# ORAL HISTORY 3 TRANSCRIPT

GLYNN S. LUNNEY
INTERVIEWED BY CAROL L. BUTLER
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BUTLER: Today is February 8, 1999. This oral history is with Glynn Lunney at the offices of the Signal Corporation in Houston, Texas. The interview is being conducted for the Johnson Space Center Oral History Project by Carol Butler, assisted by Summer Chick Bergen and Kevin Rusnak.

Thank you for joining us again.

LUNNEY: You're welcome. Glad to be here.

BUTLER: We'll start with Apollo. In the earlier interview you talked some about the early Apollo missions, Apollo 1, Apollo 7, and Apollo 8, but you mentioned in our last interview that while Gemini was going on, you were working on some of the unmanned Apollo missions. What can you tell us about what you did?

LUNNEY: There were actually sort of two series of unmanned flights. One was called the boilerplate. "BP" was the designator, and it was a set of tests of the escape system, the Apollo abort escape system, the little tower that was on top of the spacecraft that would pull it over, pull it off the vehicle, if there were a problem during the launch phase. That was considered critical enough that there was a whole set of tests designed that were conducted out at White Sands. We used a solid rocket motor, and the idea was to boost the spacecraft to high dynamic pressures, high loads, and then trigger the abort system to see that it worked properly under a variety of sets of conditions.

I can't recall how many flights there were out there, but I was sort of in charge of the flight part of it. The flight part of it had to do with tracking the vehicle and determining when it was getting into conditions that we wanted, and then hitting a button that basically destructed the launch vehicle, or stopped the launch vehicle, opened it up so that it would stop propulsion, and also triggered the abort system. We had a number of those. I can't remember the number, but over a period of probably, I don't know, a year or two, maybe less than two years. Those tests were conducted out at White Sands and basically qualified the escape system as a total system for the later flights.

Let's see. I don't know that I can recall anything terribly significant about them except the solid rockets kicked them up awful fast. We got the conditions very quickly, the aerodynamic conditions we were trying to match, and the abort system worked, as I recall, every time, although the destruct system on the launch vehicle didn't work, I don't think, quite the first time, and I can't remember all the reasons. I think there was some problem with the cables pulling out of a box. Once that got resolved, everything out there went fine, and I can't recall any other real problems with it.

We scrubbed one day because of high winds. The solid rockets were just sort of stabilized with a small thrust vector control system, but if the winds got to blowing too much from certain directions, then it would take the vehicle off course. We had to scrub one launch, I remember, because the winds were high, and actually the vehicle, instead of going where we wanted it to, probably would have come close to coming back over the range where the pads were. So we scrubbed that, and there was a little excitement about that within the management ranks, but that all settled down and everybody decided that was the right thing to do, and we went on a few days later and launched it, and it was fine.

Let's see. That was the series that was conducted out at White Sands. They were rather small-scale vehicles. They went up to maybe 30,000 feet, and that went well. After that, we got into tests of the spacecraft overall, but mostly tests of the heat shield itself.

There were a total of four unmanned tests of that order. Two of them were on the Saturn 1B, which was the smaller rocket that was used for the earth orbital flights. That was, for example, the rocket we used when we flew Apollo 7. Then we came back later, by the way, and used it for the Skylab missions, for launching the command service modules, and also for the Apollo-Soyuz mission in 1975. So it continued to be used over the course of the program, but was really only used for one manned flight in Apollo.

The first two, as I said, were on the Saturn 1B, and basically what we did was we put the vehicle in an orbit, and then we would put it up high, in a high orbit, and then drive it on down with the propulsion system that existed on the command service module. It was called the service propulsion system, SPS. It was the engine that the Apollo spacecraft itself used, a fairly big engine, and those flights were fairly uneventful, I think, in terms of what went on in them. I can't recall anything exciting or anything to tell you about, although in the launch of one of them, the launch got scrubbed for some reasons at the Cape [Canaveral, Florida] that I can't recall, and then they decided that everything was okay.

Kurt [H.] Debus was in charge of the Kennedy Space Center [Florida] at the time, he came back on the loop and asked me if we could unscrub. That was kind of a new term for us. We'd never done one of those, but everything was still up, so we got everybody settled back down and went ahead with the countdown, and it went fine. Both of those flights went pretty much by the book.

We then flew the first Saturn V unmanned, and I was the flight director on that one, too. It was called 501, five for the Saturn V designator and 01 for the first flight on it, and it, again, was basically a test of the heat shield, and the idea there was to propel the vehicle all the way to conditions just about what they would reach when they reentered from the moon. We came close to those kind of conditions, and the flight went very normally. Everything worked just exactly as we expected, and it was fine.

We flew a second one called 502, logically enough, 502 after that, and Cliff [Clifford C.] Charlesworth, a good friend of mine, was the flight director for that flight. That flight really misbehaved. One of the center engines on the second stage—what happened was, one of the engines on the second stage wanted to shut itself down, but the wires that did that were crossed to another engine. So we ended up with two, I think, engine shutdowns, and then we ended up with a bad vibration, a pogo kind of a vibration, on the set of beams that hold all the engines to the tank. That was of great concern to us later on when we were considering manning the next Saturn V flight.

So we got into some funny orbital conditions, but we got into some kind of orbital conditions with the Saturn V, and again we used the service propulsion system, the engine on the Apollo spacecraft, to drive it back down in to get a high-heat entry test approximating those that we would see when we got back from the moon.

I don't know if we got all the way to the conditions we were trying to match with that flight, but it was kind of peculiar because the flight I was on, 501, went just nominal-nominal once we got it off, and then Cliff, bless his heart, walked off and got this next one, and there were all kind of problems, especially with the launch phase of the vehicle, and he had to deal with all those. But in the end, the mission was considered successful.

We learned quite a bit about the launch vehicle, and we made some modifications to avoid this pogo situation that we were getting into with the center engine, they think was causing it. And what we ended up doing on the later flights, the manned flight, was shutting the center engine down a little bit early, and the rest of the propellant, of course, would go into the four outer engines, and it worked fine. That was the fix that we put in for the manned Saturn Vs that first showed up, then, when we flew Apollo 8.

Today it seems like, especially in countdowns, Shuttle countdowns run really pretty smoothly. I mean, they're pretty well thought through, the hardware works very well. But I remember when we were getting ready for the first Saturn V flight, they had what they called

a "countdown demonstration test" [CDT] or something close to that name. Normally that should take, I don't know, three days or so to go through all the preps and fuel the vehicle and take it all the way down as if you were ready to lift it off, and then, of course, not do it in a test.

But it took us, I think, the best part of two weeks to do that test that would normally take three days. I mean, it was just a—looking back, it wasn't at the time, but it was almost a circus of things that could go wrong, and they did. The team of people, mostly at the Cape, were responding to it, although here in the Control Center in Houston we were participating in the count. So we kind of stayed with them for that almost two weeks of getting a countdown test done, and that was probably the most anomalous part of getting ready to do the first Saturn V flight.

We also had some probably extra bold things that were built into the spacecraft, even when you flew 201, that we never had to exercise, and I'm glad we didn't, because we actually had the ability to control the attitude of the vehicle as if you were flying it from the ground, but it gets pretty tricky because you have to have the right displays, you have to have the right controls, you have to send them the right way, and we practiced that a bit, to have this ability to control the spacecraft, but fortunately the automatic system worked fine and we didn't have to get into any of that stuff, because it would have been very hairy for somebody to be looking at an indicator on the ground and then try to, in effect, fly a vehicle that was airborne. Today you could probably do that more reasonably than the way we were going about it at the time, but we never had to use that, thank God, and everything went fine.

BUTLER: And everything did go fine. The Saturn rocket has—

LUNNEY: An amazing record.

BUTLER: An amazing record.

LUNNEY: Amazing record for what was asked of it. Two test flights, and then we used it throughout the Apollo series for all the moon flights, and it worked fine. It did work fine on every flight except when we launched it and got hit with lightning on Apollo 12.

BUTLER: And even then it got up to orbit.

LUNNEY: Even then it worked fine. Yes. A little scary, but it worked fine.

BUTLER: You mentioned the countdown and training for flying the rocket from the ground, and we had talked before about how you trained for the earlier missions like the Mercury and having to make the tapes and then changing it for Gemini. How did you change your training for the Apollo missions?

LUNNEY: Well, by the time we got the Apollo, we were really much more adept at using digital computers to do that for us. So we had simulators that the crew used that we modified some to do these unmanned things, unmanned flights, but the simulators could then be flown, and as the simulator responded to events and the information that would be displayed in the Control Center, which is where we all were by that time, was accurate. So we didn't have to make tapes and preconceive what the courses of action might be and send them all around the world, around the network stations that we talked before, but rather we had a simulator that was flying on its own, generating the telemetry that was true to, or accurate to, whatever it was doing, and that was the telemetry that was displayed in the Control Center. We also derived from the simulator what the trajectory was and simulated the radar data coming in

also so that we had an accurate simulation of the flight, and it was good training. I mean, it was very good training.

