. Guys on the Operations sides of the house weren't quite as positive at that point, because there was a lot of uncertainty about where were we going and where things were going for them. There was a lot of cutbacks in terms of dollars for the total programs, and so there was some, quote, restructuring of NASA and cutting down on the numbers of civil servants. So there were some moods where it was a lot of uncertainty and people were not happy. But for those that were still involved and had responsibilities, it was still a positive situation. We were still doing basic good engineering and development and analysis-type work.

ROSS-NAZZAL: When you first started working on the Space Shuttle Program, what were some of your first assignments?

SMITH: My first assignment was to go find out how to fly an airplane. I'm an electrical engineer. I knew nothing about airplanes, so I spent about a year taking courses and studying to understand airplanes and how and why they fly so that we could, in fact, develop and analyze and work with the contractors and the crews in developing the control systems for the Shuttle. I had worked the basic on-orbit phase for Apollo, and I was basically put in responsibility in an area of atmospheric flight for Shuttle, which at the time I knew very little about, so I had to go study. My first assignment was go learn, which is what you do in a development and analysis world.

ROSS-NAZZAL: Once you were through learning how planes fly, what was your next task?

SMITH: Basically, my responsibility for Shuttle until I left the Engineering Directorate was the entry flight control systems, the atmospheric, the entry all the way from post de-orbit to landing was to work and analyze and do what I had to do with the other guys that were working the same problem for entry on the Shuttle.

ROSS-NAZZAL: Can you share with us what the entry control systems consisted of?

SMITH: Well, basically, again, you've got the similar problem for entry as you had on orbit. You've got a navigation problem to decide where you are and where you're going and how to

target for it, and then you've got a guidance problem that tells you how to do that, and then you've got the flight control problem, which maneuvers the vehicle to accomplish those commands. In the Shuttle, you went all the way from no atmosphere where you had to control the vehicle with just reaction control thrusters all the way to being in a complete aerodynamic flight with a rudder and an aileron and that kind of thing.

So you had to have a system that transitioned from flight where there's no atmosphere all the way to a typical and going at 25,000 miles an hour all the way down to a landing at either the Cape [Canaveral, Florida] or Edwards [Air Force Base, California]. So you had many phases of this, so you had to transition your control systems as they became functional, and transition out the ones that were no longer functional. And you had to do this, and the guidance had to make sure you were targeted so you didn't burn the vehicle up. So you had all of these phases to operate through such that if you've looked at an entry profile, and you see that you de-orbited and you turned the vehicle around and you came in at a high angle of attack and then you transitioned to a lower angle of attack as you came down, and then you maneuvered and landed, basically, dead stick, because you're unpowered. So you had to have systems that operated through that, and obviously that's such a big problem that there were hundreds of people involved in doing it.

I was the point man in our division for the analysis activity that went on there that coordinated with the outside world. We had contractors all over the country at that time working on the same problem. It's a difficult problem to solve, so it takes lots of people.

ROSS-NAZZAL: What were some of those problems that you encountered while working on the systems?

SMITH: Well, basically, it wasn't so much the problem with the instrumentation or the control effectors themselves, it was understanding how to manage this vehicle through the severe environment that it was coming through, and we went all the way from Dr. [Maxime A.] Faget's initial design, was a vehicle that flew in at a high angle of attack, like 60 degrees, what they call 60 degree angle of attack, so you're basically coming in almost straight up like that. And we evolved to another vehicle where we flew in from a lower angle of attack, and it was too hot. The higher angle of attack vehicle took too long and got too hot, so you had to manage the profiles you were flying.

So understanding the environment and the profiles to fly through that was the difficult problem. The control laws and the instrumentation to manage the vehicle and the aerodynamics of that was another problem. We had never tested a vehicle at these velocities. The low velocities and the wind simulators at Langley [Research Center, Hampton, Virginia] were used to understand the subsonic flight and some of the supersonic flight, but most of the hypersonic or velocities at very high mach numbers had never been looked at before. So that was a learning experience for the aerodynamic guys, and once they had their input to us, we could go react to it, but their input was uncertain so we had this interaction going on with those guys, too. So we had interaction with the Structure guys, the Thermal guys, and the Aerodynamic guys, so it was an iterative process to evolve the design, not that it was a—it was a complicated task, it wasn't a difficult task. The main thing was understanding the problem to be solved.

