# Oral History 2 Transcript

Glynn S. Lunney
Interviewed by Carol Butler
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BUTLER: Today is January 28, 1999. This oral history is with Glynn Lunney at the offices of the Signal Corporation in Houston, Texas. The interview is being conducted for the Johnson Space Center Oral History Project by Carol Butler, assisted by Summer Chick Bergen and Kevin Rusnak.

Thank you, Mr. Lunney for joining us today.

LUNNEY: You're welcome.

BUTLER: To begin with, let's go back to when you first became involved with the space program and the Space Task Group. What were your initial duties?

LUNNEY: We were at the Lewis Research Center in Cleveland, Ohio, and the month that I got out of college, in June of '58, this drawing crossed my desk of what became the Mercury capsule. Caldwell [C.] Johnson made the drawing. I said, "Wow! That looks like a lot of fun." The group that I was in was involved in doing kind of high-speed reentry research for different shapes of reentry vehicles and what kind of heat transfer, aerodynamics they would experience. It turned out the group at Langley that started the Mercury Project—it didn't have that name in the beginning—was in the same field. They did it a different way, but they were in kind of the same area of research. So we began to consult with them about all the aspects of it, but the people in our group started off—and I wasn't there long enough to have any real technical ability in the heat transfer and thermodynamics and so on, but a number of the people did. So they were involved in helping with the design of the vehicle so that it would survive reentry.

I got involved in the trajectory aspects of it in terms of the launch phase and what that was like and how we could monitor the launch phase and how we could begin to control the landing points so that we didn't have recovery forces everywhere, so that we could begin to focus our recovery efforts in a few places. Then I worked on the orbital mechanics and the reentry dynamics.

The only real maneuvering we had to do with the Mercury spacecraft was to fire the retro rockets to come back down. So I got involved in analyticals, computer-based studies of all that in a time when you didn't do it at your desk. You did in a way, but you submitted your data cards to a central computing system somewhere, and people punched them all up and ran the computer, and then you would get your results three or four or five days later, and then you'd have to remember what it is you were trying to figure out when you did that and so on.

I got involved in, really, I guess I would say, the orbital mechanics and the launch phase and reentry aspects of the vehicle, and that evolved into what we needed to have in the Control Center in order to monitor those parts of the flight, in order to control the retrofire, the retrorockets, and to monitor both the entry and the launch phases.

BUTLER: In the Control Center, as you were moving into the actual missions—because I know in your earlier interview you did talk about some of the build-up to the missions, a couple of them, but what did you specifically do in the Control Center once the mission started, both unmanned and manned?

LUNNEY: Well, I was actually in a couple of different Control Centers. Early on, I was at the Bermuda station. Bermuda is 800 miles or so out in the ocean away from Florida, where we launched them, and the place where the vehicle went into orbit was about halfway in between, and the situation was that the radar and the tracking were all sort of at the tail end from the Cape [Canaveral, Florida] but just beginning for Bermuda and just picking up. So we felt that Bermuda would be a good location to help with the confirmation that the vehicle was really in orbit.

Being in orbit is a small difference in velocity from not being in orbit, probably 100 or so feet a second, say 60, 70, 80 miles an hour, perhaps, is the only difference between being in orbit and being shy of orbit and coming back in. And since this was at the very horizon from the Cape and going out of sight, there was some question about how well we could know whether the vehicle was in orbit or not. So I started off as a flight dynamics officer at the Control Center in Bermuda, and I was there for a number of the flights, both unmanned and manned.

Then I moved into what was called the Mercury Control Center in Florida, where I was a flight dynamics officer, and I was a flight dynamics officer for three flights, I guess: MA-7, 8, and 9. And there we had, again, the situation with the launch phase monitoring, being sure that the vehicle kind of stayed in the nominal trajectory and didn't go out, and, if it did, what kind of an abort procedure should we have. We were involved in being sure that it was in orbit properly, calculating the orbits from the tracking all around the world, and then figuring out what our various retrofire times would be for our primary landing site but for a whole bunch of contingency landing sites. We had probably a de-orbit opportunity once or twice a revolution around the Earth. In those days, we were not all that sure that we were—you know, once up there, we didn't know how long we were going to stay up there. So there was a lot of planning for something going wrong and having to exercise a secondary abort or a recovery area, even from orbit. So we had to do all that kind of stuff during the orbit phases.