We ran a lot of flights, simulated training flights, for the unmanned flights, and again, it was a big learning experience, because the Apollo spacecraft was new to us at the time, since most of the ops team had worked on Gemini, and then we started to mesh with the design team at North American Aviation at the time, is what was the name of the company before Rockwell bought it out, and the fellows, the men there, who built the spacecraft. So we had, in the course of those unmanned flights, a lot of chance to interact with the team of engineers, both within NASA, the program office, and the engineering team, and the engineering teams at North American Aviation, and we got where we understood the Apollo spacecraft pretty well. By the time we flew Apollo 7, the team had a very good understanding of the Apollo spacecraft and what it was capable of and what you had to do to keep it working right, etc., etc.

BUTLER: Certainly had a lot to learn for that.

LUNNEY: We did.

BUTLER: How many hours would you estimate that you would put in to train for a specific flight?

LUNNEY: Well, in those days the flights themselves probably slipped a lot more than we had when the program became more mature, for mostly hardware, spacecraft or launch vehicle hardware reasons. So we would end up having, probably, extended training periods getting ready for an individual flight. If I had to guess, like for the first 201 or 202, we probably had twenty all-day training sessions in the Control Center or thereabouts. We had a lot of them.

Today, for a Shuttle flight, they probably have an integrated training with the crews in the simulator and the people in the Control Center of probably, I don't know, maybe a dozen or so full days of work. Integrated sims they're called, integrated simulations. But we had probably double that number. Compared to what we're doing today, we had double that number, at least when we were doing the early flights, because it a learning experience all around. The ground systems were struggling, the simulators would struggle, the cases would go awry on the people who had planned them, and on and on and on.

So we had plenty of opportunity to see a lot of different kind of things happening and get used to the equipment that we had, both the vehicles and especially the ground equipment, because things would break, and we'd have to figure out why did it break and can we launch under those conditions, and do we have some kind of workaround or whatever? It was quite a learning experience for all of us all around, and meshing the spacecraft and then using it as an operational vehicle—well, it wasn't quite operational, but using it in flight was also a big bridge to make because the people who had designed and built it had spent their lives doing exactly that, and it was their baby, and it was a little hard for them, I expect, to sort of turn it over to both the team at the Cape, did the countdowns and the launch, and then when it lifted off, of course, the team in Houston, the flight operations team, picked it up and took it over.

So we had bridges to build there in terms of connecting with those folks, both in terms of planning the missions, understanding what all the mission rules were, and then having them follow the flight in real time so that in the event of a problem, if there were time, we could consult with them, as we talked about before. And that gradually got to the point where that worked pretty well, too, even with the bigger team of people that we had, engineering team that we had on Apollo, compared to what we had on the Gemini spacecraft.

BUTLER: You grew, and you meshed, and everything happened step by step.

LUNNEY: Just kept absorbing more and more entities or organizations into it. Yes, it took a lot of exercising, but we got there and it worked pretty well.

BUTLER: Yes, it did, and it got to the moon.

LUNNEY: It got to the moon.

BUTLER: During this time frame, you became chief of the flight director's office.

LUNNEY: Somewhere in there, yes. Do you have the date, by the way?

BUTLER: I believe starting in 1968. What were your responsibilities?

LUNNEY: Well, in the Flight Control Division, we had just a handful—I have to stop and count, but it would be like four or five of six people who were in the flight director's office who would be flight directors when the actual flight occurred. Their duties involved a lot more than the actual flight because it was getting ready for the flight that consumed so much of our time, and what we got in the style of appointing a lead flight director for each flight, who was then sort of the overall orchestrator with the flight crews and the training schedules and was the overall orchestrator or referee when we got to arguing about mission rules and procedures and what we were going to do under certain circumstances and so on. And that worked pretty well for us.

We also found that individual people kind of focused, either planned or accidentally, on different parts of the mission so that we kind of did, not completely but some amount of

repeating of the phases of a flight. Where somebody did this certain phase before, they might do that again either in the next flight or a couple of flights downstream.

So we didn't go into each flight with everybody having to learn everything about each phase, all of which would be very different and very complicated. For example, the launch phase is one thing, the earth orbit is another, the going into orbit around the moon is another thing, getting ready for landing on the moon and landing on the moon is another set of things that are going on. You're introducing more of the hardware. For example, when you get to landing, you're introducing the lunar module in a much more intimate way than we had before.

And then there was the EVAs, the walks on the moon, where we got to the point where we were beginning to mesh with the scientists, the geologists and other kind of lunar scientists who planned—made inputs to, I should say, what they wanted to accomplish on the moon, and then a team of people in the Apollo spacecraft program office let what they called traverse planning, traverse for where you were going to go on the moon and what you were going to do at each place and how long it was going to take you.

So that was another group of people that we began to integrate with and kind of absorbed into a single set, a team of planners, and then executors for the actual flight itself, and that was all a big learning experience for us. So we didn't stick rigorously to "You do this part, you do that part, and leave it that way forever." We did kind of move it around a little bit, but probably half the time we had people repeating given phases that they had done before, and we didn't have to restart and redo and reinvent all the training for any individual.

So the flight director's office basically had people assigned to each flight, and then each one of the flight directors, each one of those assignees, lead flight directors, would kind of be the orchestrator of all the details of what was going on on a particular flight. I guess my job was to see that people were selected, trained, and then conducting those planning steps before we got to the flights the way they should. Then, of course, during the flight

itself we would be on individual shifts, so there wasn't any oversight, for example, from the chief of the office, like myself, because each of the people were involved in a given eight-hour shift as I would be, and by that time we were all very confident in each other and didn't really need much in the way of oversight.

When there got to be significant problems, people would sort of coalesce almost like telepathy somehow. The word would go out that there was a problem, and people would show up and help as best they could, but that was, you know, just for special events. Most of the time it just kind of ran along like that.

We found that planning the training schedule with the crews and the simulations and then getting them conducted and then what kind of training might be changed as we went along. For example, if things didn't go well in one phase of the mission or not, we might repeat some simulation exercises that had to do with that phase or whatever. So it was kind of a learning, adjusting experience. I mean, it wasn't potted, it wasn't fixed, it wasn't rigid, it changed as we had to as we went along, both in terms of the people assignments and in terms of the phases.

The other thing that was a significant part of this planning and preparation phase of getting ready for a flight had to do with getting the shift of people that you would be working with in the Control Center, getting them all working together, because, again, at the other consoles it was the same thing as the flight director's office. People would be assigned. Sometimes they would show up regularly during one phase, sometimes they wouldn't. So there was always new faces for a given phase, and it was a matter of sort of bringing a team together, getting them all thinking and working right, and then getting them interfaced with the flight crews right. You could tell. You could tell how it was going, and you could tell when it was rough, and you could tell when things weren't quite right, but then as you approached a flight, generally it all smoothed out and people knew their jobs and they did them very well. They really did them very well.

BUTLER: You mentioned the different shifts of people and the different flight directors working with the different teams. Were the flight directors involved in selecting which [people worked on their team]?

LUNNEY: No. I think those assignments were usually made by the branch chief. For example, Arnie [Arnold D.] Aldrich was the branch chief of the people who looked after the systems in the spacecraft. Mel [Melvin F.] Brooks and then Jim [James E.] Hannigan was in charge of the lunar module systems people. Then we had the Flight Dynamics Branch, the trajectory guidance part of it that I had earlier run and that probably was being run by Jerry Bostick by about that time. So they would make assignments, but they would generally discuss them with us as to why they were doing something and so on and so on.

I don't recall every having any real conflicts in that. There were certain flight controllers that each flight director always wanted to have because they were very, very good, but I don't recall any real conflicts with the assignments, and, in general, it seemed to work out pretty well.

BUTLER: It was certainly a good team.

LUNNEY: Yes, and mixing people up and moving them around and putting them on different teams served a real good purpose, too, because each person brought sort of individual skills and talents, and then they could get mixed in with another set of players. So it was pretty homogenous, I would say, in terms of talent across the board for each one of the shifts.

BUTLER: You mentioned that for each mission there would be a lead flight director. How did you determine who that would be?

LUNNEY: Well, once we got started, it kind of got a little sequential. For example, I was the flight director on Apollo 7, and I guess Chris [Christopher C.] Kraft [Jr.], who was flight operations director at the time, appointed me for that. Then Cliff Charlesworth was the lead flight director for Apollo 8, although there, of course, were several of us working on all these shifts. Gene [Eugene F.] Kranz was the flight director for Apollo 9. Then I was the flight director again for Apollo 10, and Cliff was the prime flight director for Apollo 11. Then somewhere in that mix, Gerry [Gerald D.] Griffin had been operating as a flight director, and then he became the lead flight director for Apollo 12, and Milt [Milton L.] Windler was the lead flight director for Apollo 13. Now I'm starting to run out of who was what. I can't remember who was 14. I think I was the lead flight director for 15. So once we got started, it was a little bit sequential, although that wasn't entirely rigorous. It depended on what else people were doing and what other assignments they had and so on.

