ORAL HISTORY 3 TRANSCRIPT

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INTERVIEWED BY ROY NEAL
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NEAL: We're now on the 3rd floor of Building 30 at the Johnson Space Center. Mission Control, as it once was. It's been reinstated. And that gentleman on camera right now is Gene Kranz. We're about to hear more of his remarkable history. In an earlier interview, we covered a lot of the beginning bases, going back to the Space Task Group and the early days of Mercury and Gemini. And, Gene, when we ended, we were talking about Apollo 9. As a matter of fact, you had just said something about Jim [James A.] McDivitt, as the commander of that mission, and I think that's probably a good point to pick up. What do you remember of Apollo 9?

KRANZ: Well, there were many things, Roy. I think the principle change that we saw was the very long-term association we had with the crew preparing for flight. We were originally in the slot that—and had the command service module that the [Frank] Borman crew took for the Apollo 8 mission. We were shoved back in the schedule. But Jim, from our standpoint, was a cut from a different piece of cloth than the majority of the astronauts that we had worked with. The previous crews had been literally the steely-eyed missile men, the test pilots that I had known when I was back working with McDonnell [Aircraft Corporation]. But Jim was, I think, the first astronaut who really made an effort to reach out and work with the controllers. He had established a game plan for the mission, and one of the key elements in the game plan was to make sure that the controllers on console here in Mission Control had exactly the same procedures that would be used by the crews onboard. Now this sounds like a very simple change to the process; but, at the time of the early Apollo Program, we still had not quite come together. We hadn't fully come together as a team.

And Deke [Donald K.] Slayton's troops guarded their checklists and flight plan very jealously; and it was very difficult to get one of the crew copies. The exact copy. And at times, we would find minor discrepancies between what the crew was carrying onboard in previous missions and what the procedures we had in Mission Control. So McDivitt said, finally, "Enough's enough! The people in Mission Control are going to have exactly the same copies of the flight plan and procedures that we're going to be using in the spacecraft. That's the way I want to do business." And from then on, every team (actually, every crew) followed McDivitt's lead.

NEAL: That's remarkable. Particularly because, looking back on it, Apollo 7 rang out, essentially, the module; and from that point in, Apollo 8 demonstrated that it could fly around the Moon. Apollo 9 was the first all-up test of all the hardware. So, I guess it was a good time to start indoctrinating new procedures, wasn't it?

KRANZ: Well, I think it was a good way to establish a new game plan. The other thing was: Dave [David R.] Scott was the command module pilot in that mission. And basically, he started putting out what he called "pilot's notes." And he would write down every thing that he understood coming out of the training. Every timely debrief of simulation, he tried to write it down. And then he'd simplify it to the point where, "This is the way I understand it. This is the way we're going to proceed." And he'd send it out to my Mission Controllers. And again, this was another step in closing the loop, to make sure that the team on the ground and the team in the spacecraft were perfectly synchronized. And again, this was a standard that was carried forward by many crews in subsequent missions.

NEAL: What was your role on Apollo 9?

KRANZ: I was the lead flight director. It was basically my responsibility to not only pull together my team for the mission events that we had, I would launch the Saturn with the crew. I also had many of the maneuvers associated with rendezvous. So, it was basically to make sure that my team was up to speed but also to oversee all of the other Mission Control teams that would be working. One of the real surprises that came out of Apollo 9—it really wasn't—it wasn't picked up immediately—was the workload associated with following two spacecrafts (each with crewmembers). And at that the time that we separated for the rendezvous process, I really had difficulty tracking the spacecraft that was the lunar module, which was in the—performing the majority of the rendezvous maneuvers, and the command module, which was basically quiescent. But it still required a look-see. And I came after the mission debriefing and I talked to the other flight directors and I said, "You know, once we get into the lunar phase of the program, we go up to the Moon with two spacecrafts, we'd better have a way that we can split the team in Mission Control. So, you've got one entire team that's working with a lunar module. Another team working with the command module."

Glynn [S.] Lunney and Cliff [Clifford E.] Charlesworth were flight directors, and they were—had the next two missions. And they were somewhat skeptical that you could actually take and break the Mission Control team into two chunks. They then got their experience on Apollo 10; and by the time that we were on Apollo 11, we had started moving in the direction now where, once we got into the lunar phase of the mission (we had separated the spacecrafts), we would have two Mission Control teams operating in the same room at the same time. In fact, we had two flight directors at the flight director's console following these spacecraft!

But, the entire process of Apollo was getting the flight test experiences, both on the ground as well as in the spacecraft, and finding what is the best way to assemble the pieces so that we have the greatest chance of success for the final step, which was to go for the Moon. And I believe Apollo 9 fit in a very key part in that building the confidence needed to go to the Moon. From my team's standpoint, it was very important because this was my second experience with the lunar module. And we found out that Grumman Aircraft [Engineering Corporation, Bethpage, New York] had built a spectacular spacecraft! It was rugged; it was capable of doing the job. And as a result of the Apollo 9 mission, we had total confidence in the spacecraft that would ultimately take us to the Moon.

NEAL: Just now you said this was your second experience with the LM [lunar module]. What was the first?

KRANZ: The first experience was a unmanned flight test. It probably turned into one of the most difficult times I'd ever had in Mission Control. It was a mission that was supposed to be totally automated, under the control of the onboard computer. But 3½ hours into the mission, a programming error in the computer caused a glitch that—just as we were starting the key parts of the flight objectives, the engine shut down! And we had to take over manual control from the ground. And for a very fast-moving set of sequences, like starting rocket engines and accomplishing abort staging, it's sort of a tough business on the ground. But this team hung together and, over a 4-hour period, accomplished all of the mandatory objectives on that unmanned mission so that we could proceed with the manned phase of the program.

NEAL: Once you got to the manned phase, was it still able to be automated, controlled from the Earth?

KRANZ: We had a lot of capability from the Earth. But basically the majority of the control exercised from the Control Center here was basically to make the crew's workload easier onboard the spacecraft. We would initialize the computer with the data, what we called "the state vector position velocity data." We'd put the targeting data in there. We would manage the communications. We'd operate the recorders. But basically, these were all (what I'd say) satellite services so that the crew wasn't bothered with the routine, the mundane. They could do the thing that they'd been placed up there to do, which is accomplish the flight test and go for the objectives.

NEAL: And actually make a landing in a safe place as was proved rather rapidly, wasn't it, slightly later on? Getting back to [Apollo] 9 for a moment, how did the crew split out? Were there two aboard the LM and one aboard the command module?

KRANZ: That's right. Yes. We had the—Jim McDivitt and Rusty [Russell L.] Schweickart were basically the crewmen that moved into the lunar module. And Apollo 9 had several aspects we hadn't faced on a mission before. Once the spacecraft had separated the lunar module from the command module, they had to come back together because the lunar module was incapable of reentering the Earth's atmosphere. And through this process, we had accomplished and were testing many of the rescue rendezvous sequences that we might need to use later on in the mission. In the process, however, we had a very critical training exercise that at time, we didn't realize the importance.

The training people left us. They killed the lunar module engines; they couldn't use them any more. So we had to perform a rescue with the command module. And we performed this rescue in training very successfully. But in the debriefing, SimSup [Simulation Supervisor], who was the training boss, said, "Why did you leave the lunar module powered up? Don't you recognize how important resources are in case you have some trouble?" We listened—we thought it over and said, "Hey, that makes a lot of sense!" Well, this was the beginning of what we would in later missions call "the lifeboat procedures." That if for any reason we would run into problems during the mission, we had a series of procedures in place where we could evacuate the command module temporarily and use the lunar module as the lifeboat. And on Apollo 13 mission, as history proceeded to lay out for us, this was the first set of procedures we went to when we had the problem onboard the spacecraft. And this was the characteristic of the training.

The training—there wasn't anything, no matter how obscure, no matter how way out, that we didn't look at and say, "Hey, we might be able to use this downstream. So, let's take it, write it out completely," and we'd assign a responsibility, a—basically establish the Center procedures for this case, and then we'd put it sort of like in a bookshelf in a library. But in desperation, when time's short, you want to go back to something that you've known and maybe tested before as opposed to trying inventing on the spot. And our lifeboat procedures were part of that package.

NEAL: If I'm reading you correctly, you're saying that essentially Apollo 9 was the focal point around which the later procedures were built.

KRANZ: Oh, yeah.

NEAL: You checked them all out, didn't you?

KRANZ: Yes. And the—going through the manned sequence, Wally [Walter M.] Schirra's [Jr.] flight in Apollo 7 basically demonstrated the capability of the command module to do the job and the procedures that we had written for the command module. Apollo 8 demonstrated our ability to work with the Saturn booster, inject the crew out to the Moon, we then got around the Moon, we determined how well we could navigate, proved our ability to navigate around the Moon, proved our ability to perform maneuvers, and to return to Earth coming in at the extremely high velocity of 7 miles a second. So, Apollo 8 put that. Apollo 9 then really gave us the flight test checkout—the single flight-test checkout—of the lunar module, along with the rendezvous technique so that we had a building block. Apollo 7 proved the command module; Apollo 8 proved our ability to work in the vicinity of [the Moon]; Apollo 9 proved the lunar module. Then we put all the pieces together in the next mission in a full dressed rehearsal for the lunar landing.

NEAL: As I remember Apollo 9, it was a fairly uneventful mission. It went pretty much by the book, at least what we saw from the outside looking in. For the inside looking out, was it?

KRANZ: Well, I think from—the thing that surprised us on 9, and we never really realized the significance on the ground (the medical doctors did), is that we had the first of the crewmen, Rusty Schweickart, who indicated that he had been sick in the early days of the mission. In fact it was to the point where actually we deferred the extravehicular activity to give him time for recovery. And again, in Mission Control, we looked that—at that as a singular event. Yes, space motion sickness; a crewman did get sick. But we sort of put it aside because we didn't have any other reports.

Much later we found out from the medical community that almost half of the astronauts experienced some form of space motion sickness in the early days of the mission. To the point where today in the Shuttle Program, we really don't schedule highly critical activities in the first 2 days of the mission; and we try to work around that particular malady that seems to be experienced by many crews.

NEAL: Didn't Borman show something like that on Apollo 8? Wasn't that the first real symptom?

KRANZ: Well again, this was a question of having enough instances occurring. The only real focus that we had (or I had) in Mission Control was basically the Rusty Schweickart incident, because basically I had to come up with a game plan to work around it. In those days, we were moving so fast that we were launching a mission every 2 months as we were approaching the end of the decade and we had to fulfill the pledge that we had made to President [John F.] Kennedy that only the most significant events stood out. And you would find some way to reshape the mission to accommodate the lessons learned. Again, without the crew incapacitated or unable to accomplish the job, we just assumed that we'd press on. And that's exactly what we did.

NEAL: How serious was this motion sickness? How serious was this illness? Was he really incapacitated? Or was he capable of some activities?

KRANZ: I think the principle concerns here is internal to the spacecraft. That the crew is capable of continuing the work, albeit at a reduced level of—reduced skill level. But they could get the job done. But once inside a spacesuit, if they would get sick, vomit, throw up, there's a possible chance that they'd be able to choke. It became a very serious concern in the program. And again, this is why in the later programs that we avoided extravehicular activity if at all possible in the early days of the mission.

NEAL: As flight [director], how did you work around it on Apollo 9 the first time you really experienced it?

KRANZ: Well, Apollo 9, the principle task was to basically re-plan the mission. And we had—Apollo 9 was a 10-day mission. It was broken down into two periods: a 5-day period with the lunar module, and then the 5-day solo period with the command module. So, we had a lot of maneuvering room to actually defer the extravehicular activity until we had indications from the flight surgeons that the crew was feeling much better. But this is a—this was not an option that you would have in the early hours of, say, a lunar mission, where you're injecting to the Moon. You have a limited number of opportunities to use that Saturn booster. So, the process, what we call of—what would eventually be called the space adaptation syndrome (everybody's got to have an acronym, SAS, and the crew would refer to it as "the dreaded SAS"), really never compromised a mission to a point where we were unable to achieve our objectives.

NEAL: Looking back now, was there anything else about Apollo 9 that comes to mind before we leave it behind?

KRANZ: Again, it was this continuing flight test of the lunar module. It was the second test, and again it gave me the conviction that we had a very stout product in the lunar module. I also had the opportunity to work with Tom [Thomas J.] Kelly and the engineers who designed this magnificent spacecraft. They're here in Mission Control during the course of the mission in what we call "the spacecraft analysis area." And this is, I think, essential to develop the chemistry of the Engineering/Operations relationship such that we—when we need information on short order, they have the confidence in us to give it to us and we have the confidence that what they give us is going to be the best data they can provide in those minutes and hours that we give them a chance to dig out information for us.

So, it's this continuing process of building the team that actually started—actually in the Gemini Program. Because in Gemini, we had continued adding in the small pieces. So that, by the time that we got to Apollo, we were approaching maturity in this business of crisis management in spaceflight.

NEAL: You were welding a team together that would stand you in good stead during later flights, weren't you? Here in Mission Control, too.

KRANZ: Yeah.

NEAL: Is this room filled with memories for you, Gene—and I'm sure it is—there must be a few that perhaps might be good to tell. Do you remember anything in particular, any anecdotes that happened on the way to flying to the Moon?

KRANZ: Well, we were speaking of Apollo 9. And one of the responsibilities—jobs of the flight director is to not get ahead of his people. In fact, don't make decisions that they should be making. That's essential, really, for two reasons: one, you want to build the team and you want to give these people the ultimate responsibility to provide you the information so that you can assemble it together and pick the course of the mission. In the training process, the trajectory officer is called the flight dynamics officer. And the training process not only is verifying the integrity of our knowledge. It's also looking at the integrity of the team and the decision process, and can we make decisions in short seconds, etc.?

The—I had a simulation training run that was starting to unwind on me. I had propellant leaks onboard the command module. I was faced with some type of an abort. And as you approach the final seconds of attaining Earth orbit, your options are dwindling very rapidly. But one of the keys is, you have options to continue to go forward, to try to get into orbit, as well as you have another option that brings you back into the Eastern Atlantic—Atlantic Ocean. And my FIDO [Flight Dynamics Officer] couldn't make up his mind as to which abort option he wanted to call, and I proceeded to do his job for him.

I exercised what they call a MOTR [multiple object tracking radar] abort, which was trying to drive the spacecraft back to the Atlantic. And I called the abort that he should've called. And I passed it on. The Capcom [capsule communicator] relayed it to the crew. The crew executed this thing, and it was obvious that with the time delays, as in this entire process, that I had picked the wrong abort mode. And the spacecraft, instead of ending up in the Atlantic, ended up in Spain! Well, this wasn't a good landing point. And, you know, you feel real bad when you blow one of these training runs.

But the instructor really drove the stake in that I had done the wrong thing when he says, "Not only did you put the spacecraft down on land, you killed the crew because the mountains that you brought them in are above 10,000 ft. And that's where the parachutes should open." So basically, they hit the mountains before the parachutes opened. "And you will debrief these runs." But the key thing was, I was reading the flight dynamics officer's displays. I can read them. I know when you get into the, you know—into the cutoff box. I know when you're running out of the abort modes.