Then, of course, we were involved in the calculation of the final de-orbit time and hopefully tried to predict the landing point as best we could, and we always had a race to see how close we could come to the carrier. Sometimes we did, sometimes we didn't. But those were the kind of things that we were working on, and the work was really similar for me in the Bermuda Control Center and then, of course, at the Mercury Control Center at the Cape.

BUTLER: You mentioned all the calculations as they were in orbit and knowing all the details as to where and when, but you also mentioned earlier that for some of the trajectory calculations you were doing, you would have to send things out and wait for a couple of days to get results back.

LUNNEY: Oh, yes. That was in the office environment. Yes. It improved a lot when we got a Control Center. Then you could get things run in relatively real time and know where things stood and know what you had to do.

BUTLER: So you could do it all right there where you guys were.

LUNNEY: Right there.

BUTLER: This will be a little bit of a jump, but I don't want to, again, cover too much that was in your earlier interview. In the missions, as you began, you had talked about training in your earlier interviews and how a lot of what you had to do—you put together these tapes, and sometimes they matched what happened and sometimes didn't in the training.

LUNNEY: What people did, yes.

BUTLER: With that training, could you go into a little more details on what you would do there, the control team, but also working with the astronauts and maybe even some of the engineering teams to try and help—did you work together to try and build those training, or—

LUNNEY: Actually, the people in the training—and I was in that for a while, early on, before the Control Center really got to rolling—they tried to anticipate what difficult problems would be for the flight team, and, in general, the simulation people did not expose those ahead of time to the team. They were always a surprise. In other words, it was sort of classified of sorts, but we always tried to have cases run where the team that was going to then have to solve it did not have any idea of what the case was going to be, so that they would have to respond to it in all of its dimensions and think their way through it and then take whatever action was appropriate—sometimes none was—but whatever action was appropriate in order to come to the best outcome for the given set of circumstances that we put in front of people.

So we didn't do a lot of consulting with people in the sense of revealing our hand or revealing what the case was going to be but, rather, back then and even through till today, the simulation people take great delight in trying to find cracks in the defenses, if you will, of what the team is planning to do and then try to test them in places where they perceive that perhaps the procedures or the way it's thought out is not as sound as it should be. In most cases it always is, but that's what you try to do, is probe weaknesses, if that's the right way to put it, and find a way to force the team to respond to a difficult set of circumstances.

After I left it and even more so as an operator, either as a flight dynamics officer or as a flight director, the simulations became not so much one problem, but a multiplicity of problems thrown one on top of each other. We found by experience that one problem was generally a piece of cake. You know, this one problem we did this, did that, and out it went, and eventually simulations got to be multiple, sort of compounding of problems with various failures and various kinds of systems or people, and that turned out to be pretty good training for us for a lot of what we began to experience in Gemini and Apollo, certainly some of the very difficult—Apollo 13 is the best example of a lot of things that had to be dealt with in a short period of time. And the training we had for dealing with multiple problems all sort of simultaneously, not necessarily starting at the same time, but on top of each sort of sequentially, but all right there for you to deal with, turned out to be tremendously good training for all of the teams.

I can't recall exactly how formalized it was, but we began to realize that the flight team could get a lot of benefit from the engineering teams that had built the vehicle, the design and the testing of the vehicle, because they would have information about various things that happened in the testing of it and so on and so on that the operations team did not have. We gradually formalized that more and more as we went along. Probably by the time we got to the Gemini Program, there was a very well-organized, well-greased system for having the engineering team follow the flight, in effect.

The operations team had to be ready to do anything on a moment's notice, and that was our pride of sorts, being in that kind of position, but sometimes there was time to talk about things, or sometimes there was a situation where it would be helpful to get a lot more information or data from other things, other tests, and so on, and the engineering team kind of rode along in parallel with the flight team, and they usually were organized in a room or a series of rooms close by the Control Center, although in Apollo, for example, it was in a different building than the Control Center, where most of the people were, and they would be tied in by phone lines and data lines all the—not all, but to a lot of the factories that were involved, certainly the prime contractor factories and then other factories or places where things were produced. MIT [Massachusetts Institute of Technology], for example, was involved because they made the software for Apollo. So they would have phone lines and have—it's almost like a web or a network of people following along in real time but who would be able to introduce any experience they had on any subject if it happened to come up, and hopefully use that to contribute to the solution of the problem.