The advantage of that was not only did we, maybe every third or fourth flight, get to be lead flight director, but we generally participated in all the flights, not exactly, but most of us participated in all the flights. In that respect, we were different from the flight crews, because they would fly once every couple of years, probably, and skip a whole set of flights. But we felt it was more fun to be involved in all of them, the whole sequence, and, in general, we were. Occasionally we would miss a flight for some reason or another, mostly having to do with getting ready for the next one. But that worked pretty well.

BUTLER: It certainly seemed to. You mentioned there were different shifts. Was there four different shifts?

LUNNEY: No, generally three, although at times we had four, for reasons that I can't recall right now, except it was probably different sets of people. We had enough people, and different sets of people were very good at different phases of it.

The first time I remember having four shifts was when we got to Apollo 13. Going into Apollo 13, we had four shifts of people. Gerry Griffin had a team. Milt Windler was the lead; he had a team. Gene had a team, Gene Kranz, and so did I. We did different phases of it, and during the Apollo 13 mission, as a matter of fact, sometime after the explosion, we took Gene Kranz's team and put them off line to work on the reentry portion, that is, firing the command module back up and getting it ready for entry. So they kind of went off line to do that while the three of us continued with the process of getting the vehicle back to that point in the flight.

BUTLER: And that fourth team was a good incidence, then, for that flight.

LUNNEY: Oh, yes. It turned out it would turn out. It was nice to have a fourth set of players that we could turn over. Plus, by that time the command service module, of course, had been powered down. It was relatively unused, although we used some canisters and things from it, but it was powered off. So most of the people who were occupied with the command service module could pay attention to the planning that was going on for how we were going to try to do the entry when the time came, which would be—it was four or so days later from when the thing blew, maybe three and a half. So that whole bunch of people focused on what could they do to get the command service module ready, what kind of procedures they were going to use, how they were going to power it up.

In the course of that, they also invented how we could recharge the batteries that we had used some of out of the command module. The entry batteries for the command module had been used somewhat in the crisis that we had in getting out of the command module and

over into the lunar module. Normally they wouldn't be used at all because the fuel cells would have been providing the power, but in this case the tanks blew and took the fuel for the fuel cells with them, so the fuel cells went down fast.

At any rate, on the average, it was like three shifts of people, relatively sequentially assigned, sometimes assigned because they had spent some time on a given phase of the flight. So we just would adjust those kind of assignments for that to take advantage of it depending on circumstances, and off we went.

BUTLER: While we're talking about the early end of Apollo, very early in the sequence there was talk about the method of getting to the moon, earth orbit versus lunar orbit versus direct descent. Were you involved in that?

LUNNEY: No. There was a—I wouldn't say a controversy, because—well, it was probably controversial, but the team of people that had been planning it, especially in the person of the Wernher von Braun team, had this idea that we would launch the whole thing, one spacecraft that would do everything, that is, go out there, land on the moon, come back, and do the reentry. The problem with that was it would take an even larger launch vehicle than the one we used to really pull that kind of a mission sequence off.

There was a fellow from Langley whose name was [John C.] Houbolt or something like that, who apparently had worked on this idea of a lunar orbit rendezvous so that the vehicle you sent—it's like the UFO things. You have a mother ship, and you send down a little thing down to the moon and back, and then you discard it. He had this concept that the lunar orbit rendezvous would significantly downscale what you had to do in terms of the initial launch vehicle and make it more affordable, make it more doable, make it, perhaps—that was the argument—make it more reliable and more likely to be accomplished successfully.

I'm told—I don't know whether the story is true, but I'm told that this guy, bless his heart, was so convinced that he had the right answer, that he used to sit outside the office of the people in Washington [NASA Headquarters], the leaders in Washington—I don't want to say demanding, because we didn't really do that, but insisting on a hearing of his idea, and he was very persistent in it, and—again, this is second or third hand, because I wasn't really involved in it and didn't know the particulars—but he forced, by dint of his own perseverance, he forced a discussion and a debate about how best to do this and, after the debate, got seriously joined—and at first, people just tried to pooh-pooh it and put it aside, but once the debate got seriously joined, I believe the advantages became more evident to people, and then the choice was made to not only build an Apollo ship but also to build a lunar lander.

That must have happened fairly early in the development sequence, because you had to build a command service module to do its mission and then you had to build the lunar module to do its mission. I don't ever recall working very much with the design of the command service module that was going to do everything, that is, fly out to the moon, land on the moon, and come back. I don't recall ever doing serious work on that option, so the discussion of what kind of a mission scenario to do, either direct, all up, or this lunar orbit rendezvous with two different manned vehicles, must have been joined fairly early in the sixties, the debate must have been joined that early, and the decision was made fairly early because the lunar module got started a little bit after, I don't recall how long, but in time a little bit after the command service module contract was let with North America Aviation and Grumman up in Bethpage, New York, Long Island, won the contract for the lunar module. Of course, they were rolling along and essentially ready for it by the time we started flying it in 1969.

BUTLER: It seems like it was a good decision.

LUNNEY: Oh, yes. Oh, yes. You know, I forgot one of the unmanned flights. There was an unmanned test of the lunar module that Gene Kranz was the flight director for, and it must have used the Saturn 1B also. So that was probably another use of it, to not even fly the command service module, just fly the lunar module, not plan to recover it, but to go through a set of tests for the lunar module.

I remember, during that flight, that the lunar module engine would not light, mostly for the kind of interlocks that were in the flight software that didn't allow it to ignite. I can't recall the details of it, but I remember being at the console with Gene while this was going on, and Chris—there was a General Vince—it'll come to me—a general who was, of course, in charge of the Eastern Test Range at the time who got kind of close with Chris Kraft, and Chris asked me to explain to the general—these guys were all talking this space jargon babble stuff, and he asked me to explain to the general—Vince Houston, General Vince Houston, who was very helpful to the program, by the way, in his job at Eastern Test Range—to explain to him what was wrong. I just remember saying something like, "The goddamned engine won't light." [Laughter]

He said, "Oh, okay. I understand that." And I believe that they got the software thing straightened out and did get it to fire.

But in our discussion of the unmanned flights I had forgotten that one, because Gene was fully occupied with getting ready. Again, you had to fly these spacecraft differently if they were unmanned because all the things that the crews normally did either weren't done or were put into some kind of automatic system that either automatically called for something to be done or, in most cases, had a command back-up from the ground. So the people on the ground were much more involved in kind of flying and configuring the spacecraft than they normally would be when crews were on board.

I remember Gene getting ready for that flight. It was a wild time for him in terms of getting all the team ready to interface with this modified lunar module spacecraft that had different kinds of things to do with than we normally did when we had crews on board.

BUTLER: I guess that helped give you a chance to experiment and figure out how to do things in the event something did happen on the manned vehicles.

LUNNEY: Yes, it did, and it taught everybody a lot better than they might otherwise have learned what the internal workings of the spacecraft would be, although they were tougher than the manned flights in terms of the prep for them and the training for them, and in some cases the actual flights, because some things you just ask the crew to do that's not so easy to get done when you have to command it, or in some cases you couldn't command it so that you had to go without whatever it might be. So they were more complicated, more difficult to plan for, more difficult to train for.

BUTLER: Shows a little bit, too, some of the value of putting a human aboard.

LUNNEY: Oh, yes. Oh, yes. They're a lot easier to fly with people on board, a lot easier to fly, because they're basically designed to have people, and then they would sort of put these boxes in the spacecraft that were supposed to take the place of what the crews did, and they did a reasonable job of doing that, but they were never complete, and they never had all the flexibility, then they had a lot of procedural things having to do with how you command them and how you talk to them and what kind of feedback you got, and so on. It was more complicated.

BUTLER: As we're talking, going back to the unmanned missions, for Apollo, George [E.] Mueller instituted the procedures of all-up testing that hadn't necessarily been in place before. Did you have any thoughts on this at the time?

LUNNEY: No. I mean, that kind of a philosophy was applied to the vehicles at the vehicle level and then, of course, at the flight level when you flew them, but I wasn't involved in any discussions about arriving at that kind of an approach to things, but it did manifest itself, of course, in fairly aggressive and ambitious unmanned flights that were planned.

I suspect that, left alone, the sequence of flights that we finally used, the sequence of manned flights we finally used to get to the moon, was initially planned to be longer than it was, and I believe one of the reasons that that was able to be contracted was the Gemini experience that we had that I have talked about before, but another was, I guess you'd say, the benefit of the maturity of the program and the experience of the people in terms of being able to make those kind of decisions.

So all-up testing, however it got manifested in the program, probably was a help in that regard. You know, the engineers would like to take every little piece of the spacecraft and test and test and test it and, you know, by the time you get done with all that, aggregating at the higher levels of a real spacecraft system could take an enormous amount of time. So it probably helped, but I'm not the best person to have an opinion on that.

BUTLER: Well, we've been lucky enough to talk to Dr. Mueller.

LUNNEY: Okay.

BUTLER: Moving on now into some of the missions, as you had worked on the unmanned missions and you were testing out the different systems in the spacecraft and coming off of

the Apollo 1 tragedy, Apollo 7 came up, and the mission was—everything went right on the spacecraft, everything was great. What was that like for you, when everything did go so well?