But basically, I usurped his responsibility to make those calls. And this is the process of training that teaches you very profound lessons. And this is a lesson I never forgot, is that I am going—anybody who ever works for me, from that day forward, whether it be in Mission Control or in my organization, I expect to do his job and I'm not going to do it for him. And if he can't do it, he's going to have to find some other employment. So basically, it was a lesson well learnt in Mission Control; and I think every flight director went through similar lessons some time in their career.

NEAL: Wasn't that one of the things that your own management was doing for you, too? They were giving you the leeway to make the decisions, weren't they?

KRANZ: I was amazed that the—as in the process of growing up in Mission Control here that our bosses had so much confidence in us. Chris [Christopher C.] Kraft—I'll tell a story about Chris Kraft, and this is back in the very early days of Gemini.

Gemini V. It was time for hand over. We had all kinds of problems in the spacecraft. We didn't expect the fuel cells to continue working. We were now moving into the phase of the mission where we had to what we call "shoot the gap," we had to move from orbit 6 to about 16. Very limited orbital coverage. Everything was unwinding. And it was time for hand over, and I expected Kraft to give me the game plan. And instead of writing it down in his logs, he put his headset away, got ready to leave. And I says, "Chris, what do you want me to do?" And Kraft looks at me and he says, "You're the flight director. Make up your own mind." And he walked away.

And it was this kind of a confidence that was extruded by our management that at times you couldn't believe they would give you literally the entire future of the space program and put it in your hands and let your wrestle with it. Occasionally they'd do a bit of coaching. You'd—sitting in Mission Control, you'd hear a bit of growling from the console behind me where Kraft would sit. But in no way did he ever interfere with the direction of the Mission Control team. And this is an amazing level of confidence, when you're doing something that—not only out in front of the entire world, you're doing it for the first time. You have—it has the ability to basically rewrite the history books.

NEAL: With your background as a Marine, you were used to being the guy who would take charge when you had to. You had to unlearn some of that, didn't you?

KRANZ: Yeah, it was—I think every flight director, and myself included, had very strong learning—Mission Control is a spectacular leadership laboratory. It has the ability to give you the ultimate in confidence that you can walk right off that cliff and literally walk on air. At the same time, it can strip you to literally naked and show every flaw that you have in knowledge, ability to form teams, trust between individuals, right on down the line. But the Mission Control process, as a laboratory for leadership, is one where you accumulate these bits and pieces of knowledge. You learn to work with peoples of all races, nationalities.

I think they give the military services a lot of credit for being able to cope with the various rights and privileges of diverse groups of people. I think in Mission Control, we demonstrated that well prior to the military stepping in. Because we would have men, we'd have Blacks, we'd have Mexican Americans, we'd have Whites in here, from all parts of the country. And the whole focus was getting in the job done. And it was—you used every available asset and talent to get it. And it didn't matter what they came from or what their background was! And in later years, we added women into this very critical equation. And they had no problems, not only in measuring up but taking the lead. In fact in Mission Control today, you look at any one of these pictures in TV. We're about 40% women. So, it's basically a—it was probably one of the first truly equal opportunity employers within the federal government. And it's a real privilege to grow up here.

NEAL: Well, you had a team concept, too. Can you tell us a little about that?

KRANZ: The Mission Control team, the flight director's got the job description that is one sentence long: "Flight director may take any action necessary for crew safety and mission success." From a standpoint of American industry, this is probably the simplest job description of the chief executive of a facility. The flight director is given a team of between 15 and 21 controllers. They're people who specialize in trajectories and spacecraft systems. We have medical doctors, planners, facility operators. We have an astronaut who serves as the communications link between the crew and ground. Each one of these controllers, when they move into the control room itself, is expected to be able to make 100% correct calls on anything within his area of discipline, literally within seconds. A flight director's job is basically to assemble the pieces and, again, make the mission decision, literally, in seconds.

The controllers have always used a principle that I would call "learn by doing." There is no piece of paper. There is no technical information. There is no schematic flight—there is nothing in this control room that was not developed by a controller. A controller in the—say, the guidance system would provide all the information on that system; and then he would hand it over to a flight planner who would use it. And the flight planner wouldn't redesign it or change it. It was basically trust in that handover that that data was correct. Then this flight planner would basically develop a flight plan, hand it to the trajectory officer down for the design of the trajectory.

So, each one of these controllers is totally accountable, not only for getting the job done but for the 100% (what I'd say) perfection of the information at his console. And I think everyone knows how difficult perfection is to achieve. But in Mission Control, that is literally the name of the game. It's what I'd call excellence in the art of crisis management.

NEAL: Since no single individual can carry all that information, nor can they make rapid computation, this was really just the tip of the iceberg, however, here in Mission Control wasn't it? Each one of those flight controllers had support rooms and support people. Can you tell us a little about that?

KRANZ: Yeah. Well, the control team itself in—sitting in this room basically had the responsibility for the seconds-to-minute-type decisions. Once they moved beyond that timeframe now and we had a little bit more time to work on it, they had a support staff room. And the support staff room was basically one layer deeper. One lever—one layer more knowledgeable in the specific spacecraft systems, the jobs we were trying to do.

And then once we moved beyond the minutes into the hours' timeframe, we had hot lines out to all of the contractors, where you could literally reach out and touch the individual who designed, tested, checked out—the last individual who had ever worked with the component in the spacecraft. You could go into the laboratories. It was not unusual that within hours of a problem, we would have a test rake set up in one of the contractors' or subcontractors' laboratories trying to duplicate the exact problems that we were experiencing in flight. So, it was a—it was not a literally the tip of an iceberg. It was really an incredible focusing mechanism for decisions that were coming at us and recommendations from all over the country.

And a mission is probably the most incredible place—the wrong statement here. The process of preparing for a mission and executing a mission is an incredible forcing function, because it takes—it requires each individual to step up to their concerns, the problems they have, the gut feelings, and make a commitment, "Am I go or no go?" And it starts from the lowest guy in the factory up through his chain, where again you have this kind of a decision. And there's no such thing as a perfect spacecraft. There's no such thing as a perfect mission.

What you have to do, and you have to learn to make decisions short of certainty. And I believe this was how we were able to achieve the lunar landing, starting from a cold start, in 10 years. We were willing to accept some level of risk to get the job done. And we believed (and this to a great extent is—goes back into the design, the program manager) whatever risks remained would be put on the back of Mission Control to find some clever way to work around that risk, to accomplish your objective in spite of a problem onboard the spacecraft. So basically, our job was to—the engineers would do the best job they could. They'd hand us the spacecraft, and it was up to us to live with whatever risk remained in the spacecraft—the design of the spacecraft, design of the mission until touchdown.

NEAL: And as the flight director of that team, there must've been an incredible amount of pressure on you to bring them back.

KRANZ: Well, the—in retrospect, I could feel, yes, that there was some form of pressure. But during the course of a mission—I think this is true whether it be a surgeon—a brain surgeon in an operating room, firefighter trying to rescue some person—during the course of the event, you never feel the pressure. You have a mission that must be accomplished, and you feel superbly trained, you feel superbly confident, you've got the trust of the people around you, you've got an incredible team helping you to accomplish this task, to bring this crew back, to get the objective. So that you never think of the pressure. It's—I think the body feels it at times. There seems to be—whenever we get down close to launch, there seems to be an incredible urge to go to the restroom.

And one of the things that I always get concerned about is—when we call the launch hold, generally at about launch minus 9, we tell the controllers, "Hey, we've got 5 minutes to where we pick up the count"—that I'm going to lose a controller as they stampede out the door to the restroom, that they're going to trample over each other! But that I think is the only physical manifestation that I or other controllers have felt. I tend to have sweaty palms. All the controllers would kid me that I put my hand down on a piece of paper and they could see a perfect palm print. But it's something that is physical but not mental. You don't feel the pressure mentally.

NEAL: I think the word is focus.

KRANZ: I think it's focus. It's—we use in Mission Control—we use the term discipline, morale, tough, competent. And basically discipline is the ability to focus so intensely upon the objective that nothing, nothing is ever going to prevent you from accomplishing that objective. And it might be to land on the Moon, or in the case of a later mission, Apollo 13, to get this crew back home.

NEAL: Well, perhaps we could now leave Apollo 9 behind. The lessons have been learned, and you're ready to start flying. And next up was Apollo 10. In this case, you are not the lead flight director, but you took an active role.

KRANZ: No, I was—at this time, I was the Division Chief of Flight Control. So, literally every mission was my mission. But from my standpoint, the key was to follow how well this mission was being executed. Was the control team doing the right thing? Were the procedures all proper and in place? Because this was the dress rehearsal for the Apollo 11 mission, where I would be intimately involved.

And I was concerned during the course of the translunar phase to take a look at how well the LM spacecraft held up to being unpowered, going through this voyage from the Earth to the Moon. And then when they powered it up, were the checklists in place to power this thing up efficiently, rapidly? Was the team capable of supporting these two spacecraft in the dock mode and of staying on the timeline, so that when the time came to separate and start the preparations for the (what I'd say) the strafing pass across the surface of the Moon with [Eugene A.] Cernan and [Thomas P.] Stafford, was everything being executed 100% correctly, by the numbers, and on time? Because, once you get to the Moon, you don't have too many options. You have very limited wave-off options. You're either going to accomplish your mission or not. I mean it's black or white. There's no compromise there.

So, Apollo 10 was a dress rehearsal for this entire package. And as an observer, I was watching everything that happened very closely. I was also looking at the performance of my lunar module team, which was very critical. Because the command module people, systems engineers in particular, had several missions to warm up. So they had more a experience in Mission Control and flying that spacecraft than the lunar module people did. By the time that we would land on the Moon, the experience in the LM world was a unmanned mission, Apollo 5, then I had the Apollo 9, 10. So, the fourth time we would fly the spacecraft, they had to be ready to take that spacecraft to the surface of the Moon. So, I was quite interested in how my LM team was doing.

NEAL: And 10 was the one on which they literally rang it out and came pretty close to disaster, as I remember.

KRANZ: Yeah. Well, there's a—I think there is a—each mission leaves you with some very stark lesson that you learnt. And, again, the ability—here we had a crew that had missed a step in the checklist in configuring the autopilot. And again, the forcing function has to be such that the controllers are as exquisitely tuned to that checklist as the crew is. And if you see anything that is missed, without a second's hesitation, you have to make the call to the flight director and Capcom to go up and make a correction to the situation.

At times, you tend to look at omitted checklist items. And you back off and say, "Well, we've got an experienced crew. The crew's going to get it." We've made that mistake—we had made that mistake a couple of times in previous flights. This is one where there is no question, I think, we could have made a call that would have eliminated that problem. But again, it's—this split-secondedness, exquisite timing necessary between this crew and ground and again one of the reasons that you fly these missions. It's to address this process of achieving perfection in the business of spaceflight, and it's awful tough to get because things are happening real fast.

NEAL: In this case, if that crew had not pulled itself back from the brink, how would you have felt about that decision not having been rendered as rapidly as perhaps it might have?

KRANZ: I think in every mission that we've ever flown, I think we've found things that we could've done better. We have stepped up to assuming maybe even a greater responsibility. In our training people, interestingly enough, in the—as we prepare for a mission, you spend a lot of time (hundreds of hours) with the crew, going through the rehearsals over and over and over and over and over. And you tend to get into a routine. You tend to get into what you would say is almost perfect synchronization here.

What the training people would do to us, very—as we were approaching the time when the crew was going to go down to the Cape [Canaveral, Florida] and—actually, we're going to start the mission, they'd throw in a less-experienced crew from a downstream mission. So, all of a sudden, we'd have to go back into the coaching mode with that team. We couldn't expect them to be totally familiar with that procedure, so we'd have to talk a bit more about it. So, it was a process of the ground assuming that we had to be totally aware and on top of every exact thing the crew did. And then if the crew would then assume that the ground wasn't watching at all, you would have basically the conjunction where you probably had the best and most effective operation.

So, it was to the point where the crew had to be capable for doing the job and the ground had to assume for some reason the crew couldn't get it done. So, you drive for this very precise, incredible timing. It's—a mission is like a—watching a Super Bowl-class football team in operation, where you watch that hand off between the center to the quarterback and one of his running backs. It's all split-second. And you can't afford a miss here. That is the way that you must be focused for every event during the course of a mission. And it's really tough to maintain this level of proficiency, hour after hour after hour after hour for days at a time! But that's the nature of our business.

NEAL: In a way, what you've described—and we've just run out of tape.

VOICE OFF CAMERA: Yeah.

KRANZ: Okay.

NEAL: Okay.

VOICE OFF CAMERA: Rolling and speed.

NEAL: Okay. [We're] working now with a nice new load of tape, and I was just about to ask: Gene, it would seem that Apollo 10 was the culmination of the flight planning operations that you and the crew of Apollo 9 had put together. Meaning, of course, you now had a flight plan and everybody was on a reasonable facsimile of the same page. Is that true?

KRANZ: Yeah. It was—we had matured. We started—the maturing process started after the Apollo 1 fire. We were still—let me see if I can start this differently again. In Mercury, basically we found that man could live in space. But we also learned a lot more. We learned a lot about ourselves. We found out that teamwork was a key element in achieving the objectives. Always previously you had the flight test pilot and you had the ground flight test team, but basically the guy onboard the aircraft was the guy who was calling the shots as time went on.

And that was principally the mode of operation for Mercury. You got the crew up there. You'd provide them various voicing, but the point is we didn't have much insight to the space systems. The crewmembers really didn't have much of that confidence in the ground at that time, so it was a process of learning that space is somewhat different than the aircraft flight test. In the Gemini, we now got to the point where there was a very definite relationship between crew and ground. We had to provide the information for the maneuvers that the crew would perform or during a rendezvous. We had various abort modes during powered flight. We had to control the target spacecraft—the Agena—for them, so all of a sudden there's now starting a convergence between crew and ground. And also we had acquired much more—a greater insight into the space systems that we were flying.

For a change, we had more data than was being displayed to the crewmember. But again this was a process of now—of maybe going from the baby steps we were taking in Mercury now to the point where we are in our adolescence. Capable of getting an awful lot done, but periodically going off on tangents. One of these tangents was associated with extravehicular operations. We just kept blundering and blundering and blundering until finally, after so many failed EVAs, we had to go back in and say, "What is it we're doing wrong?"

So, then we move from that phase, okay, into Apollo; and we're immediately bloodied by the Apollo 1 fire. And I don't think anyone who was working on Apollo didn't feel in some way responsible, as a partnership, that we made the wrong calls. And if we had done something differently, maybe our crew would not have died. But at the same time, this fire set a resolve that says, "We got to grow up fast." And I think this growing up fast, the resolve, was kicked off after the fire. So, by the time we got to Apollo 10, we literally were as good as we would ever get in the business of spaceflight.

We wouldn't stop learning. But from a standpoint of a team, from a standpoint of focus, from a standpoint of intensity, from a standpoint of perfection, we were great! And

I'm saying this with no reservations whatsoever. This team knew what they were doing, and the next couple of missions would demonstrate that in spades. Apollo 10 demonstrated every part of the mission, with the exception of three: the actual descent to the surface of the Moon and the landing, the surface operations, and the lunar ascent. So, these were the only three pieces that had to be put now on this chessboard. And we were about to do it.

