

ORAL HISTORY 4 TRANSCRIPT

GLYNN S. LUNNEY
INTERVIEWED BY CAROL BUTLER
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BUTLER: Today is February 26, 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: Glad to be here. Thank you.

BUTLER: We'll start today, talking about Apollo 13. We've worked our way up through the Apollo Program to this point, and everything on the past couple missions had gone pretty well, and then Apollo 13 comes along. As you were leading into Apollo 13 at the time, how were things going in your Mission Control operations, and what were you expecting with this upcoming mission?

LUNNEY: Well, Apollo 13 was going to be our third lunar landing attempt, and people have commented that the media attention and so on seemed to drop off quite a bit, and we, of course, noticed that, not so much pre-flight, but we certainly noticed it on the first part of the mission, the first couple of days. There just wasn't the same amount of coverage, people had seen us do that twice in Apollo 11 and 12, and I guess it was a little bit of old news, and not at all unnatural that the attention and the coverage would decline somewhat.

But for us, you know, it was another mission, getting ready for it, same routine that we went through for all of them. Certainly, the early planning for the flight, mostly driven by where people wanted to land, where the scientists wanted to land when we got to the moon,

and then putting together the rest of the mission plan. As I remember, there was not anything unique about the mission plan, except this was the first time we were on what we called a non-free return trajectory.

The previous flights—Apollo 8 that went to the moon, and Apollo 10, 11, and 12—were all on a trajectory that would have made a figure-eight around the moon and come back somewhere in the vicinity of the Earth. Actually, they were designed so that you'd come back and have a safe re-entry, that is, if you didn't go into orbit around the moon. And that's what we used a number of times, and it was kind of a fail-safe kind of a thing. If something went wrong, then you could coast all the way back and maybe do a little mid-course correction somewhere on the way back, and still be close to the entry corridor.

In the case of Apollo 13, we deliberately targeted the vehicle to be on a trajectory that didn't have those kind of characteristics. As I remember, it was driven by the landing site we were going to and the lighting that we wanted for the landing and so on, but we couldn't arrange this nice figure-eight. We were on some other kind of a trajectory that didn't come back to the Earth corridor, but, rather, went on somewhere else, away from the Earth. No maneuvers were performed after we had injected the vehicle onto the coast phase.

So that was probably the single biggest new thing, and by that time we were confident enough in the systems and the engines and the crews and the missions and so on, that that did not seem like a very big—it seemed like the right time to make that kind of step for what people wanted to accomplish in terms of the lunar surface work.

So, other than that, the planning for the flight and then the training for it was kind of the same as we had been used to. You know, the days and so on of simulations that were preceded by all the days of arguing again about the mission rules, which we did all the time, although they stayed relatively the same for most of the lunar landing missions, we tended to argue about them, rehash them all the time, and then, of course, the simulations and the debriefings and the "what we did rights" and "what we did wrongs."

That went on, but again, it was kind of, at that point, relatively a replay of what we had done before, and what we were doing was introducing, of course, new crew and some new people in the Control Center in various new phases, and just getting used to all that, and so on. We did have four teams of flight controllers for the flight, and to tell you the truth, I can't remember why we had four instead of three, but we had—why did we have that many people, for one thing. But we had four teams of people so we could split the work up and people were able to concentrate on given phases, critical phases, where they might have done that work before, so perhaps the four teams was also an accommodation for shifting things around so that you could have experienced people on a phase come back and do that same phase again. But it was the first time we had flown one of the Apollos, as I recall, with four shifts rather than three—complete shifts, flight director and flight controller teams.

BUTLER: As Apollo 13 then came forward to its launch day and everything was going fine initially on the launch, but then they started out with a problem on one of their engines.

LUNNEY: Yes, I think one of the center engines shut down in second stage, and the vehicle is designed with five engines on the back end, four around the outside and one in the middle—center engine, it was called. And they were all fed by the same tank, the same propellant tank of hydrogen and oxygen, so that when the center engine shut down, and I can't remember when it did, but it was late in the stage, use of the stage, late in the flight, basically we just hummed right along, letting the other four engines use up their propellant that was in the tanks. And we didn't have to do anything, and the trajectory was still okay, so we never really saw any real effect on it, that I can recall, anyway, that changed the course of the mission in any way. So the four engines, rather than the five, used up all the propellant, added all the energy that would go with that, and we were high enough and going fast enough where the loss of the one didn't seem to change things very much, as I remember.

BUTLER: And everything did seem to go pretty well from there on out. In fact, at one point, it was going so well that the capcom [capsule communicator] commented that they were bored to tears down below. [Laughter]

LUNNEY: I don't recall that, but I expect that that's true.

BUTLER: And unfortunately that changed soon thereafter, and they did have their problem with the oxygen tank.

LUNNEY: Did indeed, did indeed. Had around fifty-five, fifty-six hours, somewhere like that, into the flight. As a matter of fact, the time spent, once we got out of Earth orbit, after the S-IVB stage had reignited and put the vehicle on the path to the moon, the crews turned around, got off the command service module, turned around and docked, and pulled the lunar module free, and then they coasted out there with just the command service module and the lunar module, away from the last stage, the Saturn IV, S-IVB stage.

And those periods were generally always fairly quiet, in terms of the air-to-ground traffic and in terms of activity on board the spacecraft. There generally was not too much to do, except an occasional—you know, we had to keep what we called the "barbecue control mode," the passive thermal control mode, going, so that the vehicle was warmed and cooled on all sides, about equally, by the sun. Communications—we would switch antennas and stuff like that, and occasionally stir up the cryogenic propellants for the fuel cells, the hydrogen and the oxygen. But they were very quiet.

As a matter of fact, on the day of the explosion, or the accident, it was really a pretty quiet day, but at the end of it, the crews had a TV in this flight, a spacecraft TV program, where they spent, oh, I don't know, probably an hour, an hour and a half, going through the

spacecraft, showing people what they were doing, and talking about what they were going to do when they got to the moon. And they closed off and it was fairly quiet, like all the coast phases, and it was routine, I guess, although it never is really routine, but it felt like a quiet time, and here we're going to go into another sleep period, and then we have another day or day and a half, and then we get to the moon and things would start picking up again.

The team that I was in charge of at the time was probably almost—probably all the people were in the Control Center at the time that the tank blew. It was our custom to come in about an hour before we went on duty, and kind of go over the log and go over—just conversation with the present shift, my console flight director, but all the other consoles the same way. And I also had a habit of kind of going through some of the back rooms and seeing what was going on back there, and to see whether anybody was working anything special that hadn't gotten recorded in the logs, or whatever, or also just touch base with people.

I was in one of the back rooms, and when the report came of, "Houston, we've got a problem," somebody turned to me and said, "Glynn, you'd better get out in the front room. Something's going on." So that's when I came out and plugged in next to Gene [Eugene F. Kranz], who was on duty. He and his team were just about coming to the end of their shift. As a matter of fact, my team was coming in to pick up the sleep shift, when the astronauts were supposed to be going to sleep. It was an interesting period.

I mean, I think, in retrospect, a number of us describe this and have clearer vision now of what was going on than we did at the time, or even that they did at the time, because it was not clear for a while how serious the problem was. And we had spent a lot of time in our training, learning not to jump off too quickly before you really knew what you were doing, because if you started to do things and you weren't sure why you were doing them or what the circumstances were, you might make a given situation worse.

And the indications that people were getting on the telemetry were so pervasively wrong, that the assumption was that there was something wrong with the telemetry system or the electronics or something, that might be causing all these readings to look funny, and although it's sort of obvious in retrospect also, I don't think a big connection was made with the crew reporting the loud bang and then reporting the venting that was going on. There wasn't a good, solid connection made very quickly. It was made, but it wasn't made as quickly as you might think, that the venting and the low readings that people were seeing there, the out-of-limit readings that people were seeing, and pressure in the tank, for example, all correlated and were really telling us that, yes, indeed, we have this thing happening that was real.

So just as the astronauts upstairs were struggling with trying to understand it, I mean, they had master alarms and a lot of red lights on their caution warning and so on, they were struggling trying to figure out what had happened, and, frankly, for a while we were struggling with how to clear it up and get reset so that we could get everything back to normal and go back to sleep and go on with the landing mission that was planned. And so that was sort of the first instinct that everybody had, that there's some funny problem here, but as soon we get to the bottom of it, we can get all this back on track and we'll be okay.