ROSS-NAZZAL: Who were some of the contractors that you were working with on the system?

SMITH: Okay. The primary contractor was Rockwell at Downey, and their sub for flight control system was Honeywell. And the guys at Honeywell, primarily we worked with the guys out of St. Petersburg, Florida. But the contractors were all over the country. Like the actuators on some things were designed in one part of the country and instrumentation in another and all this. It all came together through the Program Office coordinating it and all this kind of stuff, so it was—we worked with lots of different guys over the years, some of them the same as the Apollo guys.

ROSS-NAZZAL: I was going to ask that question. How similar was this position to your position in the Apollo Program while working on simulators?

SMITH: It was very similar in terms of the function to be performed. The magnitude of the job and understanding the job was different, and by that time we had evolved a lot better technology in the computer world, too. I can't remember ever doing an analog simulation with Shuttle. It was always digital. But at that time, we had faster and bigger computers to make things better. So we evolved from doing problems with graphics and slide rules to doing design with all-digital systems, so very interesting problem.

ROSS-NAZZAL: How involved, if at all, were you with the approach and landing tests?

SMITH: Approach and landing tests, and that's another guy you ought to go interview, is a guy named David [A.] Dyer. He lives up off of Livingston [Texas] somewhere, I think. David handled most of that, and my interface with that was very limited because that was basically

looking at the guidance and control systems to land the subsonic aircraft from a dead stick situation where you had dropped it off of the 747. Dave Dyer worked most of that problem from a guidance and control standpoint for the landing, and a guy, Frank [M.] Elam, was the guy that worked with the guys to do the separation analysis between the Shuttle and the 747. Okay.

But no, I was aware of what was going on, but I was not involved in it. We picked up and built on what they had done kind of thing.

ROSS-NAZZAL: What did you learn from those tests then?

SMITH: What did we learn? Well, we learned quite a bit from the aerodynamics standpoint, that the Aerodynamics guys picked up and finalized a lot of their data based on those tests. It knocked out a lot of the uncertainty that had to be dealt with in the design, which made it nice. We learned about, "we" NASA, not me necessarily, learned about tires and the fact that some of them come apart at high speeds. They learned about brakes, the fact that some of them burn up at high speeds. There was a lot learned from the approach landing tests. They were well worth the tests being done, and the crews got a lot of experience from a landing standpoint. I think it's significant that [some of the guys] that [were] the primary driver[s] there that [did the] flying [were Fred W. Haise and Joe H. Engle] because [they were the right guys] to do it.

Just basically, we learned a lot from those tests to get the uncertainty out of the landing operations phase.

ROSS-NAZZAL: Were you involved at all in terms of software for the entry systems?

SMITH: You talking about responsible for the development of the software?

ROSS-NAZZAL: Some of our research indicated that you were working on some software for the Shuttle, that you were involved in some of the various groups.

SMITH: I was working on the software in the sense that the designs were digital, and by definition that means that they're in the software, and we were [responsible] for making sure that those designs were implemented and tested and verified as part of the onboard software. But as far as—I was basically—what did they call it? They had a name for us. Basically, I was responsible to the Program Office for making sure the entry flight control systems were implemented right in the software. But as far as the hands-on of the software, no, I didn't have any hands-on of the onboard software.

ROSS-NAZZAL: In 1980, in your oral history you mentioned that you moved from the Engineering Directorate into Operations. Can you tell us about that move and how different that was for you?

SMITH: Well, basically, in 1980, the design verification phase of the Shuttle was basically over and I'm basically a design and analysis guy and there wasn't very much of that left, so where do you go from here? You go and get into the verification of the system and the actual flights.