NEAL: You certainly were. Because you were about to do the big one. The point at which this program had been literally moving for so long. Apollo 11. You were, what? The lunar landing flight director, weren't you? You were in charge of that. But you also took part in the whole thing, didn't you?

KRANZ: Yes.

NEAL: So, let's go back over Apollo 11. And what a thing to go back over! That's a big project.

KRANZ: The—there's many things that stand out. If a person says, "Where were you when?" I had sure had an awful lot of great breaks in my life. I mean, whether they be in college. Whether they be in flying airplanes. But one of the ones that I remember that is related to Apollo 11 in a very direct fashion was the day that I got the assignment to do the landing phase. Cliff Charlesworth was the lead flight director; and one of the responsibilities of the lead flight director is to identify which flight director is going to cover which phase of the mission. And moving in there, this was the first mission where, in Apollo now—where Lunney, Charlesworth, and myself, who had been flight directors on Gemini, were actually coming back together again.

So, you had probably the three most experienced people at the console; and it was a question of who was going to get to do what. And Lunney had been to the Moon a couple of times; Charlesworth had launched Saturns; and I had the lunar module experience. So you had no particular driver that says, “This person ought to be doing this phase of the mission.” And I was Division Chief at that time, and Kraft had been really on top of us to nail down who was going to do what! Until finally after the Apollo 9 mission, we all managed to get together. And Charlesworth, as lead, had to make the calls.

And I called him and said, “Cliff, we got to make a decision on which flight director is going to cover which phase of the mission.” And this is probably the most anticlimactic meeting that I’ve ever had in my life. He looked me straight in the face and he said, “Well, I’m going to launch it, and I’m going to do the EVA. So, that only leaves the landing and the lunar liftoff. I think Glynn is going to do the lunar liftoff. So, you got the landing.” And it was all over in about 60 seconds.

And, you know, each flight director—I don’t think there’s any question, everybody wanted to do something for the first time. And the beauty of the Apollo Program was there were enough firsts to go around for everybody. But when it came time for the—this first lunar landing mission, I really got to respect Cliff for saying, “Hey, you take the job instead of me.” And I think he gave me the job principally because I had spent most of my time with the lunar module people, and I had just happened to have just a little bit more experience in the lunar module than any of the other guys. And it was a totally unselfish decision. And I think this is the way the flight directors always worked. We’re always trying to find out, “What is the best chemistry between flight director, team, and mission that’s going to get—give the greatest assurance that the job’s going to get done?”

NEAL: And it worked.

KRANZ: Yeah.

NEAL: But it had to work, didn't it, Gene?

KRANZ: Yes. There was no question the—every mission in Apollo had a large number of firsts. And every mission had a very visible profile, from a standpoint of the media. If you even missed the slightest thing, you know there was always this question somebody would ask you at a press conference, "Is the lunar landing in jeopardy?" And fortunately, as we went through these early missions (and we only had a single shot at each one of these, so they all had to work), you could look him straight in the eye and say, "No, we're on track, we're going to get the job done." And the—by the time you got to Apollo 11, however, the media coverage, the external pressures were incredibly high.

But again, this is one area where Cliff Charlesworth again, as lead flight director, one of their roles was to try to provide the external focus. So, he covered the majority of the mission briefings of a technical sense. He covered many of the media briefings. So basically, he kept the pressure off myself and Lunney so we could get ready for the jobs that we needed to do. But there was no doubt as we were approaching July 20th that we were doing something no one had ever done before.

NEAL: Feel a lot of pressure? Did it worry you?

KRANZ: Again in retrospect, I would say: yes. But when you start feeling the pressure, what you do is you find some way to keep your focus so that basically the pressure moves into the background. And there was so much to do to get ready for this first lunar landing that you just immersed yourself in the job and the pressure faded into the background. The only time

I ever felt pressure during the—I mean, felt intense pressure (maybe I can say this), we had had—it was as a result of our training.

In the consoles here in Mission Control, there used to be a phone directly behind the flight directors. And routinely during training runs, the Program Managers and Chris Kraft, Division Chiefs throughout the Center, added two small squawk boxes in their offices. And if they ever wanted to hear what was going on in Mission Control, they just turned on the squawk boxes and they could hear the crew talking to the ground, and they could hear the flight director talking to his team. So, it was reasonably customary that you would turn up these squawk boxes. And it was always going along in the background while you were having your meetings or making your telephone calls or whatever.

In training, the first month of preparing for the lunar landing, it really went pretty well. It seemed we had a hot hand. We had come off the Apollo 9 mission. We had achieved all of our objectives. The lunar module people had done well on Apollo 10. And we proceeded into the training process, and it seemed that, boy, every time the training folks threw us a problem, threw us a curve, we'd pick it up, we'd run with it, we'd come up with the right conclusion, etc. And then SimSup, who was a—again, the training boss, a guy by the name of Dick [Richard H.] Koos, must've looked at us and said, "That team's too cocky. That team needs to get a few lessons." And he called his team up and [said], "Let's put the screws to these guys."

We ended up, now in our second month of training, we were only training roughly about 1 day a week. The second month of training, we had a particularly bad day where we couldn't seem to do anything right. We would crash. And learning to land on the Moon, you have a time delay of about 3 seconds. So, anything you see—and by the time you can respond and voice up instructions to the crew, you're 3 seconds behind what's happening onboard the spacecraft. And as you get down close to the surface of the Moon, there is what you would call a dead man's box. [In] every airplane landing, there's some point where no matter what you're going to do, you can pit the throttles to those engines, you're still going to touch down before you're going to come back off the ground again. We really had not defined very well this dead man's box as you're coming down to the surface of the Moon, because it's a very complex geometry you have to define. It's tied into how fast you're descending. What is the altitude at this rate? What kind of attitude are you in? So basically, it's got many parameters. And then if you add on top of this, this lunar time delay, it can get pretty bad pretty quick.

We went through a bad, bad, bad day. We had crashed, and we had crashed. And then to avoid crashing, we'd become unnecessarily conservative; and we'd abort when we could've landed. And by the end of the day, we felt pretty bad. And about that time, Chris Kraft calls up on the phone. And from his initial comments, I knew he had been listening to these simulations, and I knew he was watching us struggle. And he said, "Is there anything I can do to help you?" Well, there wasn't anything he could do to help me! I mean, it was—my team had to find the right answers, we had to find the right timing, the right chemistry, right on down the line. And for the first time in this entire process, I felt the pressure that, "Hey, maybe our bosses were starting to lose confidence in this team that they had signed to do the mission." And that's when I felt the pressure.

My response was very straightforward. I put a switch on this phone so it wouldn't ring anymore. So, he could call all day and he'd just get a busy signal. But we proceeded to dig ourselves out of the pit that we had somehow dug for ourselves. We set a different set of parameters in defining this dead man's box. We biased the times that we would use to make the calls. We became more conscious of the clock. But piece by piece by piece, we started putting it back together again until we felt not only were we going to get the job, "Hell, yes, we're going to get the job done!" There was no question that we would get this crew down to the surface of the Moon.

And the training process then—I mean, we just seemed to be on top of everything until the last day of training. And this was again a—I think a very fateful exercise that, to this day, I thank Koos for giving it to us. We have a game plan that we call the Mission Rules. And the Mission Rules are basically a preplanned set of decisions where the controllers in the cold light of day will sit down and take a look at all the things that could happen in the spacecraft or on the trajectory on a mission-by-mission—I mean, on a phase-by-phase basis through the mission. And there's a lot of phases to the lunar mission. So, you end with a book of Mission Rules that's literally about 4 in. thick. Literally thousands of rules.

But the controllers have come to the point where we've exercised these, we've proved them right, right on line. The training people looked, and they saw one entire area that wasn't treated in the rules. It was associated with the various alarms that are transmitted from the spacecraft computer down to the ground. And on the final day of training, which I would—I had expected would sort of like be the graduation ceremony, they'd give us some problems, they'd give us tough problems, but they wouldn't give us anything that would kill us. Well, that wasn't their approach to doing the job. And in the final training exercise, they gave us a set of problems onboard the spacecraft.

We started off high. And on the way down, we started seeing a series of alarms coming from the spacecraft. And there are two types of alarms: one of the alarms said, "Hey, I'm too busy to get all of the jobs done. So, I'm going to revert to an internal priority scheme; and I'll work off as many things as I can in this priority scheme until a clock runs out, and then I'll go back and recycle to the top of this priority listing." And it's going to get the guidance job done. It's going to get the control. But it may not be updating displays. It may not. And then if these type alarms continue for a sustained period of time, it goes now to a much more critical alarm, which we call POO-DUE. A due program zero zero, where the computer will go to halt and await further instructions. Well, if this happens up and away, you're not going to land on the Moon that day.

Well, they gave us these series of alarms. We had never seen them before. My guidance officer, Steve [Stephen G.] Bales, was absolutely flustered it seemed, and he calls the abort. I feel that we've executed the right decisions. And in the training debriefing, SimSup comes back to us and says, "No, we don't think you exercised the right decisions. We think you could've landed. We think you should've looked beyond that alarm to see if you could figure out what was happening in the guidance, the navigation, were the displays being updated, etc.? You acted prematurely."

We didn't believe it. But Steve Bales, the guidance officer, you never leave anything untested. He says, "Hey, flight, I'm going to look at this overnight. I'm going to call together a bunch of people from MIT [Massachusetts Institute of Technology] Draper Labs, and we'll find out what we should've done here." Well I got a call about 10:00 that evening that said, "The training people were right. We had made the wrong decision." And they wanted to do some more training the next day.

So, these were two episodes associated with the training for the mission. One where management had got involved in when we were having a very—we were really struggling, when I felt pressure. The second time was when I found out that, hey, we didn't have everything wrapped up as well as we should have. We had some loose ends, and now the crew was going down to the Cape. (We were just weeks from launch.) So, these were the two times that I really felt pressure during the course of this mission. But, I didn't feel anything externally.

NEAL: Finally, they launched. They had TLI [translunar injection]. And there they were, coasting out toward the Moon. And your crew were still operating, getting ready for the big event. What was happening during that time?

KRANZ: Yeah. The—several interesting things. This was my first experience with the translunar phase of the mission, because I had worked [Apollo] 7 and I had worked [Apollo] 9. But we had never had this continuous communication. And it was absolutely marvelous to sit in Mission Control now and see the spacecraft 24 hours a day, throughout this entire transit period. So, from my standpoint, we used this to continue binding ourselves together as a team. I would go over through every one of the telemetry measurements. I'd talk to the controllers about it. I'd find out how, you know, "Let's go through the Mission Rules one final time here." We started dusting off all the very loose ends. So, the translunar phase of the mission is the final period to pull all of the pieces together, to go over any of the little items that maybe you didn't close out as well as you should have, to maybe go through the final discussion of the Mission Rules. ("Will we really do this if this happens?" kind of thing.)

But it's a time to continue to build this chemistry that must exist between flight director and team and crew when you have to make a very short-term, rapid, time-critical, irrevocable type decisions. Because once we got to the surface of the Moon—I mean, once we got to the point where we were getting ready to land on the Moon, there were only three options that day: you were either going to land, you're going to abort, or you're going to crash. And, you know, those options are pretty awesome when you think about it, that, "Hey, we're not only in this particular mode of operation now. We're going to be doing it in front of the entire world."

And it's now to the point where you look to each other for this confidence you need to work through any times when you might have just the slightest tinge of doubt. And generally, the slightest tinge of doubt comes when you're tired. So, what you got to do is, you got to continue and you got to help each other up. And that is the magic of this flight control team that we have here. It is so self-supporting! You know in Mission Control when a person needs a little bit of help, a little bit more time to make a decision; and this team is so totally focused. It's marvelous. Marvelous experience to live with.

NEAL: Well, all of this paid off eventually, because that landing was not a piece of cake.

KRANZ: No, the landing, I don't think there was anything that really prepared us for the intensity of the landing. If I'd back up a little bit. One of the Mission Rules (I'm talking about game planning) that was given to me exclusively, where I had to make a decision, is in the preparation for the mission. Headquarters people, the Program Managers, as well as Chris Kraft was concerned that if we would crash and not have enough data to figure out why we crashed, we'd be in jeopardy of the—not only losing the lunar goal, maybe the entire program. So, everybody wanted to make sure that there was some formula that would be used by the team to say, "Okay, we got enough data to continue."

I fought this particular rule, because they wanted something quantified. They wanted some numbers with this thing. And I fought this rule all the way through the process of building the rules, going through the reviews (the mission reviews), etc. And I wanted a very simple one that says, "The flight director will determine whether sufficient data exists to continue the mission." And that's—I just wanted that—it that simple, that it was a subjective call by the flight director. And this was batted back and forth until very close to the mission; and it was not resolved. So, I wrote into the Mission Rules that exact statement: "The flight director will determine if sufficient data exists to continue."

Well, going back to the landing day now, this adequate information means voice information and telemetry. As soon as the spacecraft cracked the hill and we were now silently coasting down to the 50,000-ft mark above the Moon, the telemetry was broken. The voice was broken. We wouldn't communicate. It seems nothing was going right. And immediately that rule came to mind: do I have sufficient information to continue? But then we'd get a bit and I'd say, "Ah-hah, we can look at the spacecraft!" And there were a couple of times when I would make calls for the go/no-go point of saying, "Okay, all flight controllers, go/no-go time. Use the last valid data points that you saw." Well, this might be 30 seconds old. So, they're making decisions based on stale data.

We kept working, trying to figure out what was the problem with the communications. And this turned out to be a—bad information on the attitudes used in the spacecraft, because we were getting some reflections off the skin of the lunar module. But again, this is too late. We had to try to solve the problem in real time. And I again go back to the teamwork. Charlie [Charles M.] Duke [Jr.], who was my spacecraft communicator, was looking at the signal strengths, and he saw the signal strengths varying. And he had seen—he had also worked the Apollo 10 mission. He suggested to Don [Donald R.] Puddy, who was the TELMU [Telemetry, Electrical, EVA systems engineer (Lunar module)], he had the responsibility for the communications but also the life support, electric systems on the lunar module, he said, "Don, do you think we could've changed—make an attitude change? Would that help any?"

So, then we tried an attitude change. Fortunately in training, we had also worked in relaying voice information from the ground to Mike [Michael] Collins back down to the lunar module. So, we were using every conceivable ways to communicate. In the meantime, time is marching down to my go/no-go points. We then have a anomaly onboard the spacecraft where Buzz [Edwin E.] Aldrin [Jr.] calls down, and he's not seeing what he expects to see on the AC [alternating current] electrical from a standpoint of the voltage indications. And again, this is very critical from a standpoint of gyros, landing radar. A very critical measurement. And again, the controllers looked at it and said, "Okay, it's looking good."

Now by this time, my guidance officer, Steve Bales, has now got some tracking information, and the spacecraft isn't where he—where it should be! I mean, it's that straightforward. Now he didn't know whether the data he was getting was bad, whether it was just bad navigation, or we had some kind of problem with targeting in the spacecraft. But the problem was—is that, he really got my attention; he says, "Flight, we're out on the radial velocity," which is the vertical velocity, "and we're halfway to our abort limit." Well, boy, when you haven't even started down to the Moon and some guy comes to you and says, "Hey, we're halfway to our abort limit," it sure gets your attention! But he continued and said, "I'll keep watching it."