LUNNEY: Well, it was a tremendous relief, of course, and Apollo 7 flew something like ten-plus days, ten and a fraction, in Earth orbit, and it was the first time we took a manned spacecraft and actually flew that duration of time. The early Mercury, of course, was the first Mercury. John Glenn's was three orbits. The first Gemini was three orbits, on Gemini III, and it took us a little while to build up to ten days, and we never did in the Mercury. Even in Gemini it took us a while to build up to that.

But the spacecraft itself—and I think that was part of the learning that was going on in the country about how to build this hardware, and by the time we got to Apollo, the hardware itself, as demonstrated through the testing programs, seemed to be benefiting from the experience that the country had gained in building the earlier ships. In general, the Apollo spacecraft worked pretty well. We had, of course, some problems with it, but in general it hummed along pretty well. The fuel cells worked fine. The reaction control system, which controls the vehicle and can also translate it, make some maneuvers in space, that worked well, and both of the those systems were trouble-plagued in the Gemini flights. So we were pleased that it worked so well.

Apollo 7, of course, was kind of the first of the series. I don't really remember when I learned that Apollo 8 was going to the moon. I can't remember whether that was right before or right after the Apollo 7 mission, but that was a big relief to us, of course, to have the performance that we did on Apollo 7, which gave us, again, good confidence that Apollo 8 had a good chance of being able to go to the moon and back the way it should. So all in all, I think we were very pleased and very satisfied with the way the spacecraft worked, and it did a great job. I mean, it really worked very well the first time out.

BUTLER: Do you think if it hadn't worked as well, that the sequence would have changed?

LUNNEY: It might have, yes, depending on how much it misfired, if that's the right word. That would have affected, I think, the decisions that had been made. I mean, you could imagine a very poor spacecraft with a lot of problems with it, and that probably would have affected the decision-making, because the decision-making was based on the confidence in the hardware and the confidence in the people, and had we not had the experience to establish that confidence, we would have stumbled along a little bit more, that is, more flights to get to the lunar landing than we did. We went to the lunar landing mission in very short order once we got to manning the Apollo hardware, that is, manning it with flight crews. We got there very quickly.

BUTLER: And successfully.

LUNNEY: And successfully.

BUTLER: You mentioned earlier, when we were talking about the unmanned missions, that one of the Saturn V missions, in fact, the one right before Apollo 8, had experienced a variety of difficulties.

LUNNEY: Yes. Right.

BUTLER: Which were solved. But when the decision was made for Apollo 8 and you were going to use the Saturn V again, did you have any concerns about it?

LUNNEY: Well, we did, but we talked about this pogo thing that was causing one engine to shut down, and then the mis-wiring caused another engine to shut down also, and there was a good fix for the center engine just by shutting it down early. The engine testing had gone well. The other thing about it is, once we were getting to the point of saying we were going to put people on board, you know, you're going to light this thing and fire it, so we got to the point of saying, well, as long as we're going to do that, we're taking all of the risks, we might as well try to get the best gain that we possibly can out of it. You could have used the Saturn V to do an earth orbital flight, but it was oversized for that, and you wouldn't have gotten a full, complete test of it, or you would have—you know, people might have fired the engine in such a way in lower earth orbit to keep it in lower earth orbit but still fire the engine the whole duration. And we began to adopt the attitude, well, as long as we're going to fire this thing the whole way, then let's go for the mission that it was designed for and take it out to the moon, which was done on Apollo 8.

So once we got over the initial problems that we had on 502, the unmanned flight, and saw that those things were fixed, then it became a matter of getting used to the idea that, well, we're going to light this thing, it's going to burn full duration somehow or another, in some direction or another, so instead of going sideways, why don't we go to where we want to go, go to the moon. Once you decided to take the risk of putting people on it and firing it for full duration, you might as well fire it at the mission that it was designed for, rather than some strange thing that may have kept it from less—would have been less than a lunar mission but still would have entailed all the risk of firing the engine and running it full duration, firing the stages and firing them for the full duration that they were planned for. So once we got used to that idea, we said, yes, let's get on with it.

BUTLER: And Apollo 8 was quite successful.

LUNNEY: Apollo 8 was great. Apollo 8 was great. We talked about that, and Apollo 8 was kind of like the door opener for the lunar landing mission. I think all the people, certainly in the operations team—the flight crews, I think, didn't feel quite the same way, but for us, all that had to be done to plan and execute the Apollo 8 mission says that we really knew how to do that. We kind of opened the door so that the next couple of flights were test flights. Getting to the lunar landing mission was shorter than it otherwise would have been, but we got there with confidence as a result of Apollo 8.

BUTLER: Looking at Apollo 8 and talking about the risk with the rocket, in hindsight, after having seen Apollo 13, there was some risk with the spacecraft to some degree. Do you ever look back at it and go "Wow!"?

LUNNEY: Oh, yes. There are a lot of—I'm not sure I could recount them all, but there are a lot of times when things happened that, had they happened in other sequences or under other conditions, would have been really bad, but for the most part, the things that happened were handle-able, manageable, in the sequence we had them in.

Apollo 13, for example, had it blown up while the lunar module was on the lunar surface, we'd have been stranded without a way to get home. So the fact that it blew up when it did didn't leave us very much margin to get home, but at least it was some margin to get home, because we still had a full-up lunar module to live off of. And had it happened thirty-six or whatever hours later, we'd have been stuck. We'd have lost the mission, we'd have lost the crew, etc. So there's a variety of things that happened where the sequence of them turned out to be forgiving, if that's the right term, and the program was able to continue without grinding to a halt.

We were lucky. I think I talked about this before, if we hadn't gotten to the moon as quickly as we did and Apollo 13 happened somewhere in the getting ready to go to the moon,

it probably would have engendered another debate about, gee, maybe this is too risky and we shouldn't be doing it at all, especially if we'd missed the goal of doing it within the decade. It just would have had a different flavor to the discussion than it did.

Apollo 13 happening after a couple of lunar landing missions made people feel confident that, well, if we fix this problem, we can go back and repeat what we were doing before. All of that wasn't still in front of us. We already had that under our belt as two successful lunar landing missions. If we did not have that, then the terms of reference for the discussion would have been different.

BUTLER: You mentioned or we talked around, kind of, the build-up to the lunar landing of Apollo 11. In between Apollo 8 and Apollo 11 was 9 and 10, both critical missions.

LUNNEY: Both critical, and 9 was primarily—although, of course, we flew the command service module, was primarily the first manned test of the lunar module, and so people wanted to put the lunar module through all the paces that they could in lower earth orbit, and that's what the Apollo 9 mission was scheduled to do and did. I didn't work on Apollo 9. I was around the Control Center, but I didn't have a planned shift for Apollo 9 because, by that time, I was occupied with Apollo 10. Apollo 10 was another step like that, although it took the lunar module out of earth orbit and we took it all the way to the moon, and we did everything short of the actual descent phase and the lunar surface phase.

So we had to do all the navigation things having to do with the two vehicles in orbit. We separated them. We approximated the rendezvous sequence that we would have when we lifted off from the moon. So we got through all of the phases of flight except the actual descent itself, and then, of course, the traverses that were planned for the surface work.

So we took the lunar module to earth orbit, did everything we could with it, took it to the moon, did everything we could with it, and then, on the third flight, we were ready to

commit it to the landing, did, and it worked fine. It worked fine in terms of most of its performance. There were a few problems that people had to work around in order to be sure that it got to landing.

BUTLER: Go into a little more detail with Apollo 10, if we could.

LUNNEY: Apollo 10 was a great flight. I was the lead flight director on it, and it was, you know, do everything except the landing phase, is basically the way the mission design came down. A number of us argued at the time that if we're going to go all that way and do all that, then we ought to go land on the moon. Probably the staunchest advocate of stopping short of the descent phase was Chris Kraft at the time. He wanted us to have the experience of navigating these two vehicles around the moon, navigating, knowing where they are and how fast they're going so that you can get them back together. Because there were unknowns associated with flying so low, close to the lunar surface, because the trajectories would be disturbed by concentrations of mass from whatever hit the moon and it would change the orbit a little bit, and that doesn't sound like much, but you can't afford to miss very much when you're doing what we were doing.

So we debated that for a while, but after a while we all got satisfied that that was the right thing to do. So we set about to do everything. Tom [Thomas P.] Stafford, Gene [Eugene A.] Cernan, and John [W.] Young were on Apollo 10, and we had a chance to do everything short of the landing on that flight. The flight pretty much went by the book. There were a few funny anomalies where the spacecraft got out of configuration at one time and was kind of spinning up or going in a direction that the crew didn't expect, and Cernan reacted to that, I think, profanely on the air-to-ground, but that got settled down and got the configuration right, and they got that fixed, and things went smoothly from then on.

Basically, Apollo 10 was sort of like the last clearance test for the Apollo 11 lunar landing try, and the flight went well, everything behaved well, and basically the whole system, hardware and people, passed the clearance test that we needed to pass to be sure that we could go land on the moon on the next one. Adding the descent phase and the lunar surface work was a tremendous amount of additional training, planning, getting ready for that had to occur with both the flight crews, with the people in the Control Center, and, of course, all the people that plan all these flights.