I talked to the guys over in the Operations Planning world, which at that time was called Mission Planning and Analysis Division, about making a move, and it turned out to be positive for me to make that move, and so I went over and went to work for, basically— I guess, at that

time Ron [Ronald L.] Berry, who's on your list, was the Division Chief. Jim [James C.] McPherson was an Assistant. Claude [A.] Graves and Morris [V.] Jenkins were the Branch Chief and Deputy Branch Chief. And Jon [C.] Harpold was the Section Chief for Entry.

So I went to work for Jon Harpold as one of his Senior Engineers to actually take all of the ground test data, analyze it, and verify that we were ready for flight with those systems. So I, basically, along with Jon and a guy named Joe [D.] Gamble, a guy named Larry [B.] McWhorter, we manned the backroom console called Aero Console to support the flights for the early, early, early Shuttle flights and crew training for those flights to make sure that the guidance navigation and control systems were performing operationally the way they did on paper in an engineering world. And that's where I went in 1980.

ROSS-NAZZAL: What are your recollections of STS-1?

SMITH: Oh, it was pretty exciting. [Laughs] At that time, we were working all of the, you know, basically, John Harpold and I and these other guys, we were kind of egotistical in the sense that they can't operate it without us there, so we were there. When the crew was awake, we were usually there just to make sure that we knew what was going on and all the planning and activities. So we were around for STS-1.

There were some issues with STS-1, which we had to work on an ongoing basis. I don't know how many people know, but we actually lost some tiles during liftoff, and we had to evaluate where those tiles were and what it meant from a thermal reentry standpoint, did we need to change the entry profile to accommodate it, and all of that. And we, along with the team working that, which—I was trying to think who headed that up. I'll think of it in a minute.

Basically, we worked those problems continuously until we did a de-orbit and landing. We were on the console during all the dynamic phases of the flight, so we knew what was going on. It was exciting.

ROSS-NAZZAL: You had worked in the backrooms for Apollo. How was it different working the console for the Space Shuttle Program?

SMITH: It was quite a bit different. If you look at the philosophy behind the three directorates there, Engineering was responsible for designing a system that did a particular function and then designing enough margin in it that you can manage uncertainty with it. Operations Planning was responsible for taking and turning that design into a mission and making sure that design was compatible with the mission. When you go into the actual operations, you look at what-ifs to the extent of how I can manage this system if something else puts it outside its design requirements.

So you learn the systems and what they're capable of totally so that you can operate outside the design boundary if you have to. So those three philosophies flow [together so] the backrooms in the Control Center know what the total capability of a system is as opposed to the design constraints on it to start with.

So you take and you make sure that you're monitoring that system to see where you are with that system, and that's what we were doing when we started looking at the tiles. Okay. That system was designed to operate under certain conditions. What would happen if you operated it under different conditions? So it's a different look at the article, i.e. the Shuttle, about what can I do with this vehicle, not what was it designed to do.

ROSS-NAZZAL: Were you working on console during STS-3?

SMITH: Oh, yeah, yes.

ROSS-NAZZAL: What are your recollections of the landing at White Sands [Missile Range, New Mexico]? Were you involved with that at all?

SMITH: Yes.

ROSS-NAZZAL: Can you share with us those details?

SMITH: Well, actually, we really didn't know at the time exactly what happened. There were several things going on from a flight condition standpoint that we did not understand. First of all, that was a landing at White Sands, and we had never really analyzed what happened if you came into White Sands with the terrain the way it was. So we did not know at the time if we had an environmental problem that we didn't understand, or if we had an onboard control problem that we didn't understand. We didn't have sufficient data to analyze it in real time.

Now, after that was over and we got the mission data tapes and deciphered them, it was a little clearer about what was going on there, and basically, the, "entry and landing guys" went back and reanalyzed it based on post-flight data to see what happened and, in fact, verified what happened.

ROSS-NAZZAL: How long did you work in this position, and how many Space Shuttle flights did you end up manning the console?

SMITH: Let's see. I went to work in MPAD [Mission Planning and Analysis Division] in '80, and if I remember right, in 1984 they reorganized us and put us in the Flight Operations Directorate, if I remember right. And in 1984, I was made an Assistant Branch Chief, and I was still on the console at the time. Basically, let's see, in 1985 it may have been when we went to the Flight Operations Directorate. Whenever that happened, I was not— I didn't work the consoles anymore after that. So about working on the console from about 1980 starting training through the first flights, and in about 1985 when I was promoted to Branch Chief, I didn't work the consoles anymore. The guys that were in my branch worked the consoles.

