ORAL HISTORY TRANSCRIPT

PHILIP C. SHAFFER
INTERVIEWED BY CAROL BUTLER
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BUTLER: Today is January 25, 2000. This oral history with Phil Shaffer is being conducted for the Johnson Space Center Oral History Project, in the offices of the Signal Corporation. Carol Butler is the interviewer and is assisted by Kevin Rusnak and Sandra Harvey.

Thank you so much for joining us today.

SHAFFER: You're welcome.

BUTLER: To begin with, if you could tell us a little bit about your early life, early career, how you became involved, or what led up to you becoming involved with NASA, maybe starting with your college days and how you chose your area to focus in.

SHAFFER: Sure, but I'd rather start with going into the Air Force.

BUTLER: Okay. Great.

SHAFFER: Because I didn't know what I wanted to be when I grew up, so I did that, and as a part of that I got some training in electronics, which I hadn't had any exposure to, and was stationed in Newfoundland for a couple of years. One of the big events that happened there was that a monster snowstorm that really isolated us to the workplace or the barracks, wherever we happened to be at that time. And out of sheer boredom, while they cleared the area, everybody read whatever was available. One of the other fellows in the barracks was

reading a textbook on the principles of rocketry. And after I'd read everything else in the barracks, I picked that up and looked at it, and that's how I knew what it was I was going to do.

BUTLER: That's interesting.

SHAFFER: So when the tour in the Air Force was over, I went to college at a small cow college in Oklahoma, lots of math and physics and chemistry and that sort of thing. I sent out my resumes to all the people that had rockets and computers, which was the government. The Navy offered me a job at the Naval Weapons Laboratory down in Virginia, and I went there to do whatever it was they wanted me to do, with the title of interdisciplinary mathematician physicist. I had no idea what that meant and I still don't, but the function was more about ballistic bodies and how they behave at hypersonic speeds, because I was working on the Polaris program.

The basic job was to try to take the test firings that they did with the Polaris missiles and reconstruct the miss. [You know,] what was it that contributed to the miss? Because it always missed a little bit whether it was a quarter mile, a half a mile, or a mile, or whatever it was. I mean, they weren't perfect.

Lots of serendipity in that job, because it got me into real-time operations and atmospheric and exoatmospheric trajectory management, and the Polaris guidance steering laws and hardware were the same that was used in Apollo to go to the Moon.

So after three years at the Naval Weapons Laboratory doing that, a guy named Bob [Robert] Regelbrugge called me. He was one of the heavy hitters in the rendezvous analysis area for getting ready for Gemini. We had shared an office for a little while in Virginia, and he moved here to go to work for NASA and he called me. And he says, "You need to come here and interview with these people. They're hiring flight dynamics officers."

I said, in the vernacular, "What the hell is a flight dynamics officer?"

He says, "I don't know, but they're hiring them."

So I came, and he set me up with a guy named Glynn [S.] Lunney for an interview. Glynn told me what a flight dynamics officer was, and I said, "I can do that." And he said, "You're hired," and here I came. So 1961 to the Naval Weapons Laboratory, and 1964, here, and we started getting ready to go to the Moon.

BUTLER: So when you came in, you began working directly on Apollo then?

SHAFFER: I did. I did. The first project was, part of the qualification of the launch escape system for the Apollo command module, which was a series of launches out at White Sands [New Mexico], and then triggered the launch escape system just to test it in all the environments and test that hardware. So we supported four or five flights out there with vehicles like Little Joe and that sort of thing, and started writing requirements for the computing facilities on the ground for Apollo and trying to understand translunar, which is more like interplanetary spaceflight, and all that that entailed.

BUTLER: Did anything that you were working on surprise you, or after you had talked with them, was it all that you had expected it would be?

SHAFFER: I really didn't expect to go to White Sands. I really hadn't anticipated that. I thought I would come and get ready to work in the control center and I would work in the control center, and that would be it. But White Sands was pretty primitive. They had limited trajectory capability with things called XY plotters and a radar or two. And they had these guys called visual observers, which was where we started. I mean, we were stationed out in the desert with a headset and a line laying on the ground, and we were like the backup to the

radar system. We reported what we saw, which was to help them confirm what they were seeing on the plot boards in the little control center.

I'll never forget, probably BP-22, BP stands for boilerplate, because it was not a real command module on the stack. It launched, and it turns out that somebody had left a manhole cover loose as part of the launch facility, and when the vehicle ignited, the pressure blew that manhole cover up and it hit one of the control fins, one of the stabilizers, and jammed it. So when the vehicle comes up off of its pad, it yaws off to the right and straightens up and then it pitches down, down range, and then straightens up and then it just loses it and starts spinning.

The Algol rockets, which were the solid rockets inside, weren't supported at the top, and the centrifugal force, they just peeled out and came out through the sides of the launch vehicle and there's rockets going everywhere. [Laughter] It was amazing, absolutely amazing. So that was a surprise. [Laughter]

BUTLER: I can imagine. Luckily, it came out okay.

SHAFFER: It did. It did. I was up on the tower on top of one of the assembly buildings and could see one, it looked like it was headed my way, but it went into the desert floor out in front of us.

BUTLER: That's good. Quite a sight.

While you were working at the weapons lab, had you been following the space program and the early flights?

SHAFFER: Oh, yes. Oh, yes, absolutely. I sat in a parking lot and listened to John [H.] Glenn's [Jr.] flight in Washington, D.C. I had had to go to town for something that day. And

I sat in the parking lot, blew off whatever it was I was in town for, and listened to his whole flight. It was great.

BUTLER: Did you think at that time about the possibility of being involved with the space program?

SHAFFER: No. No, I was very much involved with what was going on there. It hadn't become repetitious yet, so it never crossed my mind at that point.

BUTLER: Just until you got the call.

SHAFFER: Yes, right.

BUTLER: After you had worked at White Sands, then you came back here to Houston?

SHAFFER: No, we were in Houston here the whole time and we traveled to White Sands to do those launches. But they were in addition to what we were doing here, which was primarily getting ready to do the lunar landing mission. And the principal job was getting the computing requirements defined for the control center here at Houston and getting ourselves trained to work in the control center and participating in the functional design of the guidance and control system of the Apollo spacecraft and the lunar module about what they were going to have to do and the ground would interface with those. That really was a training kind of process for what turned out later to be the mission techniques, which, when we started, didn't exist. There was no such thing as the mission techniques process. It was a lot of people on their own initiative trying to put all that together and get it documented.

BUTLER: Do you recall what some of the stages were as you were training, as you were looking at these systems and beginning to put these techniques together? Did you get together and have classroom sessions or training sessions or just strategy sessions?

SHAFFER: It truly was all of the above. It was all of the above. Since in flight control people were doing Earth orbit mostly. The function, the control function, came to Houston [from Cape Canaveral] for Gemini IV, and all of the senior flight controllers were fully occupied with the Gemini program, there weren't any experienced flight controllers to help people with the definition of the computing requirements. So I was the only one with anything resembling some real-time experience that was available to some of these other folks, and all I'd done was [analyze] launch[ed] Polarises, so I didn't know anything about how NASA was going to do business.

So we had lots of sessions with the Gemini guys after work. We had lots of sessions with the Mission Planning and Analysis Division [MPAD], who were doing the mission design and the analysis for how we were going to get to the Moon and back. We had lots of sessions with the Guidance and Control Division, guys like John F. Hanaway and some of those folks, who were in charge of the hardware and the control systems.

So there was this circulating around in all of the different organizations and which fairly quickly led to spending a lot of time in California with Rockwell [North American Rockwell Corporation], who was building the Apollo vehicles. I didn't spend much time with Grumman [Aerospace Corporation], who built the lunar module, but we spent a lot of time with the integrating contractor, who was Rockwell at that point.

In a while, the classroom environment switched, and as we became more versed in what it was going to be like to go to the Moon, then we started teaching the Gemini flight controllers about that aspect of it. We kept hiring people to work on the Apollo, because we

were nowhere near well staffed enough for that, so all of those guys had to be brought up to speed, too. So it was big-time busy, is what it really was.

BUTLER: Certainly it was. It certainly was.

SHAFFER: The flight dynamics people were really kind of the pivotal point between all of it, because all of the systems-oriented engineers had to support the trajectory, which was to get to the Moon, and the radar tracking systems and the ground computing maneuver computations and all that. That was the pivotal business. They called us the "Trench," by the way, if you ever run across that, because we had the front row of the consoles in the control center. So everybody was above us. But, of course, we considered ourselves the pick of the crop, you know. [Laughter] We thought we had the hardest job of all.

BUTLER: Certainly a very important one.

SHAFFER: After I became a flight director, I realized that that was not true. [Laughter] But it worked while we were there.

BUTLER: Yes, we've run across a few references to the Trench, and it seems like everybody had a pretty good feeling about themselves and the camaraderie down there.

SHAFFER: Yes.

BUTLER: Quite a few stories surrounding—

SHAFFER: Yes. I guess we were probably the largest sub-team in the control center, because we had the retrofire officer and the guidance officer and the flight dynamics officer. Yes, we were the largest sub-team in the control center. Not the largest team—I'm sorry, in the mission operations room, but in the control center, the systems guys had the larger teams. The complexity of their job was tough, they needed lots of books, which I learned as a part of my flight director training.

BUTLER: You mentioned that when you first came down, or when your friend first called you, that you didn't even know what a flight dynamics officer was, and here you came down and were one of the people most experienced with this type of work. What, if you could define for us, what a flight dynamics officer was meant to do for Apollo.

SHAFFER: No one has done that for you [before]?

BUTLER: Well, we've had a couple, but we haven't talked to many, so—

SHAFFER: Well, the flight dynamics officer is predominantly responsible for the management of the trajectory. That means he's got to determine what the trajectory is, which is a position and velocity at a time—a position, velocity, time relationship, and that allows you to tell where you are and where you're going to be, a trajectory is predictable and projectable. The flight dynamics officer also is the leader of the Trench. The guidance officer manages the guidance system and monitors it and loads it for the maneuvers, and the RETRO [retrofire] officer is continually figuring out how you're going to get home from where you are. Both of them are dependent upon the job the flight dynamics officer's doing in terms of trajectory management, what it is now and what it's going to be reflected by the maneuvers that are being planned. Is that concise enough?

BUTLER: That's a great definition.

SHAFFER: Okay.

BUTLER: One thing that's interesting to look at is the fact that the computers that you used to help you in these computations and the trajectory and so forth don't measure up to a desktop computer nowadays.

SHAFFER: Oh, that's very true.

BUTLER: Did a lot with slide rules and such?

SHAFFER: No.

BUTLER: No?

SHAFFER: No. But we did have Olivettis that we did a lot of work with, which was an early kind of a precursor to the PCs. It was a desktop computer that you could program and had a little magnetic card that you wrote the programs on, and if you built enough cards and did them right, you could do a reentry trajectory with an Olivetti, which was pretty fascinating.

But I remember very well when the PC thing started. We had guys walking around talking about these things called microprocessors. I didn't have time to figure out what those were, but I kept hearing them get all excited about it, some of the nerdy kind of guys. [Laughter] But later I understood what they were; that was the precursor to these PCs. The guys that liked those liked it because they didn't have an operating system. I mean, they

interfaced with them with switches and machine language kind of stuff. It was not a nice interface thing like [Microsoft] Windows or the operating system for Apple.