I can't remember how well organized that was during Mercury. I can't really recall when we really started to do that, but by the time we got to Gemini, we were doing that pretty well, and by the time we got to Apollo, it was a greased machine. The team followed along. They had their own disciplines. They had their own people in a building, and they were plugged into the communications loop so they knew what was going on, and they provided a lot of help on a lot of occasions based on their detailed knowledge or their knowledge of how something was done at the Cape or how something was built or what happened in some test two years ago and so on, and they could bring that kind of information into the flight team, and we often used it in solving problems, I think, and I think it worked very, very well.

The teams didn't compete for their role, they were complementary roles, and it really worked very well. As a matter of fact, if you went over to the Control Center today during the Shuttle Program, you would find the same kind of arrangement still in operation. The number of people involved on the engineering team is probably down a little bit because the frequency of problems is nowhere near what it was early on, but, nevertheless, they have kind of a team of people who can be quickly augmented by specialists or experts on any subject that you can imagine, either locally here at the Johnson Space Center or tied into the plants where these things are produced all around the country. So it works well.

BUTLER: Sounds like a great network.

LUNNEY: It is. As a matter of fact, being on the flight team, it was always a great source of comfort to me to know that people were following along and that the best advice that you could get in America was available to you and you could tap it, and when there was time, that was a good thing to do. For example, if you had twenty-four hours to consider some solution to a problem, the engineering team was usually engaged, and they went through the options, brought them in, the flight team reviewed them, and out of that would come whatever course of action seemed appropriate. It was a real source of comfort. A real source of comfort.

BUTLER: With this network, did the astronauts get involved? Were they support for you as well?

LUNNEY: Yes, in the following kind of way. It wasn't that they were so much involved in dragging up the engineering data to help with the problem, but, rather, there were a number of times when we wanted to try something in a simulator, and the astronauts, of course—there used to be a back-up crew for each one of the flights through Apollo, and, I think, some of the early Shuttle flights. But if we wanted to try something different and had time, we could either run it in the simulator or we could run it in a suit, if we wanted to try something in suits, and the astronauts, who were, of course, involved with all of the planning for the mission know the mission, knew the crews, would generally be involved in kind of running those cases off-line on a simulator or in a space suit or in an altitude chamber or something and, in that way, again, engage the best input that we could from the astronaut corps as we went along, and, of course, the astronauts were in the Control Center.

There was a capcom [capsule communicator] position, but my experience was that whenever things really got hot and heavy, there were a lot more than just one single astronaut in the Control Center. When we had a problem, there would generally be a number of them, some of whom may have recently flown, some of whom were planning to fly, some of whom might have some special expertise on the problem that we're having, and they would be around the Control Center and available and often gave inputs off the loop—that is, not on the communications loop—but often gave us inputs and suggestions.

The Control Center as a focus was a great way to bring all the people together, the astronauts, the operations people on the ground, the engineering teams, the doctors, and through that process we were able to usually get all the considerations that we had to weigh, and generally everybody supported the actions that we had to take, whatever they might be. Sometimes they happened real fast so there wasn't a lot of time to consult, but other times there would be time, and that just lent strength and a sense that when you finally arrived at the answer, that it was the right answer. It was, again, a real source of comfort during those flights to have that kind of support available, and sometimes it just wheeled along not doing very much, you know, sort of idling, I guess would be the way to put it, but whenever there's a problem, I mean, everything would click into gear and the phones would start humming, and people would get answers.

BUTLER: Sounds like a real strong team to help make it all work.

LUNNEY: It's a strong team, and it's still the way it works today. It's still the way it works today. I think the people who are in the Control Center would say the same thing. They feel pretty good about having the engineering team follow along, and whenever they get into something dicey, then there's some experts that they could call on and see their way through to the right answer.

BUTLER: With some of the problems that arose back in the early programs—I know in some of our research we've come across times where coming up with a fix was, I guess, a little easier than it might have been today, whereas if something was wrong, you could sometimes just run out to the hardware store or run out to the pad and fix things quickly, whereas now there's more details to it and more steps. Was there any of that in the control room that you remember, things being different in that respect?

LUNNEY: Well, I think this total team support that I've been talking about kind of evolved. I mean, it did not exist on Day One, that is, the total team including the astronauts and simulators and the engineering teams. It didn't exist right at the beginning, but we gradually felt the need for that, the whole system did, and put it in place, and before it was fully in place, people in the Control Center had to do what they had to do, so decisions were made on the basis of what had to be done.