And I think people struggled with that for a while, and then probably within, I would say, somewhere like a half hour, thirty, forty-five minutes, it was really dawning on the people in the Control Center and the astronauts that the command service module was really dying, in effect. The fuel cells were gone and the oxygen tanks soon would be, the cryogenic oxygen tanks. We had small oxygen tanks in the cockpit, but they were basically for entry—a little bit more than that, but they were basically for entry.

But it probably took thirty to forty-five minutes for people to realize that things were really collapsing on us, and probably at about three-quarters of an hour, we started to talk to the crew about moving over to the lunar module, and they already had that in their mind, I

think, at the time, and there was this kind of a rapid scurrying for "This is really a real problem, it's not a telemetry problem, it's not an electronic problem." All these readings are really telling us this thing is in bad shape, and we don't have any power left on board the command service module, except for the three small batteries that are used, basically, to power the ship for the last couple of hours when it's on its own, unhooked from the service module, which is where the fuel cells were located. They're called entry batteries.

So the spacecraft for entry is sort of self-contained, but it's very limited in terms of its capacity, and you can only power up for a couple hours in that configuration. You can't power up very long, or you use them up and then you don't have any power left at all. So I think, as I can recollect, that, as we talked about it later, it probably took us half to three-quarters of an hour for this thing to really sink on us, because the initial struggles were with, "Well, okay, what happened and how is it manifesting itself, and what do we have to do to get settled and so on, and get back on track?"

But when we started to shut off the cryogenic supplies to the fuel cells, that was, in effect, irreversible. Once shut off, you couldn't restart the fuel cells. The fuel cells were the primary electrical power source on board the command service module. So, you know, when we were starting to take those steps, they were done very deliberately. I guess I would add that word to this, in that, in retrospect, I would like to believe we got to this thing a little quicker than we did, but on the other hand, people were being fairly deliberate about how quickly to respond to these indications, and they didn't want to do anything, as I said, to make it worse. And there were so many readings that were funny that we didn't quite know where to start to try to fix it.

So it was fairly deliberate, fairly evenly paced. Some of the console's operators were struggling with an array of crazy-looking data on their television screens and their panels, the light panels that we had for warning us that the thing's at a limit. But I would say by the end

of the forty-five minutes, we were talking to the crew about moving over into the lunar module's lifeboat, and they were already in that mode.

And it was about that time, my whole team—the color of the team was called "Black Team," because we named the flight directors by colors in those days, so I was Black Flight, and so Gene's team had been at the end of a long day, and basically about that time they unplugged and we took over and we were faced with something had happened to the command service module, we didn't know what, and we didn't know how bad the damage was or whether this command module would ever work when we powered it back up again, but we also had kind of an approach, as anybody would, to put off things that you can't do anything about right now anyway, so we operated on the assumption that, well, okay, when we get back around to it, we'll figure out what we have to do with the command module, and it's either going to work or it isn't going to work.

But in the meantime, we were on this non-free return trajectory going, you know, well out into space, and we had the crew in the lunar module. We had never really simulated a lifeboat mission. We had limited supplies on board the lunar module. I don't know the exact numbers, but let's say it was configured for two days of operations, when we were facing four or five days of flight to get back to the Earth. And so the struggle was, okay, we've got this, we've got to get them in, we've got to get it stabilized. We've got to get the lunar module powered up, we have to make it livable.

We had to transfer—we knew that we were on a non-free return trajectory, so we knew we had to do a propulsion maneuver at some point. Therefore, we had to get the guidance system up and running so they could control any such maneuver, and we never had tried to align the inertial measurement unit of the reference system, the platform, in the lunar module, when we were out in space. It was designed for orbiting around the Earth or the moon, or on the surface of the moon, and we didn't even know how the equations in the guidance system would work, but we knew we had to get a burn done.

So one of the things we did was use a manual technique for reading numbers across, punching them into the lunar module computer, and that, in effect, aligned the computer on board the lunar module to the same reference that had been, that was and soon to be gone, available in the command module. So we did a hurry-up job of getting a lot of readings read across and a lot of punching in of the numbers, in order to transfer that alignment.

At the same, the flight control operators for the lunar module systems were very concerned with how long we had to stretch this thing, because they knew they didn't have consumables for a full-up powering of the lunar module all the way back to Earth, so they were very nervous that we not power up too much. They knew we had to do a maneuver, but they didn't want to be running the spacecraft at full power any longer than they had to, because they had no idea of what they'd have to do to stretch the batteries and the water and all the other consumables, all the way back to whenever it is we were going to get back to the Earth, because we didn't even have a plan at that point for how long it was going to take us to get back. I mean, we knew within twenty-four or thirty-six hours, but other than that, it was sort of open-ended as to where in that range it was going to be.

So we had to get the lunar module powered up, and at first we started with, "Do this, do that," and we quickly abandoned that. We referred the crews to one of their checklists, which was used for powering the vehicle up in the normal power-up where they would get ready to land it on the moon, so we started to use that checklist as a baseline, and then asked the operators to look for changes or deltas to that plan, most of which would fall in the category of, "We don't need that equipment. Save the power, save the cooling," and so on, that that equipment might cost us if we turned it on.

So we got started on powering the vehicle up by checklist, and then making delta calls to it as we went along. The first order of business, then, was getting the crew over, getting the lunar module powered up with the guidance system configured in some way that we could use it, and then not powering it up too much. And overriding all that was our

concern that we not screw anything up any more than we already had, because we were kind of in serious problem by the time we got into the lifeboat mode.

We did get everything powered up. By the time we were in the middle of that—this is sort of a parenthetical comment—but by the time, probably within an hour, the Control Center had filled up with the management, and a lot of extra flight control people, and a lot of the astronauts were over, those who had flown on previous missions, those who'd been backup to this one and so on, they were all in the Control Center, so there's people connected on headsets all over the place, but the discipline in the room was very good. I mean, it was ticking along, and the people who were observing, if I can call it that, were engaged. Their brains were engaged in what we were dealing with, and they would occasionally make some suggestions.

I remember very clearly, early on, when we were just getting into the power-up mode, Tom [Thomas P.] Stafford was in, and Deke [Donald K.] Slayton, they were both there—well, there were a lot of other people, too, but Tom, Deke. And Tom was very concerned that we get the guidance system powered up with the reference on board, transfer from the command module over, and figure out what to do about the power later, but we had to get it powered up in order to control the burn that was coming up. Tom was a big advocate for getting on with that, even if we didn't know what the consumable run-out for the mission was going to be.

And that's the way, basically, most of us felt at the time, so we went ahead and got it powered up and then we got our first burn-off a couple of hours after the event occurred, and got us back on our free-return trajectory. We were then—a number of the problems that we had to worry about, like how were we going to conserve the power, how were we going to conserve the water to cool the electronics, and then how were we going to take care of the environmental control system. We knew the carbon dioxide scrubbers were going to not last all the way back. By the way, that was not something that happened at the last minute.

People realized it almost instantaneously. Certainly the experts in the back room knew that the carbon dioxide scrubbing system was going to be limiting, and we'd have to figure out a solution for that. In the front room, we weren't occupied with that immediately, because it was a twenty-four or forty-eight-hour-away problem. We were concerned with just getting things stabilized and getting this burn off, which we did.

And then we had to put the vehicle back into this passive thermal control mode, and when we started that early on, we did it first on Apollo 8, with the command service module alone, not the lunar module attached on that flight, it was difficult to do. It was very touchy, and you can get it going like this, rolling around, with the axis pointing up, and the sun and the Earth being in this plane, but it would wobble off if you didn't do it exactly right. It would kind of wobble off and then you'd have to restart it.

I remember when we first started to do that on Apollo 8, we had to restart it a number of times. I guess, later on, we kind of figured out how to do that a little better, with the command service module, and lo and behold, it worked. But in this case, we had never done it, or really trained for or thought about how we would do that with the lunar module engines and control system.

So we were experimenting with that for a while, about how to get this thing reasonably rolling with the axis up and down in the plane of the ecliptic, which includes the sun and the Earth. So if the sun is here and the Earth is here, we were trying to keep the vehicle pointed up and rolling like this so it would be evenly heated and cooled as it went along. And that was tedious. It took a little while to do that.