So in retrospect, Apollo 10 probably could have landed on the moon, but it was a matter of how much do you bite off at a time, and the way it came out, Apollo 10 was absolutely the right thing to do. I enjoyed it. It was great.

BUTLER: And it was successful. And it set up Apollo 11. When you realized Apollo 10 was a good success, the astronauts were back on the ground, and here you were ready to go on the next one, did anything change in the Center?

LUNNEY: Well, it's hard in words to recapture kind of the mood and the feeling of things at that time, and I'm talking about it in fairly—sort of an unemotional way today, but we had been involved in this whole thing for a long time, we and everybody else, and there was a powerful sense of people wanting to pull off the Apollo landing and return within the decade. There was a powerful sense of wanting to do that, that having been the challenge and the goal. So it was a very strong motivator.

Then all these flights had their own unique characteristics, both the unmanned ones and the manned ones. They had their own unique set of problems in getting ready for the flights, special kind of things that we had to learn and put in place, you know, kind of step by step, and then each flight had its own character when we flew it, because there were always things that happened that were a little bit out of the ordinary and had to be dealt with. So

each one of them. But in the whole course of that thing, I mean, the program had this energy that was pervasive, and everybody that worked on the program for all parts of it, you know, down to the janitor and the guards who were around, and even today I still see some of the guards at the Center who were around in those days, and they still talk to me about how exciting it was. They always like to chat about it.

But there was a sense of electricity and intensity and excitement about the whole thing, and it was like one right after another. We flew Apollo 10 in May and flew the Apollo landing in July. There wasn't hardly ever any time to sit around and savor and bask in the success of a flight, because it was always getting on with the next one that was occupying us. But that whole time, I mean, throughout the sixties, but especially in that last year, year and a half, before we landed, there was this tremendous sense of adrenaline flowing, excitement in people, common goal pulling everybody towards it, lots of technical problems all the time occurring that had to be dealt with one way or another, and it just kept everybody occupied all the time.

So it was like busy hands are good and idle hands are not so good. We were busy the whole time, but we were busy in what we felt was a constructive way, but throughout it there was this constant feeling of excitement and energy just pulsing through the whole program. There were always issues to be decided, you know, about how to do this, how to do that, what to do about this, and so on, and people struggle with those all the time. Just issues like which astronaut is going to walk down the ladder first occupied a lot of people for a while, and which one comes up the ladder last, you know.

So besides the—I don't want to call them unsubstantive—besides all the regular technical problems and difficulties that we had, there were other issues that had to be dealt with of that class. So there is a constant, never-ending agenda in front of us about what to do and how to do it that was being grappled with all the time. But the energy was there the whole time, just crackling, almost, and certainly, certainly crackling when the simulations—

the simulations were not so crackly as they were sweat and work. I mean, sweat in the sense of you wanted to execute the simulation well, you didn't want to screw up, and they were long, and we had a lot of them, so it was a lot of work, a lot of time. But the flights themselves, it was always kind of just walking into the Control Center, day or night, was always kind of like goosebumps. You know, you just felt kind of tingly about it. I think everybody felt that way. I mean, it just infected all of us to the point that we all had the same sense of urgency and sense of intensity about it.

BUTLER: And what an amazing time it was.

LUNNEY: Amazing time.

BUTLER: As you did move into Apollo 11 and the mission launched successfully and you were working the mission now—actually, we'll go forward as to when they were landing on the moon. As they were coming down, they experienced several computer alarms. At the time, where were you?

LUNNEY: I was in the Control Center, plugged into the flight director console, as were all the—all the flight directors that were working the console were plugged in anyway during the descent phase. Gene, of course, was on duty for it, Gene Kranz, but all of us were there.

This alarm thing had been experienced somewhere in the system, in the testing somewhere or in the simulator, I can't remember where, had been experienced in the last couple of weeks before the flight. So the people who had designed and built and tested the flight software, both here in Houston and up at MIT [Massachusetts Institute of Technology], spent a lot of time trying to understand these alarms and what they were indicators of. They were sort of indicators of how loaded the computer was, but it never was an all-or-nothing

thing or a black or white thing where it just stopped, or it wasn't very clear how many of them you could experience over a period of time and still be okay. So there was a sense that they might occur and they had to be handled, but I don't recall the team ever having absolutely concrete, firm indicators that if this happened it was going to be okay or not okay. It was kind of a judgment call as to what the loading really was and whether it would be okay.

So during the descent phase, lo and behold, these little old alarms that we had worried about for a couple of weeks showed up, and the team began to respond to them in no time at all, and as it progressed, you know, the judgment was made that, well, we're getting them, but we're not getting them so bad that anything seems to be not working right, and it doesn't seem like we're getting them every second or anything like that. So they were infrequent enough, although still enough to be troublesome and very bothersome, they were infrequent enough for people not to be willing to call off the landing itself, and we proceeded with the landing. But during the course of the descent, that was kind of a frightening thing, that the computer indeed might be overloading and wasn't going to get all of its functions done properly so that the landing could be achieved. It was a little scary.

BUTLER: And then on top of that, Neil [A.] Armstrong had to adjust his landing spot and—

LUNNEY: Look around, look around.

BUTLER: —began losing fuel.

LUNNEY: Yes. The landing is sort of a race against the clock in terms of looking for a good place and still having enough fuel to set down, because the lunar module system was designed so that basically you were pretty close to empty by the time you got to landing

phase. We didn't have a lot of margin built into it. There was some, but the crews had gotten pretty good at knowing what they were looking for on the lunar surface to set down on and pretty good about getting it down when they needed to and pretty good about keeping track of the fuel and keeping away from what was called at the time "bingo," which meant, "You're out. Get out of there."

So although it was a breath-holding kind of an exercise in the last minute or so while Neil looked around, and difficult for us in the Control Center because we didn't know what he was looking at or how close he was to it or anything—well, we knew what his altitude was, but we didn't know how close he was to really picking a place and getting on with it, so it was kind of a breath-holder, and, of course, he's busy. He didn't have time to be chit-chatting about it. So it was basically an exercise in our confidence and faith that Neil knew what he was looking for, knew where he was on fuel, and knew how far he had to go against how much fuel he had left, and that he had that under control. And everybody had confidence in Neil that that was the case. Indeed, so it was, and he found a place with few enough boulders that looked okay to him and exercised it.

Then, of course, there were a lot of concerns early in the program—not so much later on, but earlier in the program that the lunar module was going to sink into the dust, you know, all these wild scenarios about what was going to happen when you landed on the moon. But the landing itself was fine, the engine shut down, the vehicle sat there for a while, nothing was broken, the lines didn't pop, the fuels didn't leak out. Although getting it on surface was one big relief, there was still a question as to whether you got there with everything intact, and that took a little longer to ascertain, but, in time, a matter of what in those days was a long time, maybe a minute or so or less, I mean, people were pretty satisfied that the lunar module had indeed landed and nothing else had gone awry and it was going to be okay.

As a matter of fact, we used to use terminology like "go," "no go." We had to revise that terminology when we got to the moon because we were dealing with, are we going to stay or not stay, because "go" or "no go" could be misinterpreted. "Go" could mean "go back up" or it could mean "you're okay." It would normally mean "you're okay, stay what you're doing," but "go" might mean—so we got in terminology of "stay," "no stay." All the cards and all the votes came up "stay," and that reflected the condition of the vehicle, and it was accurate and it was fine.

BUTLER: When they did land and everything was fine, what was it like at that time?

LUNNEY: Oh, I mean a tremendous sense of relief, a tremendous sense of having gotten there, and probably more experienced by those of us who were plugged in, sitting there, but not actively on duty, because the guys who were on duty had to worry about, "Okay, it's the same old thing. Yeah, we got over that one. Now we've got to worry about the next one." They were worried about the whole next set of things that had to occur and were they ready for it and what was going on, so they were watching all the telemetry and so on.

So the team that was plugged in on duty probably had less time to realize that we really were there, because they were occupied with the next round of questions that was on everybody's mind about what we had to do next. The rest of us probably had a chance to relax a little bit more. I don't know that I would say—I don't recall that there was like a celebration or anything in the Control Center, but there was this giant sense of relief and probably some more off-line talk and chatter than there normally is at any such event, and people just had to look at each other to communicate a sense of—you know, one look would say, "All the things we've been through for ten years, and here we are, we got there." Communion amongst the people was such that it was easy to read and it was there. I mean, it was all there.

BUTLER: What an amazing time to be able to experience.

LUNNEY: A great time. Great time. I was—how old was I? I was thirty-two, I guess, at the time we landed on the moon. I'd been doing this for eight years or so before that time, but—yes, I was kind of young at the time. We were all fired up, of course, the whole time, but events like that just supercharged that sense of energy and excitement about it. It was really powerful. Great stuff.

BUTLER: Oh, definitely, and definitely a once-in-a-lifetime type of thing.

LUNNEY: Yes. It doesn't happen very often, probably more than one lifetime.