For example, when Chris [Christopher C.] Kraft [Jr.] was the flight director on John [H.] Glenn's [Jr.] first flight, this heat shield deploy thing came up. I wasn't there, I was in Bermuda, but my impression was there was a fairly small amount of time to consult with experts. I think Chris certainly consulted with Max [Maxime A.] Faget. But the idea of leaving the retropack on opened up a whole bunch of new questions like, what were the aerodynamics going to be like? Would the vehicle fly properly? How about all the heat differences that we now have with this retropack sticking in front instead of the nice flat, blunt shape that the heat shield was?

I think they did not have a lot of time to evaluate that, and they probably didn't have, therefore, the time to do it a great deal of depth, and that kind of decision was made—it was something they felt in all prudence they had to do, but it was made probably with a not large amount of information or data behind it. It was, rather, done probably with the instincts and the experience of some handful of people who were involved in the design of the blunt body shape that the Mercury spacecraft really was.

As we ran into event after event of that class, we began to build this larger network, and that's what you have today, and it works well. But we had to invent a lot of things. As a matter of fact, today in the Control Center and in my time in the Control Center, a lot of things got decided by the operations teams just because they had to be done immediately. You know, we did the best we could to arrive at those things, and we didn't have a lot of time to consult. It still happens today when things are rushed by whatever is rushing it, you know, we have to get something done by so and so, we have to decide this by a certain time, or we have to respond real quickly because something is not acting right. Today the ops teams, operations teams, know that they may be faced with that and they may have to deal with anything in a very short period of time, and that's the way they train, and that's the way they get ready, and that's the way they fly.

BUTLER: You just build on that experience, and then learn more as you go.

LUNNEY: Learn more as you go.

BUTLER: We talked a little bit about your training and the computers, how you would have to, in the office, run back and forth, but when you got in the control room things could go at a faster pace, looking at those computers that you were using in the Mercury Program and then through Gemini and Apollo and comparing them to what we have today.

LUNNEY: Oh, yes. I mean, the stuff we had, I can't rattle off the specifics of it, but the computing machines that we were using, IBM make at the time, were sort of centralized facilities, as mainframes were at that time, still are to some degree, but the power of those machines was probably less than what people have in their pentium processor PCs today. I mean, it was limited, and we had to program them and keep them stable for a while, so you couldn't change it very easily, it sort of had a certain way of being inputted to and a certain way of outputting, and that was it.

Today the young people can rearrange their displays, their color displays and so on. In our time, we had to figure that out ahead of time, how we wanted to look at things, and program it all, and it was fairly rigid, because to change it would take months to get it changed through the software system and to get it tested and validated and verified and be sure enough that it was right so that we could use it in a flight. So we went pretty slow on making any changes in the computer system, and therefore we had to anticipate what we wanted and program it ahead of time, and sometimes, when we got there, it wasn't exactly in the form we needed, but that's the way it worked.

BUTLER: And it did work.

LUNNEY: It worked, but the machines were probably nowhere near as powerful as the average machine that people have on their desk today.

BUTLER: We look at how history will look back at things, and kids nowadays are raised with pentium computers sitting on their desks.

LUNNEY: I know. I know.

BUTLER: Do you think they might look back at these early programs and say, "Wow, how did they do that with what they had?"

LUNNEY: Well, they might. Certainly the kids who are real good at computers, which most of them are, would certainly, if they knew what we had in those days and were able to compare them with what they use today, they would probably laugh. But I think the thing that I sense in young people who want to look back and hear about it is, they respond more to the adventure of it than they do to the technical details of how good or bad or early the computing systems were. My conversations with young people, they just get fired up about how exciting that was and how exciting it will be again in the future some day when we go farther away from Earth orbit than we are able to do with the Shuttle and the Space Station.

So we're in kind of a consolidation period of exploiting lower Earth orbit, and that has its own adventure, its own agenda for adventure, built into it. But the Apollo stuff, I think, triggers in people kind of a sense that something big and something unique and something first time in the annals of humankind was done, and it was done fairly early on with nowhere near the kind of technology available to people today, especially in the computing field. I think people recognize that. I don't know if they have exact bit-for-bit comparisons to the capability that we had, but I think it's the adventure that captures them.

BUTLER: And what an adventure.

LUNNEY: Yes, it was, a great adventure, a grand adventure.

BUTLER: You moved from the Mercury Program to Gemini, and with that move, the Space Center moved to Houston. When did you hear that it was going to move to Houston, and what were your thoughts at that point?