So, all of a sudden now, you've got communications problem, you've got the minor electrical problem, you've got navigation problem, and you're still trying to struggle in to meet all of these windows for making your decisions as you're now saying, "Hey, we're ready to ignite the engine." We got down to the go/no-go for start-up powered descent (this is done about 4 minutes prior to the landing point), and again we—there's no reason I had to wave off. The team was working well. So, we made the go to continue. And as soon as we gave them the go to continue, we lost communication. So, we couldn't even call the crew! So again we relayed—Charlie Duke relays through Mike Collins down to the lunar module that they're go to continue. Here we're getting ready to go to the Moon, and we can't even talk to the crew directly! Anyway, we keep working through this problem until it's time for engine start.

We've had data intermittently. Engine start; and again at the time of engine start, we need to capture the telemetry of that point so we know the exact quantities of propellants in the tanks. Because now the propellants are being settled by the acceleration of the spacecraft as the engine start ups. As soon as the engine starts, we lose telemetry again. So, we miss this very valuable point. And we continue on down. And now, from the time we start until the time we land on the Moon, it should take about between 8 and 9 minutes. And this becomes a very intense period where again Steve Bales, my guidance officer, has been trying to figure out, "What's with this navigation problem, that we're half way to our abort limit?"

Well, he comes back and gives me a call that really has now a bit more confidence. He says, "It's—we're still halfway to the abort limit, but it's not growing." And he tends to believe that something happened upstream. It might've been a maneuver execution, where the engine didn't shut down perfectly or it was—well, in retrospect we found out (this was after the mission) that the crew had not fully depressurized the tunnel between the two spacecrafts. And when they separated the spacecrafts, it was like a champagne cork popping out of a bottle. It gave the spacecraft a little bit more speed than it should have; it's like performing an extremely small maneuver. Well, over the period of time of the lunar orbit, this maneuver now has placed the spacecraft in a different position than it should have been [in] to start the descent. But we didn't know that at the time. We had to figure this out.

So, now we're in the process of going down and we're making the calls. Everything seems to be going right for a change. You're never quite relaxed during this process. We've learned to work around the broken communications, but it seems to be getting better. And we're now at the point where we're starting to evaluate the landing radar data. Now this is an extremely important junction because the lunar module is now using the altitude we gave it, based on the tracking data and our knowledge of the position of the Moon. We now have to update that altitude by the real altitude measured by the landing radar. If there's a very large different between the altitude we've given it and what the radar's seeing, they have to find some way to smooth it out, because you can't make that correction instantaneously.

So, we're now in the process of determining whether the landing radar is acceptable to enter into the computer when we get a call from the crew that they've had a computer program alarm. And for a few seconds, it's just total silence. Nobody's commented on this thing. We've all heard it. And then the crew comes down and gives a reading on the alarm. Well, it's certainly coming to a fork in the road. Half of my team (in fact, most of my team) is trying to decide whether to accept this radar; and Steve Bales, my guidance officer, is an important part of that decision.

But now he's got to answer to this program alarm kind of thing. And it's—for a period of time, half the team was moving in this direction, the other half's starting to move in this direction here. So, I got to pull these guys back. And Charlie Duke makes the call, "Can we give them a reading on the alarm?" And again Steve Bales now has studied these alarms as a result of this training exercise. So, now he goes back to his back room controller (Tommy Gibson) and says, "Tommy, these are the ones that basically we reviewed after training run, and I don't see any problems. Do you see any problems?" And then very rapidly, we've got a go to continue.

So, now we've worked through this. Now we're starting to accept the landing radar data, and these program alarms are continuing intermittently through the descent. And one of the things that Steve comes up with, that he says, "Hey, it might be related to some of the displays the crew's using." So, we [tell] the crew to back off the very high utilization onboard displays on altitude and altitude rate; and we tell them, "We'll provide the read ups," you know, for them during this period.

So, this team now is faced with—I mean, we're going to the Moon! For real. This is not a simulation anymore. And it's faced with incredible problems that nobody had ever really anticipated. We thought it's—whatever happens, it's going to be clear-cut. But this was far from clear cut. And yet this team seems to be getting tighter. The more problems they got, the more effectively they're working. And this almost makes me happy. Because a flight control team is always best when they're working problems. All of a sudden they are now focused on something.

And from a back room loop, and we are never able to identify who said it, a voice comes across that says, "Hey, this is almost like a simulation." And, you know, I sort of snicker. I mean it's sort of a mental point where you mentally back off now. And the intensity's still there. But all of a sudden you say, "Hey, we licked these problems before. We're going to lick them again." And we continued down the process.

Now communications. We're about to the point where we're in powered pitchover. We're about 5 minutes off the surface. The communications have improved dramatically. So, this worry that was in the background festering, that I might have to make a call because we didn't have adequate data, is now out of the back of my mind. And all we're doing is working these very focused activities. And again the communications gets very tight. You can now feel the crew has got their landing point identified. They can see it. They can see that, if we continue this automatic guidance, we're going to land in a boulder field. So, we see Neil [A. Armstrong] take over manual control, and he uses a input with his hand controller that redesignates the landing point.

He's got a grid in the lunar module window that's sort of like a gun sight. And throughout the mission, it's basically oriented that if I don't do anything different right now this is where I'm going to land. So basically, he's redesignated. So, we see that now, as a result of this error in the separation of spacecraft, where we're further downrange, we're going to land actually about 2½ miles, I believe, from our designated landing site. And this is a rocky, boulder/crater field area. So, now Neil is working into this area. And all of a sudden you start becoming intensely aware of the clock that says, in most of the training runs, we would've landed by now and we haven't landed.

And they say, "Oh-oh, it's going to get tight." And this is reinforced moments later when my propulsion guy, Bob [Robert L.] Carlton, says, "Low level." Well, we don't have a fuel gauge onboard the spacecraft. Once you get to the point where you're in the round part of the tank, down at the bottom, there is a sensor that says, "Okay, if the crew is at a hover throttle setting, he's going to have 2 minutes to go." But now in the back room, this is where some of the magic in Mission Control comes in. The crew, when they're actually flying or hovering, is—is above this hover throttle setting and below. Say it's 30%. Maybe they might be up to 40. They might be down as 20. So, the crew is throttling up and down here as they're scooting forward across the surface of the Moon, much faster than we had ever expected to move this low. And I have a controller in the back room now who's looking at these squiggles on the analog recorder. And he is mentally thinking, "They're 3 seconds above 30%, 2 seconds below, 4 above, 2—." And he's mentally trying to integrate how many seconds we have remaining of fuel. And he got pretty good at this during training. He got to the point where he could nail it within about 10 seconds.

So, we put a number of a 10-second uncertainty and biased it high, so whatever number he gave us we were always on the safe side. Well, then Carlton calls, "60 seconds," and the crew's not still on the surface of the Moon. We have 60 seconds before we're either going to land or we're going to abort. And Charlie Duke at this time says, "We'd better be pretty quiet in here right now, flight." And this has been a mutually agreed on point: that our job is to get the crew close enough to attempt a landing. And from then on the only calls we're going to make is fuel remaining. Well, we've just told them it's 60 seconds.

And they're still not down there. Between 60 and 30 seconds, we get a call that the crew says, "Kicking up some dust." And about the time they say that, we get the call, "30 seconds." So, now we're down to 30 seconds remaining; and we're all watching the clock, counting down. And about the time the clock hits 17 seconds (and it took a few seconds for me to recognize this) we heard, "Lunar contact." And this is—there's a probe underneath each one of the feet on the LM. And when it touches the surface, the crew actually will hit engine stop and they'll actually fall in the last few feet. You hear that "Lunar contact," and then I hear the crew going through, "ACA [Attitude Control Assembly] out of detent." It's going—but it takes seconds to recognize that they're going through the engine shutdown. We must be on the surface.

And then the only thing that was out of normal throughout this entire process, that we had never seen in training, was the people behind me in the viewing room start cheering and clapping and they're stomping their feet. And our instructors are over in the room to the right of the room, again behind a glass wall, and they're all cheering. And you get this weird feeling. It's chilling that it soaks in through the room; and I get it, and say, "My God! We're actually on the Moon!" And I can't even relish that thought because I got to get back to work. Because we have to make sure, almost instantaneously, whether the spacecraft is safe to leave on the surface of the Moon or should we immediately lift off? We go through what we call our T-1 stay/no-stay decisions. So that within 60 seconds of getting on the Moon, I have to tell the crew, "It's safe to stay on the Moon for about the next 8 minutes." And I don't have any voice. I'm clanked up.

And about this time, Charlie Duke's saying—we hear, "Tranquility Base here. The Eagle's landing," from Armstrong. And then Duke says, "You've got a bunch of us down here about ready to turn blue." Okay. And now I'm trying to get started on my T-1 stay/no-stay, and I'm punched up. And this all happens in seconds! And finally I rap my arm on the console and break my pen, and I finally get going. Get back on track again. And in a very cracked voice say, "Okay, all flight controllers, stand by for T-1 stay/no-stay." And we go through this, make the stay/no-stay decision, then we go through a T-2 stay/no-stay. And still everybody else is celebrating and we're intensely focused to make sure that it's safe to stay here. And then we have to go into a T-3 stay/no-stay, which is the final one after almost 2 hours, that we're safe to be on the Moon for an extended period of time.

In the meantime, the pressurant gas we use (the supercritical helium), has had some—again, this is something we didn't anticipate from the design. We got some heat soak back from the engines, so this tank of very cold gas is warming up very rapidly. We don't know whether it's going to explode. We don't know whether the relief valves are going to fire. But we know we got to stay on our toes through this whole process. And we're in a crisis mode down here while everybody else is still celebrating. Until finally, we see the pressure start to decrease very rapidly. We believe the thing is vented. The relief valves by design had done what they should've done. And for the first time, we can power down.

It is only after we made our T-3 stay/no-stay that we could really—I won't say "pat each other on the back," but say, "Geez, we did it! We—today, we just landed on the Moon!" And walking over—I walked over to the press conference with Doug [Douglas K.] Ward. And all I really wanted to do was to get back to Mission Control because we had made sort of a silly mission design decision—and nobody believed it—that once we get down on the surface we're going to put the crew to sleep. Well, we knew and the crew knew (and I think the world knew) that the crew wasn't going to go to sleep. They wanted to get out on the surface and start the exploration. So, at the time I was doing my T-2—T-3 stay/no-stay, I had two whole flight control teams. I had Charlesworth's milling around in the room, and I had [Lunney's] milling around in the room, trying to figure out who was in charge at that point.

VOICE OFF CAMERA: And speed.

KRANZ: Let's see. Where can I—

NEAL: You had just landed and identified—

KRANZ: I'm going to go back to T-3. Okay.

NEAL: Okay.

KRANZ: We had—I had gone through the T-3 stay/no-stay. And for the first time, we had the opportunity within the control team to just take a deep breath and say, "My God, today we just landed on the Moon!" And throughout this entire process, there had been several things that just in reminiscing [stumbles over word] well, whatever it is, okay?

NEAL: Yeah. [laughs]

KRANZ: A few things that I didn't really think back on. And it was in debriefing the controllers. They came up and they said, "You know, that was the best speech I'd ever heard." And I thought back, "Gee, I just was telling the guys what I thought—" In the Mission Control, after we had had loss of signal, just before we were in the process of now getting ready to see the spacecraft again and go down, the controllers—the adrenaline was incredibly high in this room. It had built up. And I said, "Okay, all flight controllers. Take five. Be back in the room at landing" or actually descent. And in fact—I'm sort of screwing this up. Let me start back over again.

NEAL: Sure.

KRANZ: The adrenaline in the control room was building up. You could feel it; it was palpable. It was almost like a heavy fog, that it was so real! And the controllers got a break while we—during the loss of signal period, and when they came back into the room now, these guys were going to be here and there were only three options: we were either going to land, we were going to crash, or we were going to abort. And the room goes through almost a ritual. We go through what we call "battle short condition," where actually we physically block the circuit breakers in this building, because now we would prefer to burn up the building rather than let a circuit breaker open inadvertently at a critical time. And we lock the control room doors.

And I really didn't realize until after the mission, when a couple of the controllers really talked about how all of a sudden it was really sinking in, that they were now not going to get out of this room until we had gotten our job done. Steve Bales was probably one of the most vocal about it of saying, "You know, you don't really know what you're doing when you've got a 26-year-old kid in this room and basically you're going to write in the history books whatever happened today. And then you lock those doors, and I realize, I can't leave anymore! I can't say, 'Hey, I don't want to do this job! Okay? It's too much for me.'"

And I felt I had to talk to my people. And I called them up on the assistant flight director loop. And this is a secret loop that we use only for debriefings. People in the viewing room can't hear it. People training. It's just tied in to the people in this room. And we use it only when we debrief and we've got some real heavy-duty talking. Somebody didn't do the right thing, or somebody's got to be chewed out. So it's very private, very personal.

And I called the controllers up on the loop, and I told them how proud I was of this team and the job that we were chosen to do. I indicated that I believed that from the day we were all born, we were destined to meet in this room this day, and at this moment, and that from now on, whatever happened, we would remember this day forever. And we then proceeded to give just a few coaching tips and this. And I said, "Whatever happens, I will never second-guess any of your calls. Now let's go—let's go land on the Moon." And terminated the loop, and all of the people in the viewing room were probably wondering what the hell we were talking about. And that's a blank on the tapes.

But again, Steve Bales, the guidance officer, came up, and he said how important this settling down process was. Not only to him, but actually to his people in the back room. And since he was such an intense part of the job—Steve was a very interesting guy. He was what I would say: the prototype of the nerds or the geeks that work in the computer world today. He was the first guy working with this data, making absolutely irreversible, time-critical decisions. And about 4 years out of college, he had grown up in the business. And Steve, you could feel his emotion. When we would poll the room and go through his go/no-go's, I didn't need an intercom loop. Because Steve, you could feel this "Go!" And it ricocheted!

In fact, there was one time, as we were actually almost to the surface, when we did our final go/no-go, he was so "Go!" that I actually had to—I mean, I almost chuckled, that he was so intense in doing the job. But this is a group of young people who had signed up to do a job. It was generally the first generation in their entire family who had ever gone to college. Most of these people were Midwesterners. Their work ethic was absolutely spectacular! And I had no doubt that this team was capable of doing the job.

NEAL: They were young.

KRANZ: Ah, they were! They were young. Their average age was 26 at this time. I have a picture of them, and it almost looks likes some of these kids you saw flying the bombers in World War 2, where they'd have the—these troops outside their B-17s, their B-24s. You're just feeling so intensely proud of these people.

In the—after we had completed the T-3 stay/no-stay, I made one final trip to the training area, which is right in the corner of the room, because I wanted to thank all of our instructors for the job they did in getting us ready. And I was concerned because the one—before we started shift, I'd gone in and Koos wasn't there, our SimSup. When I went down this time, however, he was in there; and I found out that in his haste to get into Mission Control the day of the lunar landing, my lead trainer had rolled his car. He had fortunately emerged unscathed; and without a second thought about the car, he continued to get a ride in here and reported to his console in Mission Control.