ROSS-NAZZAL: When you became appointed Branch Chief, how did your duties change other than not working on the console?

SMITH: Well, Branch Chief is basically an administrative division, you know, a function, and we went from an engineer who had a hands-on in the day-to-day operation to basically being involved with reviewing what other people did and making suggestions and assignments and doing what all Branch Chiefs do from a personnel and performance standpoint. So went from a totally technical activity to a probably 50-50 technical/administrative-type activity, and that's kind of where it stayed from '85 until I retired.

ROSS-NAZZAL: Did you enjoy that switch, moving out of a field that you had been working in for so long into more of a management position?

SMITH: Oh, yeah, it's fun. And like I say, I was still responsible with my people for the technical aspects of it, so I didn't really give up the technical, other than being a reviewer as opposed to a doer. And at that point, if you look back, by that time I had been out of college twenty years. The kids coming out of college were a lot smarter than I was, knew a lot more than I did, and so it was easier to let them do it than me do it because they knew what they were doing. While you might guide them technically, they were much more capable technically than I was.

I had experience about things outside of the detail, but they had the experience with the tools and background and everything that I did not have, so they were basically smarter than we were. They had the advantage of all that we learned and had tools to use it for, so it was a positive experience as far as I'm concerned. And because of the type of individuals that we were dealing with, we had very little administrative problems. Usually we were in a position to let people work the kinds of projects that they liked to work. Sometimes we had to make assignments that people didn't particularly care for, but they did them.

ROSS-NAZZAL: When you became part of the Flight Operations Directorate, in your last interview you mentioned that you started working operations planning and operations for flight dynamic systems. Can you share with us the details of that?

SMITH: Well, flight dynamic systems are basically the same thing that I worked on in the engineering world, just taking them and putting them into an actual flight process. For instance, I had worked the entry guidance, navigation, and control design based on certain criteria. Now let's take that system and put it into a mission environment and work the planning and execution of that mission plan, and that's basically what we call flight dynamics, is working the execution of that plan in a dynamic world.

At one time or the other during the time that I was in the Operations Directorate from '85 to '95, I worked all of the onboard on-orbit systems, the entry systems, and the ascent systems from a planning standpoint to make sure that they were within the design constraints of the vehicle, and that's basically all we're doing here was looking at the dynamic phases of flight and making sure what goes on there is compatible with the mission and the design of the vehicle. Okay?

ROSS-NAZZAL: Okay. Where were you when *Challenger* occurred?

SMITH: Where was I? Oh, I was in the backroom, wasn't working on the console, but I was in the backroom monitoring what was going on on the console for the launch.

ROSS-NAZZAL: How did the *Challenger* accident impact the systems that you were working on?

SMITH: Well, the response to the *Challenger* accident was somewhat overkill, in my opinion. Because we were down and not flying, we reviewed every onboard system and design and went in where we had the resources and the capability to upgrade the system to do things beyond what

its original design requirements were, and to that extent, we had the time, we had the people, and we had the resources to do that. And the only reason we did that is because we had the downtime. The downtime, in my opinion, was political. We could have launched the next flight on schedule and been safe, in my opinion.

But we were down two years, and we accomplished a lot in that two years in terms of refining and smoothing the operations for the Shuttle. So it was not a negative time in that sense, but in my opinion it was not a necessary time. In my opinion, what happened on *Challenger* was a result of not doing good quality assurance at the Cape and launching a vehicle in conditions that it was not designed to operate. So in my opinion, we could have launched the next flight with the proper QA [Quality Assurance] on the assembly.

But that's an opinion. I don't do responsibility for that. Somebody else had a responsibility for it.

ROSS-NAZZAL: Did you have any responsibilities for any return to flight activities?

SMITH: Yes.

ROSS-NAZZAL: Can you share with us those details?