LUNNEY: Let's see. I can't remember the month exactly, but we heard after Carla had hit the Houston area in Texas, Hurricane Carla, and apparently—I mean we weren't here at the time, but there was very high water around here, and as a matter of fact, we were all making contributions to the poor people in Texas who had just been through this terrible hurricane. Then not long afterwards, it seemed like a month or so afterwards, the announcement was made that we were going to be moving from Langley Field in Virginia down here to Houston.

We moved here—let's see, I moved here in August of '62. I'm not sure of the dates. I think that was either after or before MA-8, Wally [Walter M.] Schirra's [Jr.] flight. I can't remember. We moved down here, and the place where the center is now was a cow pasture. I mean, the photographs of it are still kind of laughable. It was just populated by cows and probably some deer and a few other critters, and a little two-lane road out here that was—it wasn't called NASA Road 1 in those days, but a little two-lane road, and it was pretty unimproved, I would say. So we moved here, and we probably worked a year and a half or so in office buildings down on the Gulf Freeway, right around—Gulfgate, right above Gulfgate. I was in a couple of different buildings at various times.

To get back to your question, we knew early on that the Space Task Group was going to move. Originally it was going to move to the Goddard [Space Flight Center] area right outside of Washington, D.C., in a place called Beltsville, Maryland, which is just outside the loop around Washington. That would have been fine with me, but once this thing got going, then there became a kind of a wider search. I think the solution of going to what became the Goddard Space Flight Center in Beltsville, Maryland, that was the first idea that the people at NASA had, but then when people realized the magnitude or the significance of this thing, there was a wider search across the United States for locations.

These are done in typical fashion with a lot of criteria and so on and so on, but the truth is the decision was made, I think, by the political system as to where we would locate this activity, and Texas was very strong in those days. It still is, but in those days it was especially strong, especially in the Congress. And here we are, and it's worked out fine. We've loved being here in Texas, loved it since we got here, and it was a great move. Great move.

I remember when I was a young boy seeing football games in Texas, and up in Pennsylvania where I lived, it would be snowing and cold and terrible, terrible cold, and then they would show these football games with people in a wide open stadium, in shirtsleeves, beautiful sunshine, blue sky day, and I remember that image of Texas just sticking in my head as to what a wonderful place that could be compared to the cold, freezing weather that I was experiencing back in Pennsylvania and where I went to school out in Detroit, Michigan. I mean, it was cold winters out there. So it was like an image of going to Florida, almost, going to the beach that I had in my head about Texas, and to a large extent that's really turned out to be true.

BUTLER: That it has. Little did you know back then.

LUNNEY: Little did I know. My dad was in the service in World War II. He got drafted late in the war. He had three children at the time, and he was working in a shipyard up in Philadelphia. He got drafted, and one of his stations was up here in Wichita Falls, up in Texas close to the Panhandle. And the only thing he said about Texas when he got back is, "I don't ever want to hear any of you kids moving to Texas. There's nothing down there but sand and rattlesnakes." [Laughter] So that was 1945 that I heard that description of Texas, and, of course, it changed a lot, and things worked out well.

BUTLER: What did he think when you ended up coming down here?

LUNNEY: My mom and dad were always very, very proud of the fact that one of their children was involved in the space program. I mean, there was publicity associated with it, and that was something absolutely new to our family. As a matter of fact, Tom Brokaw has written this book, *The Greatest Generation*, about the Depression/World War II era parents, families, and my mom and dad, I guess, are typical of the people who were living at that time and trying to raise their family and then had to deal with the World War II events and all the disruptions that that brought.

But out of that and the descriptions that I've read in the Brokaw book about people's attitudes certainly were very strong in my folks. They had a strong sense of patriotism about the country, and they had a strong sense that their kids needed to go to school and needed to do well. College was something that most people back in Pennsylvania at the time hardly talked about, but then by the time I got out of high school, or got in high school, that was becoming a real possibility. So the generation that I and my brothers and sister represent were really the first generation in our line that got out of the kind of work that was available back there, which wasn't much, I mean the coal mines and some other things, the coal mines my dad worked in a number of years, and they're awful. It was awful kind of work.

Matter of fact, I'd tell the young people—I used to tell them when I was the general manager over here at Rockwell and Boeing for the work we did here, I said, "You know, this stuff we do isn't work. Work is a four-letter word that my dad and perhaps some of your dads had to do to support their families, but what we get to do is fun." It's a lot of fun compared to going down in a coal mine or working on a farm. That's gotten better, but people really did some back-breaking things, and we were fortunate to be born in a time when things were changing enough and, to a large extent, as a result of the sacrifices that the generation represented by my mom and dad made for all of us. So it changed the world for me, my bothers, and sister, and I'm forever grateful for that.