We had a backup guidance system called AGS, the abort guidance system, so we were worried about having that available to us, too, and then we were concerned with what guidance system were we going to use when we actually got to the burn, because we didn't know whether the equations that were in the computer were going to work right, because they were all designed for either being in orbit around a body like the moon, or for being on

the lunar surface, and here we were out halfway in between, and we were concerned that the guidance system wouldn't have some funny, in modern terms, Y2K [Year 2000] problem in it, that it wouldn't recognize until we got to doing it. And all the people in the back room and up at MIT [Massachusetts Institute of Technology] were trying to chase down which of the guidance systems, the primary or the abort guidance system, would be better to use. We finally ended up using the primary guidance system, as I remember. I don't think it was because anybody really figured it out perfectly at the time, but it looked like our best shot, and that's what we did.

Then we spent our time trying to set up this passive thermal control, and then we started to think about, okay, now how are we going to manage the consumables all the way back to the Earth. And the first thing we needed to do was get some kind of a plan for what's our sequence for getting back to Earth and how long is it going take, and probably the second half of our shift, after we got stabilized and the first burn-off was devoted to this passive thermal control stuff, getting that settled down, and then starting to consider which options, scenarios, we could invent, that would get us back to Earth in the best possible shape. And it was a tradeoff with how much propellant do you use out of the propulsion systems and how long does it take to get back.

There was even some consideration for trying to find a way to power up and use the engine that was the service propulsion system, which is the normal way that we get back to Earth from the moon, but our conclusion was, there was too much risk associated with that, there was too much unknown about what was going on back there, even if we could reinstitute power to the vehicle. So we concentrated on the lunar module engines, and we concentrated on using the descent engine.

And by the end of our shift, and we were probably on about ten hours, which I would describe as kind of a stabilization period. By the end of our ten hours, we were about stabilized. We had developed several scenarios for getting back that had to do with how

much propellant are we going to use, when do we do the next burn, how long is it going to take us to return to Earth, what's the landing time, in effect, and what ocean are we shooting for. I mean, we had recovery forces, but, of course, they were only in a couple of places, so we had to figure out which of those places we wanted to shoot for.

There was a way, that I apparently can't remember, that said we could have gotten it back a little bit faster than we did, maybe by twelve hours or so, but it probably would have involved using either all the propellant out of the descent system, or even some people talked about dumping the descent stage of the lunar module and just going to the ascent stage, which would have left us again with very little in the way of power, because most of the batteries were carried in the descent stage. So we didn't like that one either on that side.

So we settled for kind of a middle-of-the-road approach of using as much of the descent engine propellants as we felt comfortable with, and then that resulted in a certain return time and a certain landing time. Let's see if I can remember. This thing happened just before sixty hours—fifty-seven, or something like that, fifty-six hours, and we finally landed at about 140-some hours into the flight. So, you know, it was ninety-some hours, best part of four days, on the way back.

And then once we got through all these scenarios, as to what we were going to do, the next shift was about to come on. It was Gerry [Gerald D.] Griffin's team was coming on duty about that time, and he and I went—I went over all this with Gerry and we'd, by the way, in the meantime, powered the vehicle down as much as we could, but we did still leave the guidance system up, so it was still operating at fairly high power levels, because we knew we had to do another burn when we went around the moon. We did a burn two hours after we went by the moon to push the vehicle back towards the Earth as fast as we could.

So we were still struggling with that, but we had to select the scenario in order then—or the return time to the Earth, in order for everybody to figure out exactly how far we had to stretch things and what they had to do. So we went over all that and we selected the option

that we liked, and I tell you this part of it, because I think it's a good part of the story. By that time, it was the next morning. We had most of the management down from Washington headquarters. Tom [Thomas O.] Paine was the administrator at the time. George [M.] Low, of course, who had been the program manager and spent a lot of time at JSC [Johnson Space Center, Houston, Texas], was the deputy administrator, and they were both there, as were all the other management folks were there by the next morning.

And so we went to one of the viewing rooms, the one that was not in the room we were operating out of, the next floor. We were operating on the third. I think we went down to the second floor. And I went over the options for what the various ways of getting back to the Earth was, and what engines, and how much propellant and what the tradeoffs were, and what the return time was going to be and so on and what the risks were and so on, and we told them that we recommended that we do the option that we finally ended up doing. And there was just a brief discussion of whether we should try to do something and use more of the propellant or maybe even use some of the other engines and get us back quicker. But that didn't last very long.

But the point I want to make is, after we went through these options and scenarios and made a recommendation, in effect, to the management team, the only question they asked us at the time—this is Tom Paine that's the administrator—the only question he asked us, and we're all thirty years old, you know, thirty-two years old, doing this stuff, the only question he asked us is, "Is there anything we can do to help you folks?" That was the only question he asked us. "Is there anything we can do to help you folks?"

And by that time, of course, the whole world had been energized by this thing, and support offers were coming in from the Russians and various countries around the world, in terms of whatever that they could do by way of being helpful, and I don't think there was any real connection we could make with any of that support, because everything that we did was

sort of special and unique and had to be in place, like the recovery ships and so on, special equipment on board them. But it certainly was appreciated.

But I would say that probably the ten hours or so from the time of the event and my team coming on duty within the next forty-five minutes to an hour, and the next ten hours of stabilizing the mission, and coming out of that with a clear plan for coming home, a clear understanding of how far down we had to power the lunar module for the rest of the way, which, by the way, was a lot. We had to power down to a couple of lightbulbs' worth of power, to put it in terms like that. And we knew we had to do that.

But we came out of that ten hours knowing what we were going to do for the scenario to get home, the mission scenario, knowing what we had to do to power—what levels we had to power down to, knowing how to do the passive thermal control. In effect, the thing was stabilized. We knew we had another maneuver to perform when we got around the moon, but we'd already done one, so we were pretty confident that that was going to be okay, and we'd about convinced ourselves by that time that we could leave the guidance up, using power, but leave it up until we got around the moon and made the second maneuver.

So we kind of settled everything having to do with how to get the lunar module, the lifeboat part of this mission back. The big unknown, of course, was what status the command module was going to be for entry, but it was an unknown that we weren't going to be able to know any more about until we got there, so we pressed on, and then spent the next couple of days keeping the vehicle powered down.

It was very cold, it was very uncomfortable for the crews on board. They never complained about it, and, frankly, I'm not sure we were terribly sensitive at the time to how uncomfortable it was, but it was uncomfortable for them. It was very cold, it was very clammy in the vehicle. They probably didn't do well eating and drinking. They'd been up—I mean, this thing happened at the time they were supposed to go to sleep, and they were up for another ten, twelve, fourteen hours after that, and then they always had somebody on duty

following that, so there were some very, very long hours by the crew and, you know, a lot of new things were being attempted.

The engineering team that I've talked about before that followed the flights along, you know, they were immediately energized. I mean, they had support up at the Grumman factory and MIT that did the guidance computer. The command service module, of course, from North American Aviation at the time, the program offices, the whole universe of support was in place and working.

Somewhere towards the end of my shift, I think, we got to asking about the fact that the canisters, the carbon dioxide scrubbing canisters on board the lunar module, weren't going to be sufficient, and the guys were already working on a technique for using the command module canisters in the lunar module. As luck would have it, the ones in the command module were kind of like small boxes, like six-packs of beer, squarish, and the ones in the lunar module were cylinders, nice and round, so they just didn't fit in each other's equipment.

But by the time the flight team got around to worrying about that, the word came from the back room, "Yes, Flight, we already know that. We're working on it, and we'll have you an answer in twelve hours," or whatever, and they did. And then it was a matter of just kind of holding our breath and keeping things under control.

Somewhere along the line we did the maneuver, after we came around the moon, and that worked well to put us right back on—accelerate the vehicle on its way back to Earth, to the landing place, the recovery forces that we wanted to use, but that was all sort of decided at the end of that first shift when we laid out the mission scenario. And at the same time, teams of people were off working on how to power up the command module for entry, and how to use it.

The concern was that we had used some of the power out of the entry batteries in the last dying gasp of the primary fuel-cell power system on board the command service module.