BUTLER: You worked the ascent phase of Apollo 11. Did you have any concerns about the computer because of the alarms?

LUNNEY: No. No. By that time we were settled down, and the ascent phase was a lot less demanding on the computer than the descent phase. So we weren't concerned about that.

The other thing about it is, generally we always struggle with do we have to pull back from what we're doing and not go any further and find a more conservative or less risky way to deal with the situation in flight. That's generally kind of the thing that occupies you, can you commit to the next step, or can you stay in this stage, do you have to back out of it? That was generally the frame of mind we always had as to, can we stay here, or do we have to back out?

In the case of the ascent, it was a no-brainer. There was no backing out of it. There was no backing away from it. When the time comes, we've got to light this thing and get on

with it. So it isn't like we were getting ready for ascent, thinking, "Gee, if everything isn't quite right, we're going to not go," or, "We're going to stay. We're going to sit here." So that made it, in terms of any decisions that have to be made, mission kind of decisions, that made it kind of easy because we weren't going to back away from ascent, no matter what was going on. So that went by the book, and, of course, everything behaved well. The rendezvous went fine, the crews got back in, that went fine. That was kind of uneventful, I think, in terms of being anything other than normal, I believe, and the rendezvous back was fine, and that all worked well. So we were pleased with that.

BUTLER: And they landed safely.

LUNNEY: Landed, and everything went well. The lunar work went well, and back we went.

BUTLER: And back you did go with Apollo 12.

LUNNEY: Back we went to Apollo 12.

BUTLER: And you mentioned earlier the lightning strike on Apollo 12.

LUNNEY: Something else that happened, I believe it happened after Apollo 11. Chris Kraft used to involve some of us in various subjects that were a little bit outside of our normal sphere, and he did that on some basis or another out of his own head as to what he thought was good for us, but it seemed to me that it was probably between Apollo 11 and Apollo 12, he invited me to a discussion of lunar science over at the Lunar Science Institute. I don't know if I told you this on any of the previous discussions.

Well, that was a funny thing, because all the people, the lunar science people, the principal investigators and different scientific types around the country who had invested their reputations in supporting this thing and planning for the flights and so on, they had an agenda of wanting to do an awful lot of science, and the people who were running the program kind of made the decision that, look, especially on the first flight, science is not our first priority. Landing there, being there, walking around, collecting rocks for you, etc., is fine, but that's not our first priority. It's getting there and getting back is our first priority, which is appropriate, I think, still today, was the appropriate decision.

But I walked into this meeting with Chris and relatively few people from Johnson Space Center and this community of people from outside who were involved in planning of the lunar science, and their agenda was science is the number-one priority for all the stuff we're going to do on the lunar surface. To me, they seemed fairly hostile and kind of ugly about what we hadn't done and we hadn't paid enough attention to the science and so on and so on. It was that kind of flavor, like, "You're not paying attention to our priorities," and so on.

I remember my reaction, looking around at them all, was, "Who the hell are these people? Where were they when the shooting was going on? They showed up afterwards to tell us that we didn't do something right." It was kind of a young man's reaction to this set of sage, older, supposedly wiser—I'm not sure—set of people who had a different set of priorities for the lunar landing missions. And that was fairly entertaining in a way and kind of confrontational in a way because they were pushing the agenda that we had to do good science while we were there, and they wanted to accelerate that and do it more quickly and so on and so on, and that was valid from their point of view, completely valid from their point of view, but I remember my reaction was, "Who the hell are these people? Where were they when the shooting was happening?"

Past that, the ops team, in terms of the planning of the traverses and the activities that the crew was getting involved in at all the various stations became, again, more and more of a team subject as more of the people from the operations business got involved with the scientific community, and like all other new groups that were being added to the missions themselves, that gradually worked itself out as we all got to know each other and understood the priorities and so on that an individual group would represent. After a while you understand that it's valid, they have a valid set of thoughts and concerns and priorities. So you've got to find a way to work those into what you're doing and work them off.

Now, I'm not sure where the idea of landing Apollo 12 near the old Surveyor came from. It probably had some—and maybe a lot, I don't know—support within the scientific community. There was a sense that people wanted to get back to the Surveyor and see what had happened to it in the years that it had been there since it had landed originally. On the other hand, I don't know that there was anything more scientific about that, except getting back to the Surveyor and landing at a single point on the moon would be important for the later missions when landing at a place you're really trying to land at and then going on the traverses that we really had planned required relatively accurate control of the landing point itself. So, control of the landing point was probably more important in their mind than whatever it is we might get off the Surveyor and see what happened to it over the years it was sitting on the moon.

So after Apollo 11 and this discussion with the sciences—I don't think this came up, or maybe it did, but that wasn't my strongest impression of that meeting, but soon after it became clear that the program intention was to land by the Surveyor, which was a pinpoint landing compared to what we'd been doing. We'd not been constrained in the Apollo 11, you know. Wherever Neil put it down within several hundred yards or, for that matter, miles would have been okay, but here we were. I remember it was a little bit like my reaction to Apollo 8 when I first heard about it, which was, "Oh, my God, we can't hardly pull that off so

easily," but then this idea of landing next to the Surveyor, a pinpoint control landing, came along, and my reaction was, "Holy God, we don't know how to do that. We barely got this thing down on the lunar surface the last time. What do you mean find a particular space within a hundred, two hundred, three hundred yards so that people could walk to it?" That just seemed to me to be incredible.

But, lo and behold, our set of planners—Bill [Howard W.] Tindall [Jr.] was the spiritual and real leader of that group of people—started to work on all the—it really was a navigation problem. How can you navigate the vehicle, know where you are, so that when you get there you are where you want to be and so on?

So Bill had his analytical guys working on that problem, you know, examining mascons, mass concentrations, were these things that were buried beneath the lunar surface that would perturb the orbit of the vehicle as we went over. So they began to work on that and how to track it and how to put little fine adjustments into the guidance system actually during the descent phase from the tracking that we were making, and they developed a technique for how to refine the guidance system as it went down so that it knew where it was and, of course, it knew where it wanted to go, and that it would be more and more accurate.

It wasn't like we had little beacons down there, you know, like you do at airports, or flashing lights telling you where the airport is. So we began to work on this idea of landing at a specific, pinpoint place, and the analysts, the planners, began to figure out how to do this, so we began to incorporate it into the operational things that we had to do in the Control Center and on board, that the crew had to do, and gradually figured out a scheme as to how to do that with these little corrections that we were putting into the guidance system from the ground.

Apollo 12, you know, I think when they landed, they couldn't tell where they were relative to the Surveyor, but when Pete [Charles C.] Conrad [Jr.] and Al [Alan L.] Bean got on the surface, there it was across the crater, something just a little ways away that was

within easy walking distance for them. We thought we were close, but until they got out and looked around, because the windows weren't looking at it, as I recall, until they got out and walked around we didn't know how close it was, but there it was.

Now, for the launch of Apollo 12, I was sitting there plugged in with Gerry Griffin, who was the lead flight director for Apollo 12, so he was doing the launch phase from the Cape. The weather was such that we should not have been launching at all, but we weren't smart enough about how to measure the threats for lightning potential and so on, which, by the way, we later incorporated quite a bit of mission rules and measuring of field potentials and so on, so to know what the potential for lightning was.

But the thing lifted off in a fairly dark, cloudy—not cloudy, but overcast, dark, and I think it was even raining, kind of a day, and that's not so evident in the Control Center as it is at the Cape, of course. I mean, you could see it on TV, but it doesn't—seeing rain on TV is not the same as being in it. So anyway, this thing starts to go up, and—ZAP!—you know, we see this kind of thing come out of the tail like a lightning bolt, and then all the systems started to go haywire, you know, and things started getting—we had main buses, which are the main electrical power stations in effect in the spacecraft, and we started to see undervolts and things kicking off line and all the stuff that happens when the electrical system is not right. I mean, it was frightening.

Then, of course, the launch vehicle itself behaved properly. It had different design for the guidance system and the rest of the electronics than we had in the spacecraft, and it, probably fortuitously, was designed in such a way that the lightning and the discharge of all that energy didn't affect these digital machines, which could have been zapped, had they taken a direct hit from that kind of discharge, but the launch vehicle continued to fly and continued to fly right, and on board, I mean, the crew had all these lights and alarms going on, caution and warning things kicking off, undervolts, and the little eight-ball that they used to display their attitude was just rolling and twisting and flipping all over the place, but we

were able to assure them, from the tracking of the launch vehicle, that the launch vehicle was flying right.

So they were watching this eight-ball flying all over the place, as if the spacecraft were flying all over the place. After a while, I think, they got to laughing about it. Several minutes after it occurred, I think, I remember listening to the cockpit tape after the flight, and they—Pete Conrad, especially, who could find humor in anything, Pete just got to kind of chuckling, laughing about the things that this eight-ball was doing.