Walking over to the press conference with Doug, it was—Doug and I talked about the fact that, not only had we landed on the Moon, but I almost felt cheated of the emotional content of that landing where everybody else was out celebrating. And to this day, I just sit down there, you—in Mission Control, you have to stay so intensely focused that, other than just a very brief cheer, sort of a "Whoop!" from the team at the time of landing and the realizing how close this thing was, we immediately had to get back to work. And it was—I would've liked to have found some way to get some of the feelings and the emotions of the other people.

I know Chris Kraft and Dr. [Robert R.] Gilruth were behind us. And it was just a—it was a marvelous time. It was a time of pride within the nation. It was a time of turning young people loose, giving them their head, seeing what they can do. And for a very short period of time, I think we united not only our country, but the world. And it's marvelous what could be done by such an event. I just wish we could recreate it, do it again today.

NEAL: Perhaps at some time in the future, maybe on a mission to Mars or something similar, there might be such a moment again. Do you think that might ever happen?

KRANZ: I sure hope that my children and the youth of America can find this kind of a dream that we were given by President Kennedy. Because it was a dream we lived. We were so fortunate and proud to be Americans, and living and to be challenged by such a magnificent set of goals. I don't think anyone ever considered themselves overworked or underpaid. The pay was the job that we were doing. And it was a unbelievable time. And we were privileged and proud to be born and a part of that very violent decade, however.

NEAL: Ah, but there were other missions still to be flown, Gene. And they were tremendously important in your life as well. Let's not leave Apollo 11 until I'm convinced that you've said what you really wanted to say about it. And then, if you have—

KRANZ: Well, I think the final thing: I saw Neil Armstrong. We had celebrations and all of this kind of stuff. But, a bit about Neil Armstrong. All through the preparation for the mission, I was absolutely amazed at how quiet, how calm he was. We'd go through debriefings, and generally Buzz would do most of the speaking. He would take most of the notes. And the quiet, absolutely superbly confident assurance that Neil had, also, was a—in retrospect was pretty inspirational in itself.

Here's a guy who knew he was destined to do a job. And I believe that, again, he believed that from the day he was born, this was a job that he was singled out to do. I think every person who ever worked with Neil had such a respect for the very quiet confidence that he exuded; his incredibly professional demeanor. He was literally a man for all ages within Mission Control. And I think every person today has that same respect. Even it's increased.

After the mission, the one time that I ever remember Neil talking, almost with boyish glee, was: he was sitting over in a corner (I think it was over in the conference room, I think it was 930 in Building 1), and we were just shooting the breeze. And all of a sudden he just says, "You know, I think this says a lot for American craftsmanship," because in those days American craftsmanship was really in question. Were we capable of building the high technologies that seemed to be coming from Europe at that time? At that time, the European standards were the ones everyone was trying to emulate. And there were questions whether we were capable of competing in the world of the '60s and the '70s; were we capable of competing for the future. And Neil proceeded to elaborate on his feelings about the American craftsmanship and the ability to do something so intensely complex and be successful the first time around, that it was marvelous.

NEAL: I think then, having said that, it is time to move on to Apollo12. And I can remember Pete [Charles C.] Conrad [Jr.], since you were talking of one great test pilot, let's talk about another, who said to me, "Lord, those guys landed on the Moon! What do I do for an encore?"

KRANZ: Yeah.

NEAL: Was there a similar feeling here in Mission Control?

KRANZ: No. I think that the—in fact, it didn't take a second for the Program Office to ratchet up the complexity, the objectives. "Once you land on the Moon, what are you going to do to top it?" "Well, I'm going to land on the Moon next to a *Surveyor* satellite that was put up there a couple of years. So, what we're going to do is: at the time the crew is descending, we're going to give them a verbal guidance update they're going to enter into their computer, which is going to alter their trajectory so they can land right there." And doggoned if they didn't do it! I think the entire Apollo 12 mission had this—

Now for a change, I was sitting back. I was a spectator. So, it was neat to watch other people do this thing that we had just done. And the mission started off with a real bang. Literally. Shortly after liftoff, the spacecraft was hit by a couple of bolts of lightning. And the navigation system, the platform had started tumbling. The electrical system had dropped off line. Data in Mission Control literally made no sense. And a young controller, John [W.] Aaron, became a legend with a call that he made. Gerry [Gerald D.] Griffin was flight director. And Aaron, after studying his data for just a few seconds, says, "Flight," (Judas priest, I forget the—mental blank, okay?).

NEAL: Yeah, go.

VOICE OFF CAMERA: It was something to auxiliary.

KRANZ: Yeah. SCE to aux. SCE to aux. John Aaron with just a few seconds of reflection calls up Gerry Griffin and says, "Flight, have the crew take SCE to aux—SCE to aux." Well, this was a recommendation no flight director had ever heard. No crew had ever heard. No Capcom had ever heard. And Gerry stammers, "SCE to aux?" And the Capcom says, "SCE to aux?" All with the question marks behind them. And we voice this up to the crew. Well, Pete Conrad in the voice tapes that we got after the mission onboard, he's talking to his crewmembers, Al [Alan L.] Bean, leans over and he says, "SCE—SCE to aux, what the hell is that?" And we repeat this statement one more [time].

Well, Al Bean—each one of the crewmembers in the spacecraft had a portion of the command module that they were responsible for. And down in the fourth switch in on the lower edge of the main display panel, is this switch which is: signal conditioning equipment power normal/auxiliary. So, he flips this thing down to auxiliary. All of a sudden the data is restored properly in Mission Control. Now the controllers can get back to work. Well, what we had is we had a 2-minute window of opportunity. Because the concern at that time was, whatever happened onboard the spacecraft may have closed the reactant valves to the fuel cells. And if this occurs, the fuel cells will starve from oxygen and hydrogen in about 2 minutes and you can't restart them.

So, it was extremely important to get data back and figure out what happened onboard the spacecraft real quickly. John Aaron was the—again, one of these 26-year-olders in Mission Control. And he proceeded to talk the crew through bringing the fuel cells back on line. And then once they had gotten power restored normally onboard the spacecraft, then it was a question of another controller, Buck [Briggs W.] Willoughby, trying to establish what to do with this tumbling navigation platform. Should they pull the circuit breakers? What should they do? But the bottom line is: by the time that the crew got to orbit, we had restored the majority of the spacecraft systems. And Gerry Griffin, in a very gutsy move—and with the help of his leadership—made the decision "Go to the Moon."

That day I was sitting in Mission Control; and Sig [Sigurd A.] Sjoberg, who was Kraft's Deputy, was very concerned about the impact on the spacecraft of this lightning strike, as was Kraft. Well, Sjoberg went down into the trench, and he started polling each one of the controllers down there and basically saying, "Hey, whatever happened on the spacecraft, if you don't have the confidence to send it out to the Moon, I'll support you in that decision." I have a picture of Chris Kraft leaning over the console, talking to Gerry Griffin, giving him exactly the same coaching. And it was, "We don't have to go to the Moon today, young man."

And this immediately relieved the political pressure to achieve the missions, to the point where this team had only the technical issues to work. And in the business of Mission Control, the business is spaceflight. What you've got to do is you have to make your decisions based on the technical data, and that's this team's job to do. And it is up to the people that sit in the consoles, behind the flight director, to take the political heat from whatever decision had to be made. And this is the kind of inspired leadership that we had in the program that was capable of stepping up to the plate and buffering the outside world from the technical decisions these guys had to make.

NEAL: I guess in part that's because people like Kraft had the same experiences that you had, wouldn't you say? As a former flight director, he knew—

KRANZ: I think Kraft's name, Christopher Columbus, was entirely appropriate for this guy because he was the pioneer in Mission Control. He launched each one of the Mercury missions. But most important, he was the mentor, the teacher, the tutor for this first generation of young people who became known as Mission Controllers. He set the mold for everything that would be done thereafter; and in particular, he set the mode for the flight director and the flight director being able to take any action necessary for crew safety and mission success. Chris had been there. He had been and done that. And the beauty of the thing was—is, even though he physically left the console, he knew what these guys down here were doing. And he knew his job now was to give them the confidence to make the technical decisions. And he was going to broker whatever political fallout might occur back there. A spectacular man!

NEAL: He was the interface between top-level management and politics.

KRANZ: Yeah. I found that out in later years, because when Kraft moved up to Center Director, I became the Flight Operations Director, the broker, external interface for the Skylab and the Shuttle Program. So I had an opportunity to feel this political heat that comes down when somebody might want to land the Shuttle down at the Cape even though we don't think it should be landed at the Cape with a fuel cell down. Or we made a call to launch when maybe all the Mission Rules weren't satisfied. Or we used more propellant than we should have pursuing our mission objectives. I managed to spend some time up at [NASA] Headquarters [Washington, DC.] explaining the control team's decision.

NEAL: You actually walked in Kraft's shoes in a certain—well, getting back, however, to the fundamentals of the earlier flights, because we're coming up on the one that really made you famous—most of all, even more than the lunar landing, which you bossed. Nonetheless, Apollo 13 was the story of Gene Kranz as much as it was Jim [James A.] Lovell [Jr.] and Fred [W.] Haise [Jr.].

KRANZ: Yeah. [Apollo] 13—13 was, again, a mission where the basic maturity of this team continued to—I mean, just spread forth in almost a magnificent fashion. We had made the decision missions earlier that we would always have four Mission Control teams in place during the course of a mission. And this gave us several advantages, because quite frequently the mission events don't fit neatly into 8-hour shifts. So, a team might have to do what we called a "whifferdill." Either show up a shift early or show up a shift late. And having the fourth team in position made that transition much easier.

But it also was designated as a crisis team; that if we had any problems during the course of a mission, major problems, this team would try to find some way to work itself off line and the remaining three teams would have the—would continue to work 8-hour shifts throughout the mission, whatever it turned out to be. My team was designated as lead team; and we were the—we were responsible—our principle responsibilities during the mission: we were going to be doing the lunar orbit insertion and also we were going to do the ascent from the Moon. And that's what we had been trained to do. During the course of the mission, it changed dramatically.

The launch was normal. And our crewmembers were Ken [Thomas K.] Mattingly [II], Fred Haise (and Mattingly and Haise were the experts in the lunar module, and they were scheduled to descend to the surface of the Moon at Fra Mauro). Ken Mattingly was the command module pilot; but very late in the mission sequence, he had been exposed to measles and he was replaced by Jack [John L.] Swigert, a member of the backup crew. We had trained with Jack—we had trained with the backup crews during the course of preparing for a mission, so we had all the confidence we needed in Jack. So, it was a question of getting a few extra training runs under his belt with the Mission Controllers, getting him tuned up again, and then getting him into the mission assignment.

The mission had been—gone very well. We had had a minor problem: we lost an engine on the second-stage powered flight, but Mission Control provided the crew with the new engine shutdown times. The remaining engine—remaining engines kept working like a champ. And they got to orbit, made the decision to inject to the Moon. The injection went normal. Transposition, docking, extraction went by the numbers. And as soon as that first sequence of mission events had been accomplished, my team picked up the console; and we were following in the shift rotation where we would now take a look over the command service module. And we didn't see anything of significance in the—our first shift operation; and basically used this time period in the mission to sort of look ahead at the mission and try to close out any open items that might've been left over from flight planning, Mission Rules, get the crew tuned up, etc. So, the first mission went well. And then my team went into one of these whifferdills. Basically, we had to get into the sequencing where we would now be in the proper shift for the lunar orbit insertion. My second shift, then, was in this new timing sequence.

I basically came in 8 hours later. And during the course of the shift, we had the lunar module—the initial lunar module inspection where the crew would open up the hatch. They'd go into the lunar module, and they also had a television broadcast (sort of a TV tour) of the lunar module. The television broadcast was concluded. And the final—we were in the process of closing out the items in the shift prior to hand over to Glynn Lunney's Black Team. After television broadcast was concluded, the wives and families had been behind me in the viewing room, and as they left we sort of waved, "Okay," etc., "Adios," and they went off. They turned the lights out in the viewing room behind me, and the final thing we had to do was to get the crew to sleep.

And we have a very detailed pre-sleep checklist we'd go through. It's about 5 pages in length. And we had gone through each one of these checklist items very meticulously because in Mission Control, the greatest error that always lends to a lot of levity at the post-mission party is for some flight controller to miss something in this pre-sleep checklist that cause us to wake up the crew. And we have a series of awards we give out at the parties if this happens. And it's not all the jollies you get; you get really ridden pretty hard. So, we were very meticulously following through this checklist. And we were down to the final item in the checklist. We were getting ready to close it out.

Now, earlier in the shift, we had had a anomaly—a problem with the communications antenna, that did not seem to work properly. And we were in the process of troubleshooting this. And we came to no answer, and I hate to hand over incomplete problems to a next shift, Glynn Lunney. Now the nature of the problem was—is: the antenna would not track the Earth signal properly. Then all of a sudden after troubleshooting for about 20 minutes—all of a sudden it started tracking. And we could never figure out what caused this. In a similar fashion, we had—my EECOM [Electrical, Environmental, and Communications Systems Engineers] had a series of anomalies associated with the tank pressures, where they had gone through some very rapid cycling in there and the tank pressure had been reading, which is reading about 87—I mean, tank quantity had been reading about 87% at that time also. It failed and started reading 100%.

So, we'd had a series of what we call "funnies" that we had to close out during the course of the shift. And we were down to the final entry, and—the cryogenics, the fuels that we use onboard the spacecraft, are oxygen and hydrogen. It's a super dense, super cold liquid at launch at temperatures of –300 to –400°[F], packed in vacuum tanks. But by the time you're 2 days into the mission, you've used some of these resources. And these consumables have turned into a very thick, soupy fog or a vapor in the tank. And like fog on Earth, it tends to stratify or develop in layers.

So, inside the tanks, we have some fans we turn on to stir up this mixture and make it uniform so we can measure it. Then we use some heaters to raise the pressure for the sleep period. Well, we had asked the crew to do this. In the meantime, the next control team was reporting in for shift hand over, so the noise level in the room was building up; and their flight director, Glynn Lunney (he was the leader of the Black Team, and we used colors to identify those teams), was sitting next to me at the console. He was reading my flight director's log. And we advised the crew that we wanted a cryo stir.

Jack Swigert acknowledged our request, and he looked behind him and coming through the tunnel, from the lunar module, was Fred Haise. Sy [Seymour A.] Liebergot at this time, who was my EECOM had the responsibilities for the cryo systems, had now switched his attention to the current measurements that he had (the electric current measurements). And Swigert started the cryo stir. Liebergot saw the currents increase, indicating the stir had started and he was now taking a look at the—computing the time from the time started, etc., etc. All of a sudden I get a series of calls from my controllers.