BUTLER: Very different at the time.

SHAFFER: Yes. The Naval Ordnance Research Calculator [NORC] was one of the first major electronic calculating devices, and that was the computer that existed at the Naval Weapons Laboratory and it was used for all of the analysis we did there. That was a vacuum tube system [as opposed to transistors], and each vacuum tube tray was about the size of a PC now, or certainly at least a laptop. There was this room, which all the walls were full of these trays of vacuum tubes, and the operators sat at a console that looked a whole lot like out [of] Star Trek... But the total interface with that was punch cards, [we] loaded program[s] and loaded data with punch cards.

BUTLER: Certainly very different than today.

SHAFFER: Yes, very different.

BUTLER: But you were able to make it work and help do what you needed.

SHAFFER: It was nice to start at all of these almost first-of-a-kind things, too, because it wasn't such a culture shock to walk in and try to be competent with something that was extremely complex, one of the problems with that being that there's an awful lot of assumptions that people make about where you come from when they design these very complex things. You can't just pick up a PC and use it.

BUTLER: Yes, not that easy.

SHAFFER: No. You've got to find the path.

BUTLER: That's right. As you continued to work on the program and you began to find that path and you built up the skills and techniques and programs necessary to make Apollo happen, along the way were there any major stepping points or challenges that were hard to overcome, or did it all flow pretty smoothly in that?

SHAFFER: I'm assuming when you say "hard to overcome," you mean technically?

BUTLER: Yes.

SHAFFER: Because "hard to overcome" also has an emotional component. So the answer to your question is, yes, in both cases. As we learned and as we developed the processes and the requirements, the complexity became obvious, that we really didn't comprehend the complexity of what it was going to be. The interconnectivity in all of the [technical] areas became more and more obvious, and it got really clear to a lot of people pretty soon that the integration role that the flight controllers, and in our case the flight dynamics people, that the integration role for that was beyond us. I mean, we couldn't, we were inexperienced, too inexperienced and too junior and too parochial, frankly, to do that job.

The program office recognized that, and I don't remember the man's name that really surfaced it, but he did the program a favor, and they invented the Apollo Data Priority, which was the precursor name for the mission techniques activity. They chartered Bill [Howard W.] Tindall [Jr.] out of the program office. He didn't work in the program office; he worked

in the Mission Planning and Analysis Division. He was a charging, assertive, integrating kind of guy, and they named him to lead the Apollo Data Priority.

We in Flight Dynamics felt like we had been gutshot, because they were taking our job away from us, and we thought we were capable of doing that. But in retrospect, we clearly weren't, and Bill understood that. So Bill's early data priority meetings were with the three of us who were doing the Apollo [flight dynamics] work, and what he did was document what we said we were going to do, and he didn't harangue with us about it. His business was about understanding about how we said we were going to do our part of the job. We were pretty resistant to interacting with him, but he was kind of like resisting a glacier. [Laughter] He'd ask you the question and you'd be resistant, and he'd ask you the question and you'd resist it a different way, and he'd ask you the same, you know.

But in a while he had that fairly well documented, and then he went to management of the lunar module out of lunar orbit and down to the surface. We all twigged really quickly to how deep our ignorance was at that point and how unprepared we were for that, and how we truly needed—now we needed a lot of help. So the tables between us went away and we all got on the same side of the table. That was really a turning point. The operational integration of the program really pretty much happened out of that charter and everybody, the contractors, the analysts, the hardware people, everybody got on the same team.

BUTLER: I guess he knew what needed to be done and had the patience to—

SHAFFER: Well, plus the NASA management, the program office management, knew that to charter it out of the program office would give it the clout that it needed to operate with everybody. The program office relationship is, they got the money, and so they're the money management, or the business management, of the program. So if you wanted to get some

money to do something, you had to go through the program office. So this kind of an integrating function was a natural to come out of the program office.

BUTLER: An example of some of the good leadership throughout.

SHAFFER: Exactly.

BUTLER: That's good. Well, and it all did come together, and Gemini eventually came to a successful conclusion.

SHAFFER: Although they didn't have the mission techniques or the data priority for Gemini. The Apollo was the first one. To provide a segue for later, Bill Tindall got his revenge for my resistance, too, because when it was time for him to go on, he insisted that I was to replace him as the chair of that, which I did do.

BUTLER: Well, at least you had learned from him and been through it with him, so you were able to build on that. That's good.

Talking about Bill Tindall, unfortunately we won't have a chance to talk with him for this project, but can you tell us a little bit about him and maybe some of the other people you were working with at the time, too, that were influential, or that made an impact on you?

SHAFFER: Well, Bill was influential because not only the relationship in the [data] priority, but we became reasonably close personal friends, in part because he said we thought alike. We didn't have much tolerance for "airbags" [statements that had form but no real content] and that sort of thing, and we always wanted to solve the problem. It wasn't required to be our solution, it was required to be a solution, that satisfied most of the constraints.

He was a bit older than I was and more experienced, particularly in the management kinds of things, so he gave me a lot of help a lot [along] that way, too. He became the director of Data Systems and Analysis Directorate. He didn't stop at the lower level where we were doing flight techniques; he kept right on going. He was a bit of a wild man. I mean, he enjoyed high-energy kinds of things. He had a Ford Pantera, which was a sports car with the engine in the middle and all these kind of things, and he'd get it out on the highway and drive it very fast. [Laughter] Basically he worked hard and he played hard, and he was among the most ethical people that probably I've ever known.

BUTLER: That's great.

SHAFFER: Number one kind of guy. I remember once when we were doing simulations for probably the first orbital Apollo mission, I was the flight dynamics officer and we were training and we had gotten into a launch abort sequence that—it got overly complex, is probably a good way to say it, in that they put us in a trajectory that was going astray and then failed the control center.

BUTLER: Oh, my. That's complex.

SHAFFER: So we didn't have any more data, any more real-time data. Of course, it was appropriate to be prepared for that, so the call that I made was the one that I thought was conservative, which was to go on to orbit instead of terminating the launch space. Almost nobody agreed with me. Of course, when they brought the system back up to see what the results of what the call was about, we were in a safe orbit and etc., but everybody said I should have tried to terminate it. Well, my problem with trying to terminate it was I didn't know how to keep them out of a hard landing in Africa without the computers, and I had no

idea whether or not we'd still have the engine on as we intersected the atmosphere, which landing in Africa meant you didn't have to worry about that. But I had a fairly good idea of how to get the orbit from where we were.

So anyway, there was this big harangue with all these people doing Monday quarterback kind of things. Well, there's this guy called Chris [Christopher C.] Kraft [Jr.] that's sitting back up at the flight director console, just observing all this. After it came to no resolution and decided that I wasn't going to give, because I truly thought it was more dangerous, and after it was all over, Chris comes down. Chris is nowhere near as tall as I am, so he's standing on the next step up, and he's just a little bit above the eyes, and this is the first words he ever says to me. He looks at me with his flat expressionless stare and he says, "You are an arrogant son of a bitch," and turned around and walked away. [Laughter]

I thought my career was over. I thought the end of the world had come—but what it really was, was that he was acknowledging that I had taken a position that he didn't find untenable and had held it, and that he approved of that. Boy, I didn't think so at the time. [Laughter] I really didn't.

BUTLER: [Laughter] A very unique way of telling you that.

SHAFFER: Yes. I had another one like that. Bob [Robert R.] Gilruth was in that genre of people that were very much worth emulating. I suspect because of the difference in seniority, he was the center director when I came here, but one of the things we got into was interminable flight plan updates while we were in lunar orbit, because we could never get to the Moon on time. We could get into the right orbit, but we always got there sooner or later than we were supposed to, and so the times in the flight plan would all be off by however much the time of arrival was. A guy named Tommy [W.] Holloway—that's a name you have to know—he called and said, "We've got to do something about this time stuff." He said,

"We're just taking entirely too much time with this air to ground updating the times of the flight plan."

I says, "Tommy, it's not a big problem. We'll just change the clocks."

He says, "You can do that?"

I says, "Tommy, we do that during launch phase. When we find out what time they release the inertial measurement unit, we put that in the computer during launch phase. I mean, changing the clocks again, you know, and during coast, that's a nonevent."

He says, "Well, that would be wonderful."

So we have to go to the Change Control Boards, because this is a new procedure and it makes a lot of people nervous. This was a precursor to Y2K, [is] the way people thought about it. "You're going to change the clock?" [Laughter]

So that piece finally got to the center-level Change Control Board. Bob Gilruth was there that day, and I made my pitch for changing the clocks and all the stuff we'd do to be sure we'd done it right. Does it sound like Y2K to you? He listens to all of that, and we finally get to the point, and Gilruth looks at me and he says, "You're out of your mind," and he got up and left.

BUTLER: Well, I guess that's one answer for you. [Laughter]

SHAFFER: I, particularly, sat there kind of stunned. So I said, "Well, that's great. We can get on with implementing it now."

They said, "What?"

I said, "Yes, he didn't say not to do it, he just said we were out of our minds."

"Oh." They said, "No, that isn't what he meant."

I said, "Well, you'll have to ask him. I'm not going to. I'm going to go implement it."

And they didn't and we did, and that was the end of the flight plan time problem. We went through it and was very, very careful and did it in a time when it was really benign and it worked wonderfully.

A guy named Jim [James A.] McDivitt was the CCB chairman at that point, and when we generated the first load to the computer to change the times, I burned a hard copy and took it up to him and made him autograph it, and I still have that somewhere in my memorabilia, this old hard copy with his signature on it with the clock load.

BUTLER: That's pretty unique. That's pretty good. You've had some interesting times.

SHAFFER: Well, there's some interesting people. All these guys, they were the giants.

BUTLER: They certainly were. When did you begin running simulations for the missions for Apollo, and was it during this time when you were building up all these techniques?

SHAFFER: We began running simulations before it was possible to run simulations. There were simulations where we ran against a computer model of a crew, and then there were simulations that we ran with crews, and we could hardly wait to get to where we could run simulations with real crews. But we didn't have simulators here, and we didn't have a control center here, but we wanted to do it anyway. It turns out there was a facility called the ME-101, which was a spacecraft simulator in Downey, California, at the Rockwell plant there. It was hooked up to computers out there. So we developed a communication system between that facility and a computer here.

We set it up so that the trajectory data out of the ME-101 in California would print out vectors, you know, position, velocity and time, on a computer here and we would manually load those into another computer and compute rendezvous maneuvers and then

read them back to the crew on a telephone and then they would do them. So we were running integrated sims really early to do that, long before we had sims that resembled anything like we would run after we had a control center. So, still building the control center, getting ready to do Gemini stuff here, and we were running [Apollo] simulations with real crews and that simulator in California.

BUTLER: Figured out a way to make it all work.

SHAFFER: We were really anxious to get on with it. We knew that was going to be fun. [Laughter]

BUTLER: Always good to do the fun stuff.

SHAFFER: Yes.

BUTLER: Always. While they were building the control system and putting the whole space center together, where were you based out of, do you recall? Scattered throughout Houston?

SHAFFER: You mean what building?

BUTLER: Yes.

SHAFFER: Sure. We spent the first probably four months in the second story of the Stahl & Myers warehouse building, where Oshman's is now, on the freeway. No windows, not very good air-conditioning. The control center was one of the early buildings that they built here,

and when that was ready, we came out before it was done and moved in. So our offices were basically next door. They were in the same building as the control center in the Building 30.