But we got the spacecraft kind of settled down and reconfigured after we got in orbit, so that we're all kind of sitting there looking at each other saying, "What the hell do we do now?" Well, something might have been damaged, but it wasn't at all apparent. All the readings that we had once we got things reconfigured back the way they should and put the things back on the electrical bus that had been knocked off, they were all behaving right. So again we were faced with, well, we've come halfway, and the launch vehicle's okay, the spacecraft's okay, so there's not a heck of a lot of point in turning this thing off. There's nothing that we can see that's a problem, and if there's something bad happened, for example, to the parachute circuits, well, if we stop now, we've still got that problem, and if we go to the moon and back, we have that problem, so why don't we go for the mission?

It was a little bit similar to the Saturn V, manning it, kind of logic: Let's go do it. We spent two or three revolutions in Earth orbit, which is less than four and a half hours or thereabouts, during which time we looked at all that stuff. I mean, I was not on actual duty. I was just plugged in there holding my breath and praying like everybody else, but everything seemed to be working fine, no indication of a problem, so the decision was made, well, let's go and do it. The launch vehicle did fine, did its burn, put the vehicle on a lunar trajectory, and off it went. Off it went.

Having done everything else on Apollo 11 and Apollo 10 and other flights, the issue really was, the concentration was, "Okay, let's get everything back in place so we can go do

this pinpoint landing." That was the brand-new thing and the difficult thing that we were trying to pull off with Apollo 12, and it went well, did fine, and worked just great.

BUTLER: And it did work great. Of course, pinpoint landings did come in very important later.

LUNNEY: Yes, they did.

BUTLER: Especially if you're landing in the mountains and—

LUNNEY: Right. They had very good maps of the lunar surface, so they knew exactly where they wanted to land. When we were doing the walking flights, which would have been 12, 13, and 14, that was even more constrained, but we had planned by that time that on 15, 16, and whatever else was going to happen, 17, maybe more, we had this little buggy, the lunar rover, that was added to the lunar module, and it, of course, had more range than walking did, but still, in order to effectively plan the use of time and where you wanted to go and what you wanted to do, there was a high premium placed on landing where you wanted to land so that everything else would be according to the plan. That was the driver in Apollo 12. I mean, it's proof positive when you can get out and—they actually cut some pieces off the Surveyor and brought it back with them. I never did know what happened to them, but the guys cut them off and brought it back.

I talked to Alan Bean the other day. He sent me a copy of the book that he has where he annotates a lot of the flights and ties them into the paintings that he's been making of the lunar surface stuff, and Al and I were talking about how exciting that was and how lucky we were to be part of it. It was kind of nice to walk down memory lane with Al for a little while, but he talked a little bit about the flight and the excitement of it and how great it was for him

to work with Pete Conrad and Dick [Richard F.] Gordon [Jr.]. It was great. That worked out just fine, too.

I mean, most of these flights, although there would occasionally be a problem, we were able to return to normal, sort of, in most circumstances, and things would stay under control and stay on time line. The only case where that did not happen, and, of course, it did not happen in a very real and significant way, was Apollo 13.

BUTLER: You mentioned Al talking about how fortunate he was to work with his crew members Pete Conrad and Dick Gordon. That did seem to be kind of a unique crew. They really bonded, it seems.

LUNNEY: Yes, I think they did. I think they did. Pete and Dick had flown a couple of Gemini missions together, Gemini—no, Gemini V, [L.] Gordon Cooper [Jr.] flew on, but either Pete or Dick flew on that flight, and then they flew together on Gemini XI. They had known each other from Navy days, I believe, and were close together, and this opportunity came along for Al Bean to join that crew, and he was just thrilled and excited about it. I mean, he's written and told me that he was off working on some advanced stuff, and he was sitting around wondering if he was ever going to get an Apollo flight, and some set of circumstances caused him to be the guy that they tapped to join Pete and Dick for Apollo 12, and Alan considers it the break of his life, I guess, for that to have happened.

They did, they seemed to get along very well together. They had a great time together, and Pete Conrad was just a hoot. I mean, he could find more fun. Again, they would go to a cocktail party or a beer party or whatever we'd have some night, people would all be standing around, and the crew would have spent the day—Al Bean with Pete would have spent the day in an altitude chamber, wearing their suits, doing a whole bunch of stuff, working very hard, physically working very hard against the suit and so on and so on, and

then at night they'd go to a party of something, and Pete would start to recount all the funny stuff that happened there today and laughing about it and so on and so on.

Alan said he was always amazed. He thought they were working like hell, and he never realized that for all the hard work he was putting in, how funny it was until Pete started to talk about it at night, and then he realized, yeah, sure, this was funny and that was funny, but at the time it was hard sweat work. That's what he was experiencing and thinking about all day long. He had no idea that Pete was seeing so much to laugh about as it occurred.

But that was the way Pete was. He brought a lot to the crews, and he brought a lot to the program and the people in it in terms of his attitude. It was always upbeat, always good, and always a hoot to be around in terms of how he looked at things and how much kick he got out of thing, even when they didn't go well.

BUTLER: A very good outlook. On Apollo 12, you did mention there was some concern about the parachutes and whether or not—was there an extensive concern on that?

LUNNEY: No. No, it was just one of the unknowns. It wasn't extensive for us. It might be extensive for somebody. The parachute guys it was very extensive for, and when I say parachutes, I'm thinking of the little electrical devices that sequence them and operate them properly, because, you know, when you get an electrical discharge like that to the spacecraft and you don't have any telemetry on these things, people have a tendency to worry about what might have happened, and I'm sure that the people involved in that stuff worried more than we did, but our attitude was, well, you know, all that we can see working, which is most everything, looks fine, and if something like that is not working, well, it's not working. If it's not working for going to the moon and back, it won't be working for just coming down now and stopping the mission, so let's go for it and bet that it's going to be okay. We didn't have any indicator that it wasn't, and we weren't disposed to wring our hands for a long time.

Hand-wringing was viewed as an undesirable trait. Let's put it nicely. So we didn't have an attitude about staying around wringing our hands. By wringing our hands I mean wringing our hands and worrying about things that we didn't have any knowledge of or couldn't control anyway, even if they were there laying for us. So the attitude was, okay, everything's working fine, let's go use it, and if something's not working, we'll find out when the time comes, but you can't get back from 150 miles earth orbit, you know, any easier than you get back from the moon if something is laying there and not working right. So we didn't wring our hands about it very much.

BUTLER: Apollo 11 had been such a big event and was covered extensively by the media, and then by the time of Apollo 13, there was little coverage. Were you aware at the time that—

LUNNEY: Yes, we could see that, because, of course, it would show up in the numbers of people from the media who would come here to follow the flights. It would take the form of the coverage that would occur in the television, newspapers, or whatever. And we had a sense that the coverage was dropping off, and a number of people—people react to that in different ways. A number of people felt like they were disappointed and it should always be the same as it was, for example, for Apollo 11.

My attitude, I think, all along was there's just something natural in this. I mean, people pay attention to things when they believe that they should pay attention to them. Certainly the first lunar landing mission was something in that category. But then when you repeat it once and you're going back to repeat it again and again—and I say repeat it. From the outside that's what it looks like. From the inside you're doing a lot of different things, but from the outside it looks like you're repeating it, then the interest and the anxiety about it probably goes down a little bit.

So, yes, we sensed and saw the decrease, the indicators of decrease of attention to the flights, and my reaction was that's normal, that's human nature, and it wasn't anything to be terribly distressed about, although some people were more stressed, certainly, than I was about it. But I think it was unrealistic to believe that the attention that the world focused on Apollo 11 was going to continue to be focused on every subsequent flight. It just isn't like that. So, while others might have been more upset, I was sort of benign about it. I thought that was normal, and I didn't get too upset about it.

BUTLER: Looking at the attention of the world and the media, some people have mentioned before that they were so caught up in the Apollo Program or the other programs that they kind of lost touch with what was going on in the outside world, like with Vietnam. Did you—

LUNNEY: Let me talk about that, because the sixties were such a tremendously volatile and kind of a tearing-apart kind of environment in the United States, and speaking for myself and, I expect, really, for other people, we experienced all that, I mean, especially the Vietnam stuff, so many young men being killed and wounded and just a sense of you didn't have any idea of how long it was going to go on, how bad it was going to continue to be, and so on. It was bad. So, you know, as an American or even as a human being, I was affected by all that and all the other things that were going on in America at the time, civil rights, the assassination, marches, the hippie stuff, the drug stuff started to come on the scene.

I remember the convention that was held in Chicago in 1968 where there was so much mayhem, really, on the streets of Chicago, tear gasses and the police hitting people to control the crowds, and the people were expressing their point of view, mostly about Vietnam, that we were on the wrong track and needed to get out of there. It was a very divisive, terribly emotional kind of issue. That and other things, all those other things were

terribly emotional, and we still were in the middle of the Cold War. The threat from the Russians was real, and on and on. So there was a lot of just emotional things that were upsetting—that's a mild word. I mean, "upsetting" is just too mild to capture it. It was distressing the hell out of people in the country, and it had that kind of effect on me.

The difference, though, that I felt for myself and maybe for those of us in the program was that we had a real focus on significant events in the sixties and we could do something about it. I think a lot of people were frustrated because, depending on what their interest was or what their main concern was during the sixties, most people couldn't do very much about it. I mean, people protested, and that was, by the way, an activity that eventually had its result, but it was a long time frame, and it was not clear that it was going to have a positive outcome.