SMITH: Well, basically, my return to flight responsibilities was what I said. It was reviewing what the systems were that we had, what we could do to make them better, what we could do to take that capability beyond what the design requirements was so that we could handle those what-if cases that were out there that possibly could occur, and we did, in fact, do that. We

expanded the envelope of not operations necessarily, but the envelope of failure protection on the Shuttle, and we put in some modifications to the entry flight systems, for instance, that gave the crew capability to fly the vehicle in a different way than what they had flown it in the previous missions. And I don't know if they ever actually stepped up to using that system, but it was developed.

ROSS-NAZZAL: Could you explain how the crew was—they potentially didn't use it, but how the crew was able to fly the Orbiter in a different way, can you explain that a little more?

SMITH: Well, if you go look at again at the entry flight, you're transitioning from an R[CS] reaction control jet system to an aerodynamic system. It becomes a question of what is the best way to fly at that high angle of attack using the jets and the aerodynamics as they evolve to being able to manage the aerodynamics of the vehicle. And during that transition time, you can operate the vehicle two different ways. The original design took one way, which relied primarily on the thrusters a longer period of time. The new design relied on the aerodynamics at an earlier time than was used in the old system. So it was a tradeoff, and the system that we went with was the system that was more conventional. The new system that was designed was not as conventional, and both systems worked. There wasn't any question about that. It was a question, making a choice and going. So a choice was made early.

But when we had this downtime, we had better computers, faster computers, so we actually had the ability to implement both onboard. And when I left there in '95, they had not flight-tested the new system because they hadn't needed to. And I don't know if they ever—I don't know in the last ten years if they've actually flight-tested it.

ROSS-NAZZAL: Do you have any other anecdotes or stories from that time from ’85 to ’95?

SMITH: Not really. It was a time we had a lot of fun. We worked with a lot of different people, and it was, you know, nothing that I can think of as too outstanding from an anecdotal standpoint.

ROSS-NAZZAL: Why did you decide to retire in ’95?

SMITH: [Laughs] Well, in ’95 it was really a good opportunity for me to retire for several reasons. I’ll go back and a little bit of history that probably relates to work more than family. From about, I don’t remember the exact dates, but sometime in the ‘80s, the agency focused on what its job was and what it could and couldn’t do started changing. I believe in basic research and development and the agency went from a research and development organization in the ‘60s to the point where it was basically an operations hands-on group in the ’90s. And, it didn’t look like to me like it was ever going to get back into an R&D world, and from what I can tell it has not.

As far as Space Station is concerned, it’s wonderful that we’ve launched it and use it like it is, but it was not an R&D project. We could have done Space Station in the ‘60s. At this point, there’s some limited basic research going on.

So in ’95, given where we were with everything and where my personal life was at the time, I decided it was time for me to bail out and let somebody who was having more fun than I was, take over. I didn’t leave in a negative sense; I left in a positive sense. Everything was

great. Everything was operating fine. The organization that I was in was operating fine. But the basic agency's goals to me seem to have changed from research and development into operations and somewhat more political environment than I wanted to operate in.

So, at age 55, I had 34 years of government service, and my kids had graduated from undergraduate school. My house was paid for, and I had a contract to sell my house in Dickinson [Texas] and move, and I said, "Goodbye." And it was fun while it lasted, and when I walked out the door I have only made one visit since. It's not something that you can stay a little bit involved with so I chose to not be involved in it at all. The only time that I have offered to be involved in it since was I called to offer by services when *Columbia* blew up.

ROSS-NAZZAL: Would you like to take a minute?

SMITH: Yes. Didn't realize it was still there. I was in North Carolina sitting in a travel rest station on the freeway watching it on TV when it blew up. Anyhow, you can't be just a little involved. So you don't get involved at all, and that's where I've been. You can turn that back on if you want to.

As far as retiring [at] 55, it was a good opportunity for me personally. I was financially in good shape. I had this lake house here. We had decided a long time ago that we were going to leave the Houston area when we retired. Neither one of us had deep roots there from a family standpoint and the girls were gone to places other than there, and so we decided to move here and see where we wanted to stay permanently, and we decided to stay here permanently.

ROSS-NAZZAL: It's beautiful, right on the lake.