For long time we moved around a lot. We ended up over in the second tallest building, it's Building 47, which is a six- or seven-story building over there. We moved out of the control center and over there when we finally got too large for the room we had.

I don't know where those guys sit anymore. I haven't known for a long time. But it was really kind of interesting, because we'd get up from our desk and then in a few steps be in the control center.

BUTLER: That's convenient.

SHAFFER: Plus we kept a lot of data in our office area, because it was going to be convenient. We had to carry it all over there. That was very much worthwhile, too.

BUTLER: Certainly. As part of all this building up for Apollo, were you involved with any of the details of the construction of the control center, or just more with the computers?

SHAFFER: No. Our job was—you know, they had these big projection TVs and those kinds of things at the front. Our business was deciding and recommending what was going to be on those. The little TVs that had all the data, we were deciding, recommending, what was going to be on those, the configuration of the communications panels and who we would need voice loops to and from. In the case of the flight dynamics officer and the booster systems engineer who was on the end or far left, we had always had abort command switches on the console.

So getting those configured and the same for everybody, it was that level of stuff in the control center itself, but the basic design of the control center, it was probably under way

before we had people at my level to think about that. Lyn [Lynwood C.] Dunseith and Jim [James C.] Stokes [Jr.] were probably the big pushes for that, which are also guys that I respected and admired very much. They did just an outstanding job.

BUTLER: Certainly able to put together a good center and make it all work.

SHAFFER: Yes, they did. You know, their private contractor for that job was Philco, Philco Ford, and guys like John [W.] Hatcher, who also is not with us anymore, was integral. John's a guy, slight, not very tall, dynamo, absolute dynamo. One of his favorite activities was hunting white-winged doves down by the Mexican border. If he disappeared and was out of town, that's probably where he was, was chasing the wily white wing.

BUTLER: I guess you always knew where to find him if you needed him then.

SHAFFER: Right.

BUTLER: That's good. Well, as you came along, you were building up to Apollo. What was the first mission then that you were going to be working on, assigned to work on?

SHAFFER: Oh, the very first Apollo, which was Apollo 201, which was not a real spacecraft. It was a launch vehicle test and had a spacecraft with some capabilities. We all worked all of those things in some capacity. In the early days, we didn't have crews working with us yet, so some of us would do capcom functions, and do the things in terms of sequencing the computer, like the launch abort mode would change when it was time to jettison the launch escape system, that tower with the rocket. So you had to tell the computer when that had happened, and that nominally was done on a voice report from the crew, so we had those

kinds of inputs to make to the computer. When staging happened and you switched first stage to second stage, the astronaut, the capcom, would tell us. So we had those kind of functions early.

I was not the flight dynamics officer on any of those until probably the first real [manned] Apollo. We had other folks in training that were running all of those jobs. I was very much involved in this integration function that I had done almost from the time I came here, so they were doing that, but when it came time to put people in it, then I was the lead flight dynamics officer. We went and did that.

BUTLER: Unfortunately, the first one that was supposed to be—

SHAFFER: Well, not the one we actually flew.

BUTLER: Oh, the Apollo 7?

SHAFFER: Yes. I had the same role on Grissom's flight where they got killed, yes.

BUTLER: That, unfortunately, did cause some changes that were necessitated and such, but yet a lot of people have said that without such an incident they wouldn't have been able to make it to the Moon probably eventually.

SHAFFER: I hear that. I don't disagree with it, nor do I understand it. I don't know whether they mean that there was design deficiencies or whether the quality wasn't good enough to go. I've never truly been able to make that distinction, but they do say that, and so we ended up with a very different vehicle in terms of its capability. So I'm certainly willing to accept it. I [don't] have reservations about that. But sometimes it takes something like that to really

clear the air, too, and to get everybody really serious about what we were doing. Maybe that's what they mean when they say we needed that kind of incident. I don't know, but it was tough. I mean, we were in the control center when the guys died. That was not one of my favorite memories.

BUTLER: I certainly can understand why. Apollo 7 kind of brought the whole Apollo program together, bringing it all, making it work, and then this was the first mission in that you worked from the control room as flight dynamics officer then?

SHAFFER: Yes, it was.

BUTLER: That must have been very rewarding to see it all come together and work.

SHAFFER: Well, it was. It not only was the first launch that I had done and the first launch of a manned Apollo, but it was also the first rendezvous that I had done, and we did it without a "transponder." Because we re-rendezvoused with the third stage, or actually the second stage of the launch vehicle, and it didn't have this wonderful transponder that gave you both range and range rate to tell you how fast you were closing on it, so you had to derive that from the range data. We got through that all right. It was also the first long-duration mission I'd done. We were there for ten days.

It was the first sick crew I'd gotten to deal with. We got involved in that. I have to tell you that the job Glynn Lunney did, Glynn was the flight director then, and dealing with the sick crew was just nothing short of magnificent. I couldn't believe the Irishman could be that cool while he was being rained on from orbit. [Laughter] He did good.

We had lots of memories about that one, too, you know. Launch phase was, I think it was this one, I think we got to orbit, we got the coast segment, we gave them a go-for-orbit, and the control center went dark, for real.

BUTLER: Oh, no.

SHAFFER: I'm almost sure that's what it was. A guy with a ditcher had gone through the power cables outside the control center. [Laughter]

BUTLER: Oops. Oh, dear. What did you do at that point?

SHAFFER: Well, we looked at the emergency lights. [Laughter] It was real quiet. Part of Apollo, part of early Apollo, was a very limited tracking network, so we had built…the Apollo instrumentation ships and had them placed around in strategic locations, and one of which was down range in the Atlantic, so that if we lost the control center, they would be able to monitor the latter part of boost and give them a go-for-orbit. A youngster named Jay Greene, who turned out to be the flight director on *Challenger* when it blew up, he was on the instrumentation ship.

So it wasn't a panic, because we knew they were there and that they were up, so we got back and got it all pulled back together and pressed on with ten days of boring holes in the sky. It was not *boring*, but it was boring. [Laughter]

BUTLER: I guess it's good that all the training and simulation that you had done beforehand was able to—and people had the experience they needed to make it all happen.

SHAFFER: Well, I had been integral in the requirements for those ships, too, so I knew what they were capable of, and I had hired Jay from Rockwell, so I knew what he was capable of.

BUTLER: That's good.

SHAFFER: Another little piece of history there that I hadn't thought of in a long time.

BUTLER: I'm sure somebody changed some procedures about digging ditches. [Laughter]

SHAFFER: Got to impound all the ditchers during the launch phase. [Laughter]

BUTLER: Definitely not something you'd want to have happen when you were about to land on the Moon or anything. I suppose if it had to happen on a mission, that was maybe the best one that—

SHAFFER: It was a great way to get started. It taught us a lot about what we needed to do with the flight crews before we flew, too, because, in all honesty, Wally [Walter M. Schirra, Jr.] and the guys were not fully briefed on all the tests that were going to be done, and some of them they heard for the first time while they were there [on orbit]. Then because we were there and because it was new, we actually invented a couple of new things to do while we were there, and at least one of those went really wrong and crashed the on-board computer. I mean, it was training for all of us. It was not just checkout of the spacecraft.

BUTLER: Had you, previous to that time, had a lot of interaction with the flight crew, or also did your interaction levels then with the flight crew change after that?

SHAFFER: No. No, we had lots of interaction with them. The flight dynamics team spent a lot of time with the flight crew, because the trajectory management was the dynamic part of the phase, doing all the maneuvers and calculating the thing, getting them there, getting them home, and so we did. But all of us were neophytes. I mean, Wally wasn't, because he had flown in Mercury and Gemini, but we were, so we didn't know all the things that we really needed to talk to them about.

Plus we had a lot of fun with them, too. One of the things that Wally and I did continually was make quarter bets on trajectory-related events while he was in the simulator. I nearly broke him with that. [Laughter] He was easy. But Wally and I had a good time. He was, for the most part, a pretty nice guy. But he was confident. But [Apollo] 7 was problematic for him because he was sick.

BUTLER: Certainly couldn't have been a comfortable situation, and then like you said, there were so many new things.

SHAFFER: Yes.

BUTLER: It was a good learning mission for everyone.

SHAFFER: It was, which is what it was supposed to be. You cannot imagine how surprised we were when, although we were really bound up in Apollo 7, when—and I don't remember exactly when it was, but it could have been like the week before launch—they said, "We're going to go to the Moon on the next one." [Laughter]

BUTLER: That must have been shocking, from your standpoint.

SHAFFER: It was. We couldn't go work on it, because we were getting ready to fly. Jay and I were clearly going to be leads on this first flight to the Moon, so we splashed down from Apollo 7 and sixty days later we went to the Moon. That was exciting. [Laughter]

BUTLER: That's one way of putting it. [Laughter]

SHAFFER: It was.

BUTLER: Did you stop at that point ever and think about, "Wow, look at what we're really doing here"?

SHAFFER: No, we were 60-day intervals then, and I mean, it was end one and start on the next one.

BUTLER: How did you bring it all together for Apollo 8 to work, or did it just kind of—

SHAFFER: No, we had started it, and we brought all the stuff that we were doing for what would have been the first one out, which would have probably been Apollo 10 anyway. I mean, we had all of that work done and the waves were started. We had some guys coming from Gemini now who were capable. I mean, Ed [Edward L.] Pavelka pretty much picked up the load while Jay and I finished with Apollo 7 and got on with that.

BUTLER: What shift were you assigned to in Apollo 8 for the mission actually going to the Moon?

SHAFFER: Jay launched it. I no longer remember who did reentry, but I did the lunar orbit parts, the getting in and out of lunar orbit. The orbit determination problem was going to be a real zoo there, because we hadn't done that before with a vehicle. JPL [Jet Propulsion Laboratory, Pasadena, California] had done it, we hadn't done it yet.

BUTLER: When they went behind the Moon for the first time and you were waiting to see whether they had gotten lunar orbit, what was that like?

SHAFFER: It was not nice. They're up there with a single engine, no backup. If they have problems with the engine, they can end up in anything from doing a whifferdill around the Moon and going away, to being stuck in lunar orbit. I mean, we had the same problem when they did trans-Earth injection. All of the things that you worried about during lunar orbit insertion are now possible again in trans-Earth injection, because they're all basically associated with changing the energy of the orbit that you're in. One of the ways the orbit gets squirrelly, instead of being an orbit that has enough energy to go around the Moon and come all the way back to Earth, it has enough energy to go around the Moon and then get to the point where the Earth and the Moon have equal gravitational pull on it. Then who knows where it goes from there, or does it become another little moonlet? It's scary.

BUTLER: It must have been a very intense time.

SHAFFER: It really was scary. So doing it again when we back on Apollo 10 and had a lunar module with us for a backup engine, you know, it was just like being in a Cadillac after we'd just gotten done with a manure spreader. [Laughter]

BUTLER: Well, it must have been very rewarding or satisfying or a relief when it did all work.

SHAFFER: It was, and we were all like sponges again. I mean, we were learning so much about translunar navigation problems and lunar orbit navigation. We were seeing things that we didn't expect, which were little perturbations to the trajectory, and were just absolutely stunned at how sensitive it all was. By the same token, we learned about how easy it was to fix, because if it was a small perturbation to disturb the trajectory, then it was a small maneuver to fix it, too.