We had to have the other batteries on for a while to help us get this guidance thing transferred and whatever else we had to do to get the crews over safely before they got shut down. So they had been used to some extent, and it was kind of dicey as to how much power we were going to have. I'm not real exactly clear on this, but I believe on the return leg, coming back from the moon, we actually—some of the guys invented a way to bypass some of the circuitry and recharge the batteries in the command module from the lunar module batteries, so that when we went into the entry phase, we went into it with a full set of power capacity in the batteries.

Initially, I think people were trying to invent a scenario for how to manage the command module with less power than we ultimately had, because ultimately, we recharged the batteries and we had a full load when we got to separating from everything but the command module. There were an awful lot of unknowns about that. You know, the vehicle sitting there. Well, one, it had been exposed to this explosion. Number two, we powered it down, not necessarily gracefully. We just kind of did what we had to do fairly quickly, and then it spent four days in near freezer-like conditions.

So we just didn't know. There were just a lot of unknowns about how it was going to behave. We didn't know how the parachutes would be. We didn't know how the pyrotechnic circuits would be, that are used for separation and for the parachute devices and so on. So there were a lot of unknowns about that, but it was kind of like, well, we've got to trust in God and trust in this command module that it's going to come back up when the time comes. And it did.

When we got to the entry phase, one of the events in that was that the crew, of course, got back in here. At some point they jettisoned, I think the lunar module first, and then they jettisoned the service module. I think it happened in that order, although I might have them reversed, and it was at that time, where they could see the damage that had been incurred in the service module, where the tank blew and blew out the panels. I remember Jim [James A.]

Lovell [Jr.] talking about it at the time, and it was obvious that it was bad-looking, because he was quite excited in his descriptions of how ugly the service module looked.

But we had a full load, and the team went ahead and powered the command module up, sort of normal-normal, and then everything on it behaved very well. As I remember—and I didn't remember this for a while, but it sort of came back after a while—there was a longer delay after blackout, in hearing from the crew, than we had been used to or had predicted. I can't remember exactly why that happened or if anybody ever really knew why it happened, but it added to the suspense of how the vehicle was, because the heat shield could have been damaged in this explosion because there was so much damage on the back end that was unclear how far it went.

But the ship had been built very well, with margins, and probably if we had gone and asked the designers what it was going to be like if we let it just freeze for four days, they probably would have screamed about not doing that, which we didn't want to do, but when it happened, it was apparent that the ship had been built with enough flexibility and resilience in it that it came through it and worked just fine.

I guess I would say that—and I've made one comment here about how the management team responded—and I'm talking about the Washington [NASA] headquarters team—responded when we had that review at the end of that first night, when we went over the mission scenario options with them and how it was kind of gratifying that their only response was, "Is there anything we can do for you folks?" And I didn't think much about it at the time, and then later, in later years, actually, you know, it dawned on me how confident—that's not quite the right term—but how confident they were in their teams and their people that they would just—had that kind of a question for us. "What can we do to help you folks?" was the major question.

And it was another example of people making decisions at the right levels, where you're not trying to escalate the decision-making to a level that's kind of unaware of all the

considerations that go into it. They were very confident and backed us completely. I mean, sort of without question. And it dawned on me later how impressive that was. I just didn't tumble to it at the time.

The other thing I would say was, here we were again, with our band of people in the Control Center, and we all had our talents and our lack of talents, but as a group of people, probably average age, hardly in their thirties, struggling with this thing for four or five days, and all the operators in the Control Center, and all around the system, but certainly the people that I was dealing with firsthand and saw for the next several days in the Control Center, they were all great. I mean, they all were on top of their jobs.

Sometimes in our job as flight director, we would push them to get answers faster than they could get them, but that was sort of normal, part of the system, but they participated, they got to the answers, they fed them into the system well, they did a lot of consideration of all the possibilities that might happen if you did this or if you did that. It was just very, very sound. I mean, it was really sound. I couldn't even name, you know, the three shifts of people, and then Gene's team that was off line, getting ready for entry. I couldn't really name all the people, even. I would if I went through the mailing list, I guess. But they were all cool-headed. They were faced with a major emergency and they were just right there, cool, doing it, and to talk back about the problem.

When the flight was over, we went through and debriefed the whole thing in terms of what we would have done differently or where did we screw something up or whatever, and we decided that we wouldn't have done anything very different than we did, that the plan, the whole set of events and sequence that we followed, we probably could have gotten to some things quicker, you know, in retrospect, but that's always easy in retrospect, because everything is unfolded for you.

At the time, going into it, not knowing the full dimensions of the problem, the decision-making was deliberate, was reasonably crisp, could have been perhaps just a little

bit faster in some places, but on balance, people responded to a terrible set of circumstances that they didn't really tumble to how bad they were or how real they were when they started in to the problem. So this little band of Americans that we had in the Control Center, and mostly young ones, just thought their way through that, "gutsed" their way through it in some cases, and did a wonderful job of figuring out what to do.

The problem, again, going back over the mission, the problem that occurred was very close to being sort of a maximum test. In other words, if you went out of your way to design a problem that there was a solution for, that you could get back, but with almost no margin anywhere you looked, this would have been pretty close to that kind of a case. There was no margin for error, no margin for screwing things up very much, no margin for misusing any of the systems. We couldn't guess there was any margin left in the command module itself when we got back, and so on and so on.

But if you had designed a case to challenge a team and had a solution that you could thread through, but that had only a very narrow band in which that solution would work, this is pretty close to it. I mean, it was a maximum test for the crew members and for the people in the Control Center. I will forever be proud of being a part of that set of people. I said "people in the Control Center." I meant people in the Control Center, but all the support elements that were engaged in being supportive of the decisions that had to be made during the course of that flight.

I mean, going back over it, when you go back over something like that, for four or five days of decisions, and come to the conclusion you wouldn't have done anything any differently, that is pretty good, because even when we would debrief simulations, we could conclude that we should have done this a little differently or that a little differently. But in this case, the whole broad outline and then a lot of the details associated with the flight itself, we concluded we wouldn't have done it much differently, when we had two weeks to think about it, than what we did on the spot, which is a tribute to the training that we got, and the

process that we went through to prepare ourselves for these things, and the knowledge of what we felt we had to know, and the support that we had within the team, and the support we had from all the—like the engineering teams that were following the flights.

It's pretty gratifying to think that that worked so well, but it was a product of a lot of the people who worked on that flight had been working together for about eight or ten years, one way or another. Not all. I remember, I've talked about the visit from the Washington management, which, of course, included all the Johnson Space Center officialdom at the time. Bob [Robert R.] Gilruth was the Center director, and Chris [Christopher C. Kraft, Jr.] was our boss and the operations director; Deke was running the flight crew at the time.

But what also was just wonderful about it was that by the time the shooting was really going on, the management had all assembled, certainly the local management, the Johnson Space Center management, and Chris and several other people, Dr. Gilruth, were in the back row behind us, and it never took hardly anything by way of communications to keep them informed as to what we were going to do, because Chris understood this stuff very well, having been the original flight director and flight director on the early Apollo before the fire, and then he moved into a less active role on the console, but it didn't take hardly anything to communicate with them. When we had a minute, if I had a minute, I'd turn around and say, "Look, the situation, I've got three things I can do, three options. I'm going to do number two because—" and they'd just nod. I mean, it was like that all night. People nodded.

The management and the whole klatch of people, extra people, who were in the Control Center, were all adding something to it. They were not interfering. It was not distracting. It was like a whole team of people, in the room and all around the country, had assembled, and they were going to do their level best to make this thing come out well, and they were all contributing something or another as we went along. In some cases, it might only be like support and so on, but in many cases, it was very tangible, real input.

It was probably—I don't want to say it that way. It was the single best piece of work that I ever did as an individual, the single best piece of work that I ever did in my life, or I think that I could ever hope to do, captured in ten hours, but it was the product of ten years of getting ready to meet that kind of a challenge, for me and for all the other people who were engaged in this thing. But this was the best ten hours of work that I ever did, and I'm very, very proud of what we all did at the time. I'm very proud of the people that were part of those teams. I was very proud of the management. I was proud of the astronauts. They put up with a lot of very uncomfortable stuff, never complained about it, never whined about it, and the whole team just came together and did themselves proud.

BUTLER: And it is definitely something you should be proud of.