BUTLER: Absolutely. They sound like a great family.

LUNNEY: Yes, and Brokaw's book is interesting. He has a bunch of different stories about people, both people who went off and then other people who stayed back, especially women, who then had to raise families, and men were in the service for the duration. They weren't in for a year or two years or something; they were in for the duration. It was tough times for people, but, boy, they sure responded in a wonderful way. I have been aware of this all my life, and as I get older, I sit with my mom and she tells me more stories about how things were when we were young and how they were struggling, and I think it's a nice tribute to a whole generation of people, even if individual stories aren't in the book, kind of the attitudes and the struggles that they had are there for everybody. They were all struggling with the same kind of things, and, God bless them, they did a wonderful job.

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

LUNNEY: We would not.

BUTLER: When you did come down here to Texas, despite the earlier advice from your father, and the program was starting up, like you said, you were in the buildings off of [Interstate] 45 for a while, but the [Manned Spacecraft] Center was being built in the cow pasture, were you involved with the development of the new Mission Control at that time?

LUNNEY: Yes. Yes. Bill [Howard W.] Tindall [Jr.] was the first guy that I can remember. That may not be historically accurate, but he's the first guy I can remember who began to talk about the fact that we could change the way that we had the Control Center and all of the remote sites operated. During the Mercury days, we had remote sites at all kind of different places around the world under the ground track, and they would be in communications with the spacecraft when it went over four or five minutes, thereabouts, at max, and then they would engage the crew and do the business that they had to do, and then they would send back teletype faxes. We could listen to it most of the time, although the communications weren't always good.

But when we moved to Texas, early on, Bill Tindall began to talk about the fact that communications was changing enough so that instead of sending people out to a remote site and being a local—in effect, I guess they're almost like PCs, right? They were all out there looking at the data on site, and then after the pass they would summarize it and send it back to the Control Center at the Cape in a fairly cryptic, simple way. So the people at the Control Center at the Cape didn't see all the data from the spacecraft when it was passing over a site, over in Africa or Australia.

But Bill was identifying that communications was such that we could begin to send all that data back and have it available in the Control Center as quickly as it would be available at this remote site at which it was received, and that made a very fundamental difference to the Control Center and the operation that we then began to use. We continued to have remote site teams for a while, but gradually moved away from that when we found out that by getting all the information and the data back here in Houston, there wasn't that much need for anybody on site locally, and we found that managing the flight and managing any problems that occur in the flight were a lot easier if you did them consistently with the same group of people, rather than engaging ten or twelve different sites around the world and try to keep the ten or twelve different site completely synchronized with the thinking that was going on in the Control Center. So there was a lot of com and talking back and forth that had to go on for that to occur, and it wasn't as efficient as being able to do with a centralized group of people who didn't have to brief a new team every time we had a pass coming up, but that they were staying in the loop.

We were still using stations around the world to collect the data and send it back to Houston, and we didn't get into the era of full-time communications in Earth orbit until we got to the Shuttle Program, when we have tracking and data relay satellites where the Shuttle can communicate back to the Control Center. So you have almost full-time com, full-time coverage. We didn't have anything approaching that through Gemini or the early Apollos, although we did have full-time com once the vehicles got going away from the Earth on the way to the moon. By that time the antennas that we had in the deep space net around the world could track the vehicle, and we could have the data available from the spacecraft immediately in the Control Center.

But full-time coverage, full-time communications was a blessing for the operation that we didn't really arrive at until we got to the Apollo flights that left the Earth orbit and were out on the way to the moon. Even then, when they went behind the moon, we didn't have communications. Nowadays, with the tracking data relay satellite to Shuttle Program, has almost full-time coverage. I think they've got a seven- or eight-minute gap once a revolution, but basically they're dealing with full-time communications coverage, and they don't have the ups and downs of reestablishing communications and reestablishing an understanding every time you have a pass over a tracking station. It's a lot easier to have full-time com. It really is a lot easier.

BUTLER: I can certainly believe that. Certainly believe that. When you did move into the new Mission Control Center with the new methods of doing things, how did your training change for that as well?

LUNNEY: We got to the point where the simulators that the astronauts trained in produced the telemetry tapes, and they did in the Mercury spacecraft, but here we were able to create a telemetry stream that was completely responsive to whatever the crews did on board, so that whatever they did on board was reflected in the data stream was brought back to the Control Center, and then the Control Center did whatever it was going to do with that kind of information and understanding, and as they went along and changed the mission, then the astronauts in the simulator and the people in the Control Center stayed on the same page, they didn't divert.

