NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

CHARLES L. DUMIS
INTERVIEWED BY KEVIN M. RUSNAK
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RUSNAK: Today is March 1, 2002. This interview with Charlie Dumis is being conducted in Houston, Texas, for the Johnson Space Center Oral History Project. The interviewer is Kevin Rusnak, assisted by Sandra Johnson.

I'd like to thank you for coming out this morning to spend some time with us.

DUMIS: You're welcome.

RUSNAK: If we can just start off, tell us a little bit about growing up and maybe what interests you might have had in engineering or aviation and your education after that, that brought you into the space program.

DUMIS: I was born in Bowie County in Northeast Texas. I attended high school in Texarkana. Prior to that it was a little school district called Pleasant Grove School District. I went there seven grades and then went to the Texarkana schools because they didn't offer school beyond that in that district. I probably was an indifferent student. I think mainly what I learned up until about the seventh grade was in the first and second grade.

But in high school and in junior high school I began to—I always had an easy time with math, but other subjects, and I had a wonderful teacher. I want to bring her into this right now. Ms. Loomis [phonetic] was my English teacher, kind of enabled me to get through the rest of

high school and college. Anyway, I graduated from there and graduated from Texarkana, Texas, High School in 1954.

I really didn't have a lot of idea of what I wanted to do at that particular time, but sometime during high school I took an aptitude test that kind of indicated a mechanical inclination, and I guess I'd already decided I wanted to go into engineering of some kind, and that kind of pointed me in that direction. Anyway, I attended Texarkana College, which was then called Texarkana Junior College, for two years. Then I went to Texas Tech [University, Lubbock, Texas] and finished my bachelor of science in mechanical engineering. Let's see. I remember I graduated in 1958, and I believe '58 was the year that they put Sputnik up, wasn't it?

RUSNAK: It was October of '57, and then NASA started in '58.

DUMIS: I remember talking about putting a man in space, and my thought was, "Jeez, I don't see how they can do that." But just thinking about the life support systems for a man, it's kind of interesting that ultimately that's what I worked in when I worked here.

Once I got out of college, I taught in the ME [mechanical engineering] department there for a year. I might have stayed there, except I didn't have a summer job, and I put out some feelers for offers, and I was offered a full-time job in Oklahoma City [Oklahoma] with the Air Force, and I took that. I don't really remember a lot about that. It was dealing with aircraft, though. Then I worked on Atlas missile sites that the Air Force was putting in, in Altus [Oklahoma], the ones they put in the silos. That was a very interesting job.

RUSNAK: What kind of work was that?

DUMIS: They were installing these Atlas missiles in the systems. The [Army] Corps of Engineers built the silos and put in some of the base equipment, and then we had to install additional equipment and check it out and get it ready to install the missile itself and get it ready to turn over to the Air Force. Our job was the installation and checkout of that equipment. I had the propulsion systems and pneumatic systems.

Then I fell into—because they needed somebody, I got to check out the control systems. Basically it was back then they used a bunch of relays. I don't know whether they had vacuum tubes or not at that particular time, but the countdown, instead of being controlled by software and solid-state systems, it was all relays and stuff like that, and we had to check out those systems. It seemed like we must have replaced a thousand relays in that system to get it to work, but we finally did. Anyway, I just kind of fell into that.

After that, that was with General Dynamics, I went to San Diego [California] for six months, which I didn't like, either being there or the work, and I transferred to Huntsville [Alabama]—or I didn't transfer, I hired on with Brown Engineering in Huntsville and spent a year and a half there working on the [Saturn] S-IVB and S-IV stages. Basically it was monitoring the work that the contractor was doing on those stages. I was a sub [subcontractor] to the government. They were the ones who had the responsibility for that.

RUSNAK: What kind of work was going on on those stages at that time?

DUMIS: Well, they were actually designing them. I think during the time I was there they actually launched the first S-IV stage. So basically it was that and just monitoring the design and

manufacturing of them, in particularly the S-IVB. I basically was, I guess, doing the legwork for the government for just tracking what the contractor was doing.

At some point I met a gentleman named Frank Barionick [phonetic]. He was from Houston. I guess he was from one of the little towns, either Humble or—somewhere around Humble, I think it was. He had a brother that lived in Baytown, and his brother's next door neighbor was a guy named Dave [David B.] Pendley, who worked for the Johnson Space Center. He told me his brother had told him that this guy was looking for people, and he told me about it, and we both put in applications. I think the experience I had on the Atlas missile site was enough to pique the interest of Mr. Pendley, and I got hired. I hired into the Apollo Flight Systems Branch at that time in 1964.

RUSNAK: Did you find that your previous experience with these liquid fuel stages had direct application to the first work you were doing?

DUMIS: I don't think it was direct application, but it was more supportive. You had a better understanding of it, having dealt with cryogenics, in particular. That was the thing. Of course, one of the systems we had on both Apollo and the Shuttle was fuel cells, and they run off hydrogen and oxygen, and we stored those or at least loaded them in a cryogenic state and stored them, I guess, more or less that way. Understanding the operation of them, that's one of the systems that I was assigned to work on, was that system. So basically understanding some of the aspects of it helped a little bit, I think, but it was more support than direct, I think.

RUSNAK: Can you describe for us this early work you were doing and the kind of training you received to perform the work?

DUMIS: You mean in the Johnson Space Center?

RUSNAK: Yes.

DUMIS: Gee. Well, first of all, I came to work here November 30th, 1964. Apollo 7 was launched in, I think, about September or so of 1968, so basically we had several years before we were going to do anything. The fact of the matter is, I was here for the whole Gemini Program, or at least the whole of Gemini flights, but I didn't work on them.

We had classes on the thing. We actually spent two weeks in California taking systems classes. There was a group of us went out, a fairly good-sized group. That was later on. Early on we actually provided some classes amongst ourselves. There was a contingent of people that came here from [North American] Rockwell as support people. I think they were headed up by Bill [L. William] Blair. I don't know how much experience they had before they came here, but ostensibly they were to provide the system expertise.

I think basically you just kind of had to go dig it out for yourself. I remember the system classes in Downey [California] that we went to, and I remember the classes that we conducted internally. I don't remember a great deal of detail about them, of course. I mean, it's been quite a while since I thought about those. In fact, until you mentioned them, I hadn't even thought about it recently.

Initially, of course, we were just trying to get up to speed on the stuff we were working on, the systems. I don't recollect a whole lot of specific, being assigned a particular systems at that particular time. It was fairly early. I think we were in the process of coming up with basically a systems handbook, which we used extensively as either our reference on how the system was—the electrical controls and the plumbing of the system and the instrumentation on it. I did some work in that area.

At some point not too long into the Gemini Program, they merged. There was a Gemini Flight Systems Branch and there was an Apollo Flight Systems Branch, and they merged them. The manager or the branch chief who was head of the Gemini Flight Systems Branch, I believe that's what it was called at the time, was Arnie [Arnold D.] Aldrich, and he became the branch chief of our branch also. I remember saying to him—I seen him in the hallway one day, I says, "I hear you're coming over to join us.

He says, "No, you're joining me." But he's a good guy. I liked Mr. Aldrich.

RUSNAK: You had mentioned working on the systems handbook. A couple of the other flight controllers we've talked to, well, most of them, in fact, have mentioned the handbook as one of the key products of their area and one of the key learning tools.

DUMIS: It was. I mean, preparing the research and stuff to prepare those things was very educational. I've always thought it was—to do that, to really learn it, you have to go dig it out. I mean, to me it's very hard to grasp the thing unless you go dig it out yourself, because the digging out is the learning tool. I mean, you'll find questions that you'll ask yourself, and then you'll go find the answer to it. If you don't do that, I would find it very difficult to gain an in-

depth knowledge of the thing, because you kind of got to know that kind of stuff to have a depth of understanding of the system, I always thought.

Typically as we worked along, I tried to do that, even though somebody else may have had the primary responsibility to do that kind of thing, like even when we got to the Shuttle and Skylab also. But we used that extensively, and the preparation for it was, in my opinion, kind of how you got your understanding of it.

RUSNAK: We've heard some stories from the early programs where they would basically take the schematics of a system and go through and highlight different parts, like here's a relay and so forth, to really learn the systems. Was there still that kind of thing going on for Apollo?

DUMIS: Oh, yes. I did that. I don't know that I necessarily highlighted them, but I searched them out. Basically, actually even today I work—in my job that I have right now, I was assigned to work on the Space Station environmental control systems a couple years ago, and to learn those things, the best way to do it is go dig it out. It still works that way. It's almost like a universal truth. If you want to know it, you've got to go dig it out. Otherwise you really never have any real depth in it.

Now, there probably would be some who will disagree with that, but it's kind of the way—maybe it's just away I have to do it. I think that was probably the best training tool, is just go prepare those things, get an understanding of what you needed to show. In other words, when you use those things in real time, sometimes you only had moments between interruptions to go look at something, and you wanted to keep them as simple as possible. What you had to have in there is the things that you could see the effect of. If you couldn't see the effect of it, then you

didn't need to put it there, because it does you no good. In other words, if it was something that could fail in the line, then you needed to show that. But like plugs and stuff like that, there was no point in doing that. It just cluttered up the drawing.

But kind of making those decisions what was necessary to do and keeping them as simple as possible, because I always found that it seemed like when I was using them I never had quite enough time to really get into them. I had to open them up, look at them, and get interrupted and come in, "Now, where was I?" and do that sort of thing.

Anyway, I always felt that not only was it the way you learned it, it was fun, just go digging that stuff out. Fact of the matter is, I guess I'd almost rather do that than almost anything, if I'm going to have to use this stuff, now.

RUSNAK: How were those systems divided up? Was it, "Okay, Charlie, you're going to work on this part of the environmental control system and you're going to work on the electrical system"? How did that work?

DUMIS: Early on—now, I guess basically I've got to establish in time. I've been talking basically about the early days, like 1964, when we've been flying. I guess basically anytime you've got a fairly new setup like that, there's a certain amount of uncertainty, particularly before you get in the real action. I wasn't assigned the environmental control at that particular point. I don't think I was. I don't have any recollection of that.

But in the interim, I went off and worked some early payload stuff for about a year, I think it was, before the reorganization actually threw me back in the environmental world. I don't know how that wound up that way. I guess truthfully, I don't know. I was not as well

attuned to what was going on as I might have been at the particular time. Well, I guess that stands for itself. Like I say, I don't know how it wound up I got assigned to environmental control. That's before I would like to have been, though.

In the first organization, there was lot a humorous things that kind of went on. I think that for training purposes they would send some of the folks in our organization out with the Gemini flight controllers in those early days where they went out to remote sites to operate. They would send them out there are for training purposes. So basically it was kind of considered a plum to get to go to a remote site like Australia or South America or wherever they went at the time for training.

I don't remember how many people actually went. I never actually went. They would have a manning list to support these flights within our branch, the Apollo Flight System Branch, and depending upon how you stood at the moment with the branch chief, that manning list changed sometimes seemed like almost hourly, depending on if the branch chief got aggravated at you or not at the time. That would be Mr. Pendley. I mean, that was looking at it from kind of the low level view of the thing. It may not have been that way, but it did change fairly frequently. I don't know, it doesn't seem like an awful lot of people went out, but some of them did.

There's a couple or several reorganizations. I guess it's about 1967 or so, so it was between 1964 and 1967, the time I'm talking about, and that particular happened just the first year or so. I worked, I think about a year, in this payloads world, and then for whatever reason they reorganized and I got cast into the environmental world. Basically I applied the same approach, tried to understand. By the Shuttle standards, the Apollo was a fairly simple system,

but it still had a lot of hardware that you had to learn about. I tried to dig out and understand how the systems work.

I remember we had some kind of valve—I think it had something to do with cabin temperature control on the command module—that had some functions, and I drew up some kind—I had one of those little bitty slide rules which we used to use occasionally back then. I think on—how did I do that? On some part of it I drew up kind of a schematic of the valve so you could slide it and show what happened at different positions of the thing. But anyway, I was in that group.

During that time I worked on a console as the ECS, ECS person, Environmental Control System, and supported one of the unmanned flights. Maybe it was the first one, I don't know, and one of the other ones. I guess it was probably one of the Saturn V flights first, unmanned Saturn V flights, unmanned, and sat out front with—I think Clint [William C. Burton] was the EECOM. That was our call sign, stood for Electrical, Environmental, and Communications.