BUTLER: It was a good learning mission, then.

SHAFFER: Yes, but we all ended with a great deal of confidence in the vehicle, too. The vehicle was really, really a piece of work.

BUTLER: The vehicle and the crews, crews supporting it, both the flight crew and the ground crews, that you all knew what you were doing.

SHAFFER: You're correct.

BUTLER: If we could go ahead and take a break here and we'll change out our tapes.

We've just finished talking about Apollo 8 and the challenge with that mission and some of the things you discovered going around. Some of the next missions were then building up still toward the lunar landing, Apollo 9 with the lunar module and command module, both testing out in Earth orbit and then [Apollo] 10 going back to the Moon and

testing them both in lunar orbit. Were there any particular incidents around either of those missions that stuck in your mind, or any particular things you learned?

SHAFFER: Yes, I launched Apollo 10, and also I got to run the first rendezvous around the Moon. If I remember the numbers, the command module and the lunar module got about 700 miles apart, something like that, and then we had to bring them back together. So that was another great reassurance builder, about our ability to navigate and to pull it off. It was an easier problem than getting the crew up off the lunar surface, which turned out was going to be next. I don't think it was supposed to be, but the way the schedules worked out, it was. So that piece, from a learning and a performance standpoint, was really important.

I don't remember anything particular about launch phase or lunar orbit other than that. I mean, it was pretty much we'd done it once and now we did it again, except when the crew came out from behind the Moon after trans-Earth injection, the crew advised the ground that I was going to get a bottle of champagne for [having done] all that. [Laughter]

BUTLER: That's pretty special.

SHAFFER: So I thought that was neat.

BUTLER: That's nice to have them recognize your work in that manner. Do you keep a recording of that part of the—

SHAFFER: No. No, I didn't. I should have. I never got the champagne. [Laughter] But that didn't really matter; it was the acknowledgement.

And sixty days later, whatever it was, we went back and I'm now ending my career as a flight dynamics officer. I pulled one shift on Apollo 11 and that was the launch rendezvous off the lunar surface, and that was the last time that I served as a flight dynamics officer.

BUTLER: That's certainly a very special mission to have your last one.

SHAFFER: At that point, Bill Tindall got his revenge, and I became the chairman of the data priority, and off we went with all the rest of the lunar missions, planning those, the J missions, the ones that a rover and the full-blown scientific instrument complement in the service module. That was very, very much more complex in getting all of that done.

I got involved a lot in landing site selection at that point, too, but it was as the data priority guy, mission techniques guy, rather than any other role. I remember the selection for Apollo 17, the geologists wanted to go to Taurus-Littrow, the crew was interested in going to Taurus-Littrow, and the trajectory guys say, "You can't get there. It's too narrow."

Taurus-Littrow has got a 200-foot scarp cliff at the end of it and it's got these 6,000-foot mountains on each side, but this scarf is 200 feet of lunar crust, it's exposed. One of the mountains has had a huge slide and you can see the debris material that's down on the floor. There's impact craters there. There's volcanoes there. I mean, everybody wants to go, but the trajectory guys are saying, "You can't get there from here."

The argument escalated, and finally we ended up in the presence of Chris [Kraft] about landing site selection for Apollo 17. Chris listens to the scientists make their plea and the trajectory guys doing their doom-saying, and then he looked at me and he said, "Well, what do you think?"

I said, "Chris, you ought to go. Let's go. We can do that."

So Bill [William R.] Muehlberger, who was the geologist guy, he made up a plaque for me for that one, with a little rhyme about, you know, basically acknowledging the role that I'd gotten to play in picking that landing site.

BUTLER: That's pretty nice.

SHAFFER: Basically that's the last—I think that's the last clear memory I have of anything to do with Apollo, and I was off to do Skylab then. Somewhere in there we had started the mission techniques work for Skylab, and it was so different from the Moon. The Moon began very quickly to be like a really good dream with all its intensity that you could reconstruct anytime you wanted to, but it was kind of surrealistic in a way, too. You all may have had that experience, to go out and look at Moon now and think that thirty years ago we were walking around on that. Say what? [Laughter]

BUTLER: It really is something to think about.

SHAFFER: It's very different.

BUTLER: Having two of the critical missions in the Apollo program, we've touched on Apollo 8 and Apollo 11—

SHAFFER: You know, I've left out a huge piece here. I have left out a huge—I didn't realize I was leaving it out. In the middle of all of this, I was made a Flight Director.

BUTLER: Yes. [Laughter] We will definitely talk about that.

SHAFFER: You know, it's a bit of overwhelm. We had data priority for Apollo, data priority for Skylab, assistant chief of the Flight Dynamics Branch, and now I'm going to be a flight director [Purple Flight]. Some of the younger guys, and I remember Bill [William M.] Stovall and Chuck [Charles F.] Dieterich, who were a couple of guys from the trench, they would come to talk to me about a problem and they would ask me which hat I was wearing. [Laughter] Because I was in a position where I was working for myself, and it was very confusing to them as to what role I was speaking, as their administrative leader or as the data priority, or was I being a flight director, because the perspective is different from all of those things.

Yes, Apollo 16.

BUTLER: When did you get the opportunity to be a flight director? Do you recall how that happened, how that came about?

SHAFFER: No. [Laughter]

BUTLER: Okay, that's fine.

SHAFFER: No, I don't. I really don't remember the specifics. Don [Donald R.] Puddy and Chuck [Charles R.] Lewis and Neil [B.] Hutchison and I, it was serendipity, all four of our home states start with O. [Laughter] We weren't really made flight directors; we were made deputy flight directors. And I didn't understand why, since the previous classes had not been deputy flight directors, until I understood that Gene [Eugene F.] Kranz, when he had been named, was named the deputy flight director. He was the Director of Flight Operations now, so he's the namer of the flight directors, so he was not going to start us out at a rank above the one he'd started at. [Laughter]

BUTLER: Certainly not.

SHAFFER: We knew that we were going to be flight directors for Skylab, that that was our principal role, and what we did on Apollo as flight directors was OJT [on-the-job training]. It was training in being a flight director. Don and I worked Apollo 16, and Neil and Chuck worked Apollo 17. The other pair worked in what was called the SPAN [Spacecraft Analysis] room, which was an advisory room to support the ones that were on the console.

BUTLER: What did your training entail for the job?

SHAFFER: Well, it was a whole lot of time in the simulators now, learning about systems, which was the allusion I made earlier about all of a sudden I found out that all those systems guys had a lot harder job than I thought they did, because you had, particularly the electrical and environmental systems, which was something we had nothing to do with as trajectory guys, we did the propulsion system, I mean, guidance and control, but not with the environmental things. My stars, those things were complex, plus they were little alien in the way—you know, didn't have any basis. So hours and hours and hours in the simulators and with those guys, learning about those things, and plus now getting involved in integration of that into our planning process and in our limiting process, because you have to take into account everything that's going on with every system when you make a decision as a flight director. It's not just what's the next maneuver look like. It's a little different. Plus we hadn't had a lot to do with communication systems, which was another thing. I have to truly say, I never really mastered the communication system in terms of comfort. It was beyond me. It was too complex.

BUTLER: I guess you had good people, though, that could support you on it.

SHAFFER: Yes, I did. Captain Video, Ed [Edward I.] Fendell, and those guys, yes. Great teams, though, first-rate people still there doing their thing. Not too much prima donna business, except those guys in the trench were a real pain. [Laughter] They really were. They were the worst of the worst when it came to the prima donnas. They thought they were something special. [Laughter]

BUTLER: Go figure.

SHAFFER: Apollo 16 was interesting. Gene Kranz was my mentor, not only because he was the FOD [Flight Operations Director], but we had a connection. So he was the one that was counseling and advising and critiquing and all that. On the first translunar shift I pulled, he came in for an hour or two or something like that, and he got up and left. That was okay, I didn't have any problem with that. And he had no more than got out the door than the IMU [Inertial Measurement Unit], the reference unit, tumbled and went away, and the crews without a GNC [Guidance, Navigation, and Control] without a reference, which I wasn't particularly concerned about, because it happens, except the guidance officer was also new. It was his first solo shift and he stood right straight up and said, "Oh!" [Laughter] And I knew I was in trouble. [Laughter] Jerry [W.] Mill. Jerry Mill was his name.

So we told the crew that we didn't see any fault, we'd just locked up the gimbals. It was not a four-gimbal platform, and we'd locked it up and dumped it and they said, "Okay, we're going to bed. You all fix it." So we went on with that.

BUTLER: And were able to get it back in order.

SHAFFER: Yes. Lunar orbit was sort of a zoo. I was the flight director for trans-Earth injection. I think Don [Puddy] had done lunar orbit insertion. I don't remember exactly. But I know I was on the trans-Earth injection. We had a mass spectrometer experiment, which was a sensor out on the end of a big wand that was sticking out from the side of the spacecraft, and one of the test objectives was to de-orbit the lunar module close enough to some of the seismographs that were on the Moon to make a little earthquake so they could see—it was all things that we were supposed to do.

The crews had had a fairly exhaustive time on the surface. John [W. Young] had gotten sick of the orange juice because it spilled inside his spacesuit and he had orange juice all over him. Those kinds of things.

Got them up and got them rendezvoused. I did that, too. Goodness. Yes, we got them up and got them rendezvoused and we were configuring the lunar, to close out the lunar module, getting ready, and all of a sudden the crews realized they had misconfigured the lunar module so that the ground control, the orbit sequence was not going to work very well. But the [control center] guys were convinced they could get it down and we might be able to get the detail. The crew was so tired that I made a flight-director-level decision that we were not going to reenter the lunar module and reconfigure it, because that meant we would have to spend another orbit, at least one more orbit in lunar orbit, and the crew was going south, anyways, and nobody argued with me.

So that was the plan, and the trajectory guys and the lunar module guys got started with the plan to do the best job they could. We needed to get it out of orbit so we didn't have a debris problem. They were doing that piece of it. We got ready to retract. The command and service module's now by itself getting ready to do trans-Earth ejection. We're retracting the mass spectrometer boom, because it turns out you don't retract it and light off the engine on the command module, that thing swings and that sensor [would] punch a hole in the nozzle of the rocket, on the command and service module.

BUTLER: Not a good thing.

SHAFFER: Yes. And it won't retract. It's stuck. It's jammed. We fooled with it, fooled with it, and we're approaching loss of signal prior to trans-Earth injection. And I remember we've got all these heavy-hitters up behind me on the console and they're going to have a philosophy, they're going to have a plan. I told them how many minutes they had till loss of signal, and I can hear them up there debating about what's the right thing to do. We ran out of time, and I told the capcom [to tell the crew] to jettison the mass spectrometer boom with that pyrotechnic device on it, and it banged it and had already gotten the vehicle in attitude so that we would punch that boom out into an orbit that we wouldn't intersect it again, you know, from trans-Earth. They did, and it went away and gave them a go for trans-Earth injection, and they went behind the Moon. In a couple three or four minutes, this gang behind me says, "We have a recommendation for you."

I said, "Nope, I have a recommendation for you. Take a break, and in about forty minutes we'll have AOS and the crew should be on their way home."

And they said, "Oh, okay." [Laughter]

BUTLER: You did the job they had put you in a position to do.