We had to make these tapes that we talked about earlier in the early days because we had all these people at different sites around the world, so we made this tape, for example, that would be the telemetry tape that would come down at Australia or Africa or Mexico or California somewhere, and we had to anticipate what people were going to do to make a tape so that we could play it for the people there. When we got here, we were able to have the spacecraft do what it did, and then the telemetry would be completely responsive to that, that information would be available in the Control Center immediately, then whatever else happened and whatever the Control Center told the flight crews to do, then their actions would again be incorporated in the telemetry.

So it was a closed-loop system, and we didn't have to send tapes out to remote sites and engage ten or twelve teams around the world with what in the early days were pre-canned guesses as to what people were going to do. Now we're able, because we had a central team not scattered all around the world and a simulator, we were able to keep that in a close-loop form, and the training became much more rigorous, much more realistic and good. I mean, it just became a lot better.

Gemini was the first spacecraft where we had a digital computer and digital telemetry, and, of course, that lent itself to digital-based simulation systems and, of course, the Control Center, being a digital-based mainframe system. So all that was able, then, to be operated in a very realistic way, and the training became a lot better. Became a lot better.

BUTLER: A very important step to make it all happen.

LUNNEY: Yes, it was. Yes, it was. So, a number of things enabled the change in the operations of the way we conducted the flights. The very fact that we could get enough communications bandwidth and reliability to get the information back to a central place allowed us to concentrate on a central team without all the remote sites and all the overhead that went with keeping them up to speed and debriefing them after every pass and so on and so on, and getting a summary of the spacecraft data on a very low-speed teletype system, that was all supplanted and surpassed by almost—almost—instant access to the data. Even if the vehicle was over Australia, you'd have the information back here in the Control Center within a matter of just two, three, or four seconds.

So it made a big difference in the Control Center engagement in the flight, and I think the operation with the astronauts became smoother because we only had one team of people doing that, not ten or twelve scattered around. So it was a big enhancement and one that served us well.

BUTLER: Absolutely. Absolutely. As you moved into the Gemini Program, you are chief of the Flight Dynamics Branch by now. What specifically were your roles at this time?

LUNNEY: The Flight Dynamics Branch was part of—I think we called it the Flight Control Division or some term. It might have been different than that early on, but it was the group of people that were the flight control team.

As we moved into Gemini also, we began to recognize that in Mercury we had two positions, the flight dynamics officer [FIDO] and then the retrofire officer, retrocontroller [RETRO], I guess we called them. So there were two positions. When we were moving into Gemini, we recognized that we also needed a third one called the guidance officer [GUIDO], because we had this digital machine on board. We had the possibility of that digital machine in the spacecraft actually steering the vehicle into orbit, as opposed to the launch vehicle computers. We had to then interact and service the on-board machine with state-vector updates on the orbit that we ran and so on, because it didn't have its own orbit determination.

So we evolved to three positions called the guidance officer, the flight dynamics officer, and retro-officer. The Flight Dynamics Branch was a representation of that. I was the branch chief, and then we had a section for each one of those disciplines. We had a wonderful collection of characters, I mean just wonderful, and different talent levels in the people, and yet they all seemed to respond to the work that we had to do, and we kind of worked at, I guess, enhancing the identity of people who worked in the Flight Dynamics Branch. We called the front row the "trench." I don't know who came up with that early on or what it even came from, but we called the front row the "trench," and the three console operators that were involved in that saw themselves as a team that was controlling all of the trajectory aspects, orbital mechanics aspects, of the flight, and then the use of the guidance computer on board to service those purposes and to keep it updated. We had to keep it updated with state vectors.

So we had a high sense of, certainly, purpose, but we had a high sense of identity as a tight little team within the Control Center, and we worked very hard at keeping that that way. We had extremely talented people show up from all points of the country, and they all did a wonderful job, they really did.

Some people were very, very talented, high-achievement people. Other people were a little bit more in the middle, and yet the mix of all that allowed us and caused us to figure things out and display them and deal with them and write the mission rules in such a way that you didn't have to be a genius to take care of it during a flight. We tried to normalize it so that the crews that we had, the ground crews that we had, could all do their job adequately. It was a wonderful time.