I never had any problem with the environmental part, and I can understand the electrical part pretty well, but the communications, I never really—fortunately, we had a guy who sat beside us who understood most of that stuff, but the comm system I never did quite totally grasp. But anyway, we were working one of the unmanned flights. During ascent one of the guys reported that he had lost some parameters or a parameter, and couldn't quite explain it, but it was kind of interesting because the way they had the telemetry system arranged, it was a mechanical system, and they had what they call gates, but basically was a roll thing where several parameters were sampled in some fashion. It was common, had a common function. It wasn't reading the bottom of the scale, which you typically expect it to do. What I suggested, "Well, go look and see if all the rest of the parameters are reading the same bay," and it turned out they were, but

that's just one of those things I remember. I don't know why. It was during ascent. It wasn't a big problem, but we just tried to understand it.

Anyway, I think I was targeted to work the ECS console in support of Apollo 7, and I think it was going to go in September, and it seemed like about mid July—I may be wrong about the date, but you tend to shape your memories to your best advantage—but they decided they were going to fly the Apollo 8 mission. So they reached down and plucked one of our EECOMs out to go work that mission as the prime guy for EECOM, I mean. That left a vacancy there, and they says, "You're it." Here I'd been studying ECS stuff. Fortunately, I had been introduced in my handbook days earlier to the fuel cells, so I at least knew a little bit about those things and comm and instrumentation.

Anyway, I got the night shift for Apollo 7. That was about like six or seven weeks. It may have been eight weeks. I don't think it was two months before flight. Then that shift was when everything happened. I mean, basically what they did during the daytime is they were powered up and doing stuff, and at night they powered the spacecraft down, and that created some changes or stuff. It wasn't all based on the power-down, but some of the things were.

At one point the crew came on, and basically we had ground sites around the—when you say around the world, it's not like they're everywhere. They weren't everywhere. There was quite a few across the United States. As they crossed the United States, when they were on the up lobe—you know how on the ground track it looks like sign way, well, when the sign way was on the high end of the sign way, you were crossing the United States, you had good coverage. For that particular path around the world, you had fairly good coverage, but when it was down lobe, you may seen them once an hour or once an hour and a half or a couple times in an hour and a half. Typically a path across the site would last about twelve minutes or so, it seemed like.

But anyway, they came AOS [acquisition of signal] one time and said that somewheres back there the fuel cell had kicked off line. Fortunately, at the time we had data that was stored or was recorded during the LOS [loss of signal] period and were dumped during the AOS periods at a higher rate. I think they recorded at what they call low bit rate, which meant there was not as many parameters and you didn't sample them as often, but basically our analytical technique was just simply to play back the data and look at it as though you were looking at it in real time, and with our guys we were able to detect. See, the EECOM had a backroom person for environmental, one for EPS [electrical power system], and one for comm and instrumentation. I don't remember, I think at that particular time they had decided the comm and instrumentation guy would sit beside us because they had a command panel. He had to do commanding to the system. But we played it back and looked at it, and we were able to detect it.

Basically, the way the crew described it, there was a master alarm, a light that came on without an event and without a panel enunciation what it was at some point, and then a few minutes later the inverters kicked off line, which the inverters were what generated the AC power in the thing. When that happened, I think almost all your fans were AC fans, cabin fan, they all kicked off. They didn't run then. It would be noticeable. Plus you've got a bunch of lights.

They were able to determine at the particular time that the master alarm occurred was when the cryogenic storage system, which had the fuel and had the propellant or the fuel for the fuel cells, the oxygen system and the heaters in it had kicked on when you got the first master alarm, and they kicked off when the inverters kicked off. Basically what we determined afterwards was that they had what they called an environmentally sealed relay box in there, and environmentally sealed means that eventually it will leak down to a vacuum in space, and as it

gets down to very low vacuum, very low pressure but not a total vacuum, you begin to get some strange effects and a lot of corona, which produces EMI [electromagnetic interference], and that's what caused it. But, of course, we only determined that that was a problem.

I might digress a bit here and describe a cryo tank, how it's operated. Basically you put liquid cryogenics, fill it up with either oxygen in the oxygen tank and hydrogen in the hydrogen tank. Then you pressurize it to above the critical pressure, and by definition it becomes a gas then, although it's the same density as a liquid. To maintain pressure, we had heaters in there. As you withdrew gas from the tank you put a little heat in there to keep your pressure up within proper range.

Early on, well, initially in Apollo we had in this heater, in this tank, we also had a couple of fans that kept the liquid or the material in there mixed up, because in a vacuum or in weightlessness, as you apply heat to this gas, the gas around the heaters tends to heat up, but not necessarily distributed throughout the tank. Periodically when you have a thruster firing or whatever, it caused some motion in the tank—there wasn't any convective action because there's no weight, no gravity to cause it—you would get some mixing, and you'd either, in the case of oxygen, generally you'd have a collapse of pressure. It usually wouldn't go down more than a hundred or so PSI [pounds per square inch], or you'd have, I think in hydrogen you tended to get quantity drifts in your quantity sensors.

But in any event, back to the thing. The fans came on automatically when the heaters came on. They ran while the heaters were on, and then they shut down. It was the act of them coming on and shutting down, because they were AC-powered, that caused the EMI. So we quit doing that, running those things automatically after that.

RUSNAK: Which we can come back to that for Apollo 13.

DUMIS: Well, those were the same fans, yes. I think because of the power-down we had a valve in the fuel cells, or at least one of the fuel cells, that was a beeswax valve, basically. Well, it has a wax. I don't know if it was beeswax. It had wax in there that that produced the desired effect. It expanded when it got warm and contracted when it got cold. So basically your valve was adjusted accordingly to maintain a temperature out in the coolant loop of the fuel cell. That, because of the power-down on the power system, it caused some adjustment in the fuel cell, and that was sticking.

We had our battery charger on the—we had three batteries on the command module that we used once a separate from the service module during entry, and the charging system on those weren't working correctly. So basically our batteries began to—we didn't use that much power out of them, but we did—I think batteries are akin to voodoo or black magic and understanding, I don't think anybody understands them. It's kind of like men trying to understand women; it just is impossible to do. That wasn't meant derogatorily, it's just that men can't do that, at least not many of them can.

But I don't think anybody can really understand batteries. They may be able to build them, but I don't think they understand why they work or how they behave. But basically initially they put out a fairly high voltage, and then after a short period of time, they drop off to a plateau and run at that level for a long time until they start fully discharging, until they're almost discharged, then they drop off.

But not having had much time to learn the system, I didn't know much of anything about batteries, and because they weren't able to fully charge them, at one time we began to see them

drop off, and that created a bit of a crisis, but it really wasn't a problem. It happened during the night, and everybody who knew something was asleep.

I think that was Apollo 7. I guess at that particular point maybe I earned my wings then, because I feel like it was a decent enough job that people felt like maybe I could do this task, and there might have been doubt before. I mean, I don't think I was picked to do that task with seven weeks or however to go because I was—well, I think I was the best guy they had left. Maybe. Or maybe just somebody had a leap of faith in me, I don't know what it was.

But anyway, after that, after that mission, I assigned to lead for Apollo 9, so I didn't work Apollo 8, although I did sit in it in the front room, ended up side saddle. I don't remember what team I was on. I can't even tell you. I know on Apollo 7 I was on Gerry [Gerald D.] Griffin's team, which was the Gold Team. I'm not sure I can tell you what team I sat in with Apollo 8. On Apollo 9, it was Mr. [Eugene F.] Kranz. That was the White Team. He was the lead flight director on that flight.

Why don't you take me somewheres else you'd like to go now.

RUSNAK: Okay. Since you were walking about Apollo 7, this was your first chance to be in the front room during a manned mission. What kind of thoughts did you have going into the mission before you actually got to sit down on console?

DUMIS: Of course, I guess all my life I have had some trepidation about going into new territory. Not that you don't do it, but you just—I don't know whether I would have volunteered for it or not, although it was a good thing. Once I got there, it wasn't bad. I don't know, I came to love doing that, and I still like doing it, although I don't know that I would care to spend day after day

after day like they do on Space Station, around the clock. But I went in with a certain amount of trepidation. I will say that. As it went on, I mean you kind of lost that. At least I didn't have to do launch right off the bat, which would have been a concern.

RUSNAK: One of the other EECOMS, John [W.] Aaron, described Apollo 7 as a systems flight controller's dream because it was about systems tests.

DUMIS: Right. Well, yes, I would say that. A lot of the things that happened, happened with systems. Of course, it's interesting, if you go back and look, other than the *Challenger* accident, a lot of the stuff, the problems we've had, has been associated with the—I mean, let's face it, the systems, the system, the environmental control system, electrical power system, we're like plumbers. You don't really pay any attention to them. I mean, the flight dynamics guys are the heroes. We're just in the background until something breaks, and typically when it broke, it was our stuff that broke.

I mean, it was our stuff that caused the Apollo 1 problem. It was the 100 percent oxygen atmosphere. It was our stuff that caused the Apollo 13 problem. I mean, we can't be blamed for the *Challenger*. I don't mean blamed; it wasn't our systems. It was a booster problem there. But an awful lot of times we don't get any—there's no glamour in this stuff, but it's basically there. Every once in a while they remind you that they're pretty vital. And it was that. I would agree with John, that it was basically a systems test.

RUSNAK: It was the first flight of the Block II vehicles, so you never know how the things are going to actually work once they're up there.

Dumis: That's true. That's another thing, too. I don't know how many hours of simulations we do in training for this stuff, but they don't really train you in your systems. I mean, typically we don't even really get that much action in the simulations. Basically I think the simulation is to train people in when to talk and when not to talk and how to talk and stuff like that. You get training out of it, you just don't get training in your systems. If you do get training, it is usually wrong because typically it's very difficult to model how those things actually perform. It was kind of like a blind man throwing darts. Maybe every once in a while you get it right, but usually it's pretty tough. Typically they're not really there to—I mean, every once in a while they throw us a bone, we get some kind of problem, but basically it's the flight dynamics thing where they can really model the stuff and get some training out of it.

We learn our particular role on the flight and deal accordingly, but basically your flight is the first time. After the first three or four hours of flight, your understanding of the system has probably trebled or quadrupled, because now you have something that really tells you how it operates. I mean, the first Shuttle flight was a couple days long. I don't know how many days it was, I don't remember, but it was pretty short. But our understanding of the system, it just was probably three or four or fivefold. If you have an analytical mind about systems, you can kind of anticipate how they do, but the interplay and the way they actually operate, you learn all that the first time out. Of course, each vehicle is slightly different, but basically all operate about the same.

Go ahead.

RUSNAK: You had brought up just a couple points I wanted to ask you about. You've mentioned several times the flight dynamics guys. These are the Trench guys, they call them.

DUMIS: The Trench, yes.

RUSNAK: I was curious about the interaction between the systems guys like yourself and the people in the trench.

DUMIS: Technically there really wasn't much interaction. I mean, of course we knew each other, and we usually suffered through their seemingly endless debriefings during simulations, but when we needed to, we'd talk to them. I don't know. I guess always there was a bit of competition there, but the competition was kind of subtle because there really wasn't much interface between our particular systems and the flight dynamics guys.

About the only thing we had to do was arrange our water to put it where they wanted the weight, and I don't know that they even paid much attention to when we vented water back then, but basically that was it. We had to kind of understand. By osmosis you pick up some of the stuff that they do. Of course, on a personal level you knew each other, and sometimes you'd pick on them for lacking so much in brevity. But this was a fairly small organization, Flight Control Division, and so you knew most of those people. That's about my recollection of it, I mean, without getting into the games they used to play.

RUSNAK: Well, I understand if you don't want to share those.

DUMIS: Yes. I don't remember that we had any unflattering names for those guys in particular. I don't know. They were kind of in their world and we were in ours, and the worlds just kind of touched each other peripherally. It wasn't much, at least from the environmental electrical systems standpoint. The propulsion guys may have had a lot more interface with them, because they relying on the GNC [guidance, navigation, and control] guys, and then GNC was fairly related to those guys. They at least had some kind of understanding of what they were doing there.