SHAFFER: There was Apollo 16. It's amazing that I forgot there for a moment I'd done that.

BUTLER: Well, you did a lot of things. Talking more about Apollo 16, before they had gone down to the lunar surface, they had some problems with the command module engine and some oscillations with that. Were you at all involved in—

SHAFFER: Jay [Greene] was on for that. Yes.

BUTLER: Did you work any of the lunar surface activities?

SHAFFER: Everybody pulled a shift, but I think we deputy flight directors were doing sleep shift planning things. I don't think we were doing active activities. I don't recall doing those, so it would make sense that we were doing the planning kinds of things.

BUTLER: You certainly had enough interesting things that happened during your times on console.

SHAFFER: Well, actually, Skylab was a lot more interesting from that standpoint than Apollo was, believe it or not.

BUTLER: Well, we will certainly talk on that. Before we go on to Skylab, there's a couple other things I'd like to talk at least briefly about on Apollo.

SHAFFER: Sure.

BUTLER: One being your thoughts on Apollo 8 and Apollo 11, both unique missions from many standpoints. Is there one of those that you think was the prime mission or the one that accomplished the goal most in your mind, or that was the biggest challenge for you, or meant the most?

SHAFFER: No, I don't think so. When I think about that sort of thing, I think about the Apollo program, okay. And from this vantage, which is thirty years later, I think the thing

that's most important to me about the Apollo program is the technology spinoff and what it did to our culture, rather than a high point of Apollo 8 going to the Moon for the first time or Apollo 11 standing on the Moon for the first time. Those are fairly esoteric things which were done predominantly for political purposes. I mean, their basic justification was politics, international politics.

But we stepped computer technology a full generation having done that. We stepped medical monitoring some untold number of generations by doing that. The whole business of space flight changed. No matter whether you do it unmanned with scientific satellites or whether you put people up there, those were the world changes. I mean, walking on the Moon was a thing that happened on the way to changing the world. It wasn't an end game in itself. It was kind of the beginning of the end in some ways for Russia, because they lost the technology race, and then I think when [President Ronald W.] Reagan started pushing the Star Wars [SDI – Strategic Defense Initiative] thing, they gave up. They can't keep up with the capitalist bastards. [Laughter] Excuse me. They were big deals, but they weren't *the* big deal at all.

BUTLER: It's true. Good perspective. Very good. Looking at that, too, and talking about some of the international impact and the world, at this time there was so much going on and you all were so focused on Apollo and getting to the Moon and making this all happen, were you aware a lot of the other events going on in the world?

SHAFFER: No. No, we were cocooned. Most of us were working 3,000, 3,500 hours a year on a standard issue 2,000-hour work year. We were all doing close to double time, and that's really all there was. No. Did anything happen then? [Laughter]

BUTLER: A few things. [Laughter]

SHAFFER: Well, you know, we really, in a sense, missed the hippie phenomenon. I'm serious. We didn't know anything about that. We'd see a picture of a young woman putting a flower in the end of the rifle and say, "What the hell are they doing that for?" Then we'd go back to whatever it was we were doing.

BUTLER: Well, you certainly had quite a goal to accomplish and work on.

SHAFFER: Yes. But I can't tell you how much fun it was. It really was.

BUTLER: Quite an experience.

SHAFFER: Yes.

BUTLER: Well, looking at a couple of the other missions, you said that after Apollo 11 you moved into the data priority area, and for Apollo 12, at least from a trajectory standpoint, it was quite a challenge to get—you wanted to go for the pinpoint landings and shooting for the Surveyor. Were you much involved with discussions on that?

SHAFFER: Apollo 12 was so much like Apollo 11 that there wasn't a lot of new development for anything that they were planning on doing. Bill [Tindall] had already done that level of thing. In fact, the J missions started with Apollo 15, was where most of the effort, the development effort, was, because the data priority piece had to be done before the crew training could really start for those differences and before the simulations could start and people start getting ready. Sixty days was nowhere near long enough. I mean, people were starting to get ready months before, so you had to be that far ahead of the curve.

The big thing that happened for us on Apollo [11] was this horrible miss distance that we had when they came around the Moon, where they were at least three miles long, if not further, and Neil [Armstrong], when they pitched up, all he can see is a boulder field out in front of him, and he knows from the training that he is a long ways down range from where he's supposed to be. And we had to understand what had caused that and what to do about it. For me, it was the same kind of problem that I'd been doing for the Navy, about why did the Polaris reentry body miss. There's a whole bunch of little things.

It turned out there were some uncoupled attitude control thrusting going on while they were doing that, and every one of those little puffs of those things was perturbating the orbit. It turned out there was some valves, probably some valves left open, and there was some outgassing of atmosphere, the oxygen, and that was perturbating the orbit. When they separate them [the CSM and LM], it's a push-away, and that perturbated it. All that stuff added up.

So we had to go through and isolate and neutralize all of those kinds of things, and basically it was a whole new [vehicle] attitude history, so that when you did those little perturbations, that you did them out of the plane of the orbit, so that they had no effect. Those things are insensitive out of the plane of the orbit and very sensitive in the plane of the orbit. So we had that piece of work to do, but other than that, 12, 13 and 14 were pretty much done pre-flight. Thirteen was not done in flight. Got very involved in 13.

BUTLER: With 13, when did you learn about what had happened and then what did you do?

SHAFFER: It's a psychic experience. I sat bolt upright in bed and knew that something awful had happened, and jumped in my clothes and my car and went to the control center.

BUTLER: Oh, my goodness.

SHAFFER: Yes, it was a peculiar kind of thing.

BUTLER: Wow. That's kind of chilling.

SHAFFER: So I got right in the middle of it just immediately. I had now been flight techniques just long enough that everybody was looking to me instead of Bill. Although Bill was still there and still involved, the piece of the development that I could do, or that mission techniques could do, was my part. Ken Mattingly and John Aaron did the thing that was the limiting resource, which was [they] finally found a way to have enough electricity to get home.

BUTLER: So you worked with them in trying to establish—

SHAFFER: Well, we did everything we could, and then they just had to take it and finish it.

BUTLER: Quite a time.

SHAFFER: Yes, very much so. I yelled something at my neighbor as I went to the car, because his lights were still on, he was still up, and what he says is, he said he went to the bathroom and then turned the TV on, and when he turned it on, I was walking into the control center, the camera was there, and the problem was, I lived fourteen miles from the—so it was a trip. [Laughter]

BUTLER: You didn't waste much time.

SHAFFER: I don't even remember that part of it. I was trying to understand it, trying to get a sense, if I could, of what had happened, and all I had was it was bad. "Go to the control center now."

BUTLER: We'll go ahead and take a quick break again and change out our tape.

We should talk now about Apollo in some pretty good detail, and you said toward the end of Apollo that, of course, you had worked as flight director for Apollo 16 and then you worked in the SPAN [Spacecraft Analysis] room for Apollo 17, is that correct?

SHAFFER: Right.

BUTLER: While you were in there, what were your duties and responsibilities for supporting that?

SHAFFER: Well, the SPAN room was a function that basically coordinated analysis. They were very much a support role, but they were a senior support role. For instance, something would be going wrong with a spacecraft system, then the interface with the contractor, the builder who had built that system, was generally handled through the SPAN. So it was more an admin advisory process than it was anything else. So that's what we did, and basically we were "gofers" for whoever the flight director was out there. If he needed us to go do something in a deputy flight director role, he'd trigger us and we'd go do it. It was a terrible demotion to go off the flight director console into SPAN. [Laughter]

BUTLER: I can imagine. Quite a change.

SHAFFER: Yes.

BUTLER: But, of course, you were at the same time getting ready to be flight director for Skylab and had also been working Skylab data priority?

SHAFFER: Yes.

BUTLER: Can you tell us about some of what was involved in all of that?

SHAFFER: Skylab, its principal difference from earlier Earth orbit missions was going to be the duration, because the longest Earth orbit we'd had was two weeks—Gemini VII. So we weren't terribly concerned about the first Skylab, because it was only going to be four weeks, but then it was going to be eight weeks and then it was going to be twelve weeks. That had some potential. We didn't think enough about the fact that the Skylab was going to be there for a year and you weren't going to be able to send a technician up to work on it. We were going to do rendezvous, but we had done rendezvous at the Moon now, so rendezvous in Earth orbit really were becoming old hat. Very quickly we had the Apollo launch vehicle. We hadn't flown very many of the 200 Series for a long time, but we flew a bunch of them early in the Apollo program, so there wasn't a lot new about that.

The other piece was the large number of experimental endeavors that were going to go on up there, and the thrust was going to be of maximizing things [scientific activities] that basically interfered with each other, which, by the way, is the same problem [you]'ve got on the [International] Space Station. They're doing that, and it's one of the big problems that the current Space Station really doesn't address, is the conflict that's there. It's why Max [Maxime A.] Faget's idea of a whole bunch of little stations, single-discipline oriented, would have been a better way to do the science, not necessarily a better way economically or

operationally, but to do the science. Anyhow, that was the problem. Milton [L.] Windler. Have you all talked to Milton Windler? Will you talk to Milton Windler?

BUTLER: Not yet, but we hope to, yes.

SHAFFER: Milton did the development of the planning process for Skylab and set up that sequence. I don't really know how it happened that he got tagged with that, because he was a flight director, too, on Apollo. But anyway, he did, and he did an absolutely, in my opinion, sterling job of pulling that off. So basically he had a planning shift, you gave it a shift of shelf life, then you'd do the detail planning shift, which was all of the crew procedures and things, and then you executed it. But that basic sequence, if it hadn't been done that way, it would have been an absolute zoo. That was the master stroke.

I was the launch, Don Puddy launched the Skylab, and I doubled with him on that job. The Skylab started shedding parts fifty seconds after liftoff. When we finally got to orbit, it was pretty wounded. Don, everything he tried didn't work, because the thing was so trashed, but he basically set up attitude profiles and a bunch of that kind of stuff that were required to make it last.

My job was the launch, rendezvous, and the de-orbit entry of all three missions and an on-orbit shift as one of the four. So I had two different flight control teams for Skylab. I had the trajectory oriented guys with an active command and service module, and then I had a different set of guys who were experiment heavies and Skylab systems oriented. So I was with Don to understand what I was going to, because we were supposed to launch the next morning, with Pete [Conrad] and the guys. But [now] we got this crippled thing up there that's flying like this instead of like this [*Shaffer gestures*]. The meteoroid shield's gone, it's getting really hot in there. We didn't get all the solar arrays, I mean, one of them is gone and

one of them won't deploy. We're real short on power and flying like this puts us out of the sun, and I mean, you know, it's a real mess.

So we basically held it together for ten days and redesigned Skylab, the program, built a parasol and took up a bunch of tools like bone saws and some of those things to try to get things loose. Then we went and launched. When we got there, I don't know whether it was worse than we expected, but it certainly wasn't better. I do remember that the launch team was there, was on console for twenty-two hours that day before we got to break. There was no place to hand over with all of this stuff that we ran into, including some problems with the docking probe. So it was a real zoo. I got to go home, take a bath and change clothes, and come back and pick up my on-orbit shift. I don't remember much about that shift.

BUTLER: I can understand why.