SMITH: So that's where we are.

ROSS-NAZZAL: I just have a couple more questions for you. Looking back over your career with NASA, what do you think was your most challenging moment?

SMITH: Actually, I guess the most challenging from a technical standpoint was working the flight systems design for Shuttle. We had many different organizations involved in that and getting them to agree on a final design when there could be four or five different approaches taken was difficult because it was something that had never been done before. It's hard to get a guy to say "Okay, my design's better than your's, but we'll go with your's." It's difficult to coordinate that compromise when you are dealing with people who are very proud of their work and don't really want to give it up.

So at one time, for instance, if I remember right there were five different entry guidance designs. There were at least four different approaches to designing the flight control system itself and to evolve to a design that accomplished the requirements was difficult in the sense that getting people to agree with approach because probably all of the approaches would have worked given you had to mature the design between selecting it and working it. So the most challenging was getting basically people on the same page to go work the final solution.

ROSS-NAZZAL: By contrast, what do you think was your most significant accomplishment?

SMITH: [Laughs] That's hard. I like to think that my most significant accomplishment was getting the people who worked for me after I became Branch Chief trained to do the job. I grew

up with it. So I didn't "train to do it." They had to come in and learn it and pick up from experience from what we had learned, and I guess I'm proudest of them being able to do that.

ROSS-NAZZAL: I just a couple of other questions for you. We're working on a paper and doing research about NASA and its impact on the Clear Lake area during the Apollo Program. I'm wondering if you can share with us your memories of how the Space Center impacted the surrounding area. You arrived there in '64.

SMITH: You mean how it evolved from being a cow pasture to wall-to-wall houses? [Laughs] There's no question that the Johnson Space Center being in the location that it is was a major impact to both the economy and the lifestyle in that area. When I first went to work down there, Clear Lake was probably less than twenty houses, most of which were model homes that were being sold as fast as they could sell them for construction purposes. I know my wife personally, in 1966, did the school census in Clear Lake by herself, that's how few people were there. Webster [Texas] was nothing but about three streets; there might have been a total of a hundred houses in the whole area. Nassau Bay [Texas] was basically the same situation as Clear Lake. They were building model homes and selling them. So, there was very little there. Basically you had the fishing villages of Seabrook [Texas] and Kemah [Texas] and not much else. So, I watched it evolve from a two-lane road on NASA Road 1, that you couldn't get down in the morning, to I think now it's what, six lanes. Wall-to-wall traffic and you still can't get down it. Yes, we saw the major impacts of that kind of activity coming into the area.

ROSS-NAZZAL: And you said you moved to Dickinson?

SMITH: When we married, actually the month before we married, I bought a house in Dickinson and we lived in Dickinson in that house for about—lived in it about six years. When my twins were two years old, I designed and built a house over in another area of Dickinson for the family. It was a unique design because we had twins.

ROSS-NAZZAL: Were you involved at all in any sort of community activities after you and your wife were married?

SMITH: Oh yes, obviously involved in the church, and we were involved in T-ball with the kids. I can't really just think of anything particular right now. We did square-dancing, we did ballroom dancing, we were involved in a volleyball team down there, and involved in some of the community activities at the cities and things like that.

ROSS-NAZZAL: Well, I think that I've gone through all my questions, unless there's something you think we might have overlooked. I didn't ask you about Skylab and ASTP [Apollo-Soyuz Test Project], I'm not sure if you had any involvement with either of those programs.

SMITH: Probably limited, just enough to say that I was there. [laughs]

ROSS-NAZZAL: Okay. All right. Well, do you want to discuss anything else or feel like we've overlooked something that you'd like to talk about?

SMITH: Not really. I was trying to think if there was anything in this last—you probably pretty well dissected this though, I suspect.

ROSS-NAZZAL: Went through and tried to get a sense of your career and—

SMITH: It's been a long time since I've thought of it. Like I say, my main thoughts went back to, number one, your function of trying to get the oral history and the fact that there's numerous people that were involved that are not currently on your list, and I don't know how many of them you're talking to.

ROSS-NAZZAL: Sure. Well, we appreciate it.

[End of interview]