Your next question? Did I answer that adequately?

RUSNAK: Sure. Well, it just seems that the Mission Control Center, no matter where in the control room you sat, was full of personalities.

DUMIS: Oh yes. I think everybody in there—if you liked doing it, I mean, there was a certain—I was in a discussion recently about people, about worry. Some person who was totally unrelated to the space program, had never been even associated, in another area of the state, said, "Those guys who did that kind of stuff in the space program must have worried a lot about the decisions they made."

I says, "Well, I didn't," and I don't think anybody did. That isn't totally true, but generally speaking, I think people had a lot of self-confidence in themselves. Perhaps sometimes their egotism might have even been too much, and "their" meaning including myself perhaps, although not—of course, as I tell my wife, I think I'm the only normal person I ever met. But I mean, it's just the way it was. If you worked there and did it for a very long time, you almost had to do that. It had to be that way, otherwise it would kind of eat you up, I think.

Yes, there were personalities, and sometimes those personalities created sparks when they met each other. I mean, even in our ECLSS [environmental control and life support system] group we used to have personalities. Some of the sessions, particularly when you're developing malfunction procedures, any kind of discussion, it might get very loud. Occasionally there might even be a four-letter word uttered in respect to some other individual. But it was almost always when it was over, it was over. It wasn't personal.

There maybe have been times when there was people I didn't even like at the time, but age tends to temper all that, and I don't know of anybody I don't like now. Maybe they did something to irritate you, or maybe they viewed you less than you viewed yourself. Who knows what it was, but there was that. There was no question about it, and we fought. But typically when the battle started, you didn't do that or when business got down to it, you didn't do that. You did what you had to do. All that other stuff happened away from the control center, well, for the most part.

But, I mean, I think another thing it did, it toughens you up. You learn to differentiate between, I guess you could say, business and personal. As long as it didn't get personal, it wasn't a problem. I might call you a name, but it wasn't personal, if you can understand that. As long as it was that way, you didn't pay attention to it. I mean, you might get aggravated about it for a little while, but it passed. But there were personalities, yes. Almost everybody had one.

RUSNAK: Can you describe for us some of the other people, some of the other EECOMs?

DUMIS: Yes. Well, I think early on Rod [T. Rodney] Loe was one of other EECOMs. He became the section head. I think he quit doing that. I don't remember him doing very many Apollo flights. He did a lot of the Gemini flights. John Aaron was the Gemini flight controller, and he did quite a few Apollo flights. How was it? How did we arrange that? I guess we had within a section, Rod Loe became our section head, and I don't think he did but one or so, but I may be wrong about that. He basically left it up to us.

Then I became kind of the lead for the ECLSS group, and John Aaron was the instrumentation and communication and—gee, I don't know, maybe he was electrical power, but I think he was comm and instruments. I don't remember who was the electrical power person at that particular—this was early on. Clint Burton was one of the original guys. Let's see, on Apollo 7 it was Clint and myself and I guess maybe John Aaron. I don't know. It might have been.

But John was a real sharp guy. I mean, he really was. A good guy. I think Clint was kind of methodical. I think Rod was a pretty good teacher. I remember him telling me one time when you're working in the control center and you have a headset and you have loops that you talk to, and in particular when you're talking to the flight director, you have to respond when he calls you. You don't really want him to have to call you twice, and you're training, basically that's one of the things that sims do for you. You basically learn to listen to several conversations and pick out the stuff out of the ones you need to listen to and go listen to that and be attuned when somebody else calls you.

Basically sometimes the flight director asks you a question, and Rod says basically, he'd pause before he answered him and thought about it. Perhaps you may notice it, I do a little of that even now, and sometimes the pause gets fairly long. I think one of the characteristics that I

kind of developed, it was unwittingly, but when I call somebody on phone and they answer it, they said they always knew it was me if when they said, "Hello," nobody responded right away. Even my wife says that now.

But basically to compose what it is you want to say, because in that environment words do mean things and you have to say the right words to convey the message you're trying to get across. In other words, you don't want to show alarm when you really aren't alarmed or particularly generally you'd like to at least kind of in most cases if you're in the early stages of a problem, you at least like to kind of downplay it a little bit. You want to let him know it's happening, but you'd like to downplay it a little bit so that he's not on your case continuously interrupting what you're trying to do go figure it out. But anyway, Rod was a teacher.

Now, later on at some point Sy [Seymour A. Liebergot] became an EECOM. I don't exactly what flight he began doing it as the prime operator. And Bill [William J.] Moon. I guess toward the end of the Apollo Program, Craig Staresinich and Steve [Jimmy S.] McLendon may have been the prime operator at least part of the time on some flights.

Sy was—gee, I used to like to pick on Sy. Still do, as a matter of fact. Sy was good at—I mean, I think he had a pretty good understanding of the electrical systems. The environmental systems was always tough for him. But mostly, I mean he did a pretty good job of using his backroom. Everybody had to do that, because there was always areas you had deficiencies. But he was a pretty good at that. He was good at that. Let me put it that way, not pretty good, but good.

Bill Moon was pretty sharp in electrical power and the systems. He was a good guy at that. Craig and Steve are pretty good guys, too. I mean, unless you want some detail about them, Craig was a real sharp guy. He didn't stay with the program much longer after Skylab, but

he was a real sharp, sharp guy. Steve was real sharp in the electrical power world and eventually in the ECLSS world, I think, as he worked in that area.

But that isn't to say we didn't fight about stuff. I think on Skylab I worked console. I think they started out with four teams, and after the first mission, they created a fifth team. Basically the fifth team was people who launched the command module to the Station, and I was on that. Phil [Philip C.] Shaffer was the flight director for that particular flight or that particular team. They became the fifth team for Skylab to allow proper or the desired shift rotation. But it was Sy and Steve McLendon and Craig Staresinich and Bill Moon were the five Skylab people.

We had lots of different ideas during Skylab, I mean amongst ourselves. We didn't always agree. Sometimes our rancor would spill over into the log, but tried to keep it internal. Basically it mainly occurred when somebody would—this was typical almost anytime, although it seemed like it was more so on Skylab because Skylab went on for a long time, but you'd do something and somebody would come in and change it because no particular reason other than they liked it better that way. That was always enough to really irritate the guy who created it in the first place.

But getting back to your question, I don't know, have I adequately answered it? I really haven't said much about any of them, but they were all good guys. I liked them all, varying degrees. We had different personalities, different capabilities. But I think we all did a fairly good job.

Sy was on the console on Apollo 13 when the tanks blew. I think that probably we always kidded him about his response, "I think it looks like an instrumentation problem." We always kidded him about that, but we played the data back, and based on things you'd seen in the past, that's exactly what it looked like. But we still razz him about that.

Next?

RUSNAK: Well, this is backing up just a little bit, but you had mentioned earlier the Apollo fire, and I was thinking about the Block I spacecraft. Did you learn the systems of that as well as the Block II or did you just work on one particular version?

DUMIS: As I recollect, didn't we fly a Block One spacecraft before? Didn't we actually fly a manned Block One or did we not fly one?

RUSNAK: No. Apollo 1 was going to be the first time.

DUMIS: Okay. Well, actually the Apollo fire happened while I was working elsewhere. I didn't actually get in the ECLSS world until then, but, yes, in general you would learn both those. While I was over there, I was learning that system, yes. I don't really have much recollection of the Block I, though. I guess I'd have to go back and refresh my memory even on Block II, although there's things I remember about it because I remember the events. There's things that stick in your mind, for whatever reason. But I guess the short answer is, yes, we would have learned both of them. I went away from that world for a while, and so when I come back, it was Block Two.

RUSNAK: While you were away, was this when you were working on some of the early payloads that you had mentioned?

DUMIS: Right.

RUSNAK: Could you tell us about that year, what sort of work was involved in that?

DUMIS: Well, basically, of course, there weren't many payloads to begin with. Probably we were talking not necessarily—well, even, I don't know when they got around to flying, but basically we were trying to track down, understand. It was the same type of thing. It was just systems world or at least basically a systems world. We were trying to understand the payload, how it worked, what demand it put on the system, and what the people wanted out of it. Basically so that we could provide the same sort of insight into it or as much as possible as the systems guys did.

The only one I can specifically remember, and I don't remember what it was, but the American Science and Engineering had a payload that we went up and spent a few days finding out about up in Cambridge, Massachusetts, the section head and I, [T.K.] Sulmeisters. But that's the only one I recollect, honestly.

RUSNAK: These ones that were intended to be integrated with the Apollo spacecraft or used on the lunar surface?

DUMIS: Well, basically I think they were pretty early stuff like for the Apollo spacecraft itself, not lunar surface things. I don't think I ever, ever did any work on the LM [lunar module], payloads or otherwise, so it'd be things that would be flown on Apollo spacecraft, the command service module.

RUSNAK: Well, thinking about the preparation for Apollo flights, they had the 2TV-1 test of the Apollo command module inside of the space environment simulation laboratory [SESL].

DUMIS: Right.

RUSNAK: Did you work on that?

DUMIS: I supported it from the MOD [Mission Operations Directorate] standpoint. It was basically an engineering function, but we did support it.

RUSNAK: What did that support involve?

DUMIS: Well, basically just watching what they did. We didn't really participate in the decision-making or anything like that. We might have discussed it with the folks over there, but basically they'd just give us a seat so we could learn about the way the system worked in that vacuum test.

I think probably there were some things obviously that changed. For example, we originally intended to—the fuel cells produced water. That's one of the by-products of generating electricity. We stored the water and used it for drinking. It was pure water, other than it might have a little hydrogen in it. But the fuel cells produced more water than the crew could drink, so eventually the tank filled up and we had to get rid of it. The original design, we'd let the tank fill up and as it filled up, we'd just let it dribble overboard. We had a little

nozzle, and it dribbled overboard. We found out we'd do that and it froze. So we changed our operating procedure to do periodic dumps.

RUSNAK: One of the other things that I had noticed from that test was that I think it was due to the environmental control system that you would get a lot of condensation buildup inside the spacecraft on some of the cooling pipes, for instance, and then they saw that same phenomenon on Apollo 7, and they would occasionally have to vacuum up the water that was around the cabin.

DUMIS: I don't have a recollection of that, honestly. I don't doubt that it happened. It sounds like reasonable, but I don't have a specific recollection of that.

Gee. Apollo 7. I do remember one thing about Apollo 7. As I say, I was on Griffin's team, and Griffin actually had been part of our branch. He was a section head at one time in the GNC side of our branch on the Apollo Flight Systems Branch, so I knew him pretty well.

I think this flight, it was in the fall anyway. I think it was September, might have been October. But anyway, typically early on they used to have—well, I guess they still have a JSC picnic every year, but early on it was in the fall of the year, and it fell during this mission. I guess that was on a Saturday and the day shift. Typically our shifts were, I don't remember how they worked, but they were basically I worked night shifts. I mean, they didn't rotate much, as I recollect, and John Aaron—we may have had regular hours. I know at times we shifted, had real peculiar hours, and sometimes he would relieve the guy that relieved you. We did all sorts of stuff. But this seemed like a fairly normal thing.

John was on the day shift, and on Saturday they let those guys, I guess they had the second shift come in a little bit early so those guys could go out and hit the last part of the picnic. I don't know whether that had any bearing on anything or not, but Sunday morning, John was late. Typically you came in early for your handover. At least you wanted to be there when your shift is supposed to start.

John was late. I mean, he wasn't late for handover; he was late. The team had handed over, and I was still there. This is one of the things that's vivid in my mind. [Glynn S.] Lunney, I didn't know Lunney very well at all, and I'd never worked with him. In fact, Lunney was a great flight director, I think. There were other great ones, too, but I think Griffin was and so was Kranz, but I never got a chance to work the Glynn. He was always a mild-mannered guy. He never seemed to raise his voice much. But I had never worked with this guy. At that particular time, the EECOM console sat right in front of the flight director console. It was between the surgeon's was one side and the GNC's on the other side, and then there's a gap between us and the surgeon console. We were on the middle row, the row up from the trench.