SHAFFER: Yes. But I'll always believe without equivocation that Pete and P.J. [Weitz] and Joe [Joseph P. Kerwin] saved the program. I think they took some risks that were above and beyond the call of duty. I think they were not adequately recognized for what they did, but then it's not my business. But things like they got in the suits, I mean, the big solar array that was held down was a major power supply. We needed that power and there was a piece of angle iron that had stripped off and was wrapped around it. So P.J. stood up in a window with something, I've forgotten what, and Pete drove up beside it and he reached out and hooked that and then Pete backed the spacecraft away, trying to pull the thing loose. He almost pulled P.J. out of the spacecraft. [Laughter] So that was a bad plan and we didn't fool around with that very much, and actually gave up on it for a while.

They went out later [in the mission] with a bone saw and were able to cut that piece of scrap loose. But by that time, the shock absorber on the solar array was frozen, so it

wouldn't deploy. Pete and Joe are out [EVA], they got under the solar array, because the analysis indicated that if they lifted, both of them lifted together, could break the shock absorber and let that thing deploy. So they get under it and with their legs lifting, shoulder on the thing, they put it out and they broke it. Solar array goes out and they go "boing" and they're at the end of their tethers. [Laughter]

BUTLER: Well, it's a good thing they had those tethers. [Laughter]

SHAFFER: Yes, you wouldn't have dared done it without the tethers. It makes you think about that elevator that fell in New York last night. Did you hear about that? Forty stories. Cable broke on it and it fell forty stories. Braking system finally caught them four stories from the ground. While you're going "boing" out here, you wonder if the tether's going to hold. It's that kind of stuff.

But once all that was done, got them to bed and got some sleep… With that out, you could reorient and let it start cooling, etc.

BUTLER: And it was ready to get under way.

SHAFFER: They did. Basically from that point on, Skylab II was as nominal as Skylab was ever going to be. We were always power limited because we'd lost one big solar array, and we always attitude limited because we had a parasol up, but we didn't have a real heat shield, etc. But the parts that worked, really worked well. Then things got worse.

BUTLER: How did they get worse?

SHAFFER: I thought you would never ask. [Laughter] On Alan's [Alan L. Bean] flight, on the second manned Skylab, we lost a [CSM] thruster quad during the rendezvous, which is no big deal. I mean, they have four quads around it and you had full control… Other than changing the propulsion model a little bit, we rendezvoused and we docked and they proceeded to get on, but during the activation process we lost the same quad on the other side. There were two here and two here, but we lost the one on the other side.

What that means is we lost the ability to yaw. We didn't have any control, spacecraft control, in this axis. So now, in addition to planning some kind of end of mission for this vehicle, we're running sims with the crew, with Jerry's [Gerald P. Carr] crew, for the next mission, we've got a plan for a recovery mission in case we can't figure out how to get Alan down in his own vehicle, and we get to do science in our spare time.

BUTLER: Well, you didn't have to worry about getting bored.

SHAFFER: I don't remember anything about that except the trajectory-related stuff. Vance [D.] Brand and I did a tremendous amount of work trying to figure out how to control that vehicle with those thrusters gone, and we finally solved it adequately with an offset CG [center of gravity], so that if you translated in that direction with the offset CG, it would yaw you. Once you got the big engine started, it wasn't a problem anymore. I mean, you had yaw control while that was going on, and once you separated the command module, it had its own attitude control system. So we got that done.

I think Jerry and his crew did not get adequately supported in terms of [pre-flight] interface because of the distraction of the recovery problem. And they were up there the longest and they were all rookies, so the last one was more awkward than the other ones were, for an awful lot of reasons.

BUTLER: Were you involved in some of that and trying to find ways to make that work and pull everyone together between the control team and the flight crew?

SHAFFER: The answer is yes, but I was unaware of the problem. I was unaware of the problem until we got on orbit and discovered that we were—well, we didn't discover, the crew finally told us that we were overloading them. It turned out that we started out treating them like we had treated Alan's crew at the end of their flight, and they'd had sixty days of training and integration and all that. For us, we'd been up there so long now, it was almost like we didn't realize we'd changed out crews. So we [had] a lot of those kinds of things to work through.

BUTLER: You had another learning experience. Luckily were you were able to make it all come together and work it out.

SHAFFER: Well, we did, but I also feel like we got lucky in some ways. A ninety-day crew in the air and a year-old crew on the ground with all of that stuff is, in my opinion, not at the top of their form.

BUTLER: Hopefully that's something they'll keep in mind for the International Space Station now.

SHAFFER: Well, it's not so much a problem with the International Space Station, because the Shuttle pilots are never going to get that worn down. It makes a difference, but it makes a tremendous difference for something like going to Mars. Big. Plus, they don't have the ground support. When you go to Mars, you're on your own when you get there. You got a many-minute time delay, so you really can't help those guys [in real-time].

BUTLER: It'll be interesting to see what happens with that when we get there.

SHAFFER: Yes, it will. Skylab, in lots of ways, is like the year that never happened, because I continued this too many jobs. With the trauma we had, I was even more focused on what was going on there than I had been on the Apollo stuff. Being a flight director was different than being a flight dynamics officer, because your perspective was so much broader, the number of things you had to deal with and integrate.

BUTLER: Certainly a very complex time with a lot going on.

SHAFFER: Yes.

BUTLER: Are there any other aspects of Skylab that you recall that were important at the time?

SHAFFER: Yes, I always wished we'd have done them in reverse order, that we'd done Skylab first and then gone to the Moon, but the politics of the problem did not support that.

BUTLER: I think a lot of people had initially had that as an idea.

SHAFFER: Well, yes, I think it was, but Skylab was never appreciated, because it [was], "Why are we boring holes in the sky after we've been to the Moon? Let's go to Andromeda [Galaxy] or somewhere really interesting."

BUTLER: Yes, Skylab often does get—it's kind of an afterthought a lot of times.

SHAFFER: But it produced a tremendous amount of very valuable information about the Earth and about the sun and about space flight and about the human physiology, metals and materials, etc, etc.

BUTLER: A lot of valuable science.

SHAFFER: Yes, absolutely. A worthwhile program.

BUTLER: Very. Very much so. Well, following Skylab came Apollo-Soyuz [Test Project, ASTP]. Were you at all involved in that?

SHAFFER: Yes, for about a half a day. Yes, [M. P.] Pete Frank said he wanted me to be the lead flight director for Apollo-Soyuz, and Kenny [Kenneth S.] Kleinknecht, who was the director of flight operations at that point, said he wanted me to become the crew/ground liaison with Rockwell for the crew interface. And since Pete worked for Kenny, Kenny won and I became a part-time Rockwell person. I spent a lot of time out there doing that job, which was directly in line with the mission techniques part now, because really mission techniques is about the crew-ground interface and who's going to do what and who's responsible for what and where does the information come from and what computations go on on board and what go on on the ground, you know, all that sort of thing.

BUTLER: Was there anything that was done differently for this mission or was it pretty similar to the other Apollo and Skylab?

SHAFFER: Well, it was very different from the impact of the international crew and the international cooperation required to do that. The vehicles are incompatible in terms of they're different electrically and they have different docking mechanisms. The Russians have got this three—thing with the three petals on it and the Americans have got the probe and drogue, which is an inverted umbrella with a retraction. So they built this adapter to go between them, and the Americans built that. I've always suspected it's because the Russians couldn't get off the dime with their bureaucracy. They couldn't get anything approved. I had the clear impression, listening to those guys, that when they finally started getting serious about procedural planning and mission design and that sort of thing that they were so—"lethargic" is the wrong word—labyrinthic in their process, that they were virtually nonresponsive. So they ended up finding themselves and proposing and the Russians saying, "Yes, that looks like a good plan." But other than the periphery of hearing people talk about it, I didn't know, I wasn't very much involved, and the Shuttle was coming on like gangbusters.

BUTLER: Did you ever think about having worked with the Air Force and then the Naval Weapons Lab and along those lines, did you ever think about the fact that now here you were working in cooperation with the Russians?

SHAFFER: No. No, I think civilians working with civilians is not the same thing. If you're not at the political level or in the armed services, then all that stuff in between isn't necessarily as tough. It's almost like the relationship between Johnson and Marshall, you know. At the top level they've got some problems, but at the working level we didn't have any problems with those people. I mean, we worked fine. We got it all done, what we needed to do. We just didn't tell our bosses. [Laughter]

BUTLER: [Laughter] Keep it less complicated that way.

SHAFFER: That's right.

BUTLER: Just do your job and they do theirs.

SHAFFER: Right.

BUTLER: That's good. Well, you mentioned that Shuttle was coming along and, of course, there was a lot that went into Shuttle, it was so different than the other programs, going to be a reusable vehicle, and just the aspects of the vehicle itself. What was then your role for the early Shuttle and building up to that?

SHAFFER: It was mission techniques all over again. I mean, I remember we couldn't get a lot of attention when we first started working on the Shuttle, because, number one, the approach and landing tests were aerodynamic and all the really dynamic phases were aerodynamic, and this thing had wings and a tail, so it was a airplane. People knew how to fly those. We didn't have to worry about that. It was the Bill Tindall-Phil Shaffer business in reverse, only I now had all these astronauts telling me we didn't need to have mission techniques for Shuttle.

So rather than argue with them, we just went and wrote a mission techniques document without their input and published it. When they saw how much more there was going to be to flying the Shuttle than flying the airplane parts of it, they said, "Oh, right. Yes." It's the same deal as with Bill Tindall, he seduced us with, "How are you doing your job?" And then, "Well, how are we going to do the lunar module?" It was exactly the same things. But I learned. I used it in reverse.

Ken Mattingly twigged probably first about what was involved. He was the first live interface we had, and the rest of them came on like gangbusters as they understood. But it was basically deciding what was to be computed on board and how, and what was to be done on the ground and how, and what kind of design thing would we have for the crew interface. I mean, not at the level of switches, but at the functional level and what would be on the TVs versus what would be hardware and all of the protocols for interfacing with the computers, etc., etc.

BUTLER: Certainly you'd seen the computers change quite a bit.

SHAFFER: The Shuttle was interesting in that it was the first time we had built-in redundancy and the phenomenon of redundancy management. So for the computing system you had four of these machines that were all doing exactly the same thing. At the end of every cycle, they compared their answers and if they agreed, they went to the next cycle. If they didn't agree, they kicked the guy that didn't agree and turned him off. So that was a whole new kind of [philosophy]—we had rate gyros, rate sensors, and in gangs of three, like Hubble has now. Had accelerometers in gangs of three, multiple platforms. That vehicle was built to fail. So generally everything was two-fault-tolerant in terms of the critical [stuff], but to manage the procedures and the software and all, to manage all of those systems in that context were really interesting. They were all different.

BUTLER: As it was all different, but were there any big surprises or big challenges in this particular program?

SHAFFER: The scary part of the program [for me] was the fact that we weren't going to be able to do any unmanned orbital tests with it, that the first time we went to orbit, it was going

to be for real. So that really kind of held everybody's attention really, really hard to be sure we did it right.

Because there were people involved, we still had parochialism. I had some tickets that I printed up. When I'd go to a meeting with my seniors and they would make a decision that I disagreed with, I often gave them a ticket. What it was, was a free ride on the first Shuttle. [Laughter]

BUTLER: I like that. [Laughter]

SHAFFER: So they were not very popular.

BUTLER: But yet you were getting across your point.