LUNNEY: Well, I expect you could ask all of us and we would kind of smile. Yes, I think we are all very proud of what we did that night. In another sense, too, I was always proud to be a participant in the program. I think I talked about his before, but I always felt like this was a privilege, a privilege of sorts to be in that sort of a key role, if I can call it that, the key roles that we had to play in the Control Center, and to be in a position in history where that just came to us, to me and to others, and to feel proud about being able to do that. You had to feel privileged, also, about being able to do such a thing, and I think you would find the same kind of feeling in all of the, mostly men, the men who were involved in that at the time. It was quite an experience for us.

BUTLER: Absolutely, absolutely. If, in all your training that did prepare you for this and allow you to work the problem so well, if anyone had thrown you something like this as a test, would you have thought it possible? Would you have said, "Hey, wait a minute"?

LUNNEY: Yes. What we used to do is, the simulation folks would give us these test cases, and they generally would throw—see, we got to the point where throwing one, two or three or four problems at us at a time was a piece of cake, just [Lunney makes sounds indicating fast movement], and the simulations became layers of problems, with multiple consequences. You know, this happens, you do this, but this is broken over here, and so on. And the way the simulation people finally got—the stage the simulation people finally got to really test the teams was simply overload. How many problems of various types can we give them at one time and overload the decision-making capacity of the Control Center, the human decision-making capacity?

And in general, they never really were very successful at doing that, even with an outlandish—what we would consider an outlandish, unconnected series of failures. Had they given us this problem, we probably would have said, "This is not realistic." I mean, tanks aren't going to blow up and they're not going to have all, you know—or if we just had the symptoms of all these things going wrong without having a central cause, like the explosion, we'd say, "Oh, this is not realistic. You guys can't do that."

The other thing is, oddly enough, we never really did spend much time simulating the way out to the moon or the way back. We kind of focused on the launch phase and then the couple of orbits that we'd spend in Earth orbit and then the ejection burn and the docking, pulling the lunar module out and so on, separating from the rest of it. Then the stuff around the moon, all the various phases and the entry phase. You know, we really didn't spend—we probably did a few, because I remember us struggling with this passive control mode, but that probably happened in flight as much—my memories of that probably were memories of what we were doing in flight as much as simulation, because I don't remember spending a lot of time simulating just tooling out to the moon. This is kind of dull, not much going on. [Chuckles] So we never did. Although, in kind of a way, we had talked about using the lunar module for that.

As a matter of fact, when I was in the Flight Dynamics Branch before becoming a flight director, we had built all the trajectory programs so that we could use any engine to model, any engine into a trajectory and use it for a burn and then reshape the outcome of the trajectory. So we had early on built the trajectory control programs that we used in the Control Center to use any of the engines, which we had at the time talked about in terms of a lifeboat. But I don't think we ever really ran a simulation or training exercise which was a lifeboat drill. I don't think we ever did that. You might say we should have, and maybe we should have, but I don't think we ever really ran one of those. That was how remote we considered such a possibility.

But we had thought about it, not extensively, perhaps, but we had thought about it and certainly had built some of the trajectory control programs so that we could model it that way and use any engine we wanted to use at any time on the way out or back. And, of course, we had checklists that we could use to power up the vehicle, and so and so on, that we could use for a starting point, which we did in this case. But I don't know that we ever really simulated a lifeboat drill all by itself till it really happened to us, till it really happened to us.

BUTLER: Well, luckily, you had simulated enough other happenings and events that you could take that knowledge and those ten years of active experience and make it work.

LUNNEY: That's how we got there. That's how we got there.

BUTLER: And it was successful and Apollo 13 and the astronauts made it back in pretty good condition. A little worse for wear, but alive.

LUNNEY: A little worse for wear, yes, a little worse for wear. I didn't talk about the fact that one of the things that happened pre-flight was a crew member got changed. It didn't really

affect much of what we did or didn't do in the Control Center. It was a big deal inside the flight crews for that to happen, but for us it wasn't that big a deal. Although there's a certain camaraderie—not camaraderie, a certain mind-reading that develops when people train together for a long time, senses. You could probably plug any one of a number of astronauts into a given crew of three, and with a minimum amount of time, they would be fine.

As a matter of fact, in this case, Jack [John] Swigert [Jr.] came along from the backup crew when Ken [Thomas K.] Mattingly [II] was bumped for concerns about him being exposed to something, and Jack had been through a lot of the same—we had run simulations, of course, with the backup crew, and because they were backup crew and prime crew, they kind of stayed close together. I think it was still kind of a big event within the flight crew community, because it hadn't happened before, I don't think, at least not that late. But for us, we just dealt with it as another crewman that knew what he was doing, which was true.

And then, of course, once we get into this, Jack, the new guy on the crew, was the command module pilot, so the command module's kind of gone for four days. Of course, it was used at the end, but then Fred [W.] Haise [Jr.] and Jim Lovell were trained for the lunar module work, which is basically the ship we were using for most of the return leg to get back.

So even in that respect, the fact that there was a new crewman, the set of circumstances we were faced with, and the fact that he was a new crewman that was the command module pilot made it a little bit easier that the two, Jim and Fred, had trained very closely on the lunar module work themselves, so they were very fluent with it and then they, of course, brought over Jack and that seemed to work out okay. They basically had to steer him around, I suppose, the lunar module, but he did fine with that.

BUTLER: Looking at the crew switch at the beginning, and being Apollo 13, and April 13 as the day of the accident—

LUNNEY: Yes, it was all that, wasn't it?

BUTLER: At the time, was there any of that superstition?

LUNNEY: No. I mean, I think it probably came up in some circles, but we didn't think much about it one way or another, and, you know, all that numerology stuff, it wasn't anything that we were concerned with in any way. So, no, I don't think it registered on us, anyway, as anything to be nervous about.

BUTLER: Just went about your jobs and the mission was the important thing and getting it done. Do you remember at what point during the mission that you realized they weren't going to be able to land on the moon, and that you realized how serious the situation was?

LUNNEY: Oh, yes. I think within the first hour we knew that the command service module was gone, as we knew it. There was still enough of it left to get home, but it was gone and that, of course, knowledge preceded the "Move them over to the lunar module." And that probably occurred within the first thirty to forty-five minutes.

At that point, I don't think any of us—certainly I didn't dwell on the fact that we weren't going to be able to land on the moon. We were focused on dealing with this mess that we had and figuring out what to do about that, and the disappointment, if I can call it that, of abandoning, or not being able to achieve the primary mission, we didn't have much time to be concerned about that. There was too much going on, and I don't even recall thinking about that as something that we didn't get to do at the time. I mean, later on, you realized, well, we didn't get to land.

But on the other hand, what we did was quite a thing, and it had a kind of an energizing effect. I mean, it was just amazing to me, the support that rolled in from around the world. I don't mean offers of equipment or anything, but people seemed to be just captured by this life-and-death struggle, all the way around the world, and we were kind of aware of that. When you would go home, you'd see a little bit of it on TV or what, you could see some of that, and you really had the sense that there was an outpouring of support.

LUNNEY: As a matter of fact, during the night, probably about six or seven or so hours into this thing, when we began to—had the burn off and we were beginning to struggle with the plan for coming home, Chris Kraft and Jim [James A.] McDivitt and probably some others, but I remember those two—Jim McDivitt was the program manager for Apollo at the time—went over and did a press conference. Sometimes when nothing was going on, we would watch that on the in-house video, and then josh with the fellows that were being persecuted when they came back, for their poor answers, but in this case, we didn't have any time to watch it.

But at the end of my shift, you know, after this ten hours, and I think maybe even before we talked to the management, but I'm not sure, that might have been afterwards, I went over and did a press conference on the events of the night. You know, the media had this certain relationship with the program. Some of them had covered it, personally, for a decade and they were very close to a lot of the people. Some of them had not covered it, and by that time, by the way, the coverage was completely energized. I mean, there were a lot of people there, and it was a strange feeling. I mean, it was like they were not being interrogating for the sake of interrogating.

I went through a scenario, a summary of what had happened and what we knew and what we did and where we were and so on, which was typical for what we did, and I probably had a couple of the flight control operators with me. And then in the questions and

answers, the discourse that followed, you had this sense of another set of people that had as much invested in this thing, in a way, as we did, and who were as concerned about a successful outcome as we were. I mean, they were another support element that night and the rest of the flight, as far as I was concerned. And that was a little different from what you normally ran into at a press conference, because sometimes people could pick on something or get into why you did this, or shouldn't you have done that, or some thing that might be in the vein of the media doing its job, keeping the government, which we were, on its toes and checked and balanced and so on, and doing the right thing.