I don't know whether you've discussed this or not, but that particular morning [Walter M. "Wally"] Schirra was in an ill mood. Without going into comments he made, he made some comments that he basically didn't agree with what the ground wanted him to do. Basically, like I say, Aaron was not there yet. Lunney really got aggravated, I mean angry. He says, "CapCom [capsule communicator], tell that blankety-blank-blank," something or other.

Jack [John L.] Swigert was the CapCom. He says, "Flight, we don't want to put that on the air." It just didn't do anything.

He says, "Retro [retrofire officer], where's that goddamn hurricane? Target him for that." He said this over the airwaves, but it was just, that's a humorous event. But, of course,

nobody would have ever done anything in that regard, but I mean that's one of the events that I remember about Apollo 7.

But here I was, and there was stuff going on, particularly in the comm system, you had to deal with it. I didn't know much about it. I was with a flight director I didn't even know. So, yes, that was a little bit kind of one of those times. John finally showed up about an hour late, an hour after handover, and it went smooth. But this was one of those things that—I guess it was scary moment there, a scary time, because I didn't know the flight director, but anyway.

RUSNAK: Here was your very first mission, too, that all this goes on.

DUMIS: Right. I mean, it wasn't so much, we didn't really have anything going on, other than that fact that our stuff was—I mean, none of the events that happened happened just then, but still there's you had the com stuff going on at least you had to deal with.

Anyway, I guess basically what else had to do was we didn't have a command system for switching the antenna, so we had to voice up to the crew every so often to switch antennas opposite omni. That may have been my participation in that, but anyway, that happened.

RUSNAK: The crew's attitudes, I guess, has become one of the things that Apollo 7's most well known for now.

DUMIS: I would imagine. I think that that set the tone for practically all the following. Well, I'm speculating now, because I don't know. You hear rumors about stuff, but it seemed like that there were certain terms were never mentioned again in flight. I don't think that they ever

mentioned certain Disney characters again in flight, at least not in describing actions that it was desired to be done. But I mean beyond that, I don't know anything about it. I think if I were going to give you my opinion, yes, it was kind of a watershed flight in that regard. But we received no formal information on the results of anything that happened after that.

RUSNAK: Well, we'll leave it at that.

DUMIS: I would be very hesitant to even voice rumors that we heard. I don't want to do that, if you don't mind.

RUSNAK: Not a problem. One of the other questions before we go on to the rest of the Apollo flights, you had talked about how your branch had become a combination of the Gemini systems and the CSM [Command and Service Module] systems. So I was wondering about the –

DUMIS: Well, when I said that, I mean, actually by that time Gemini was over.

RUSNAK: Yes. So I am backing up in time a little bit here. So what I was wondering about is the mixture of people like yourself, who had been studying the Apollo systems, but didn't necessarily have the console experience, and then the Gemini people coming in to Apollo, who had worked on console for these Gemini flights, but hadn't necessarily been studying the Apollo systems as closely as some of the other people.

DUMIS: Well, I don't recollect any rancor there.

RUSNAK: I guess I'm asking what you were able to learn, what each group was able to learn from the other.

DUMIS: That would be kind of hard for me to say because about not long after that, I went off to work this payload thing, so I really wasn't there much longer. It may have been that formal reorganization that did that, for all I know. I'd have to go back.

One of the things I don't do well is to—I remember events happening, but I don't time-tag them, so I can't tell you exactly when. So basically I was gone a year, so I'm sure that they did. I mean, you could not have not done that. As long as there wasn't any animosity created or there wasn't any resentment because these guys come in and became the prime guys for the job you was working for. I didn't hear of any of that, but, then again, I wasn't there.

I think basically it was mainly the Gemini guys that started out with the Apollo program, for the most part. I can't remember. I don't know where Clint Burton came in. I don't remember when he came into the thing. But John and Rod, they were both Gemini guys. Initially there was a guy named Dick [Richard D.] Glover, but he went off and did something else. He was the section head for a while, but he went off and did something else before we ever started flying, and Rod took his job. That almost had to be that way, that you had some interplay between the guys. I can't really tell you whether there was any feuding or not, because I was outside of there at the time.

RUSNAK: Okay. You had talked a little bit earlier about Apollo 8, how you weren't really working it, but you road side saddle, as you described it.

DUMIS: Right.

RUSNAK: Do you have any other memories of that flight or even the decision to send Apollo 8 out there without the redundancy of the lunar module?

DUMIS: No, it just happened. I went off and worked it. I basically went out and worked Apollo 9 and came in, and I remember working the flight. Seemed like that flight occurred over Christmas. I don't remember, but it seemed like I was there in the control center, and I may not have been, when [Frank] Borman did his Bible reading, but I may not have been. I remember that pretty distinctly, but I don't remember who I even worked with on that flight. It might have been Clint, but I think I worked with him on an earlier flight.

Like I say, I have real specific recollections of certain flights, but others I don't, I guess maybe like Apollo 9 and 11. I got named the lead for 9, and then I got picked up again for 11. Well, I do remember one thing now. I think I was there also when we changed the orbit to put us around the Moon. We did the TLI [translunar injection] burn, and I thought, "Gee, we're on our way," thinking it was kind of a monumental event, which it was. In retrospect, well, I mean we did a lot of things—or not a lot of things, but several things that were pretty gutsy, like that flight, the second flight of the module. I guess in retrospect and maybe at the time—but I wasn't involved in those management decisions to go do that, and I didn't even get to sit in with them or where there was discussions—or didn't do it. I don't know whether I could have or not. I might have. But even, for example, like when Apollo 12 got hit by lightning, we switched the system back on and kept right on plowing ahead. I don't know whether we'd do that today or not. But

when you think about that, that would be pretty good grounds for turning it around, but we didn't do it, and it was a successful mission.

Go ahead. Next question.

RUSNAK: You mentioned several times that you were lead for Apollo 9. What other responsibilities does being a lead EECOM entail?

DUMIS: Well, up through 11, each flight was different. It was a set of different circumstances. You had to come up with different procedures, like you had to come up with a procedure for dealing with the lunar module, and, of course, the environmental systems does come into play there because you have two environmental control systems, and you've got to go from one to the other.

I mean, the other stuff that we had, we had responsibility for the docking probe and the hatches and stuff like that, so all those things were part of our stuff. So basically we had to deal with that kind of stuff, procedures for doing that. It was developing flight rules for the combined operation, like for Apollo 9, how we were going to do this stuff. Of course, at about this time I don't know when they recognized that we needed one person to talk for the comm system. It was all right to have an EECOM for the LM or the equivalent of an EECOM for the LM and the equivalent EECOM for the—but the communication systems needed to be operated by one person, because it was not a good idea to have two different people having to come together to make them work. I don't know whether they did that for 9 or whether it was after 9, but they did that. I think for a while those guys operated from the command panel in our console until they got their own console.

So basically we had to come up with flight rules that addressed the two different—or working the two spacecraft together and what we would do in that regard and then procedures. So it was all of that. There's probably other things I don't recollect, but basically it was primarily developing that kind of stuff. The thing about it is that you didn't have a template to go on. You had to go invent them yourself because you were in virgin territory, basically. Nobody had been there before.

Typically you had limited access to even your compatriots because, number one, they weren't working that flight, weren't thinking about it because they had another flight they were working on. These things were happening about every three months, I guess, wasn't it? So basically you didn't really start thinking about that flight until three months before, and in the meantime you're doing all this.

I remember probably more so for Apollo 11 than Apollo 9, but, "What do you think about this when we do this?" If they hadn't had time to get their mind into the right context, it was hard to get a qualified opinion on stuff, because "Does this seem reasonable?" So basically it was that kind of stuff. You had to go out and build that stuff.

RUSNAK: Were there any specific instances from that mission that you remember?

DUMIS: Apollo 9?

RUSNAK: Yes.

DUMIS: We had an ongoing problem with our hydrogen system that played in the Apollo 13 thing, that the caution and warning limit on the pressure was set so low. Basically the way the cryo system worked is they had some switches in there that when the pressure got down so low, it turned on the heaters, both heaters in both tanks, unless you had the heaters turned off in that tank, and they would stay on until the pressure got up to that upper level, at least as soon as one tank got to the upper level, it switched them off. It didn't open both switches generally, unless they just both happened to open simultaneously, which is probably unlikely, at best.

So it opened whichever switch opened, then it would shut both heaters off, and it would stay that way until the pressure dropped down low enough for that switch to come on. Well, the hydrogen tanks, I think the lower set point of the switch was like—seemed like at four or five psi above the place where the caution and warning would come on. At that particular time the caution and warning was hard wired. You couldn't do anything about it. You couldn't do even do anything about it for the whole program, because it just, number one, it would have been expensive. You'd have to redesign the whole thing, go in there and redo stuff.

So basically what was happening was is that the tank would switch off the top because it had the higher pressure in it. I mean, the tanks wouldn't necessarily have exactly the same pressure. There were check valves between them to keep them from actually equalizing. So the tank with the lower pressure would drift down at the same rate, and it may have been that however the system was plumbed that you just wound up with a differential of pressure in the tanks. The lower tank would go below the caution and warning level before the switch on the higher tank turned on, and you'd get an alarm. That would wake up the crew at nighttime, so we had to come up with techniques to try to avoid waking up the crew at night.

Basically we concluded, initially, that the gasses in these cryo tanks behaved kind of like—in mechanical engineering you study thermodynamics and a lot of stuff associated with steam, because this was a working medium for a lot of mechanical systems. They had a pretty good understanding of how steam behaved, and basically this stuff behaved the same way.

I remember early on, back before even Apollo 7, I worked with a guy named Mort [Morton] Silver. He worked for Rockwell. He was one of the subsystem guys. I was learning about or studying the cryo system. It was part the ECS world. It was assigned to us. I says, "Basically it works just like steam," and then at some point I was requested to go up and brief the division chief on these systems, how they worked. It was a point of humor between Mort and I, "Don't go up and tell him that it works like steam." It was one of Mort's admonitions. "Don't go tell him it works just like steam."

So we get up there in this briefing, and I was going through it, and he interrupted me and says, "Say, doesn't this stuff work just like steam?" [Laughs] So I mean, that was a point of humor there.

So anyway, getting back to Apollo 9, basically what we did was we come up with a technique for most of the time to use one of fans, a low-level heat input device, and just turn it on and make sure that the tank was very low, and actually I think it might have dropped below the caution and warning limit, because you didn't get an alarm when you went off, you just got it when it come on. You dropped the tank pressure low during the day as you approached night, by the time of the crew sleep period, you turn on the fan in one of the tanks, and just that low heat input was enough to supply the fuel cells, and you had a gradual pressure rise overnight. That worked for several nights. It didn't work real well, but it's basically—the other technique we might have done was to switch—that we didn't do—was to turn off the heaters in the high tank

mainly and let the other tank open and then work it that way, so that it a switch. Just run that tank at night. We could have done it that way and run the other tank during the day. But I think we learned about that.

I mean, one of the problems we had, and even run into today, is we were pretty egotistical. I mean, we knew everything. It was sometimes kind of hard to get us to listen to a good idea. Now, actually, I don't know whether the good idea was explained for a long time, but the fact is, it wasn't explained to me until after it was all over, at least I don't think it was ever proposed to do that, but in any event, we might have rejected it just because it wasn't invented here. Sometimes we tended to do that, which wasn't good.

Apollo 9, I worked with Kranz. Kranz is an interesting guy to work with as a flight director. I think that might have been his—I certainly wouldn't want to make any judgment about any other part of his career, but I kind of feel like that was kind of what he was created for, was to be a flight director. He was a good flight director, very knowledgeable. Sometimes you had to be very careful of what you had to say, how you answered him. That's where you learned your words mean things, because if you're not careful what you say, he may interpret it incorrectly, not because he's—he's just a real sharp guy. He typically tried to get an understanding of even the systems guys' stuff so he had a basic understanding of it.

I remember one time I answered him, "Roger, Flight," and he took that as a "yes" instead of a just "I hear you," so that kind of—I don't know what the problem was, so you had to be careful about that. That's one thing you learned. When you talk, you got to say what you mean—not that I'm doing that now, mind you.

RUSNAK: You're doing fine. Well, why don't we go ahead and take a short break here so Sandra can change out the tape.

DUMIS: Okay.