SHAFFER: Or at least how I felt.

BUTLER: That's pretty good.

SHAFFER: I think one of the guys that I admired a lot in that was Owen [G.] Morris. I don't know whether you know Owen Morris or not, but—

BUTLER: Yes.

SHAFFER: The early [plans for] Shuttle configuration had a fly-back booster and the Orbiter had swing-out jet engines, so when you ferried it from wherever it landed back to the launch site, it'd fly itself, like an airplane. It didn't take very long for those guys to understand that that weight and cost and complexity and all involved in this stuff wasn't going to get it. But

the solution to how are you going to get the thing home if it lands somewhere else, Owen's position was, we'll just put it on the back of a 747 and carry it home.

There was a lot of pooh-pooh and ho-ho and "That isn't going to work," so Owen went and built a model of a 747, a scale model, an equivalent scale model of the Orbiter with the little gasoline engine, and fly it, and separated the Orbiter off and flew it and showed that you could do approach and landing tests and check the aerodynamics, at least subsonically, and do all that. I mean, it was that kind of initiative that reminded me of the really early days.

A guy named Bill [William A.] Sullivan, I don't know whether you [know him]—he was a contract monitor for some work that was being done in the control center. The control center had these big tiles like so, and then underneath were the electric conduits and all that stuff. He was doing something that required cutting those tiles. Well, we were unionized by then, and so the union people were the only ones allowed to cut the tiles, and they weren't available, and the contractor personnel that were there were not allowed to cut the tiles, because they weren't tile cutters. So Bill says, "Not to worry," and he went home and got his skill saw and came back and cut them. [Laughter] Again, that's the way it was in the early days. You didn't have any boundaries, organizational or political boundaries. You did what needed to be done.

But Owen, I always appreciated Owen taking the initiative and building those models and giving them concrete proof that the idea had merit. An awful lot cheaper than you could ever have done it with analysis and computers and etc.

BUTLER: A good way to show it, definitely.

Well, we'll go ahead and take another break here and change out our tapes.

We've talked some about the early Shuttle and how you helped bring all that about. We just finished talking about convincing that the Shuttle could fly with the 747 and the tests. Were you then involved with the approach and landing test on that?

SHAFFER: No. As a matter of fact, I was gone. I left [Flight Operations] to go do other things before the Shuttle ever started flying. One of the structural recommendations I made was that the lead flight directors ought to chair the mission techniques activity for the specific kinds of things they were going to be doing, because doing as many different things as it was clear was going to be going on didn't make any sense to me. They all decided that was not a good plan, because most of them didn't want to do mission techniques. I think that's the way it ended up anyway, at least it was for a while.

But I then went on to do the payload integration job, which was a program office function, but I didn't go to do the job so much as I went to set up the organization for the mission operations side of it. I did that, got it started, got it chartered, got it peopled, and had for my deputy a guy named—dropped his name. Leonard. He was a Shuttle program manager. Oh, for goodness sakes.

BUTLER: I know we can look it up in the record for sure.

SHAFFER: Yes. Anyway, he was my deputy. When I thought it was adequately off the ground and running, then that's when I left NASA.

BUTLER: There must have been a lot of complexities going into payload operations.

SHAFFER: There was. I mean, the number of payloads for the Shuttle is infinite. The number of combinations of payloads for the Shuttle is infinite. I mean, you got a cargo bay

that's roughly the size of a boxcar, and you can put an awful lot of different kinds of things in there, and they all have to be compatible with each other and with the Orbiter and with the orbits you're going to use. So payload management is—well, it's the reason for existence, for the Shuttle, it's for whatever you can carry. It is.

BUTLER: Certainly very different from the earlier programs.

SHAFFER: Very, very different. Plus it's a reusable vehicle. I guess I think that at least for a long time the Orbiters were more different from each other than any of the other spacecraft have been, with the exception of going from the first model of the lunar configuration to the J Series. Like the different—between Apollo 14 and 15, those were very different vehicles. But the Shuttles were all different.

BUTLER: As you were setting up the office, you said your main focus was on getting the operation up and running then for the payload integration. Were there anything along the way—

SHAFFER: Just the major discovery that I really didn't have much interest in being an administrator. I didn't want to do that, so it was pretty easy to say, "I'm done," and go.

BUTLER: That's a pretty important thing to recognize.

SHAFFER: But I really didn't want to do that anymore. That was enough of that. I had started a small oil and gas development activity in about the same time frame as doing the program office integration, the payload integration, so I had that to go do. I discovered very quickly that the focus of the work at NASA, how important that was in terms of organizing my time,

that it was the central pivot and then you could order everything else around it, but without a central pivot, you didn't have any ranking criteria for what you were going to do first, and I missed that, so I jumped into graduate school and ended up with a master's degree in psychology.

BUTLER: That's an interesting choice.

SHAFFER: But that was really the way I transitioned from NASA, the NASA years to the civilian years, was via the graduate school.

BUTLER: You continued to work then with your oil and gas while you were going to graduate school?

SHAFFER: I still do that.

BUTLER: You still do that?

SHAFFER: I still do that. I still do that. There's nothing wrong with being in oil and gas.

BUTLER: Nothing at all.

SHAFFER: It's a nice way to play commodities.

BUTLER: Certainly something we all need.

SHAFFER: Exactly.

BUTLER: Have you done anything else besides that along the way?

SHAFFER: The degree in psychology, which I really did as a personal development and personal interest kind of thing, turned out to be a serendipity, because that training coupled with the technical training and the operational training from NASA, set me up to do consulting in the aerospace industry. In fact, I'm still doing some of that at a low level, but I did really about ten years of being very active in the area of business development, not as a techie, not as doing space flight, but it terms of going after the business of supporting that and helping those guys.

Predominantly that was with Rockwell local here and Rockwell in California, but it has branched out into such things as Beth Williams Techtrans International and Barrios [Technology], and some of those companies I've also worked for. In fact, I've got a job going with Joe Kerwin right now on a contract.

BUTLER: Good. So you, to some extent then, have stayed somewhat involved in the space industry then.

SHAFFER: More with the people than with the technology, because what I do for them really is dissimilar from what I did at NASA. It combines the fact that my mom was an English teacher, with the psychology, with an interest in language. It's quite different. I always told them if I was going to do what I did before, I'd go back there and do it, it was more fun. [Laughter]

BUTLER: Certainly. Well, looking back over your time with NASA, is there any one point that was the greatest, most challenging time for you?

SHAFFER: Oh, without a doubt it was Skylab. Without equivocation, it was Skylab.

BUTLER: I can certainly understand why.

SHAFFER: It's one of those things that I'm sort of glad I did it, but if I'd have known I was going to have to do it and what it entailed, I wouldn't have done it.

BUTLER: Certainly a very complex program.

SHAFFER: And for me, very stressful. Really, it was too many functions, too many things going on.

BUTLER: Was there a time that was the most significant or most memorable for you, that you remember as the best or anything like that, or when you made your most significant contribution to NASA and the space program?

SHAFFER: Well, I guess I think, and it's probably a little smug, but the most significant contribution was when I decided to come here. [Laughter]

BUTLER: I think that's a very good—

SHAFFER: Certainly from my standpoint that was probably the most significant step, because everything just evolved from—that was the classic fork in the road. Because some of the people I worked with in Virginia at the Naval Weapons Laboratory are still there and still

doing the function that goes on there. My career and maybe even a lot of who I am would be different if I had stayed there.

BUTLER: Certainly would be.

SHAFFER: We all have those major forks, though, even if you don't recognize them as such when you take it. Yogi said it. Remember what Yogi [Berra] said? "When you come to the fork in a road, take it." [Laughter]

BUTLER: Very true. Very true. I imagine you probably would have never guessed where that fork would lead you.

SHAFFER: I had not a clue. Not a clue.

BUTLER: But it certainly led you to some interesting times.

SHAFFER: I knew it was going to be different, but that was all I knew.

BUTLER: Well, before we conclude, I'd like to ask Sandra and Kevin if they have any questions.

SHAFFER: Certainly.

BUTLER: Sandra or Kevin?

RUSNAK: Yes, I did have a few.

SHAFFER: A few? [Laughter]

RUSNAK: A couple.

SHAFFER: That's all right. I didn't mean to limit your questions. That was not my intent.

RUSNAK: One of the things I was wondering about, off camera you had mentioned a few things about John [S.] Llewellyn [Jr.], for instance, and I was wondering about being a member of the Trench. It gives a little bit of the character of that group of people. I was wondering how well you fit in with that group and how that dynamic really worked while you were a member of the Trench.

SHAFFER: I don't know who you all are going to get to talk to, but people like Glynn Lunney was a member of the trench. Cliff [Clifford E.] Charlesworth came out of the trench. Jerry [C.] Bostick came out of the trench. Jay Greene came out of the trench. Ken [Kenneth W.] Russell. I mean, lots of people and they covered the spectrum. But the thing that was unique was that we were a team, recognized as a team, because our business was the trajectory. In the end game, our business was the trajectory and it really took all of us to do it.

So we had people who ranged from being almost withdrawn and reserved. If you watched them, you would consider them shy, to people who were bodacious, who was typified by John Llewellyn. Or you have these guys who presented as having extreme class, like Cliff Charlesworth. When we were locked away in a room, we had at each other, but when we were out doing our thing, we were a team. John and Jay probably had serious personal differences, and I can only think of one time when that surfaced. I mean, I think they probably disapproved of each other as people, but it didn't matter.

Does that answer your question?

RUSNAK: Yes, that's very well put. Thank you.

Also, on this business of trajectory, once you had Apollos 8 and 10 going to the Moon you really, I think, were finally at the idea of the mascons [mass concentrations] that would affect trajectory. How much did you know about those going into it, and what effect did that have on Apollo trajectory and analysis and such?

SHAFFER: I'm a little stunned that you ask the question, because that's a fairly deep level of insight, but let me tell you a story. On Apollo 8, we discovered the mascons because our trajectory prediction models were not really doing all that well. We knew that we had basically a three-axis Moon in our model, which didn't allow for the mascons.

You all understand mascons? Mass concentrations. They're areas of much denser rock than there is in other places. We don't know whether they came from outside or whether they're necessary in deep lava pools that have hardened or exactly what they are, but the Moon is a very non-homogeneous body.

So we looked around at what else was available and discovered that there was probably a five-axis Moon that would better fit the data, which had in part been developed, I think, from the JPL work with the Lunar Orbiter and Surveyor and all of those guys. However, to change flight readiness reviewed software is a major deal. It changes the computation models fairly dramatically to go to a five-axis Moon from a three-axis Moon.

But we decided that our pay scale was not the right one to make that decision and that we needed to go to the program manager to do that. I drew the short straw, so I went to tell Chris [Kraft] what I wanted to do, and Chris said he would go with me to talk to George [M.] Low, who was the program manager at the time. So it's a three-people meeting. I was really in an anoxiated atmosphere with those two guys. I described the problem to George, and

Chris added in appropriately from his position, and then when it was all over, there's this pregnant pause and then George says, "What does it mean if I don't fix it?"

I said, "What it means is that we'll have something wrong in the guidance and control system and won't know it, because we'll claim it's the mascon problem."

He said, "Fix it."

That's what mascons did to us. We had a fairly major computer mod that we had to make, particularly on board because they didn't have any external data to correct their orbit definition, whereas we always had the radar data. Plus, it was easier to change the ground.