But that night, or that morning, the sense of that was not evident in the room. The sense was "We've really got a problem on our hands here and we're supportive of you folks who are trying to deal with it, and we're not here to give you a hard time. We're just here to know what happened and help get the story out to people, and help in any other way," which, of course, there wasn't anything technical they could do, but I had a strong sense of this flowing of emotional kind of support from the media that morning, and when I went back to the Control Center, I probably would talk to people about.

It was very—I'm trying to find the right kind of expression, but it was like, it was just like, you know, electricity flowing in, recharging my batteries, because I'd been involved with this thing all night, but recharging my batteries in terms of the sense that I had from the people who would normally be our critics. That was their role, normally be somewhat something of our critics. They weren't terribly critical, but at least they played the role of keep us honest and be critical about the program. But it was a tremendous sense of emotional support coming in, and very gratifying, very gratifying.

And as a matter of fact, as the flight went on, it became more apparent to those of us involved, just from the few minutes we would see a television coverage around the world, how many people, you know, all countries that you could see, that were affected by this, and

that were pulling for us, in effect. So we had a planet-full of support, I think, and it was a great feeling, it was a great feeling.

BUTLER: Absolutely. Well, it shows that it was still a—the Apollo program and traveling to the moon was still something that could—

LUNNEY: Still an adventure that captured people, yes.

BUTLER: Still an adventure.

LUNNEY: It really was, and on that flight, it became not just an American adventure, which it might have been before that, but it became a kind of a human-race adventure, because they just became three human beings that were in pretty serious peril, and maybe that's a good way to put it. It became an adventure for the human race at that point, as opposed to just a national adventure, which it might have had a stronger flavor of, up till that time.

BUTLER: And everybody was willing to give all the support they could.

LUNNEY: Yes. I mean, faxes came in from all around the world, offering this or offering that, and, you know, most of it would be hard to accept and integrate into anything, but the good will with which those requests were made is what really flowed through the people in the Control Center. They were aware of it, could talk about it, and so on.

BUTLER: That's great. Very good system to help get through it. And get through it, you did, and successfully. What about afterwards? You mentioned how you debriefed afterwards and

you looked at "We really did the right thing here, we did this all correct," but did you change the way you would do anything for the future missions?

LUNNEY: I can't remember that we did. I can't remember anything significant that we did. Of course, after the flight, there was a major investigation into what had happened, in an engineering sense. Why did this thing happen? And, you know, a lot of attention. At first there was a conclusion, or a tentative conclusion, that we didn't have to change very much. We had just mishandled this tank some time ago, and it happened to get back on this flight, and it had been mishandled in a certain way, and therefore it might have been susceptible to this kind of damage. But that point of view didn't prevail. We did more extensive fixes than that.

For a mission that had such a high content of possibility for a lot of second-guessing, how an operation was run, there was essentially zero of that, that I can ever recall. I mean, it wasn't like people were investigating both the cause of the accident and the response to it in real time, it was like almost in no time, probably by the time we landed, almost. And people just said, "That was fine. Let's go focus all our energy on the technical engineering problem that had occurred, that caused this set of events."

There was no real—I don't remember any significant review of what we did, except we did one internally. I'm sure there must have been some associated with the investigation team that was chartered to respond to this. But, I mean, it was fairly quick, and I can't even remember very much of substance about it, so they must have been fairly satisfied fairly quickly that that was okay, and they didn't need to waste any time pursuing that.

The other thing is that there were not a lot of people outside of our small community who were versed in this real-time flight operations, so there weren't a lot of people who were really expert. As a matter of fact, there weren't any other experts, other than those of us who had been doing it, so it probably would have been a little tougher to assemble a team of

people, but we kind of were our own critics internally about debriefing every run, and what did we do right, and what did we do wrong, and, of course, the crews were involved, and there would be multiple shifts of people involved, so we had a lot of check and balance within that whole thing, that we were on the right track, doing things well.

So there never really was much of a serious probing or investigation of how the response was handled. I can't even—I mean, I can't really recall anything specific, but I'm sure there must have been some, but it ended up not going very far or very long, because people were satisfied with how it went and how it came out.

BUTLER: And it had to come out very well, and your training had proved out.

LUNNEY: Paid off.

BUTLER: Paid off. You did move in, then, after a little investigation into the cause of the accident, into Apollo 14, and with this, Alan [B.] Shepard [Jr.] was coming back to flight for the first time since Mercury, and had with him Ed [Edgar D.] Mitchell and Stu [Stuart A.] Roosa. Originally, they had actually been talking about slating them for Apollo 13, but then switched the crews for more training time for him?

LUNNEY: As a matter of fact, I didn't really work Apollo 14. I was more of an observer for Apollo 14. I was the lead flight director for Apollo 15, and that might have been why I took 14 off, but the other guys were all running their shifts and I was just kind of observing and watching, you know, and kibitzing them. So I didn't have an active role in Apollo 14 itself, but I did sit in on the flight and watch all the fun events.

BUTLER: Were you then in a role of watching rather than active console time? They did have a few problems of their own, completely unrelated to 13, but problems first with docking between the two spacecraft, and then, in lunar orbit, with getting faulty signals on the abort and then the radar, and so there were problems with that. Were you involved at all in those discussions?

LUNNEY: No, not really. Those things had all been talked about before, and the docking probe that we used kind of had a history of, you had to kind of sometimes do it a couple times and get it to work right. I say that, and I don't mean to criticize the design. Sometimes maybe the contact conditions that we flew weren't exactly what the system was designed for, but whatever. The docking system, the probe and drogue system was—it was, I don't want to say "touchy," but it had to be done sort of exactly so, or it didn't want to lock up like it should and allow you to dock. So that wasn't surprising to me, and they repeated it a couple times, or whatever it was, and got it to work right.

The radar thing for landing had been talked about many times. I believe Gerry Griffin was on for that part of the flight, had been talked about. But it came in and worked okay. So they were all things that we'd talked about in the past, the mission rules and so on and so on, and, for me, the flight was just kind of, as an observer, not participating in the exact decisions at the time, some of them had to be done in very short order. But we were there. I can't remember talking about any of them. We may have, but I can't remember really participating in any of it.

BUTLER: They did get down on the moon and do their mission, and Alan Shepard hit his golf ball and so forth. They made it back safely, and then we moved into Apollo 15 and the more scientifically oriented missions, the inclusion of the lunar rover and so forth. How did this change the way you did things, if at all?

LUNNEY: Let's see. The last couple of Apollos, 15, 16, 17, were what I think we called them at the time, the "J" missions, as differentiated from the earlier ones. That was just an arbitrary designator for the fact that a number of additional features were added to the missions. So there was the lunar rover, the descent module had more power, and we had a longer stay capability on the lunar surface. We had a whole bay of the surface module that was full of instruments, that was used for looking at the moon or other places, but I think it was mostly to look at the moon. We called it the SIM bay—I can't remember what "SIM" stood for, scientific instrument module, probably, something like that, anyway—that we used, and it took a lot of measurements while we were going around the moon.

The surface stations that were left became more sophisticated. They were called ALSEP [Apollo Lunar Surface Experiments Package], Apollo Lunar Surface Exploration something or another, I expect, something like that, was the acronym, and they were becoming more and more sophisticated in terms of what we would leave on the moon and the equipment that the crews were handling and using for scientific purposes was becoming more sophisticated.

The traverse planning was becoming, at least dimensionally, wider than it was before, because with the addition of the rover, the range that the crews could explore was larger than it could walking around. So a whole set of variables opened up a little bit. I don't remember the exact numbers, but let's say the early lunar modules were good for two days. This one was maybe good for four days, something of that order, which was a significant jump in time.

I think we were doing three EVAs, weren't we, by the time of Apollo 15? Three surface walks. I should say "traverses" because it included the lunar rover. So it was a big jump up in our capability and sophisticated equipment, both in the service module that stayed

in lunar orbit and in the equipment we brought down on the moon, and in terms of the instruments and the techniques that the astronauts were handling.

I've talked about this one earlier time, but by the time of Apollo 15, the crews were fairly well into—and they were before this time—but by 15, they were really well into this geology training, and Gerry Griffin and I went on a couple, at least one or two, field trips with the Apollo 15 crew, and I think Gerry had gone on some earlier ones. But this was my first experience with really going out into a place where the geologists try to teach the astronauts—well, first set them up for what are they looking for, and then try to teach them how to observe.