I guess we was talking about Apollo 9, I think it was Apollo 9, like I say, basically, I like to pick on, I mean, we all like to pick on Sy. Sy was always good. You could hang a line out there, and Sy would nibble on the line. You could always get a reaction out of him. But one time early on we had these—we still do it this way, but basically to transmit information between us and the Mission Evaluation Room [MER], we'd write chits. I think it was about this time [James A.] McDivitt was the program manager. It may not have been Apollo 9. It might have been 10, but I think it was 9.

Basically we was talking about dumping water. We had a water tank that they put clean water in, and when it spilled over, it spilled over into the waste tank when it was full. Typically we'd dump the waste tank. Waste tank is where the condensate went. Urine went directly overboard. They had a little device that they urinated into. It was hooked to a nozzle, and it just went directly overboard without any going in, never stored anything. But the waste tank had gray water in it, because they put condensate in it from the condensing heat exchanger. We would have the crew dump these things, and typically we just dumped it until the waste tank was a low quantity and quit, but under certain circumstances if you continued dumping it, it would begin dumping the clean water tank, called supply water.

Sy had gone off and worked with the engineering community. He thought he had an agreement if we needed the volume, for example, if there was a period where we were constrained and didn't want to do dumps and needed to stretch longer than we could do for the

waste tank itself, in other words, we could dump part of the supply tank. He thought he had an agreement that allowed us to completely dump the waste tank, which would pull a vacuum on it and start feeding out of the supply tank. He proposed doing that during the flight, and the engineering community really screamed at him about that, "You don't want to do that."

At some point after that, these chits that we wrote typically were just handwritten. Basically you'd take and write out in hand. We didn't have people typing it up or anything. We'd send them over. I think they were in a room in Building 45 at the time. So I figured, well, I might as well tweak Sy about this, so I personally wrote up this chit and asked who was the—and it had a word meaning a body part that was unflattering—that proposed to do this, dump the wastewater tank to zero, and put McDivitt's name on it and hung it on the board.

Then when he come on duty, it might have been later than that, I don't think he was an EECOM, but anyway, whenever it was, he come on duty to relieve me, I said to him, "There's a chit over here you might want to look at." I wanted to be sure he didn't miss it. He goes and looks at it, rips it off there, and gets up and heads out the back—and McDivitt typically was in the SPAN [Spacecraft Analysis] room—goes back there to jump McDivitt. My regret is I stopped him. I should have let him go do it. But anyway, that was one of the cleaner things that we did. But I didn't exactly expect that response. I just wanted to insult him was all, but he was going to go back and jump the program manager for it or at least the project manager.

Anyway, go ahead.

RUSNAK: Something you mentioned inside the story brought up another question I had about the relationship between the flight controllers and the engineering community. Can you comment on how that worked?

DUMIS: Well, early on, I think it started off kind of rocky. I mean, I remember one incident where—and this was before we ever even started flying—one of the flight controllers asked a guy for some information about a system, and he says, "I'll tell you when you need it." That created a little incident, but basically, as I said earlier, we—gee, how would I describe it? Sometimes it was harder for the engineering community to get us to listen, okay, at least in my world. I can't speak about the rest of the world, but eventually we evolved to, certainly I did, to try to incorporate what those guys wanted to do as I grew more mature in the job.

But initially, I think it was little bit—I mean, it depended on individuals, basically. But I think we tended to be a little bit—have our blinders on a little bit. There were good guys over there. I think that was our fault. We should have been a little bit—but this is—I don't know, we were young. That doesn't excuse it, but that's what happened.

I don't know that we actually dismissed any good ideas, but I'm just thinking that sometimes it was hard for those guys to get us to listen to them. That's unfortunate, I think. I regret that, at least for whatever part I had in it, and I was probably as bad as any of them.

RUSNAK: Can you describe for us how this whole string of the support network during a mission worked with your backrooms, the staff support rooms [SSRs], the SPAN room, and the mission evaluation room?

DUMIS: Well, the backroom, of course, was our guys. Typically in those Apollo days, the NASA guys operated front room consoles, and the contractors operated backroom consoles. There were some real sharp guys back there. We had some sharp guys. I mean, each one of

them had something to bring to the table. But basically we talked to those guys all the time. I don't think that the guys over in the mission evaluation room could even talk. Certainly we were jealous of our loops and didn't extend them over there. I think as time grew on they at least were allowed to monitor our loops, although we had one loop that was kind of limited. It wasn't one we typically was supposed to do business on, but at least we could have private conversations on it.

I remember one time Arnie Aldrich was working as kind of like the SPAN manager or something like that from MOD, and somebody wrote a chit, proposed a chit, something like asking some guy's opinion on something over in MER. I don't remember when this transpired, but it was fairly early on. He says, "You don't want to do that. If you ask their advice, then you're kind of obliged to accept their advice." So we basically from then on always tried to send information over and let them comment on it if they wanted to. At least we then had no obligation to them or we didn't ask them for it, is basically what it amounts to.

One other thing that you—be careful what you ask for. Basically to talk to those guys, now we could walk—if we chose to, during long LOSs we could get up and go walk over and talk to them. In fact, I guess on occasion I've done that.

I didn't know those guys that well then early on personally. I knew some of them, but I didn't know them all for all that well. As time grew on, you got to know them better. One of the things about it is that you got to know somebody or if you're talking to them face to face, it's a whole lot harder to call them a so-and-so face to face or somebody you know and respect. As you get to know people, you tend to be a little bit more attentive and cooperative, I guess. Some of the things I'm telling you is early on.

But basically the exchange of information was done by paper, typically. Now, between missions you may talk to these guys and get data informally, but during flights, that's how it worked. Typically we never discussed things over the loop, almost never. There might have been some on some occasions.

On Apollo 13 I stayed in the control center. I think John went off and worked with those guys developing whatever we needed to develop for getting us back, but a situation like that tend to help interfaces.

Like I say, as the program wore on, basically it was more informal. The guys said, "We'd like to do this," and you'd try to, if you could get it in. Of course, one of the problems is it's very difficult for anybody to get the flight director to let them do anything that wasn't absolutely necessary to bother the crew. That was one of the things. It was always tough to persuade the flight directors to get us to do anything that wasn't absolutely necessary.

Where are we in the time line now?

RUSNAK: Well, we had talked about Apollo 9. I didn't know if you had skipped over 10 in preparation for 11.

DUMIS: Well, I skipped over 10. I sat side by—I don't remember much events about 10, other than we spun up the LM, which I didn't have anything to do with, but something happened that we did that. I remember that mission had John [W.] Young and Thomas [P.] Stafford and Gene [Eugene A.] Cernan, I believe it was. Those guys were colorful guys.

Of course, you know there weren't a lot of women in the program then. It was a guy thing mostly, and guys do what guys do when guys are around guys, you know, basically. That

was before we had profanity on TV or even in the movies to any large degree, so even though we swore, we kept some of the swearing away from the women we had to be around like the secretaries and whomever it was. I think Anne [L.] Accola was the only woman in our division at the time that was an engineer, early on at least. There might have been other one, I don't recollect for sure. There was a few, but women hadn't begun to go into engineering that much. I don't know whether that's because—I don't know why that was. It may have been because businesses wouldn't hire them. I don't know why. There was a lady out—a woman out in California, I think she worked in electrical power. She became a manager out there. But there was a scarcity there.

The reason I bring it up is because they usually had somebody transcribing all the air-to-ground, and I always wondered about how those poor women had to—because it was typically women that did that—how they had to put up with the—this was the voice tapes, like onboard voice tapes that they'd downlink that were never actually aired. But anyway just—because those guys were colorful, to say the least.

But anyway, I don't really have much recollection of Apollo 10. I was there, but I was just there. I mean, there wasn't a lot of events that stood out to me, unless something comes to me later on.

Apollo 11 I was the lead guy for. I remember [Clifford E.] Charlesworth was the lead flight director, Cliff Charlesworth. Once again, that was one where we had been in lunar orbit. We had to deal with the landing part of the thing, so we had to go and develop the rules.

Early on when we used to do these redundant component tests, basically, we'd switch on equipment to see if it worked. We finally concluded that that was pointless. It was a waste of crew time, like coming in and switching on a light to see if it still works. Doesn't mean it will

work the next time, so basically, the same way with the equipment, we finally decided you don't need to do that.

The crew was real quiet during this mission, Apollo 11. We got ready to go into lunar orbit, it seemed like, and one of the things we did do before, we had a loop for cooling the spacecraft, basically. It went into the cabin and provided cooling for the cabin, removed crew-generated heat and the heat generated by the equipment. I think there was even some of the equipment may have had cold plates. Basically it had an evaporator which used water, and what it is, it put water in this heat exchanger and let the water boil off in a vacuum. Water will boil at thirty-two degrees in a vacuum, basically. We had a valve on the outlet duct to maintain a certain back pressure that kept the—instead of being in a vacuum, it was just a few, slightly above a vacuum, so that it boiled at about forty degrees, cooled a glycol that circulated through that thing at forty degrees.

Basically before it did, it went to the radiators, and they dumped heat into space. We had a secondary loop as a backup to that, and it didn't have as big a radiator, and it had pretty much the equivalent of an evaporator, but the radiator was much less effective. It wasn't used except in a contingency.

But typically what we did, when we were flying along, we had the radiators isolated. The radiators from the service module had to be isolated from the command module, and we opened up the valve. We had a valve that isolated the command module part of it from the service module part, so if we got a hole in the service module, at least we had the evaporator effect.

But we opened up that loop to see if we still had a full system, and we opened it up, and the crew reported that the pressure dropped or the quantity dropped a whole lot. I don't know what percent, quite a bit, though. But it turns out at that particular time we had been—

occasionally in going to the Moon, we'd get in the Moon's shadow, which put us in total blackness, and things got cold. That's this flight, we were in the umbra of the moon, so we're cold, and that's the reason. That was just before we ejected into lunar orbit. It was go/no-go for lunar orbit or basically getting there, and we went. I guess it didn't leak, because there was never any evidence of it. Anyway, I never mentioned that to anybody. [Laughs]

Of course, I worked on the command module and it basically just went around. The LM did the landing thing. I don't remember us having any significant events on that mission. It seemed like it was pretty smooth.

Coming back from the Moon, at some point the flight dynamics guys, not this particular flight, but they decided it would be to their advantage if we had as much water in our tanks for CG purposes. I frankly doubt if it made any difference. I mean, number one, as long as they didn't skip out or burn up, they were going to land somewheres in the vicinity of the ship, I guess. I think they would have landed in the vicinity of the ship anyway. Typically those guys always claimed that if the ship was ten miles away instead of however close it was supposed to be, then the ship was in the wrong place, because they landed where they were supposed to land, and that could be. But I always suspected that the amount, whether our tanks were full or zero, might have made about a ten-foot difference in where it landed in the ocean. I always suspected that.

But anyway, they always wanted us to have it as full as possible, and it was kind of difficult to do because we had to estimate how much water would be produced. We had to dump it twenty-four hours ahead of time and had to have the crew cut it off at a time, if they were attentive, that we'd guess would allow us to have it essentially full when they turned on the secondary evaporator just before entry. That's what they did before entry, they brought up a

secondary evaporator to really chill down the command module, and it used water. That's all they had was—they brought up a secondary loop, turned the evaporator, and it'd run through radiators.

I think on Apollo 17 we finally hit it right or almost right. We almost got it right. I think I did that the day before. I did the dump the day before, and I had to do entry for that flight, and I come in, and the thing was almost full. We sat there and watched it. It got full. The fact of the matter is, I think we was backing up water in the fuel cells for at least thirty minutes before they finally turned on the evaporator. The flight director agreed he'd dump if I wanted to, but I says, "No, we don't need to." We knew that—or we felt like the fuel cells could handle two hours' worth of that, and we were going to bring them back anyway, and it worked that way. But we finally got it right that last mission.

I got an award for that. Some of the guys in my group give me the Full Tank Award or something of the equivalent of that. Basically it was a piece of wood with a sketch on it, and it showed a command module with a bulge out to the side where the tank was. I don't think that was signed by anybody important. But anyway, I still have that.

Like I say, Apollo 11, gee, you'd think I'd remember every detail of that, but I don't remember. I mean, I thought it was a pretty benign flight for us.