So a lot of people, I think, were frustrated because there was nothing that they could personally do to make any of these things that might have been distressing the hell out of them come out okay. I mean, there they were, and events were out of their control, and these things were happening. So there was a lot of loss-of-control frustration, I think, that people had over the things that were going on, and people felt it all to varying degrees, I suppose, but I think most people in America felt it pretty strongly at the time. All these things were occurring. It was a very difficult environment, and it all caused people to be stressed and frustrated, perhaps, at not being able to do anything about it.

At least in our case, and certainly speaking for myself, I always had the sense that we were involved in a significant activity of our time, significant for our country and for our country's position in the world, and we were kind of—I've used this term in previous discussions—I've always felt like we were, and I was a steward. I was a small, perhaps, but one of the stewards for this program to make it come out right. So we could return to our little island or our little Camelot, or whatever you want to call it, that we had here in the space program and that we especially felt here at the Johnson Space Center, where everybody

in this thing worked so closely together, and, of course, we worked with the other Centers, too, but it was keenly felt here at the Johnson Space Center in terms of the teamwork and the comradeship, and the reliance that you had to have on other people. So there was a strong sense of community and people working together and pulling in the same direction and so on.

So the frustration that other people had, perhaps, where they couldn't do anything about this inability to control these events, we at least had a set of events that we had some active control that we could apply to, even on a personal basis. We could personally do our best to assure that our part of this national scene was going to go well. I think it gave us a sense, also, perhaps, of insulation from the emotional fallout from all these other things that were going on, the frustration, the lack of control, the stressing part of it. They were all real, but for me it was a little different, I think, than for most of the population, because we had this major sixties activity that we were involved in, and we could actually go do something about it every day. We'd go to work every day and work on it, and we could do something about it.

So in that sense, I think, we had an outlet that most people probably didn't have to express their feelings and their sense of what they thought ought to be done about conditions in the country. We had this thing we could do, so it kept us together, and it was a little bit like, when we did our thing, we were on a little island and around us were all these terrible thunderstorms and hurricanes and tornadoes and earthquakes, which were the events of the time, both nationally and internationally, but they were kind of violent, and you almost had the feeling that they were cataclysmic, although it turned out that they weren't.

You got a sense that there was an impending just blowup of all these things going on, but we were on this little island with all this going on around us, and yet we were able to focus on the stuff that we had to do, and in that sense it gave us something that we could control personally and something that we could go do and contribute to, and we could do it every day.

So for us it was probably a rock that we could hang onto, and it did mitigate, to some extent, at least for me personally, the frustration in the sense of out-of-controlness that most other people must have been suffering from. But it was very real. It was very real and very painful. No matter what point of view anybody would represent on a given subject, it had to be painful for everybody that was in America—maybe not everybody, but everybody who wanted the country to do well and come through this stuff. It was very painful for people. It was very distressing. And they're mild words. I think what they were feeling was a lot stronger than that, and lots of points of view on almost every subject.

But we had our island and our rock, you know, that we could go back to, that we could do something about. We felt like we were making our contribution. Yes, all the rest of this was going on. We could contribute what the program was going to contribute to the country. So it was like a solace of sorts, or a port or island in the storm that was going on all around us.

So we were in a different condition, I think, than other people in the country, and we benefited from that, I mean, benefited from it in the sense that we had a focus and a way to express ourselves that was constructive. And it worked. I mean, it did help, I think.

BUTLER: I think it did make a difference. I have found in my research that after the Apollo 8 mission, a woman sent in a telegram saying, "Thank you for saving 1968."

LUNNEY: Yes. 1968 was a violent, difficult year. It was the year of the Chicago thing. It was the year of the Tet Offensive that started the year off. Assassinations. I mean, it was awful stuff. The hippies and the drug thing was going on. Everybody had a reaction to that, pro or con or otherwise. Difficult. Difficult. And then Apollo 8 ended the year with, you know, Genesis being read from the moon. It was quite a change. It was a very absolutely different in-kind public event than a lot of the previous ones, most of which had been—you

know, just with hurt, pain, and agony wrapped around them. This was an entirely different kind of thing, and we were part of it and felt like we were continuing to do—we had more in front of us yet to do.

That's the other thing that happened to us. Because of the pace of things, we never really had time to stop and just enjoy it or even to reflect very much on it in a kind of a broad way or an overall way. We never had, really, time to sit around and talk about it. We were always so involved in this one and then the next one and then the next one, that we did not have time to enjoy it, perhaps, as much as we should have, although the enjoyment came from the energy and the adrenaline that was pumping the whole time. But we didn't have time to be very reflective about it, and that's really come, for me, in the last five to ten years, has been a revisiting of a lot of the events and a lot of people, one thing and another, books and movies and coverages and so on, anniversaries.

I'm now grandfather to twelve little people, and, you know, a sense of what life's going to be for them and what, as a member of the family, what I participated in in some way, and you're helping with that, to leave something for them to have some sense of what I had a chance to be a part of. All that kind of stuff and probably age, stage of life, makes me now stop to think about it.

We were up at an event in the White House in winter. Tom Hanks had this series, and they had a showing up there, and they invited a couple of us up *From the Earth to the Moon* to it, and a lot of the Apollo astronauts came back for it. So it was nice to be in the White House, it was nice to see all that and see the other people there, but it was like a reunion of old comrades, and we did think that the White House was a very nice place to have our reunion and thought it would be a nice idea to have one every year there.

BUTLER: I think it's a great idea.

LUNNEY: It hasn't happened this year. Well, '99 is early yet. Who knows?

BUTLER: As we're going to close today, is there anything of what we've talked about today that you wanted to cover in more detail?

LUNNEY: Well, we never really have done Apollo 13 yet, have we?

BUTLER: Not yet.

LUNNEY: Okay. Well, no. I think I don't have a sideline that I wanted to introduce. I wish—all of us wish, I think, that we were better able to capture the mood and the sense of things as it existed at the time, but it's one of those sort of "you almost had to have been there." But you guys are very empathetic about it, but it's hard to capture, it's really hard to capture, as to what it was like every day to come in and work on the next round of things and so on, but it was really exciting. It carried us and moved us, pumped the adrenaline. It was just charge-up time all the time.

But to answer your question, I can't think of anything else I would add about that period in the context of what we talked about here.

BUTLER: Well, you certainly had quite an exciting time of it, and—

LUNNEY: It was. It was quite an exciting time. I mean, I can't believe, looking back, at how fortunate I was. I understand there's a new movie out, *October Sky*, about a fellow that apparently ended up working at Marshall [Space Flight Center, Hunstville, Alabama]. It was interesting. Somebody saw it and was telling me about it, and then I saw little clips in the paper, and it was interesting because the little town I came from was in a coal mine district in

Pennsylvania where most of the men worked in the mines, and my father did for some amount of time, not his whole life, but some amount of time, enough for him to get the black-lung problem that eventually took his life.

But, you know, the mood in our family was, "You kids get an education and get out of this." Because, for generations, the mode of living had been the men went to work in the coal mines. That was all there was to do. Of course, after World War II, you know, the circumstances changed, a lot of things became possible that weren't possible before.

As a matter of fact, I'm also reading Tom Brokaw's book *The Greatest Generation*, and it's interesting. Of course, my parents' story is not in there specifically, but it's there sort of generally. They went through that same time, married right after the Depression, raising a family. My dad got drafted late in the war and went off, even though he had three kids, three boys, at home. Even at this stage, my mom tells me some stories about what they were doing and what they had to do, and what they had to do to survive, you know, a powerful sense of what those folks went through and how much it has changed, how much opportunity came to pass because of their sacrifices, really, and the circumstances that were in this country, but the opportunities that came to pass for the generation that's represented by my age and others younger than me, probably that we don't always appreciate as much as we should, either.

But the attitude in our family was, "You boys get an education. Don't even talk about going back into the coal mines." I gather this movie has the flavor of the family wanted the young man to remain and work in the coal mines. Not in our house. Nobody wanted that. I mean, it was awful. It was awful. Nobody wanted that for any of their children, certainly in our family. That was my sense of most everybody back there. Some got away and some didn't, and then the mines have kind of slowed down dramatically. There's not the activity that there used to be, and that gives people an economic problem, but in a way, thank God, because it was an awful way to make a living, just terrible, to go down in that stuff every day. So I'm fortunate in that regard.

BUTLER: Very. And it's not something that, fortunately, nowadays a lot of people don't have to do.

LUNNEY: Right. And work today is a different thing than work was fifty years ago. Work was, as my folks knew it and all the generation of that time, tough, very tough, but they were good. Tom Brokaw titled this book *The Greatest Generation*, and, you know, that's quite a title, but for what they did and the attitudes that they had and what they sacrificed, it's not too far off, if at all, not too far off. Great people.

BUTLER: We wouldn't be where we are today without them.

LUNNEY: So there you are. Enough for today?

BUTLER: That's enough for today. I want to thank you again.

[End of Interview]