My first one is from guidance. It says, "Flight, we've had a computer restart." The second controller says, "Antenna switch." The third controller says, "Main bus undervolt." And then from the spacecraft I hear, "Hey, Houston, we've had a problem." (It was Swigert calling.) And there was a pause for about 5 seconds. And then Lovell comes onboard to say, "Hey, Houston, we've got a problem." Within Mission Control, literally nothing made sense in those first few seconds because the controllers' data had gone static briefly; and then it—when it was restored, many of the parameters just didn't indicate anything that we had ever seen before. Down in the propulsion area, my controllers all of a sudden saw a lot of jet activity. Jets were firing. We then see Lovell—and this is all happening in seconds—we then see Lovell take control of the spacecraft and fly into an attitude so he can keep communicating with us.

And for about 60 seconds, literally, the calls kept—I mean, just coming in. But they made no sense. They made no pattern, right on down the line, until finally the training that's given the controllers kicked in. And very meticulously, they started making the calls that were called—relayed up by Jack [R.] Lousma, who was my Capcom at that time. And Lousma's calls very gradually started restoring some of the functions that appeared to be lost on the spacecraft.

I'd written the time of this event. It was 55 hours, 55 minutes, 4 seconds. And I called over my communications guy and say, "Can you see if you can take a look at your data and see if anything else happened at the time of that event?" And he comes back and he says, "Flight, that's when we also saw this antenna beam switch." So, all of a sudden I went down sort of a false track to thinking, "Hey, we had had a antenna problem. A glitch in the antenna. Some kind of an electrical short circuit, similar to the one we'd experienced earlier in that shift. And that shortly we'd resolve the problem and be back on track to the Moon."

In the meantime, however, most of the problems had been resolved. And those that remain all focus on the single controller by the name of Sy Liebergot. And Sy has the system you need to stay alive in space. He has power. He's got pressure. He's got electrical. He's got heat. He's got water. Basically, everything you need to stay alive. And none of the data Sy is seeing, from his standpoint, is believable. Very quickly it looks like we've lost one of our fuel cells and possibly a second one. Cryo tank 2, oxygen tank 2, is reading zero quantity where previously it had been reading 100% quantity. The temperatures instead of being -300 and so degrees Fahrenheit are now at +17°[F]. I mean, that data doesn't make sense. Another tank is starting to decrease in pressure. So, he's trying to put all these pieces together in the back room.

In the meantime, a new problem is occurring because we're now approaching what we call a gimbal lock. And whatever happened is now pushing the spacecraft around, and the crew's got manual control—fighting it—but some of the valves apparently have been shocked closed. So, again we have to reopen the valves so the crew has the ability to control the spacecraft attitude. And it's tough for me to work with the controllers because, interspersed with all the problems, we get a call, "We're approaching gimbal lock again," and then we have to interrupt the thought process. And Jack Lousma has to voice it up to the crew. And for probably about 60 to 90 seconds, it's literally chaos in this place.

And then it's amazing how this whole thing, it starts to take focus. We still don't have the slightest clue what's going on. Well, this continues in a unresolved fashion until Jack Lousma, who's my Capcom, comes to me and he says, "Flight, is there anything that we can do? Is there anything that makes sense? Is there anything they can trust?" And Lousma sort of—he's sort of acting as my conscience right now, because we've been sort of scatter shooting in here. And I call the control team up, and this occurs just about the time the crew is calling down. And we realized we had—the crew says—they use terms like they've had "some kind of a jolt" or "some kind of a shock."

And all of a sudden I start—instead of listening to every crew call and—controller call and relaying it up, I start being much more selective in this process. Because I'm starting to get the feeling that this isn't a communications glitch. I'm about 5 minutes into this problem right now. It's something else. We don't understand it. So, we proceed very meticulously. And I call the controllers up and I tell them that, "Okay, all you guys, quit your guessing. Let's start working this problem." Then I use some words that sort of surprised me after the fact. I say, "We've got a good main bus A. Don't do anything to screw it up. And the lunar module's attached, and we can use that as a lifeboat if we need to. Now get me some backup people in here and get me more computing and communications resources." I'd said these words, but then I immediately went back to tracking this thing.

And it took about 20 minutes and it was really frustrating, because the situation is becoming more and more and more and more desperate. We're still not at the bottom. Because now it looks like this oxygen tank is shot. The second oxygen tank (oxygen tank 1) is now continuing to decrease. Two of our fuel cells are off line, and these are our principal power-generation systems that we use. Liebergot then comes to me and says, "Hey, flight, I want to shut down fuel cells 1 and 3." And I say, "Sy, let's think about this." And he says, "No, flight, I think that's the only thing [that's] going to stop the leaks." And then I go back to him the third time and I say, "Sy," and he says, "Yeah, flight, it's time for a final option."

And very reluctantly I agree to advise the crew that we're going to shut down fuel cells 1 and 3. And about this time, Kraft has come in. And we—the crew then also realize their—they feel very uncomfortable about shutting down these fuel cells. We go through a dialogue that lasts several minutes with the crew until, very reluctantly, they agree to shut these fuel cells down. And I think this is probably the point in the mission where everybody has realized that we've now moved into a survival mode because with two of the three fuel cells shut down, we're not going to the Moon anymore. We're going to just be damn lucky to get home.

And Kraft did come in. He was home showering. I had to have Lunney give him a call. And when Chris comes in that's probably the only vernacular I've ever used that I probably never used again. I said, "Chris, we're in deep shit." And I think that sort of expressed it. And Chris went up to the console there and plugged in. And again Kraft's business as—what I'd say his experience in the flight control business and as flight director, he got back up to console. He didn't bother bothering me. He was letting me try to extricate myself from whatever problems were occurring in here.

By this time, Lovell's called down and indicating they're venting something. And we've come to the conclusion that we had some type of an explosion onboard the spacecraft; and our job now is to start an orderly evacuation from the command module into the lunar module. At the same time, I'm faced with a series of decisions that are all irreversible. At the time the explosion occurred, we're about 200,000 miles from Earth, about 50,000 miles from the surface of the Moon. We're entering the phase of the mission—we use the term "entering the lunar sphere of influence." And this is where the Moon's gravity is becoming much stronger than the Earth's gravity. And during this period, for a very short time, you have two abort options: one which will take you around the front side of the Moon, and one which will take you all the way around the Moon.

Well, Lunney has gone down to the trench (the flight dynamics area), and he's brought me up a list of all of the options that we've got. If I would execute what we call a "direct abort" in the next 2 hours, we could be home in about 32 hours. But we would have to do two things: we'd have to jettison the lunar module, which I'm thinking of using as a lifeboat, and we'd have to use the main engine. And we still have no clue what happened onboard the spacecraft. The other option: we've got to go around the Moon; and it's going to take about 5 days but I've only got 2 days of electrical power. So, we're now at the point of making the decision: which path are we going to take? My gut feeling, and that's all I've got, says, "Don't use the main engine and don't jettison this lunar module." And that's all I've got is a gut feeling. And it's based, I don't know—in the flight control business, the flight director business, you develop some street smarts. And I think every controller has felt this at one time or another. And I talked briefly to Lunney, and he's got the same feeling.

In the meantime, my trajectory people are scared out of their wits that we're going to execute this abort—direct abort, because it's very late in the trajectory to make this kind of a computation. And swinging this mission around the front side of the Moon is going to be a very risky job. In the meantime, my systems guys want to get back home as soon as they can, because they know they're in deep trouble. So, it's now decision time; and with nothing more than the gut feeling to make the decision to swing the mission around the Moon rather than come around in front. So, this then puts us on the trajectory path that we got to start very rapidly coming up with answers for. We talked briefly to the crew. "I don't have much time to say why we're doing this," and they're willing to follow whatever direction we're going to give them at this time.

In the meantime, we've now got the crew moving over to the lunar module, starting the power-up process. And Glynn Lunney's team has finally come up to speed to the point where we can hand over to them. Because my job now as the crisis team is to get off shift and come up with some kind of a game plan from here on then. As soon as Glynn hits the console, he's immediately challenged because our final fuel cell is now dying; and he's got 15 minutes to get over to the LM and get it powered up. But what is most important, he has to transfer the navigation data from the command module computer, which is dying, over into the lunar module computer. And this is all pencil and paper and slide rule. In those days, we would've killed for a pocket calculator; but they didn't exist. And this data transfer has to be absolutely perfect.

So, as Glynn's doing that, I'm walking downstairs trying to figure out which direction to go. And it's obvious whatever we come up with, it's got to—we're going to have to come up with answers in hours and days what normally takes months and years from a mission planning standpoint. We're going to be outside all known design and test boundaries of the spacecraft. We've got to come up with the answers. Walk into this room. My team is down there, and it's loaded with my controllers and their back room people. This is a data room. It's a room that is used only when there's trouble, and you can sense trouble in this room. It's got two overhead TV monitors. It's got one small comm [communication] panel in there. But it's just filled with gray government desks, around all sides, where people can spread out their records and start going over them.

Well, every table is filled with people spreading out records. They're down on the floor, kneeling down there. And in those days, it was a very difficult job even to figure out times from records. You had to break your time—

VOICE OFF CAMERA: Speed.

NEAL: It was the Apollo 13 crisis room.

KRANZ: We're in the—we're in the data room. And the orange telemetry records from the analog recorders we used were scattered all over. And one of the very difficult problems that we faced was that there was no instantaneous data retrieval in those days. It was literally hours from the time we would request a printout of the telemetry days—data until we would see them. So, the only records that we had to work with were the ones that were in the recorders themselves and a few of the hard copies. (We could take and make a copy of the television display a controller was looking at.) So, we had these pieces of paper. And these controllers had been watching the life's blood drain out of the spacecraft, and we knew there had been some type of an explosion. But that was about all there was.

So, our job was basically to try to figure out what onboard the spacecraft was still usable, and to come up with a game plan to get them home. By now we had made the decision that we were going to go around the Moon. And I made sort of a brief opening speech, because I had a lot of new players who were starting to show up from the engineering community. We had astronauts who were reporting right onboard. It was obvious that the—that this team was much larger than we really needed at this stage of the game. I needed to get focused upon the most immediate problems.

Now throughout all of this problem as it was emerging, we kept hearing one voice as we were going through the evacuation into the lunar module, and that was Tom Stafford's. And Stafford and Cernan had started telling us about the problems that we would have in accomplishing a alignment of our navigation system using the lunar module optics while we're—the spacecrafts were still docked together. And they kept being insistent in this to the point where this became a principle concern of myself and Lunney. So, with this background piece of information, we're now starting to look at, "Can we afford to power down the spacecraft and get it to the point where it can very easily stretch these batteries?" The game plan broke down now into three distinct phases.

One is, come up with a set of master checklists that we would use to get the spacecraft from where we were, around the Moon, and then back to Earth. And I assigned one of my more trusted controllers—it was Arnie [Arnold D.] Aldrich (he had been with us since very early in the Mercury Program, he was in remote site engineering, he sort of became the model for the systems engineers that we used in Mission Control). So, Arnie was given the job to sort of be the individual who would maintain the master set of checklists for the remainder of the entire mission. John Aaron, a new controller (joined us in the Gemini

Program), was given the responsibility to sit on top of all consumables, all resources available on both spacecrafts. And John Aaron had absolute veto authority over any checklist entry. So, Aaron and Aldrich were almost welded at the hips with Aaron being the guy who had the veto authority. A third one, it was obviously needed, was some guy to figure out how to turn the lifeboat into a survival vehicle. And Bill [William L.] Peters, one of my LM controllers, got that. So basically, these were the three key individuals. And I told these three people to look around the room; and anybody that they didn't think they needed for the next few hours, to send them back to their consoles and get them out of there so we could focus in a smaller team.

We then did a blackboard exercise that listed—very quickly listed the majority of the issues that had to be worked and who would work them. John Aaron, who was the power guy, came and said, "Gene, one of the things we've got to do is we've got to get powered down immediately." And I said, "John, I'll work on this but we got to figure out new ways to navigate because we can expect the navigation system to continue drifting. And we have to find some way to realign it." So, we gave Phil [Philip C.] Shaffer the responsibility to come up with ways to use the—and I'm sort of getting ahead of myself.

One of the things that was giving us problem was that this explosion that occurred had set a cloud of debris around the spacecraft and frozen particles of oxygen. And we'd normally navigate with stars, and we couldn't see stars anymore. All we could see was the Sun, the Earth, and the Moon. So Phil Shaffer was given the responsibility to come up with techniques to check our spacecraft attitudes for maneuvers and those kind of things using only the Sun, Earth, and Moon, and to continue to refine the techniques of aligning the navigation system onboard the lunar module once we did have to shut it down.

I took my team off line and tried to figure out ways to cut down the return trip time, because John Aaron said, "There's no way we're going to make 5 days with the power in the lunar module. We got to cut it down to at least 4 days, maybe 3½." So, we were now moving ahead. The team split up and moving in several different directions. I had one team working power profiles. I had another group of people that was working navigation techniques. I had a third one that was integrating all the pieces we need. My team picked up the responsibility to figure out a day to—a way to cut a day off the return trip time. And we set up formal tag-in ties. We set up working areas down in the control room proper.

And it was amazing how literally presidents of corporations would respond to these 26-, 27-year-olders I had in charge of these teams. But again, I think that was one of the real miracles in Mission Control here, is that the—not only the team structure but the relationship between program manager, designer, flight controller, crew is one of absolute and pure trust. And once a person was given the responsibility to do the job, everybody would snap to and support him. Once decisions were made, you never second-guessed those decisions. This process continued for the first 24 hours. And my team came back on console again to execute a maneuver that goes back to Apollo 9.

During Apollo 9, we did a lot of testing of the lunar module engine while the two spacecraft were docked together. And immediately as soon as we recognized we had to perform a maneuver to speed up our return journey, that's the set of procedures we fell back to. We updated these procedures, based on the situation at hand. My team came back on console and executed these procedures, and increased our velocity on return by almost 1,000 ft per second. Changed the landing point from the Indian Ocean now to the South Pacific. Sent the aircraft carrier *Iwo Jima* to the landing location. And now with this maneuver behind us, we could power down for the first time. And then the power level, you can explain it very simply: it was about the equivalent of 200 W [Watt] light bulbs in your house, or about a quarter of what today's microwave uses. And that's what we had to sustain us. It was a survival level to get the crew all the way back to Earth.

Once we started this—got into this power down process, we had only one major management flap. Deke Slayton wanted me to get his crew to sleep, and he was very forceful about wanting to get his crew to sleep (as Deke can be). And I said, "No, Deke, we're going to keep them up and awake until we get the spacecraft in a passive thermal control mode." Kraft wanted to power down even more. And I had to tell Kraft, I said, "Chris, no, we're not going to power down completely until, again, we get this passive thermal control." So, what we had to do is, we had to invent a rotisserie-type maneuver to spin the spacecraft on its axis because the only energy we had was the Sun. And it took quite a while to do this. The first attempt was unsuccessful. And again we had Kraft and Slayton grousing that they thought they had the right take on things and we could solve this problem later. And basically, I was the guy in charge who had to say, "Nope, that isn't the way we're going to do business. We're going to set up this PTC [passive thermal control]."

There were emergencies, contingencies, all the way through this process of returning to Earth. There was no such thing as a free ride in this mission. We had to perform a couple of emergency maneuvers because our trajectory was flattening out. We didn't know why. We had to correct that. The crew was suffocating. We had to invent techniques of using the square chemical scrubbers we used for the air from the standpoint of the command module and be able to adapt those over to the lunar module. Finally, as we were approaching the final phase of entry, the procedures weren't coming together quite as nicely as we would have liked to. The crew wanted to see how we intended to accomplish this final sequence.