It was kind of a scientific method, if you will, for geology, for people in a new place, and what to look for and how to go about observing and what do various patterns mean and, you know, what's obvious after a while. This thing is on top of that thing, and so on. And it was a big eye-opener for me. It was another whole—it was a window into another whole world of stuff that I knew very little about, but it was very enjoyable.

Bill [William] Muehlberger, I remember, who still teaches at the University of Texas, was a big player in that, and I think Bill was the guy in charge of our field trips that I went on, and it was educational. I mean, I had a good time with it. I don't know that I learned a heck of a lot of geology, but I learned to be empathetic to what they were trying to do, which I think was what their purpose was in having us along, because then, again, the whole melding of the operations team and the science team, the lunar science team, just continued to improve throughout the lunar landing missions, once we got past 11, where the primary goal was to land and be out there and come back.

The improvement and the melding of the science point of view with the operations team just continued to get better, I think, during all of the flights. And I don't want to say this has culminated, exactly, but Jack [Harrison H.] Schmitt, a geologist, flew on the last Apollo, Apollo 17, so that was an indicator, perhaps, of the increasing amount of integration,

melding, that was going on between the teams of people that would represent operations and the teams that would represent the lunar science program.

BUTLER: The goal for Apollo had originally been, get to the moon and get back safely. It was very politically motivated, but there was a lot of science to be done.

LUNNEY: The only thing I would say slightly different about that is, I think it was policy motivated as opposed to—political motivation sounds a little bit—can be taken negatively. I think it was a policy that was basically a response to real fear and concern and threat by the Soviet Union and so on, at the time. Yes, but I accept your point. I would just use a slightly different term to describe it. It was not political in the sense that people use the word sometimes today.

BUTLER: True, very true.

LUNNEY: Party politics, and so on. But go ahead.

BUTLER: But yet as you were moving into the scientific phases of Apollo—or, sorry, the more scientifically focused phases, Apollo was beginning to lose support, or funding. Did that affect you at all at the time?

LUNNEY: Well, you know, I guess I could answer that in a couple of different ways. When I was doing this work in the sixties, I mean, I never thought about what was going to come afterwards. I had this sense that it was going to go on forever. It's probably a failing or an idealism of youth, I guess, but you sort of think like, God, this is wonderful stuff, you think

it's going to go on forever, so I never really—if I thought about it at all, I sort of probably had that kind of feeling, rather than thought, I suppose.

On the other hand, this was set up, as you said, as a response to what was considered to be a major threat, and this was seen as a way to demonstrate capability and accomplishment in this field, and we had done that. Within the program, it's probably like any bureaucracy or any enterprise. You know, once you get to do something, you think you'd like to do it several more times and repeat it and so on. And as a matter of fact, at the time, there wasn't an alternative that was sitting in front of us that says, "Okay, now that we've done that, we're going to go do this." It took a little while to develop one as to what we were going to do next.

So there was a sense of inertia carrying the missions along, and there was a sense in the program by a lot of people that they wanted to continue and fly another one, another two, another five, depending on, you know, whoever you talked to. Some people just thought we ought to fly them indefinitely, I suppose. And certainly that was a very strong opinion in the lunar science community, because, to them, we had just gotten over all this operational stuff and we were really getting ready to be able to do the scientific things that they wanted to do, and the 15 was the first mission that had an extensive set of scientific capabilities after the initial capabilities of 11, 12, and 14. And I'm sure they would want to have continued it, and they would probably still be exploring the moon today, you know, in follow-on ways.

But it was a response to a certain set of circumstances, and then once responded to, I think what we saw was acknowledgement, explicit or otherwise, by both the political system in America and probably by the public, that we had indeed achieved satisfaction of the purpose, or that the response that we undertook satisfied what caused it in the first place. I think the political system was satisfied, and the public was satisfied that we had done that, and that there was a sense that it was costing a considerable amount of money. The percentage, for example, of the federal budget that NASA took in the peak years was like 4

percent. Today, and for most periods of time, for long periods of time, almost all the time, it's been one or less than 1 percent of the federal budget. So, 4 percent and 1 percent is a big multiple. It doesn't sound like a big number, 4 percent or 1 percent, but it's a big multiple.

And there was a sense that with everything else that was going on in America, everything else that was going on, that the priorities needed changing, and that was the political sound bite that became popular to describe the fact that we needed to reorient this and couldn't be spending this amount of money or this high a percentage of our federal budget for this kind of thing, in light of the fact that it had accomplished its original purpose, and the return, although seen as very valuable by the lunar scientists, was not seen as so valuable as to be worth that kind of money by the political system. And I think that was reflected probably, although they might not have known exactly what the numbers were, probably the sense that the public had at the time.

So I think it was kind of like natural that it had kind of served a purpose and the purpose had been served, so, therefore, there wasn't a lot of purpose to be served by just continuing to do the same thing over and over again. And it was disappointing to people, I think, but being realistic about it, I think it was appropriate.

You know, other endeavors were different. In other words, what I mean by that, is, for example, the opening up of the New World. There clearly was, once people got over to here, there clearly was a lot of reason to come back. There's a lot of things, in terms of trade or raw materials or whatever you want to say, there's a lot of reason to come back.

In the case of the Apollo sequence, the reason to go back would have been the satisfaction of scientific understanding, or the gaining of scientific understanding about what's going on, and that doesn't have as—didn't at the time and doesn't today—have as high a priority as some other things, like the motivations that were operative at the time of the opening up of the New World. Not only was it trade, it was competition with the other major European powers and so on. So it was a different set of circumstances. I think, you know,

although we would have liked to have done it some more, it was kind of natural and not to be unexpected, that it came to a graceful end a couple years later and we moved on to do something different.

BUTLER: Well, we'll pause here for a moment and change the tape out. [Tape recorder turned off.]

LUNNEY: Yes, it is curious how that happens, but there are a lot of things that get started and then they kind of have a momentum of their own, and sometimes they continue and sometimes they don't, and it just depends on what the power bases that are affected want to have happen and how much money it costs. That's why it's difficult, I think, to get another major new initiative in space started, beyond Space Station, because it isn't obvious what the relevance and what the rationale is for going ahead and doing that, especially if—especially if—and maybe we'll get better at this—but if it's very expensive. If it's a very expensive thing, it's hard to convince people that we should go do that to satisfy somebody's curiosity. It's not much the curiosity of the American public, at least as I can read it today, and I suppose they would say, "Yes, I'm curious about that, and if it costs ten bucks, go find out, but if it costs lots more than that (which it would), then, well, then I don't know that I'm all that curious about it today. I'll wait another day. And maybe you can do it cheaper in the future. Technology changes and things will change and so on and so on, so what's the hurry. I can do that later."

And I think that's the kind of valley that the space program is in, in terms of the surrounding environment in the country. There's no urgency to go do something, and there's nothing very specific or tangible that we can articulate that there's a reason for going to do that. If, for example, we could solve all the pollution problems of energy and do it on the

moon or some other place and microwave it back to the Earth, well, that might have some interest, if we could do it at a price that was competitive or effective.

So if you can make it real tangible to something like that, that people can understand, but I think it's difficult to sell exploration for exploration's sake when it has a real, real high price tag on it, and that's the difficulty that the space program is going to face, in trying to chart a course—the manned space program—in trying to chart a course beyond the Space Station. It's not clear yet what that rationale and relevancy is going to be, but I think we need to struggle to find it, so that we can continue, because in the big scheme of things, man has moved, and he's probably going to continue to move, and it will take a while.

But on the other hand, the exploration of the New World took a while. I mean, it went on for decades/centuries, so, you know, this will, too, and it will have periods when it's fast and periods when it's not so fast, and periods when it's searching for what are we going to do next, and what are we going to do next is probably going to be an agenda for NASA. It is today, to some extent, but it will become more of an agenda as the Space Station Program begins to mature.

BUTLER: And we will see, as you mentioned, for those new technologies and possibly things getting cheaper.

LUNNEY: Yes. There will be new things coming on. There may be some entirely different ways to do things than what we know about today, that somebody will invent in some laboratory, or some breakthrough someplace, and that makes it a different story.