Ask me a question about it.

RUSNAK: Obviously the focus is on the two guys in the LM landing, and as long as everything is going well in the command module so they can pick them back up.

DUMIS: Right. I don't remember us having any significant problems. I hadn't had a whole lot of dealing with the astronauts at that time, but I did have lunch with Mike [Michael] Collins one day on a, I think, Saturday. We came out and he wanted to go over something, and I did that. I was doing something with him, and we went out and had lunch together. I never had any significant dealings with Neil [A.] Armstrong or Buzz [Edwin E.] Aldrin [Jr.]. I had lot more dealing with crews later on, but not so much then. Mike was a nice guy, at least I thought. I liked the guy.

RUSNAK: Were you in the control room for the landing or the EVA [extravehicular activity]?

DUMIS: Like I say, I think we were on duty when they come out of the spacecraft. John Aaron did and Kranz's team did the lunar landing, which I didn't realize at the time, but I guess that was the big show. Of course it was the big show. I mean, I didn't think a whole lot about it. But I think I was there for when they stepped out. I mean, as many times as I've heard that replayed, I think I heard the original voice down on it, but sometimes your mind plays tricks. I may not have been there. I think I was there.

I was at home when they landed on the Moon, because I remember. I don't remember what shift I was working, but I think I was watching a ballgame or something. The TV was on anyway, and somebody announced that—maybe the Astros were playing Montreal or something at the time, but they announced that two Americans had landed on the Moon. Actually, I say I was home when they landed. I think I was, anyway. I mean, typically you couldn't hang around there. You could, but you needed to sleep sometimes.

Usually for major events like that, the place filled up, so it's possible I might have been there, but I think I was at home. I don't know, but anyway. I probably was there, but who knows. I don't remember. Like I say, the real show was in lunar module, so our stuff, as long as we didn't have any mission-threatening stuff, there was very little concern about the command module, the service module.

RUSNAK: Let's go ahead and move on into the next few flights, Apollo 12. You spoke very briefly about that earlier, but was there anything else you wanted to talk about with that flight?

DUMIS: John, like I say, was on duty for launch, and I worked that flight. I can't tell you what team I was on. I don't remember. That's one of the flights I just don't—I mean, I was an operator on it, I just remember what team it was. Some of the flights I was there for the lunar landing part of it on the team, but I don't remember which ones. I'd have to go back and look at a manning list to tell you who my flight director was. I think I was on the Gold Team for Apollo 13.

But Apollo 12, like I say, Aaron was on duty for launch. They had that lightning strike. I think the crew was pretty uncertain what had happened. Apparently John Aaron had been at the Kennedy Space Center during some tests where they had turned off or dropped the voltage on the system. Anyway, the primary instrumentation system actually dropped down below about twenty-two volts. It just shuts down, basically. All the measurements go to zero, so all the lights come on, all the stuff like that. John had seen that happen in a test and kind of recognized it. There was a little-used switch on the main control panel in the command module that was labeled aux, auxiliary instrumentation, AUX INSTR, something like that. Basically what that

did is it switched to a backup system that would process at a lower voltage. He had them go to that, and then he could see the fuel cells were off line, which is what happened when the lightning struck. He had them switch them back on, and then he could see they basically recovered and they went on.

I think Griffin commented after, he was the flight director for launch, he said if somebody had just uttered the word "abort," he would have had them come off, that's how close we came to doing that, I guess.

I want to go back to Apollo 9 for a minute. After Apollo 7, we were trying to—see, flight mission rules basically is the thing, is what we think we're going to do, is pre-made decisions on what we're going to do. Of course, they're not decisions we blindly obeyed. They're just where we think we want to be then, and they dealt with these batteries that I was telling you about that are black magic.

We changed the rule basically and for Apollo 9, whatever the launch rules were for 7, we changed for 9, I think it was, and they switched those batteries on line with the fuel cells about a minute and a half before launch before liftoff and before ignition. The flight rule required that they show—and these batteries typically were cold because the whole spacecraft was cold, and with the fuel cells hot and warmed up and cranking out the juice and their voltage, being cold, was kind of low, so they wouldn't crank out much current. The fuel cells were hogging it. The electrical system worked that way.

So basically when you kicked them on line, we had registered they were supposed to do so much increase in current, and there was practically zilch. There was an increase, but it was lower than the limit, and I saw that. But I had been so cauterized by the events on Apollo 7, I says—I mean, before liftoff I didn't do anything. Nobody at Cape [Canaveral, Florida] did

anything. We lifted off, and that was the right thing to do. They were just cold, but we had violated a flight rule—I mean, not a flight rule, but the launch commit criteria.

After the mission was over, I called the EPS guy in California in Downey, and I says, "Hey, we violated a launch commit criteria for liftoff," and they changed it. He proposed another change, which was what we flew with the rest of the time. Any increase at all is the right thing.

But anyway, back to Apollo 12. After the lightning strike, seemed it was—I don't remember. If you've got something you'd like to ask me about, I'll be glad to answer it my best, but I don't remember.

RUSNAK: I didn't come across any specific problems.

DUMIS: I will say this, maybe we can go on to Apollo 13, after this event happened—I actually was at home when this happened. We had a flight rule that says that if we—well, I guess you probably have been briefed on the events leading up to the thing. It's probably been addressed pretty extensively, but basically they used to do countdown demonstration tests in which they'd tank the cryo tanks for the fuel cells at KSC. I guess they did that up through Apollo 17, as far as I remember.

But basically to get the tanks out, empty, they had a tube that went all the way to the bottom of them, and you brought in some outside pressure and forced the fluid back out. That's to empty the tank in preparation for the next tanking, which, I don't know, would be several days later for real liftoff. When they tried draining tank two, they couldn't do it. We hypothesized there's a little insert about that long. These tanks are dual tanks, and somewhere in the

connection between the inside and the outside, there's a little insert about that long that tube that we hypothesized had fallen out, which meant we couldn't drain it.

So the way they got the tank empty was those cryo tank heaters that we use to keep it pressurized, they usually applied twenty-eight volts on them from the spacecraft, but KSC used sixty-five volts and basically as the fluid level fell in them and the cryo, the cold cryo got below the wires above the cold cryo in that gravity field just fried.

Anyway, when we dreamt up procedures and flight rules and stuff like that, we didn't address multiple failures. Typically you only addressed—except in certain rare circumstances. Number one, you just couldn't deal with all the possibilities, when you started considering multiple occurrences. But my recollection is we had considered a possibility that we could lose two cryo systems, at least maybe "occasionally" is the right word. We had at least thought about it, and we had looked at it enough to kind of understand what we would do, and we knew that there was a 400 amp-hour battery in the LM, and we felt like given that circumstances, we could make it back.

Basically we had also considered what we'd do if we had to use their stuff, and felt like somehow or other we could concoct some kind of mechanism to allow us to use round lunar module cans [lithium hydroxide canisters] in place of the square ones in the command module. I always wondered why we did it that way. I think those were two big problems we had to cover in the ECLSS world.

So basically when this event happened, I mean, from our standpoint I felt like it was doable. If it happened while the LM was on the Moon or on the way back, we'd have lost them. But I mean, I never really felt that it was a dire circumstance as far as our systems go. Now, I

couldn't say how the other system reacted. I felt like we'd looked at it enough to believe that it was doable.

We had a flight rule that said that if we lost a quantity, and this little old insert I was telling you about, when we did the pre-mission analysis, I said, "Well, the worst thing that could happen is it fall down and short out the quantity probe." It was basically a capacitance-type probe, and if you had this little metal insert that managed to touch both metal sides of that thing, then you'd lose the benefit of that quantity probe, but it very unlikely it would happen. Of course, one of the things that the space program teaches you is that Mr. Murphy is alive and well. If it can happen, it will happen, and it did happen.

I mean, we just on our way to the Moon when it happened. We had just gone out of Earth orbit, I think is when it happened, and basically I was there and I implemented this rule that said we will cycle the fans every four hours to keep the quantities even so that we have some clue about how much is in the tank. We felt like if we could keep them from stratifying, then we would tend to equalize flow out of both tanks. We started that, and I handed over to Sy that day, went home, and prior to going to bed it was typically my custom to call in and see if everything was okay. I think at that particular time, by that time I was the section head of that particularly ECLSS world. I called the backroom, and I got Larry [E.] Sheaks, and he says, "We got a problem."

So I came back in and looked at it, came back in to offer my support. In looking at the data, if you just looked at the playback as you received it, it looked, like I say, I could easily say I think it was an instrumentation problem, but when you look at it, it's kind of set out in a way, the way the tank two pressure rose, if you believe the data, which you basically have to do, there was not any way that we could do that with the systems we had. We could turn on all the fans

and all the heaters in the tank, and the pressure would only go up at a fairly slow rate, and this went "pssshh".

Another possibility that we were in an atmospheric field, if you lost a vacuum on a tank, it might drove the pressure up pretty fast, but we were in a vacuum, so if we lost a vacuum, it wouldn't be any worse. It wouldn't be any harm.

So if those are the two possibilities, then what else is left? You conclude, well, there must have been a fire in the tank. Now, I don't know how this could happen, but there must have been a fire in the tank. I mean, I made that conclusion that night. I told Kranz that. I just told him over the airwaves. I don't know whether he remembers or not, but I did mention it to him. He was the flight director at the time. I think I went even back. I think Aaron Cohen was the program manager, program or project manager, and I went back, I think it was in the SPAN room. I think I said that to him, too. I believe it was him. Maybe he was just engineering representative, whatever. He was back there. I think he was the person I said it to.

But anyway, I don't know if that makes any great—I don't know that that necessarily—I mean, probably a whole lot of other people drew the same conclusions. But from that point on, I basically felt like from our standpoint, I mean, I felt like we could do that. I didn't think it would be that difficult. We carried duct tape, which probably can solve most of the world's problems, and with some of the books that they carried, the crew stuff or something, we could do this with. Basically we had to just get the power level low enough so that the battery would last till we got back.

I mean, that doesn't mean it was comfortable for the crew. I think they got awfully cold, but basically it confirmed that we could do it. Of course, the command module was basically dead most of the time, other than we did charge the command module batteries up full at some

point. I think we went in there periodically and powered it up to look at it, but basically we were sitting there with a blank screen most of the flight.

I may not have been knowledgeable enough on the GNC and stuff like that to appreciate at the time their concerns. But like I say, I felt comfortable with our systems. I may have been wrong about that, too, but that's the way I felt. I never felt any sense of crisis. I mean, maybe it's just the way you typically react in a situation like that. When you're in it, it doesn't seem as bad as it may appear from the outside sometimes. Once again, I certainly didn't have all the data, either.

RUSNAK: While this was going on, were you still manning a console during a shift?

DUMIS: Yes. John was sent off, taken off. I think he was one of the team—I think we had four teams. I think they pulled one team out of rotation, and they went off and worked it, and we then had three teams. We were there, even though we didn't have much to do. I don't know whether it was John's team. It seemed like Kranz went off to work this thing, possibly, and Sy was on Kranz's team, but John was pulled off. I think he may have been on [Milton L.] Windler's team.

We had too many 13s going on in that program, not that I'm superstitious, mind you. But anyway, that's the way it worked out. We basically didn't have anything to do until it got ready to enter and do reentry.

You got any other questions you want to ask?

RUSNAK: Did you work the reentry on that or powering the command module back up, those critical phases?

DUMIS: You know, I don't remember. I probably was there, even if I didn't work it specific. I don't remember who was prime on the console.

RUSNAK: You mentioned a little bit earlier some of the fixes they made because of Apollo 13, or you alluded to them. Did you have any responsibility with that?

DUMIS: No. I was in the control center the whole time. They went off and did that. Engineering went off and did that, and John participated in it, basically.

RUSNAK: I guess I meant as a response like adding the extra cryo tank.