The basic problem we had was, we had a command module that was our reentry vessel. It had the heatshield, but it had only about 2½ hours of electrical power lifetime. We had the service module, which is where the explosion had occurred; it was virtually useless. We had the lunar module, [which] was attached on the other end of this stack through a small tunnel, and that was our lifeboat. We had to come up with a game plan to move this entire stack into a attitude where we could separate all three pieces in different trajectories so they wouldn't collide with each other in entry. Then the crew had to evacuate from the lunar module lifeboat at the very last moment, power up the command module, get its computer initialized, separate the pieces, and get into attitude for entry. So, this is the game plan we were coming up with. And we didn't really get all the pieces put together and get them verified in simulators until about 10 hours prior to the time that we had to execute this plan.

And the crew was quite concerned that they could see the Earth continuing to grow in the windscreen of the spacecraft, and they still didn't have the game plan in hand. But we kept reassuring them. This is another time when Deke Slayton came in, because he just said, "Hey, you guys, they're working on a plan. They're going to have it. Cool down. Okay?" And Deke Slayton had just a magic of being able to work with his crews like Kraft had the ability to work with us. I think those were the two real pioneers of spaceflight operations. They set the mold for everybody else that would come from that day on.

We got the procedures up to the crew. Jack Swigert had the command module part of the procedures. Fred Haise had the lunar module. And about the time we were voicing up these procedures, we realized how desperate it was onboard the spacecraft. It was in the high 30s, low 40s. The crew had the cotton coverall flight suits they had. Very moist. Fred Haise by this time had developed a high body temperature of about 104°F, severely dehydrated, bad urinary infection. He had the shakes. And we had to voice the instructions up to him so he could do the lunar module of procedures. And we kept working back and forth.

Throughout this entire process, two other guys come to mind. It's Ken Mattingly and Joe [Joseph P.] Kerwin. And Ken had been very instrumental in looking at—troubleshooting all the piece parts of these procedures, the game plans, etc. Joe Kerwin would be the—the voice of Mission Control during the final hours. And he's a medical doctor, and his bedside manner with this crew was absolutely superb. He was a mentor, a teacher, a tutor, disciplinarian, teacher. I mean, the whole 9 yards. That—at times, I almost felt he was onboard the spacecraft, placing the crew's hands on the switches and just keeping—and keeping—yeah—keeping them going.

Bottom line was—is, we continued to have a lot of surprises. We had to do an emergency maneuver. One of our three command module batteries failed just about—or was expected to fail just about the time the parachutes were due to come out. And at the time that we landed, this issue was still in doubt. The final thing I remember about this mission was its reentry period because the mood in this room was becoming very—what I'd say, mellow. When we got ready to jettison the lunar module, we started speaking sentimentally to the lunar module as we were getting ready to jettison. We'd say, "Farewell, *Aquarius*, we thank you. You were a hell of a good spaceship." And in front of the entire world, to start talking. But you didn't even know the world was out there at that time, we were so focused on getting these guys back.

And finally comes time to express our feelings. And again the entire world's listening, and Mission Control isn't going to admit we're emotional. And the rookie onboard the spacecraft, Jack Swigert, finally comes down. And he says, "You know, all of us up here want to thank you guys down there for the fine job you did." And that sort of broke the ice, and we got a few "attaboys" from Lovell and Haise, and then we go into blackout. And blackout's the time period in the mission where the reentry prevents communications to the spacecraft. And by this time in the program, we could nail it when it starts and when it finishes to within a second. And each controller during blackout, this is an intensely lonely period. Because you're left—the crew's on their own. And they're left with the data that you gave them, maneuver data, attitude information, all of these kind of things. And each controller's going back through everything they did during the mission and, "Was I right?" And that's the only question in their mind.

And there isn't any noise in here. You hear the electronics. You hear the hum of the air conditioning occasionally. In those days, we used to smoke a lot. Somebody would only hear the rasp of the Zippo lighter as somebody lights up a cigarette. And you'd drink the final cold coffee and stale soda that's been there. And every eye is on the clock in the wall, counting down to zero. And when it hits zero, I tell Kerwin to, "Okay, Joe, give them a call." And we didn't hear from the crew after the first call. And we called again.

And we called again. And we're now a minute since we should've heard from the crew. And for the first time in this mission, there is the first little bit of doubt that's coming into this room that something happened and the crew didn't make it. But in our business, hope's eternal, and trust in the spacecraft and each other is eternal. So, we keep going. And every time we call the crew, it's "Will you please answer us?" And we were 1 minute and 27 seconds since we should've heard from the crew before we finally get a call. And a downrange aircraft has heard from the crew as they arrive for acquisition of signal. And then almost instantaneously from the aircraft carrier, we get: "A sonic boom, *Iwo Jima*. Radar contact, *Iwo Jima*." And then we have the 10-by-10 television view. And you see the spacecraft under these three red-and-white parachutes, and the intensity of this emotional release is so great that I think every controller is silently crying. You just hear a "Whoop!" and then you're back down to business again.

In Mission Control, the unfortunate thing is—I guess it's necessary. You can never express an emotion until well after this mission is over. And you get this "whoop" and you're back in there. This—the emotion, you can hear it in the voice of the people. You've got some final instructions. A lot of voice up to the crew, and it's—you've really got to work to get them. And then these guys are in the warm air of the South Pacific. They're home. They're alive. You see them come out of the spacecraft. *Iwo Jima*'s circling. It's deploying helicopters and PJs. And in Mission Control, our job isn't done until we've handed over the responsibility to the carrier task force commander. And it is only when that is accomplished that we can start this internal celebration.

And our celebration always started with cigars. I don't know what the young controllers are going to do in—today, because you can't smoke in Mission Control. Somebody ought to write a Federal regulation that maybe will change it the day that the

Shuttle teams recover their crewmembers against long odds. But anyway, you start with the cigars. And they've got to be good cigars, because nobody in Mission Control is going to speak—smoke a bummer. And we had some darn fine cigars! There were about 700 that we had acquired. [They] not only went to Mission Control teams, our back rooms, program offices, it went to factories, to laboratories. Everybody had their mission cigar to light up at the same time that we did.

NEAL: Thoughtfully provided by the Cigar Institute of America.

KRANZ: Yeah. And it was really spectacular. But anyway, once you get the cigars lit up, there's all the "Attaboys!" and celebration in Mission Control. Then you unlock the doors, because they'd been locked. And the real heroes start pouring in at that time, because these are the folks in the back rooms who came up with the answers we needed when we needed them.

Final phase of every mission, final celebration, is to pass out the American flag. And we had these flags we passed—we started this tradition when we set our first American—as a matter of fact, our second record, but it was really the record when we rendezvoused two spacecrafts for the first time. And for every mission from then on, there has been an American flag in the hands of every controller at the time of touchdown. And this was just, for us, a spectacular time to live. I don't think anything or anyone will ever forget those days.

A final comment on this is: crew parties are always, always something. And while we were waiting for the crew to recover, the backup crews and the Capcoms always develop some kind of a parody on what happened during the course of a mission. And, this was a parody that was taken off after a very short set of comments I made during the mission. They say—when I say, "Hey, I don't understand that, Sy," and then Sy says, "I think it's an instrumentation flight." And then Deke Slayton says, "Hey, we're going to have to do something about that." And they took these three segments of words, and they interspersed them with (and today's people won't understand) Spike Jones and his music. And we had some gospel singing in this, and we had comments by Chris Kraft and President Nixon. They interspersed all of these on a tape, and we had to listen to this thing over and over and over as we drank the beer and smoked some more cigars with this crew. But it was that kind of a way of business. This was a honest to God brotherhood that existed in those days that I don't think anything, any group of people, in peacetime has ever come together in a similar fashion.

NEAL: Does that old gang ever get together today for reunions of any sort?

KRANZ: We have one coming up. Generally, every 5 years we get together for some type of a reunion. I think they're altogether in too frequent—are too infrequent. But I think that two or three things have done a lot to help us in this most recent years. I think that the *Apollo 13* movie has done a lot to bring back and bring some recognition to some really great people. People who stood tall when the times were short and odds were long. I think John [H.] Glenn's [Jr.] flight—I think, helped us bring together some of the real joy of living in the work that we did. And I think that's helped. And I believe now that the coming celebrations for this 30th anniversary (and we're going to have a lot of 30th anniversaries for lunar landings as well as various missions that, you know, we have flown here); I think that's bringing it back together. So, it's good to get the folks back together.

NEAL: Now we've stopped right now with Apollo 13. There were other follow-on Apollo flights, although the Apollo Program was cut short. Nonetheless there were others, and they were quite important. What was your role during the 14, 15, 16, and 17 phase?

KRANZ: Well, it was—it changed. We were at the point of having to move engineers over to the coming Skylab Program. So, that was one dimension. I was having to string my teams out more and more and more, and we literally had our feet in two programs: Apollo and Skylab. At the same time, the flight directors had become a very valuable commodity; because many of the people who caused the Mercury, Gemini, Apollo Programs to come into being were now retiring. They were leaving the program.

So, my flight directors—Cliff Charlesworth was one of the first to go. He moved over into the forming Earth Resources Program in there, because we were now looking at how we could apply some of the technologies we had to other problems on Earth. Glynn Lunney left and he picked up the Apollo-Soyuz Program at that time, which is now this next generation of involvement, trying to involve the Russians in the—space as partners. So, all of a sudden I started finding myself short in flight directors and having to bring new people onboard. So, I was in a role as sort of a mentor, teacher, tutor, same as Kraft had done in the early days. And at the same time, to stretch our assets (because I had to move training people over there), we started standardizing many of the mission phases. I would launch the Apollo 15, 16, 17 from both the Earth as well as the Moon. And the other flight directors that were still remaining (Gerry Griffin) would handle all of the EVAs, surface EVA. And then we would hand over to [M.] Pete Frank, who'd do the EVAs. Griffin would do the landing. So, basically we were in the process now of trying to find some way to use these diminishing resources and yet still provide the same quality, so we kept the experience as high as we could and moved new generations of people over to the Skylab Program.

[Apollo] 14 stands out because probably one of the most famous things that Griffin—it's the one I remember Griffin in. He had a solder ball in the abort switch. And as we were getting ready to go down to the surface of the Moon, he had recognized this indication. One of my other controllers came up with a software patch. This patch was improved by MIT, and we executed a software patch on this mission that had no more than 2 hours' shelf life. From the time that we recognized the problem until the time we started down to the surface of the Moon, we were executing a very complex procedure onboard the spacecraft to patch the software, to ignore the abort switch during the startup phase. And what we did is, we used the engine to settle the solder ball in the back of the switch. And once it was properly settled in the back of the switch, then we re-enabled the abort function. So, we were doing this to the point now where this Mission Control team literally knew no limits. They could do no wrong. There was no problem too tough or too time-critical for them to sign up for.

Apollo 15, I remember because of the heavy penalty the crew paid due to the intense workload down on the lunar surface, where we got Dave Scott and Jim [James B.] Irwin basically now with our rover extending the surface operation, extending the surface time, and basically working against the suit. Their fingers were hemorrhaged. They were—became dehydrated. By the time they finished their EVAs and we lifted them off, they got into lunar orbit and Glynn Lunney was on console at that time. And he had the darndest time trying to get the spacecraft—spacecrafts had been rendezvoused but getting ready for the separation of two spacecrafts. Getting the equipments transferred over into the command module. Getting the suit integrity checks, etc.

I was sitting next to [Lunney] in the console, getting ready to take over the shift. And it's like the crew was having mental lapses, blackouts, in—with the instructions we'd give them. And then they'd—we'd clarify the instructions for the suit integrity check, the cabin integrity check. This wouldn't get done. The separation maneuver didn't get off in time. It was like we'd lived in a time warp. And after the mission, we found that, due to the crew's dehydration, we ended up with the severe potassium deficiencies as a result of the surface operations, the fatigue. And this is one of the characteristics.

And to prevent this in future missions, we spiked John [W.] Young's orange juice with potassium because that was the quick fix for the thing. We tried to find some way to back off on the timeline. But frankly, this ended to the famous orange juice rebellion onboard the spacecraft; and we had some problems with the thrust vector control. Mattingly was to execute a maneuver on that mission in here, and he came around the back side of the Moon. The maneuver didn't get executed. We had another quick fix we had to work up for Mission Control to keep that mission going. So, if I remember, the missions after 13 (14, 15, 16, approaching now 17), it was a series of go-for-broke things that we and the crew would do to keep this mission going, to accomplish our objective. The missions becoming more and more and more difficult. And, to put it bluntly, this was a Super Bowl-class elite—world-class elite team in crisis management that, to put it bluntly, was at top of their form there.

We moved into 17. And it was with a degree of melancholy. I don't think there's any person alive who had worked the lunar program, who had worked these missions, that started to say, "Hey, we've been to the Moon. What do I do after this?" I was looking at the end of my era in Mission Control as a flight director. I had to find some way to inspire a next generation of controllers to go on and say, "Skylab in Earth orbits, circling endlessly in there, is equally as exciting as it was going to the Moon." And I had to convince us. So, it was a traumatic period. A period of great change as a organization, as teams, and personally. And the final thing that Gerry Griffin and I decided to do: all previous—all previous flight directors, they were in the console one day and then the next mission they weren't there anymore. And Kraft had gone out that way. Lunney had gone out that way. Charlesworth had gone out that way. We were determined that this wasn't going to be the way we handed over the shift.

Bob [Robert T.] McCall, a spectacular space artist, was sitting in front of me at the console, sketching out, during the first and second EVAs, the crew. And he was very gifted. He'd take a look at the pictures on—that were on the television screen and, in 60 seconds, he'd have a pencil sketch done. We went to the coffee shop that was in Mission Control at this time. And I was interested in the legacy, because I wanted to leave a different legacy than the one Kraft [had left]. Kraft had established the legacy of the flight director. I was looking at the one—the legacy in a broader sense—the one of the team. The one of the Mission Control itself. So, I asked Bob to design us an insignia for Mission Control, and in the—I talked—I put my thoughts out pretty well. And I said I wanted to talk about the commitment. It's really the one that led to the flight controller's pin. You'll see it several places in Mission Control today.

It represents everything we learned about spaceflight, the commitment and the teamwork of the Mercury and the Gemini Programs. The discipline, because once we failed in Gemini 4, we got into a series of arguments between crew and ground in how the job was to be done. It carried over into the mission. Morale, believing so strongly in your mission, your team, and your success that you literally cause the right things to happen. Tough and competent came out of the Apollo fire, where basically we weren't tough enough. We didn't step up to our responsibilities. We have to remember, in the business we're in, we're always accountable for what we do or what we fail to do. Competent we can never stop learning. So basically, I sketched out to Bob the elements that I wanted to be representative of the emblem of Mission Control. And he agreed to go do this.