BUTLER: Absolutely. Looking at the last three Apollo missions, in fact, actually, the last one specifically, you mentioned Jack Schmitt, the geologist. Well, he had also proposed, at one

point, that since Apollo had done so well all along, trying to land on the back side of the moon.

LUNNEY: Yes.

BUTLER: What discussion surrounded that?

LUNNEY: Well, let's see. I probably was in the second ring of the audience that might have listened to that at the time, and some of it might have been indirect, but there was a sense of wanting to explore as much as we could of the moon while we were still doing that, because, you know, people were developing an idea that this wasn't going to go on forever, and it was a finite series of missions.

So people were looking for adding—to give them the benefit, I think they were looking for adding substantially new information to what had already been learned about the moon, and to some extent it had a certain PR to it. You know, you're going to land on the back side of the moon that nobody had ever seen, and so on and so on. But I suspect the back side is just like the front side. [Laughter] I mean, I think people tried, and, of course, most of the people in our business would be concerned that then it was sort of an in-the-blind kind of an operation, and you would occasionally get communications from the command module going over them, but basically it would be sort of a com-less, no-com, communicationless kind of a mission.

By the way, that might also have been fairly dull for people, I mean for the public. They go behind the moon and we don't hear or see from them and then several days later they're back around telling us how wonderful it was back there. So there was that kind of discussion, but my impression was, it never really went anywhere seriously. It got aired as

an idea, but I don't think anybody was picking up on it in any serious way, and so it never happened. Never happened.

Now, had we had ten more missions to the moon, we probably would have done it on some mission. I mean, somebody would have prevailed with an argument that it would be a good thing to do. Whether it would truly end up being a better thing to do than landing on the front side or not, I don't know, but somebody would have prevailed with that argument, because it would have been different. But we didn't have ten more flights, and it never happened.

BUTLER: Apollo 17 was the last mission, as you said. As it came to a close, would you have ever anticipated that today, almost thirty years later, we would just now be getting a Space Station up for permanent status?

LUNNEY: I have to say that I believe—I would say that all of the people in the program at that time, and the Shuttle Program had been approved, and the Shuttle was by its very name, "Shuttle," back and forth, conceived of as something that would go to some place and come back from it, not just the vacuum of space, perhaps, but a Space Station. So they were initially conceived as a pair, and then Shuttle was taken as the first step.

And if you had asked us at the time, I mean, we'd thought we'd had a Space Station, you know, a whiz-bang Space Station, in, you know, another ten years, fifteen at the outside, or less, even. So, you know, I think we ended up, the scale of events is going to be different by a decade or two than what we would have imagined back in the early seventies, the answer being, I think we thought we'd had been flying the Shuttle and Space Station in the early to mid-eighties. And the Shuttle in the seventies, I mean, we were expecting to be flying it in the latter part of the seventies. It took a couple more years, but we were expecting it to be flying early, late seventies, so Space Station would have been a couple years later.

At the time, given what we had just done, that seemed like a piece of cake, just a piece of cake to go do that, but it didn't turn out that way, for whatever all the reasons are, and there it is. There it is. And that's another problem, by the way, with looking forward. You can project—you always project the present into the future. We might find in the future that dramatically new circumstances have emerged and have introduced a real need to go do something or another that we can't foresee today. So that's another value, and a lot of the people who struggle to give birth to some of these missions, bless their hearts, because it's a necessary activity, because sooner or later, we're liable to find some set of circumstances that do indeed suggest we go do something like that, and the people who have been working on it then for all that time, that work will pay off, if not in the direct form that they applied to it, maybe some slightly different form, but it'll pay off at some point in the future.

BUTLER: And the space program's progressing right along, and maybe slowly, but we're getting somewhere.

LUNNEY: Well, right now it's slow compared to some sense of schedules in the past. On the other hand, some of what's being done is a little bit invisible to people. What I mean by that is, I think people would intellectually recognize that a significant amount of international participation is going on in the Space Station. In America, they would especially recognize that in the form of the Russian participation, mostly because there's a lot of talk about the Russian thing slipping or this or that happening.

But I think some of that attention obscures the larger worldwide international effort that the Space Station is, that may indeed become a model for some, if not lots, many of the space initiatives that will be taken in the future. It may not always be the model, but it certainly has—it's gone from—it's like the thing I talked about in Apollo 13. It's gone from what was a national exercise to something that's a total, international human-race kind of

activity, although the Space Station does not engage, of course, all members of the human race, but it engages a lot of people from a lot of different countries around the world who are capable and able to afford this kind of exploration. So in that sense, it may be a model for some things that will happen in the future on significantly bigger scales. We'll see.

BUTLER: We shall see. And, in fact, hopefully, next time we can talk about the first international venture, Apollo-Soyuz. Is there anything today that we've talked about that you wanted to close off points on?

LUNNEY: Let's see. I will probably say this a couple of different ways, a couple of different times, but when I look back on it, I mean, I think we would all say the same thing in slightly different words. We loved what we were able to do. We loved the opportunity to be able to do it. We loved the—I don't want to dramatize this about the challenge of it—but we loved the newness and uniqueness of it, and the fact that we were able to participate in it. I loved being privileged enough to be in the role that I was.

I felt like—now, I go back and talk about what happened in space, and I find that, gee, I was kind of in a spot doing something on almost all of the significant events that ever happened in the human space program in the country, one way or another. Didn't get them all, but I got a lot of them. And you know, it was done by—not only what we did, but the whole program was done by people all over America. They weren't necessarily the best and the brightest at anything, they were just pretty good and dedicated.

What took it to another level was dedication to doing it very well, and you took a set of people that I guess you'd have to say were average, and they were dedicated to doing something that was really, in its sum, far above average. And they were successful at pulling that off, and I think, therefore, they all carry with them a sense that they were involved in something that was much bigger than each of us as individuals. It was even bigger than the

sum of us, if you added us all up. What we ended up doing in Apollo was a lot bigger than the sum of all of us as individuals, and I think we all articulate it differently perhaps, but we all carry a sense of that kind of a watershed event in history, and in the development of civilization and the race as we knew it.

It remains to be seen what forms that this new frontier is going to take in the future, but I think all of us who participated would have confidence and faith that, yes, indeed, we have opened up an entirely new thing that was not a window, perhaps, a dimension that was not available before. And I don't know exactly what the form of exploring and exploiting that window will be in the future, but it will be there and it will be significant for all of here on the planet.

So, we loved it. We loved it, we loved the work, we loved the comradeship, we loved the competition, we loved the sense of doing something that was important to our fellow Americans. We were obsessed with it. But it took a lot of average people, a lot of us are that way, and a few extraordinary leaders, and we managed to do pretty big things.

Maybe that's a lesson to take away from this history. You know, you really can do pretty significant things and accomplish extraordinary things just by the proper energy and structuring of what you want to do, but it has to be meaningful and relevant to people, and I think that was part of what was so right about Apollo, you know, articulated, of course, at the beginning by John Kennedy, but it was something that the American public seemed to need over most of that period, and it tells you that part of the success of it, I think, was the fact that it was very relevant to what people wanted and needed, in terms of a response and a reassurance about America's role in the emerging new frontier.

So I think we have to watch to be sure that we have that kind of component, and not a self-serving interest only, purely a self-serving interest in our rationales and attempts to justify new exploration initiatives. It's going to have to be something that people feel, American people, so you get the support that you want from the political system.

But Apollo was a wonderful adventure, a wonderful adventure. I wonder how often those sorts of things come along, you know. Short of war and what that can both do to people and for them, in terms of just a civilian or a civil enterprise of sorts, I suspect that the founding and building of some of the modern companies might have had a flavor of this, modern organizations. But these kind of things, I think, probably do not come along too often, so I really feel grateful and privileged to have been around and then to have been able to play the role that I did in it. It's wonderful.

BUTLER: Certainly. And they don't come along very often. You can pretty much relate it to the discovery of the New World, as you did earlier, because you went from being confined to one certain area, to having a new world open, and now with the space program, you went from having a confined area on the Earth, to having a whole frontier open.

LUNNEY: Open up. Remains to be seen what we can do with it, but it certainly opened up. Opened up.

BUTLER: Great adventure.

LUNNEY: Yes.

BUTLER: Thank you, again, for joining us today.

LUNNEY: Thank you. Glad to be here.

[End of Interview]