DUMIS: Oh, you mean as a result? Oh, yes. I had some. Ultimately they redesigned the cryo tanks, and they were talking about they wanted to get all the electricity out of the thing that they could. They had to have heaters. They took the fans out. It turns out, I guess sometime later, after this was all over, I was talking to a guy—I guess it was when I was down in the Shuttle, was talking about putting fans in those tanks there because they were bigger tanks. Basically in doing some research, if you have oxygen flowing in a line out across country, like they might at KSC, and they have to put a booster pump in it or a pump anywhere, they put the pump in, build kind of a blockhouse around it, and when it explodes, they come out and replace the pump. The operative word is "when" as opposed to "if." So basically it's kind of a foregone conclusion that at some point it will go. I don't know whether that's necessarily quite that dire, but basically they elected to not put any fans or pumps in the Shuttle cryo tanks.

But when they redesigned the Apollo tanks, basically McDivitt, I think—I guess it wasn't Cohen. I think McDivitt was either program or project manager, but he proposed doing nothing, and they just skewered him, I don't know, Headquarters or Congress or somebody basically. Probably the tanks were all right the way they were, but that wasn't good enough, if you just corrected your procedures.

But what we wound up doing was the wires that fed the heaters, they put a glass insulation around them and then coated them with stainless steel, so basically even steel will burn in the presence of pure oxygen if you can get it ignited, but it's a whole lot harder to ignite steel.

But my contribution to that effort was to keep the quantity probe. I did an analysis on it and demonstrated that if you took the quantity probe out, I mean, using pressure and temperature, there was a lot of time during the mid ranges of quantity, the quantity could be anywhere from 30 to 70 percent. So you had a lot of uncertainty in there, and if you took the quantity probe out, you created a pretty good risk of running out of stuff. So I think I felt like that analysis persuaded them to keep them.

Basically what happens is that you get a lot of variation in pressure performance at a fairly small temperature change, and it's kind of like when you convert ice to water to steam—or actually let me go back. When you convert water to steam, as long as you've got water and steam present, it's going to be a constant temperature in that same volume because it will be the boiling, whatever it is, basically atmospheric pressure. Because of that dome, if you track the performance, we're operating so close to the dome, that even though we're outside of that dome, the performance bands were skewed by it. So basically you had a lot of pressure change with a

very small temperature change, like if it were boiling. I don't know how technical or whether you've ever had any thermodynamics or not.

RUSNAK: I have, actually.

DUMIS: I could draw a diagram on the board to show what I'm talking about, but anyway, just take my word for it. You've got a lot of pressure change. So basically when you're there, if you're trying to base your quantity on pressure and temperature, unless your temperature was extremely precise and accurate and had very low granularity, if you had any kind of plus or minus or any histories or basically your accuracy tolerance would just skew your results all over the place. So basically if you just allowed for whatever uncertainty or your instrumentation is accurate to plus or minus something, and that plus or minus will throw you 30 to 70 percent.

Anyway, that was my part of it, although I did participate in the whole process. Again, basically they redesigned the tanks, and it happened fairly quickly, I think, too. Well, they redesigned the electrical part of the tanks. There's a lot that they didn't redesign. But they changed the wiring and took the fans out. I think actually they use pretty much that same stuff in the Shuttle system now, just bigger.

RUSNAK: Thirteen being such an unusual flight because of the instances, then after that you've got 14, 15, 16, 17, where certainly no problem of that magnitude came up. What do you recall from these later flights that really sticks out in your mind?

DUMIS: I'd almost have to go back to the log to give you any details. It seems like we basically brought on some of the folks to work flights and took people off the console, like John. I think I actually worked all those flight to some degree, although after liftoff sometimes I think I handed over to somebody like Craig Staresinich or Steve McLendon, who were younger people. I think, like I said, I was on for reentry for 17, so I was the last guy there on those.

I remember a comment John Young made on his flight about orange juice and how he wasn't going to drink it anymore once he got back to the ground. I guess they'd found that on Apollo [16], I guess it was, that Jim [James B.] Irwin, his electrolytes had got so bad that he almost was incapacitated prior to lunar liftoff. That's what I was told. I don't have any medical knowledge of that. I mean, that came from a fairly official place, so basically that's the reason they were pumping potassium into them. John was telling Charlie [Charles M. Duke] that he didn't like orange juice in no uncertain terms and when he got back he wasn't going to drink it anymore. I think whoever is on the ground says, "John, you've got a hot mike." John was colorful also, as I mentioned earlier.

Anyway, what did we do? If you want to ask something specific—I don't have any particular recollection of those flights. They were good flights. They were pretty benign.

RUSNAK: Right. That's the thing in these last few flights, there were so few significant problems.

DUMIS: I mean, they were fun flights, but we didn't work any—I don't remember any significant issues we were working. I hope these don't fall into a gray zone where nobody remembers anything about them.

I was glad I participated in all that stuff, but I haven't made it a point to refresh my memory, and perhaps I should. I don't really have anything to refresh my memory from, honestly. I might, if I went back and read something about them, could remember, okay, yes, this happened and so and so, but typically the things that happened to me, I remember for the most part.

RUSNAK: Sure. Well, that's what we're looking for anyway, is what you remember of your time there.

DUMIS: I think I was assigned to every one of those flights as an EECOM in some fashion. I know I was. I'm not sure what teams I worked on. I think I worked with Windler on one flight, and I may have worked with Pete [M. P.] Frank on one. But I'd have to go back and refresh myself. I'm sorry, but that's the best I can do on it.

RUSNAK: That's okay. At the same time, how much work did you do preparing for the Skylab Program?

DUMIS: Well, basically just like we did for the Apollo Program, had to go back and develop all the systems handbooks, the flight rules. Let's see. I pushed the guys to—basically, when you do the system, I went back and studied and other guys did the system handbook drawing. I went back and made them simplify them, just because for the very reason that it's harder to do that, maintain the train of thought when you don't have the opportunity of concentration on the stuff.

But basically I did what I did before the flight, went through and looked at all of the environmental systems and kind of learned how they worked, for my own benefit.

I think the plan at the time was I was the section head and they weren't going to use us to do that. As it turns out, I wound up doing it after all. The fact of the matter is, I think even up until the time the thing had lifted off we weren't planning to do that. I was going to do the command service module launches, and I did all the entries. Basically we launched the command service module. Well, we launched the Skylab, and then the crew went up on command service module flights with a Saturn I-B launch vehicle, and I did all the launches and all the entries, but basically I was only guy who did. We got there, we powered the thing down, and I was done with that.

Then I went back and worked on the first flight when—let's see, I believe that [Charles "Pete"] Conrad [Jr.] and [Alan L.] Bean—anyway. Weren't they the first flight, Conrad?

RUSNAK: Conrad, [Joseph P.] Kerwin, and [Paul J.] Weitz.

DUMIS: Conrad, Kerwin, and Weitz. Bean was head of the initial—got it. Conrad was there first. For that flight I went back and worked in the SPAN room, basically, was our interface with the engineering world. Then there was four teams, and they decided that for the desired shift rotation, they needed a fifth, so we became the fifth team. I think at that point I hadn't even done any work on the power systems for the Skylab. I had to learn those as I went.

My recollection of Skylab is that the first flight, it seemed like we had—everything broke. I mean, there was very little we had that didn't break. We had the most automated systems that man could devise, and it did exactly what we told it to do. We had these beeswax

valves, again, that control the temperature in some of these coolants loops we had. We had airlock coolant loops. We had two refrigeration loops in the Orbital workshop. I think we had a ATM [Apollo Telescope Mount] coolant loop, at least that many different coolant loops.

The two airlock coolant loops leaked. We had to take stuff up and service those, build a device to penetrate the line and service those in flight. The beeswax valves stuck on the refrigeration. This is where we kept the food and stuff, and it stuck so that it wasn't cold as it was supposed to be.

We had four pumps in each loop. We had this thing designed so that you use one loop, basically, and it was hooked up so that you couldn't turn on more than one pump. There were interlocks in the thing, in the loop, and then there was interlocks between loops, so you couldn't turn on the other loop while one of them was operating. But we decided that the only way we were going to keep this thing cool was basically what I'm talking about, these beeswax valves. It expanded in a position, and then it couldn't contract because it stuck or something, so a valve was in an undesirable position. The only way we could preserve the food is to operate both loops, and the system was built to prevent that. Fortunately, since there was two loops, it wasn't a single controller, it had controllers in both loops. All you had to do is disconnect those two, and they didn't know about each other then, but we had to do that.

Oh, gee. Seems like there was always some kind of problem with our power systems. We had two different types of power controllers, one on the ATM and one on one solar array that we had on the workshop. Those were different, but it seemed like some of those were always giving us problems. But after that, we were boring holes in the sky, after that first mission [unclear].

I mean, we had differences—I mean, Marshall Space [Flight] Center [Huntsville, Alabama] built this vehicle. Of course, we were still the guys who run the thing. Sometimes Marshall took exception to that, and typically when that happened, it was like, "Okay, we're not going to do what you want."

They'd say, "Okay." Their center director was Rocco Petrone, and he would go talk to the Administrator of NASA, and NASA Administrator would call Chris [Christopher C.] Kraft [Jr.], who was our center director, and we would get told, "Yes, you are going to do that." Basically after a while we quit doing that. [Laughs] We learned to coexist. I mean, sometimes you got to get hit up side the head with a two-by-four to recognize the actual conditions, but basically after that, there was some sort of that kind of stuff, but even that began to quit.

I think maybe all that happened during that first mission. After that it was just planning the next day and reviewing those sorts of things and fighting amongst ourselves. I mean, even amongst the EECOMs. I mean not anything ever come to blows, but I mean we certainly peppered the log with our opinions of people's parents and stuff like that. So that went on, anyway. It was a long mission.

When it was over, I mean, all that work in the control center, once I got used to that thing, I loved it. I guess all of us are blessed with some kind of skill in life or some kind of talent, who know what it may be. I mean everybody's different. I think mine might have been systems analysis. Whatever little talent I had, I think I was pretty good at that. I could look at the fluid system, the ECLSS system, and kind of understand how it worked and kind of anticipate how it might work. So I felt like I had found my niche in life there. Not necessarily at the time. This is in retrospect.

I probably would have had a tough time. There's a lot of things I've done and I can do a lot of things, but I think as far as something I really like, I like doing that sort of stuff. I don't mean necessarily the analytical part of it, but the hands-on-type stuff where you are there and kind of anticipate how it might behave. What I'm talking about, I'm not a computer analyst. Basically this is a mental analysis of this stuff, basically, just an understanding of how it works. I'm rambling, I guess.

RUSNAK: I was wondering, based on what you were just saying, if you enjoyed being part of the developmental process and to what extent the controllers were involved with that, whether it be Skylab or Apollo or Space Shuttle, which is what we're working up to.

DUMIS: Well, typically we never had the money, the budget to go do—I mean, like go participate in tests, which would have been nice. Of course, like, for example, Skylab came on line shortly after—I think we flew the last Apollo flight in the latter part of '72, didn't we, and then we launched Skylab in May of '73. So basically this was going on while we were busy doing other stuff. So therefore we might have been limited in what we could do anyway.

Typically our budget was constrained so that we weren't really allowed after the heady days of the Apollo Program, we didn't get to go participate in tests to any significant degree where we might have learned stuff like that. So we really typically didn't participate in the process. Well, I guess this happened differently for different people, but the ECLSS system probably were developed at such a time that we were—it was way ahead of when we were available to do that kind of stuff. There probably was somebody in the division who might have

at some point been nominally responsible for it, but they probably didn't have a whole lot of expertise in the individual system stuff.

I think that somehow or other that filtered back. Of course, the Engineering Department did, and they were there with us, and I think that we kind of shared that. They could recognize the problems and learn from the problems, and I think mainly our activities was trying to get up to speed on how they operated and what was there, rather than necessarily participating in the development process. At least I'm speaking for myself, and I think that's true for the ECLSS community as a whole. The communications community might have been a little more active in that area. I think—well, I'll leave it at that.

RUSNAK: That was true then for the Space Shuttle, too?

DUMIS: Pretty much. I think particularly at that time we were certainly more conscious of what was going on. We had a long period there after Apollo-Soyuz [Test Project], before we flew the Shuttle, where it was just dead. We were kind of limited on what we could do. Of course, we didn't go out and look over the designer's palette or whatever he used to design with and see what he was doing.

Once again, we were limited on what we could do in that regard as far as that goes. That was a real dead period, honestly. I guess we're pretty fortunate we were able to keep an intact organization then, because we had, what, about five years—well, it was actually about three years, two or three years where there really wasn't much of anything going on.