I then came back in, launched the crew off the surface, and in lunar orbit because we were going to continue in lunar orbit for some period of time. Both Griffin and myself handed over to the next generation of flight directors. I handed over my responsibility to Chuck [Charles R.] Lewis, because he had been my assistant flight director, my faithful wingman for so long. And Griffin handed over to, I believe it was, Phil Shaffer at that time. And we then proceeded to sit in the viewing room for the remainder of the mission and watch our new flight directors, now born in Apollo, carry over into the Skylab Program. So, that was the ending of the program for us.

NEAL: It wasn't really the ending of the program for you, though, because by now you had moved on into management. And it was the end of your flight direction.

KRANZ: Yeah.

NEAL: But all of it—on the other hand, there were still flights to be flown and spacecraft to be worked with. You just mentioned a couple of them: Skylab for one.

KRANZ: Skylab was—it was—people say I— "Gene Kranz, you really can't, you can't believe what you're saying." But Skylab was as exciting to me as Apollo ever was. This was—Skylab to me was a different type of focus. Focus as a leader and focus as a team. Where we had a—the Apollo missions were all short (on the order of 10 days or so). And it's one thing to hold a team together and do all the right things, keep the quality for 10 days, even though it's very intense. It's another thing to keep this team together for the best part of a year and to hand over not tens but literally hundreds of problems every shift without a glitch.

To have these people respond to loss of control because a control moment gyro that's holding the attitude freezes up, and this whole stacked space system starts tumbling. To recover from a massive short in one of the power distributors that is scattering solder balls all over the inside of the spacecraft and all kinds of problems come up. To learn to repair and replace things in flight. To go back to brute force mechanics to fix the space systems. So, Skylab to me was—it started off in a tough fashion where, again, the flight control team literally fought, took over ground command of this thing and flew it by ground command. Used half of all its propellant that was scheduled for a year in the first week because we were manually firing the thrusters, manually firing the jets. We couldn't see the Sun.

We used the most primitive, rudimentary (and I was one of the plotters for the—the flight directors called me back into action)—I was sitting in Mission Control every day for a year, myself and Pete Frank. Called me into action and we would plot external skin temperatures. And from those temperatures, we would deduce the location of the Sun and figure out where to maneuver it so we could find the proper balance between keeping Sun to generate power through the solar rays versus minimum temperature to keep the inside—everything in the inside from frying. And we flew the spacecraft using simple plots. I mean, just that way for the time until, again, this spectacular engineering team at Johnson and Marshall [Space Flight Center, Huntsville Alabama] could come up with ways to replace the thermal shroud that we had lost and try to find ways to pop one of the stuck solar arrays loose.

And then they took Pete Conrad, Paul [J.] Weitz, and Joe Kerwin and taught them to install all this stuff on a EVA. And these were the most wild EVAs I think that we had ever, ever done since the—since the Gemini Program! So anyway, this was—I looked forward—Pete and I—Pete Frank and I, who was flight director, we basically sat 12-hour shifts in Mission Control every day for a year. And we were absolutely delighted when a flight director would call for us to sit down at the console and maybe take a shift. There was one time that was really funny, anecdotal.

The—at the end of the first Skylab mission, several of the flight directors went over to receive awards from—over at Huntsville. And they flew them over in the NASA [airplane]. Well, obviously, you needed a flight director on shift here. And myself and Pete Frank carried the time frame while they were off getting their awards. And [the] flight directors came back from the awards, took a look at what we had done from the standpoint of flight planning, threw it all out, and started from scratch on that thing!

The other thing that was neat, which was—and not—really something. Chuck Lewis had been suffering from stomach problems all through the final mission, and till finally he required emergency surgery. So, 2 weeks prior to the end of the mission, I was recalled back to my flight director duties and sat his shift from the time he had the surgery until the mission was over. So basically, I had covered the Gemini, the Apollo, and the Skylab missions as a flight director. So, it was a—probably the longest span in history of any of the flight directors that were doing the business.

NEAL: Couldn't keep the old warhorse off the horse, could you?

KRANZ: No. It's a—once you get into the—into this business, it's sort of—I was a pilot. I was a fighter pilot. And when you left the cockpit, you really realized that you had lost this one thing in life you treasured the most. But you also recognize there's a thing in life called progress. You got to keep moving forward. It was the same thing with leaving the console as a flight director. There is no question, any flight director who's ever left has had the happiest times of his life on console. My job now was to continue building the teams and to continue the championship practices, that production of the caliber of the teams, for the Skylab, the Soyuz, and then into the Shuttle Program. So, that became my job.

NEAL: What do you remember of ASTP [Apollo-Soyuz Test Project]?

KRANZ: ASTP was, to me, the enigma of the entire program. I found it very difficult to believe that, first of all, we were abandoning Skylab—a very functional, useful space station—and we were committing resources, a launch vehicle, and a spacecraft to go after a purely political objective. They made a big deal about working with the Russians and learning to rendezvous and do fly-arounds. My God! We had done that as early as the

Gemini Program. There wasn't any technical aspect of doing this. And I could not believe that we were giving up an extended mission in the Skylab for a purely political set of objectives. But again, I've never been a politician. So, I did not really focus, maybe as well as I should, upon this—the broader set of political objectives. Because there has to be many constituencies in space. There are political. There are technical. There are, what I would say is our "keep America working." There is a variety. I look at the one that's most important, however, is giving young people a place to go. Young people a dream to have to hold onto and to move into the future. That, to me, is the most important legacy of space. And if it takes a political set of objectives to do it, so be it.

NEAL: Do you see that—

KRANZ: We're down to 2 minutes, so you may want to—

NEAL: Well, that's just on this load. We've got another load here.

KRANZ: Okay.

NEAL: You were not too happy with the decision, then, to end our first space station. Even that space station, of course, introduced a whole new philosophy, didn't it?

KRANZ: I believe—

NEAL: Now you're looking at the difference between a mission and a thing that stays up there, day in and day out?

KRANZ: The Skylab, I believe, was probably the most productive era of space science in the history of the program. We had four major classes of science. We had astronomy. We put astronomers onboard the spacecraft, outside the Earth's atmosphere, looking at the Sun. We had marvelous relationships with major laboratories and scientific observatories that were interacting with the crew in real time. As a control team when the crew wasn't there, we would take over these instruments, point them, so that we continued the scientific process in an unmanned fashion with ground control.

We had medical experimentation, where we continued to learn about man in space, continued to probe the very unknowns about how long and how capable will man be over an extended period of time. We continued to press the envelope from a standpoint of crew performance. We found [out] a lot about the psychology of having a crew in space and having the ability to communicate not only with themselves but with their families. To develop a camaraderie between the control team and the ground so that we feel what they feel, and vice versa.

The Earth resources, to me, was probably one of the most magnificent set of experiments. It was probably the most time-critical activities, other than lunar landing, that we've ever performed in Mission Control because we had finite resources onboard the spacecraft and we had to compute these passes to a second-by-second basis. Cameras on, off. But we would look at the major hot spots. The areas of geologic interest. The areas where the oceans seemed to be doing things we didn't understand.

And then we had a series of corollary experiments. We did such things as run furnaces and try to make—everybody makes a—kidding about making very small (what are called) microspheres. Where you're making ball bearings in space. But these had a reason also. We were trying to develop manufacturing process. We had to find out what happens when metals melt together in the zero-g environment. We had this perfect vacuum to work in. So, I really considered the abrupt termination of Skylab, after only three manned missions, almost heretical in fashion. It was sort of like leaving the Moon. And to give up this very rapid process of learning for a mission that was purely political made absolutely no sense to me!

NEAL: Do you see a relationship, however, between the fact that now the Russians and the United States are together and their objective is to build a space station? A modernized version, if you will, of what Skylab once was.

KRANZ: I believe that the process of working together internationally is incredibly important; but I guess I'm an America Firster, that I believe in America for Americans. I don't believe that we've got a businesslike relationship that is going to allow us to continue to work in space. You have to have a set of ground rules that are operational in nature, technology in nature. You cannot set a game plan that's totally political in nature. It isn't going to make sense to the participating countries, whether it be Russia or America. I believe the problem that we have with the International Space Station is that nobody in America is really understands what is going on there, why we are doing this. We have done a very poor job of selling this program. And I believe it is going to go the way of the lunar program. It's going to go the way of Skylab.

But the problem is, you can't just walk out after the mission's over because you have this massive device up in Earth orbit that has to be brought down in a controlled fashion. And it's again an—a horrible waste of financial resources within the United States, within Russia, within the participating countries. Fact is, is that we have to come to a businesslike set of agreements with the Russians in the same fashion we have with the other participating countries—Europe, Japan, and Canada. And we have not yet established that kind of relationship. We continue to make excuses for the financial problems they've got. We continue to make excuses for the lack of deliveries. The fact is: these were recognized in the early days of the program. The financial problems aren't going to go away. The technological problems aren't going away. But we still want Russia as a partner. But we also have to set up the game plan that is going to work for the next 5, 10, 15 years.

NEAL: And do you think it is possible to establish such a game plan?

KRANZ: I believe that there is enough in space for all participants that, yes, we can establish such a game plan. We have to move beyond what I would say are the national—what I'd say, almost ethnic relationships for building a relationship in space, Russians versus Americans. We have to look into it, what is good for our nation. In a broader sense, what is good for our industry; what is good for our scientists. We have to move beyond the boundaries we've got. But to do that, we have to have a better framework, and we don't have it.

NEAL: One thing we do have today is the workhorse, something called Space Shuttle. And you worked on that, and now the Shuttles have flown in an immense number of flights, very successfully. Would you like to talk a little about Shuttle?

KRANZ: I love the Shuttle. I think the Shuttle is—John Young, I think he said, "It's a magnificent flying machine." I look at the Shuttle as the last hurrah of the Mercury, Gemini, and Apollo generation. It is the device that was founded in the principles that George [M.] Low and Robert Gilruth established. It is—carries forward the characteristics of very strong leadership like a Chris Kraft, Deke Slayton, Aaron Cohen, Owen [G.] Morris. So basically, if you take a look at how this device came into being, it is probably the most advanced technological space system that has ever been built. And the—very interestingly enough, it was built by a generation of people that today just really don't receive the recognition that they have—or they should have for the commitment they made to America's, in fact the world's space capabilities.

[I] Believe that the Shuttle was the instrument that was built by the most gifted technologists, leaders, and managers that ever existed within the space program. And I think this gift that they gave to the American people, the American public—the space business—is never fully recognized. It's the most fundamentally reliable system, space system that has ever been built. It is a space system that has a broad range of missions. It's demonstrated itself fully capable of accomplished every one of its design objectives. Unfortunately, it has not achieved the economies that were intended. But to a great extent, these economies are not being achieved principally because of political limitations that have been put on the program.

At the time of the *Challenger* accident, we were one of the world's premier launchers of satellites from the Shuttle. We had carried the majority of the Department of Defense payloads. We had done payload operations, carried laboratories for many of the countries in the world as well as providing a research laboratory for people in the United States. With the stroke of a pen, it was decided that we were unwilling to risk human life to deploy satellites that could be as well deployed in an unmanned fashion. We sort of lost track of our objectives. What we were after was continuing the operation of the premier launcher within all space systems of the world, and we were also trying to make this launcher economically feasible. Unfortunately, we lost sight of what our objectives were in the early phase of the program. We basically accepted a placebo for the loss of the *Challenger* crew. And I think if they were here today, they'd say we went the wrong way.

NEAL: Do you think perhaps that too much was asked of the Space Shuttle, because it originally was conceived as something that would be all things to all programs. And perhaps that was asking too much.

KRANZ: Well, I'd say yes and no. And this is—I'm not equivocating in this. I think it literally was everything technically that we asked it to be. It could be—it could deploy, it could retrieve, it was a platform for EVAs, it carried laboratories, it was a launcher for satellite systems, you name it. Anything that was asked of it technically got done. The one thing it not—did not become was the economic workhorse that we had expected it to be. And I think this was part of this process within the nation we were using to sell programs to Congress. You overstate their abilities.

I don't think any operator ever looked and said, "Hey, we're going to launch one of these guys every week." No matter how good your space system is, really it wasn't that good. The technology wasn't quite there. It is not the [Douglas] DC-3 of the space program. It's back maybe a generation earlier than DC-3. It's some of the early Douglas transport prototypes. But I think you have to put this in the context of today, and in the context of the future. I think it is essential to maintain many of these technologies, as a nation, so that we're capable of protecting and providing for our own people before we start worrying about the peoples of the world. In order to take care of the peoples of the world, we need a strong economic base ourselves. (I think we can see that today.) As the economies of the worlds are sinking and rising, okay, we are the stabilizing influence. We're providing the funds to keep those people going.

To do this, we need a stable and robust economy ourselves. To do this, we need to continue to develop very new and very advanced technologies. To do this, we have to find difficult objectives to go after, because this is the forcing function for tough technologies. I think space is truly the last frontier for the development of very new, advanced technologies. We've been living basically on the seed crop. The technologies of the '60s provided the digital systems of the '70s. The technologies that we developed in the Shuttle and that were developed through Star Wars are the ones that we're using for this tremendous communications revolution that we've got. So I think we have to figure out: where is the research and development coming from that is going to allow us to stay on top of the job? I have concerns that we're not investing well in R&D.

NEAL: You may just have answered my final question. But the final question is really one for you because you've been responding wonderfully well to everything that I've asked for the last few hours. But it could just be that I haven't asked the one question that would elicit what Gene Kranz really wants to say. So, with that in mind, this microphone, this camera is all yours, Gene.

KRANZ: I would like to—I wish that as a nation that we could set our sights much higher. I believe it is essential to have a national purpose. It is essential to maintain the pioneering spirit that made this country great. It's the spirit that got us through this past century. It got us through world wars. It allowed us to move into a leadership role, and it was a compassionate leadership role throughout the world. It is a nation that allowed us to step up to the challenge of the Cold War, and win it. It's a challenge that took the country to the Moon. It took us into space. It made us the preeminent force in space. And in the process of doing this, we rekindled the pioneering spirit of a generation of people that grew up in the Depression and came to adulthood in the '60s, and carried space from the '60s through to the early '90s.

I would like to find some way to sufficiently challenge a new generation of people, to get them out of the "I" mode into the "we" mode. To make them want to do something rather than be something. I would like to give young people the same dream that we had. I would like to find our nation unified, the world unified, in the achievement of a common goal. I believe that space provides this. I believe difficult programs like Mars would provide it. But unfortunately, we do not have the national leadership that we need. We do not have a United States Congress that really recognized the need for this country to continue to grow and invest in R&D. We don't have the national leaders capable of stepping up and taking a difficult position and articulating why we must do something.

I'm not interested in something for Gene Kranz. I'm interested in something for my children. I'm interested in for something for my children's children. Because we are the only nation in the entire Earth that is blessed with the types of freedom that we've had. That has the economic potential of a great nation composed of so many different ethnic groups and types of people that are capable of doing these kinds of things! So, we must continue to force leadership to grow. And I was privileged and proud to be part of the years when leadership flourished in this Mission Control.

There is not one flight director who ever left here who was not inspired to do something else and to do better. And I think that is important for us to communicate, not only to people here at Johnson (people who are going to be looking at these tapes). But to people of the nation, this very magnificent era that we all lived in and maybe didn't look closely enough and find its true meaning.

NEAL: That's a wrap.

[End of Interview]