BUTLER: Pretty significant.

SHAFFER: Yes.

RUSNAK: To sort of follow-up on that, I think one of the arguments for sending Apollo 10 to do almost the landing, but not quite, was to further refine the mascon model, to get a better idea of what's going on. Do you think that was—

SHAFFER: There was nothing wrong with that idea, but the primary thing was to do a lunar orbit rendezvous. We hadn't done that. We'd only been there once and we had missed by a lot, so we had some serious orbit problems that needed to be demonstrated, and we didn't know how well we were going to be able to support a two-body trajectory problem. So we hadn't been able to do a full-scale test of the lunar propulsion system either, and I think that was a bigger deal than the mascons. We certainly got to add mascon at a significant level into that, but I would be hesitant to call it primary.

RUSNAK: You think then it was a necessary flight to not land that on the Moon?

SHAFFER: Oh, absolutely. It would have been foolhardy to try to land without a safe bail-out since we hadn't done a rendezvous of the magnitude of coming off the surface and we hadn't done a full-blown propulsion test of the lunar module. I mean, we'd flown Apollo 9, but it ain't the same.

RUSNAK: Just one last question, also on Apollo. You had spoken earlier about the Taurus-Littrow site for Apollo 17. I know prior to this selection that Jack [Harrison H.] Schmitt and some others had toyed around with the idea of landing on the back side of the Moon. Do you have any memories of that or any thoughts of that?

SHAFFER: I don't have any memories, but there were lots of people that wished Jack had gotten his way, especially the people he'd beat for the senatorial race in New Mexico. Foolhardy. It was insane, as a matter of fact, that he would think that's a realistic thing to do. It implies autonomy on the part of those vehicles, and they were not autonomous.

RUSNAK: I think one of the ideas was to put up some lunar satellites as a way to provide some more communication.

SHAFFER: Oh, I'm not saying it couldn't be done, but geosynchronous satellites so that they hang off to the side, so that you've always got communication is not a trivial program in its own right. Plus you've got to get them there. Lunar orbits are not stable, by the way. They're not stable like Earth orbits are stable, because the Earth is a terrible perturbation on a lunar orbit, as is the sun because of the small size, and then the mascons are perturbations. So lunar orbits tend to change size and shape fairly dramatically on their own volition.

BUTLER: That's certainly not something that is commonly known, I don't think.

SHAFFER: Just think about it, 10,000 miles out from the Moon, the Earth is as big a gravitational attraction as the Moon is. That's where the sphere of equal potential is. Makes a big difference.

BUTLER: Very big difference.

SHAFFER: Good question. Have you got any more?

RUSNAK: No, that's all I had.

SHAFFER: Okay. That's all right.

HARVEY: Following from Kevin's technical, I think I want to ask more about the people. When you were on some of the long missions, whether it be Skylab or Apollo and you're in mission control and there's a lot of tension going on, how did you all deal with the tension and stress? How did you break that up when you were in mission control? Or did you?

SHAFFER: You know, in large part, the actual missions were not as stressful as the simulations.

HARVEY: Really.

SHAFFER: No, the simulations, except for some of the things we've talked about where you had the multiple failure scenario, the simulations were always multiple failure scenarios. I

remember the first sim I ran as a flight director, I don't think the simulation people intended it to happen, but I lost it. I mean, I absolutely got to where I couldn't keep track of all the stuff and all that was left for me to do was get down in under the console and laugh. The missions were never that hard.

HARVEY: Because of all the training you'd done?

SHAFFER: Well, plus we'd already been stressed until we were almost stress non-responsive. I mean, a day of launch aborts, I mean, you were a zombie for a little while until finally a day of launch aborts was a day of launch aborts and you checked it off, I've done this, and you go on to something else.

It was a sense of the level of competence and comfort with who we were and what we were doing. No, I don't think we did stress very much in real time. We probably had a week or so after each flight where we went through a low, but in a week we had picked up whatever was going to be next and were reengaged. That was like a dig-out process. I can remember some of that, but it was like an awareness of, you know, "I don't really feel very good about this. Wonder what the guys are doing at work." [Laughter] And had to go back and do it.

HARVEY: I have a couple more questions. Kind of along that same line, if you could just characterize or just talk about some of the guys that you worked with at mission control, maybe somebody that when you look back over it, you think, he was the most comical, or just funny incidents that you might have remembered from your time in mission control.

SHAFFER: I have one story I'll tell you. Don Puddy, he's also from Oklahoma, very good friend of mine. I've got to do a little background here. Glynn Lunney—I had a

predisposition for striped shirts, three-eighths-inch stripes. I had a favorite one that was red and white. I wore it all the time. [I thought] it was almost like a clown shirt. So Glynn Lunney was calling me the "Peppermint Flight." Well, Puddy had a predisposition, too, that was sort of like that, only his was polka dots, and he had all these shirts with these half-inch or so dots, circles, on them. So I promptly declared him the "Polka Dot Flight."

One day when I came into work, it had to be on Apollo 16, might have been Skylab, I don't remember, but Puddy had—on the flight director console are some status lights, a green light, a red light, a yellow light, and any flight controller can turn the red or the yellow on if he's got a problem. The attention and the color is the seriousness of how badly he needs the attention. Usually the light is green. Puddy had had a new lens made for the red light and it was now a peppermint light. And he had it installed. He had gotten the M&O, the maintenance and operation guy, to take the old lens out and put this new one in.

So I said, okay, the deal is on. So we got the ten-by-twenty big, big view screen up in the front that the world map is on and it's got these circles of coverage of the ground radar stations in that horrible orange, that burnt orange color. I had one made up that had all of those, plus about 100 perfectly round circles all over it. You could tell the real tracking sites were, because they were oblong and had these notches on them where the gimbals are.

When Puddy comes in to work, he and Bob [Robert L.] Crippen, Bob Crippen was his capcom, so it has to be Skylab, and I gave the network controller the signal and he flipped the background slide on the world map, and the PA system starts playing *Stranger In Paradise*, and we welcomed the Polka Dot Team to their shift. [Laughter]

BUTLER: That's pretty good.

HARVEY: That's good.

SHAFFER: So, yes, there was some of that kind of stuff. I always had a problem with the surgeons. The surgeons were the most parochial of all the scientists. They had to have their meals on their schedule and the stool samples and the urine samples and the blood samples. It just drove us nuts with their lack of flexibility. So I'm on the console and whoever the Network [Controller] is has detected a huge explosion on the sun. I've got this huge ball of gas coming off the sun from this explosion, and they want to interrupt the Apollo telescope map and get some data on this explosion. The problem is, it's lunchtime and the doctor, he's immovable. I said, "Doctor, I want you to listen to me. I have a technical input for you." I said, "All this food you guys have got up there is a bunch of stuff. We don't have to do all that, because everybody knows that the perfect meal is the baloney sandwich. And we're going to go get that sun data," and we did. We had lunch after and that was no big deal.

The next day when I came to work, there was this baloney sandwich, it must have been that long and that wide and about this much baloney and stuff on my console [*Shaffer gestures*]. [Laughter] So I heard about a lot about baloney sandwiches after that from the doctors and the other guys.

HARVEY: Well, it sounds like there were ways to break up mission control.

SHAFFER: Yes, there was always a little of that going on, yes.

HARVEY: That made for a lot of fun, though.

SHAFFER: Yes.

HARVEY: One last question. This is more of a thought-provoking question just because you've been so involved with NASA for so many of the programs, not to mention the

operational side, but also the managerial side. What do you feel is the best future for NASA? Where should NASA go? Should we pursue the space stations or should we pursue lunar bases or should we forge onward?

SHAFFER: I want to change your question. What NASA should do is go back to being an R&D [research and development] outfit and get out of operations, out of airline operations-level stuff, and I include the Shuttle and everything like it. I include the Space Station and everything like it. They ought to build it, they ought to get it up there and hand it over to somebody that has the ability to be efficient. NASA has no ability to be efficient outside of R&D. I think they were world class in that regard. I'm concerned that they've lost it, because they get hung up in this "bureaucracy of airline" kinds of operations, and people make careers out of being bureaucrats. I don't care what you do, but that's the role that NASA ought to have in doing it, and they should not be the ones that decide what they're going to do. They ought to be the people that figure out how to do it and then hand it over and go do something else, because that's where their forte was.

HARVEY: Thank you.

SHAFFER: Now, if you'd like to ask me where I think the country should go— [Laughter]

BUTLER: What are your thoughts on that?

SHAFFER: The estimates I hear for going to Mars are half a trillion dollars. That just puts it out of reach. It's out of reach. A large part of that cost is because you have to sit on an explosion to get the stuff somewhere and/or assemble it and then get it on its way, and then stop it, and then get it started back. There's a book out called *The Case For Mars*, where

they solve a lot of those problems, but that one's fairly risky from an operational standpoint, at least the first time or two, because you've got an awful lot of automation or autonomy that I'm not sure we're ready for.

To take a leap into the far future, there are some quantum physicists who are dealing with a phenomena called a zero point energy field, which best guess is an artifact of the creation of the universe. It's a humongous amount of energy that's out there available and it may be getting close to [being only] an engineering problem to know how to harvest that, how to access that energy. If that's feasible, then it's possible to go to orbit without sitting on an explosion, because if the field theory is correct, if you can turn the field off on one side, the field on the other side pushes you, and it could lift you to your altitude and turn it off in the back, accelerate you in your orbit. That's kind of the idea.

The work's getting along, the models are withstanding peer review, the mathematics. I mean, it's getting it less and less like a pipe dream. The problem is, it redefines physics. It really redefines reality again. But then every step in physics has been the debunking of the current myth of physics. So going to Mars gets to be really easy in that environment and may be worthwhile. Of course, going to orbit—I mean going to California gets to be real easy. It puts the oil companies in the tank, but basically you have unlimited energy to do that.

I think the idea of the Space Station in terms of what it was intended to do is good. I think its ability to do it is TBD [to be determined], but the idea of understanding what we can do and how well we can do it in a zero-gravity hard vacuum is a worthwhile endeavor. I'm not very interested in going to the Moon and I don't know why we want to do that.

I mean, the people that talk about going, we need to learn to do interplanetary so we can save the human race. My response is, if we have to save the human race, then why bother? We're not being very good stewards of the place we are, which implies we won't be very good stewards of where we go.

"Well, what about a meteor, a really big meteor? What are we going to do about that?" I say, well, you watch the sucker come on, because you'll never respond to it in time. By the time you can detect it, it's too late to do anything about it.

BUTLER: Well, there are certainly a lot of possibilities, it sounds like, for the future. We'll see what happens.

SHAFFER: R&D, that's what I think.

BUTLER: Certainly. We certainly need lots of that to make these types of things possible, and you always need to keep learning and finding new ways, just as you guys did during these early programs.

SHAFFER: You know, they have said that Apollo turned fourteen dollars back economically for every dollar it cost to do the lunar program. We haven't really developed anything new technologically with our space program since Apollo. Think about it. What we've done is apply existing technology.

BUTLER: Yes, and you guys certainly had to just come up with new things all the time to make these early programs work.

I want to thank you so much for sharing this all with us today.

SHAFFER: This has been fun working with you all.

BUTLER: Good. It's been a pleasure for us.

[End of Interview]