RUSNAK: Did you have a role in the Apollo-Soyuz Test Project? You mentioned it.

DUMIS: Yes, I worked that mission. I guess a comment I make, it certainly isn't true, but there's a considerable cultural difference between Huntsville, Alabama, and Clear Lake City, Texas, at least in dealing with the technical community. There's just some wide cultural difference there. I've said it, that it was easier getting along with the Russians, the Soviets, on Apollo-Soyuz than it was the Huntsville people on Skylab. It probably isn't true, but it just seemed that way. It certainly wasn't true.

Of course, a lot of that was our own doing. So it may be it was easier for them to get along with the Soviets than get along with us, who knows, but there's some good guys down there. It was just, I think, more cultural difference than anything else, and there is a cultural difference there. I'm speaking of technical cultural difference.

Apollo-Soyuz, we managed to freeze up the secondary evaporator. I don't know how we did that, but we did. So we didn't have it for entry. I think Sy is still aggravated about that.

I met with some Russian guys, Soviet guys. I guess at that time we called them Soviets. I wasn't around them enough to get really acquainted with them. They seemed—in a different time you might have got to know them pretty well. They seemed pretty guarded at the time. I always assumed one of those guys was a KGB [Soviet secret police] agent. I don't know whether that's true or not, but I always assumed it was, since they were interfacing with the West. But we didn't get much. We got a little bit of information on their systems. They didn't share a whole lot of information with us, and we didn't with them either, as a result of that.

I don't recollect anything other than freezing up the flash evaporator. Seems like there was one other event, but I can't recollect what it was, because I remember Sy complaining about it every once in a while, that and then freezing the evaporator whenever it comes up.

I don't have anything, unless you want to ask a question about it.

RUSNAK: Did you work with the Russians a lot on that?

DUMIS: Not a lot, but some.

RUSNAK: Did you have a chance to go over to—

DUMIS: No. Sy went over. McLendon went over. I didn't go. The fact of the matter is, I guess we're pretty lucky that Sy didn't start World War III. [Laughs] I can say that about Sy. Sy, if you read this, I'm kidding. [Laughs] He didn't like the Soviets, never did like them. I don't know why. Actually, I think that may be his background. He may come from there. He may have some ancestors from there, but he really didn't care for them.

I tried to get along with them. I think Steve tried to get along with them. I don't know whether—Bill Moon may have gone over there, I don't know, but I didn't. I would like to have. I've not been over there yet. I think it would be interesting.

Actually, I wasn't a primary. I think Sy was probably the lead guy or somebody else was the lead person on that flight for us. I was still a section head, so I didn't really do that. I just worked the team. I don't remember what shift or who I worked with, whether I did launch or entry or what.

RUSNAK: Did you guys have any responsibility for the docking module?

DUMIS: Yes, we did. The way it fell, the docking mechanism was ours. It was in our world. I do remember they had a piece of the Russian hardware over there. I went over and examined it over in the Engineering Building. I think that this is borne out later, the Russians have kind of a different approach to space hardware. I mean, they build it and then they carry a whole bunch of spares, and they fix them when they break. We typically like to try to build them so that they don't break, as much as possible. You wouldn't necessarily know that by the Space Station, but it was the intent, at least. I think the Russians, with the Russian hardware, they must spend a substantial amount of their crew time repairing it, which basically kind of defeats the object of being there, I would think. But theirs works for the most part, although they've had some near-catastrophes that we haven't had. We haven't had a fire in orbit or collided two spacecraft yet. But their hardware works.

I guess getting back to the docking module, I was familiar with our half of the docking mechanism, and it wasn't the docking module per se, although we did have some hardware in there. It was more the docking mechanism that I was familiar with. Theirs is a lot simpler than theirs, and we were the active system for the docking, but theirs worked. I mean, it wasn't called on to work on Apollo-Soyuz, I don't think, but apparently it worked whenever they used it, so you can't knock it. It did strike me as looking more like it was built in Ivan's garage as opposed to—but I imagine it was a lot less expensive than ours, too. I mean, there's a tradeoff there. I saw that.

Okay, go to the next question.

RUSNAK: I was thinking about the differences between the spacecraft, because they're using the two-gas system and at a different pressure than we are. Did that interest you at all as an ECLS person?

DUMIS: Yes, it does, obviously, because that's our area. You're right, they did, and actually I think we launched with a two-gas system, but we didn't add any nitrogen. Once we were in orbit, we tried to bleed it out of the atmosphere. We weren't so concerned about five psi oxygen or 14.7. I guess, as I recollect, didn't we use—I mean, I really haven't looked at this thing in a long time. But didn't we use that thing for a—I mean, it was kind of like an airlock. We had do build from our pressure up to their pressure. Well, this would be our function.

I don't remember whether—if we used their gas, we wouldn't—I guess I don't remember how we had to do that. The answer is yes, but I don't have a clear recollection of what we did. Obviously we couldn't handle five psi at 80 percent nitrogen. That would not be enough pressured oxygen for our crew to stay alive, so we had to do something about that, but I'm going back and reinventing the wheel because I don't have any specific recollection of what we did, but we'd have to do something like that, and that would fall in our area. I don't remember any problems with it, though. Well, I won't say I don't remember any problems, but that doesn't say there weren't any. I don't remember any.

Okay. That's as far as I need to go on that.

RUSNAK: Let's go ahead and move on into the Shuttle Program, then. What sort of challenges did the reusability of the Shuttle present in terms of the systems, the operations of the systems?

DUMIS: Well, obviously you had to take into consideration when you operate a system that you used them after this, so you couldn't do like we did on Apollo 17 and just basically like the fuel cell thing; you want to reuse the fuel cells. Of course, the fuel cells on the Shuttle didn't have the tolerance for water that these do. They had smaller volumes.

As far as flight goes, a Shuttle flight, to us, basically was like a snapshot or a segment of a motion picture. In other words, we had this, and then after that it could have been another spacecraft, as far as we're concerned. Other than we had always to be mindful that we wanted to reuse this stuff, but I mean, that really didn't affect us that much, and we didn't deliberately go out to tear up anything, anyway.

I mean, there were things like tiles that had to be repaired on the bottom or the insulation on the outside of the thing. Actually, our world at that particular time in the Shuttle, we had the responsibility for the—they split off the EPS guys, but the ECLSS guys kept the responsibility in the EECOMs, kept the responsibility for all the ECLSS system, the cryo system we had before, and we also had the mechanical hydraulic systems and the mechanisms, so, I mean, actually, we had a pretty full plate.

I think today they've transferred the cryo system to the electrical guys, and the mechanism stuff has been gone off separate, and the Shuttle guys are still together, thermal and ECLSS, but basically they've shed some of that because, as they pointed out, you had two years to train for this, we don't, when I give them a lashing about doing it. But we had all those systems.

I don't think that it presented us any particular flight problems about reusability. I think that in all the simulations that I ever ran, I finally was given an opportunity to call a launch abort during—one of the sims that they do periodically is ascent abort, where they lift off and go up

and do some kind of abort. Typically it's flight dynamics problem or propulsion problem or something like that that cause them to abort. Well, the EECOMs had very few things you aborted for, and the stuff that you really aborted for was so bad, that you didn't really want to sim that, like loss of two fuel cells or maybe you wouldn't even abort for that. Whatever it was, it was bad.

But we had a silly rule one time that we have three avionics bays in the spacecraft, and each one of those has two fans in it, and they're all the same fans. Our division chief, who was Pete Frank, dictated one time that if we lost two of those things on the way up, we'd abort for it. Now, we had to have one measurement. On each one of those things is a delta-P on the pump. That's it. No backup, nothing. He wants us to abort if we lose two instrumentation points. I mean, that's what it would amount to.

Anyway, that was my day to get caught. Some guys failed one of them and then something went funny on the other ones, and I reported these to the flight director, and after a while, the flight director aborted the flight. Of course, I guess he knew the script; I didn't. But anyway, then the performance, the fans seemed to change, and I says, "Well, it looks like it's getting a little better, flight."

He says, "Charlie, don't tell me that. I just aborted."

I said, "You didn't abort for me, did you?"

He say, "Yes, I did." [Laughs] I didn't ever tell him to do that. But anyway, I got another plaque for that one—it wasn't a plaque. Yeah, it was a plaque for that one, too, from the trench, one of the guys in the trench. I still have that, too. But that was my one time, and I didn't call it.

Each Shuttle flight, obviously there are things that happen. For example, what have we flown now, 100-and-some-odd missions? By the way, did this last flight get off this week?

JOHNSON: Yes, it did.

DUMIS: Okay. I hadn't even paid attention to that. I don't watch TV a whole lot. I'm trying to spend my old age doing something constructive.

Where I was? Okay. Gee, I lost my train of thought. I was going somewhere. Where was I going before, do you know?

RUSNAK: Yes, we had been talking about the sim, you got your plaque.

DUMIS: That's the end of that story, basically. Give me your next question or repeat the question you had.

RUSNAK: I didn't really have one after that yet, but I just was thinking about the sims.

DUMIS: Let me finish that.

RUSNAK: Sure.

DUMIS: I was saying a Shuttle mission is a Shuttle mission, and between missions sometimes we had to work issues relating to the past mission as they affect future missions. For example, at

some point, I mean, we have this flash evaporators in the Shuttle that provide supplementary cooling to the radiators, and they use them during entry when the doors are closed. This is well beyond when I was an EECOM. It's just later in life. I mean, I went away from that world almost fifteen years ago, and I've been working in other areas since then for Rockwell and Boeing and Muniz Engineering and stuff like that, but I've always been kind of popping back in and out of stuff.

I worked in engineering for five years in the ECLSS world. But basically you had an evaporator in the 102 vehicle [*Columbia*] that had been in there—it may have been the original evaporator. It's one of the older ones. It was beginning to do some funny stuff. The exhaust from the evaporators has to be vented somehow and you've got some ducts that come out, and you've got heaters around to keep the water vapor from freezing on those ducts and blocking it.

It seemed like we typically lost on the A-string of heaters, and at some point there was some peculiar functions during ascent. I don't remember exactly what it was, but, for example, we went over and asked the guys, the flight control guys, who I knew most of these guys, I says, "How about next flight let's trying the B-heater, see if that makes a difference," because basically what we was trying to do was to make this evaporator go all the way to OMDP. We knew we was going to change it out, but you had to work stuff in that regard, basically try to get some information about how this thing performed.

Since I was in engineering, that was different from what the flight controllers did, but we went over to the flight control community and asked them to do this for us, and they agreed to it. I think we had to write them a note or something, but they agreed to change the procedures and do it that way, and it give us some additional data. But that's the kind of stuff that we might have been involved in.

Getting back to the Shuttle function, I just kind of digressed to give you an example of the kind of things. But other than that, a Shuttle flight is almost like Apollo flight to you. I mean, it was chapter, kind of a standalone chapter almost, not quite, but almost, at least in my world.

Of course, you had seen this vehicle before, so basically you had to kind of remember how this vehicle performed, because they weren't always exactly the same. There was always peculiarities on them, but there wasn't a whole lot that we had to do because of reusability.

Boy, it took a long time to say that, didn't it?

RUSNAK: Well, no, that's the kind of detail we're looking for, though. A related question to that, what about the frequency of flights, did that have any effect on the ability to train for it or how you prepared for the flights? Particularly prior to *Challenger*, I guess.

DUMIS: The flights themselves were training. That was the best training we had. I mean, you didn't really need to train after that. Well, that's not quite true. You might need to bring new people onboard. You might have to go do some research on something or find areas you were weak in, go do that.

We had to do a certain amount of simulation. I basically felt like for a long time that once you've been through a few preparation sims for flight, particularly if you do ascents and stuff like that, all you're doing then is training the flight director, because you've got almost as much—I mean, the curve is sort of like this, and you're way out here on the curve. It's letting the flight director get confidence in his team, is all it amounts to, because the benefit to you is pretty small. I mean, new guys, it's helpful, but once you've done it a few times, it's not a whole

lot of help, other than maybe getting used to your flight director or other team members. But the best training was the mission itself.

RUSNAK: Well, we're about out of tape again, so if we can pause here.

DUMIS: Okay.

[End of interview]