I guess we had a couple of kids at that time. We had a lot of bachelors in the group, a lot of single guys who came here out of college, and my wife used to run Thanksgiving and Christmas and New Year's and other times, but those especially, when all the bachelors would come over. In those days, they would spend all day and all night sitting around talking about things, having another beer. There were times when my wife used to ask them whether they had any homes to go home to. [Laughter] But we had a great time with it. It was a fun time.

There were probably about two dozen people or so in the branch, eight or ten in each group, and they each—also, even with the branch, struggled so that each one of them could be seen as being very, very good. There's always kind of a competition to be as good as you possibly could at your job, and the simulations, of course, and the training exercises were designed to expose any failures or lack of preparation. So people worked very hard at, one, getting ready for the flights and the things that they would have to do at their respective console, and, two, they had a great sense of not wanting to screw up in any way during the training exercises or the simulations, because there would be a tremendous amount of razz dumped on their heads. They worked very hard at being sure that they were ready so that they'd have the answers that they had to have when the time came. And it was a fun time. It was a fun time.

It was a great group, a mixed bag of people from all over the country, very excited about what they doing, very competitive about who was going to get the console assignment for a given flight and a given phase of the flight, and they worked very hard at it. They were competitive and they were tough, and they struggled hard to do well at what they were doing, and, God bless them, they all did. They all did well.

BUTLER: Can you tell us about some of them, who they were?

LUNNEY: Oh, yes. Let me see. I'm not going to do this very well because I haven't thought about it for a while, but in the flight dynamics business we Jerry [C.] Bostick, who had just got out of the Army. He was a civil engineer. Phil [Philip C.] Shaffer came to us from Dahlgren, Virginia, where he worked for the Navy. He was a mathematician of sorts. Grady

Meyer [phonetic]—I don't even remember where Grady came from, but he was a real character, flew his own airplane, a free spirit kind of a guy. Dave [H. David] Reed came to us from Wyoming—I was going to say Montana—Wyoming. Willaim M. Stoval came to us from Wyoming. Charlie Parker was the leader of the guidance officer group. Will Presley [phonetic] was in that.

Charlie was an amazing guy. He was very quiet and very thin—he's still around the Center—and he never said very much in getting ready for the flights. He got on console when we started doing these things, and he had to look at these strip charts that would say what was going on in the booster guidance system, the Titan rocket, and how well it was steering the vehicle. And Charlie—it was a complete surprise to me, I never realized he knew so much about how this thing was really working. I mean, he could interpret all kinds of things about how the launch vehicle was behaving, just from looking at these squiggly lines, as we used to call them, on his strip charts, and he was just amazing. He would get up there with his headset on his leg—wrapped around his leg, and he would just have this insight into what was going on on the launch vehicle, being able to call it very well.

There were times in that system where it was designed where we could switch over to the guidance system in the spacecraft. We never did that in a real flight, but that was the problem that he had, whether to keep going with the launch vehicle system or switch over. Charlie just could read mountains of information out of these squiggly lines and know exactly what to do every time. He was wonderful.

Then he trained a bunch of guys who came on with him—Will Presley, Will [William] Fenner. I can't remember who else was in that group. John Llewelyn was our retro officer, and I don't know if you've heard any John Llewelyn stories, but there hasn't been—only one person like him in all of history of mankind. John had a group of people that he fathered in his retro officer group, and they were quite a bunch of characters, they really were. Chuck [Charles] Dieterich used to work in that group. Who else was in there? John, Chuck, Bobby Spencer. Will Fenner—I talked about Will. He was in the guidance group.

But anyway, it was very competitive. Dave [David V.] Massaro was in the retro group, and the retro group always felt like the rest of us were picking on them. They always had this kind of "You guys are picking on us" kind of a syndrome or paranoia, and the truth was, we were, as many times as we could get away with it. But John was a tremendous contributor to all of the programs, Mercury, Gemini, and Apollo, but an absolutely unique character, and they don't make them like John but once, period. If you were doing something other than this kind of a thing and had a group of people around telling John Llewelyn stories, it would go on all afternoon. Go on all afternoon.

BUTLER: Sounds like a great group and a great camaraderie.

LUNNEY: We had a great group.

BUTLER: That's what you need, definitely. During the missions, you said you were charge of this whole group, but then did you also work console during the missions?

LUNNEY: Oh, yes. During the early Gemini missions—let's see. I actually ended up skipping a lot of those because I had been assigned as a flight director—when was it—about '64, so, before the Gemini Program really started to fly. I was managing this group of people who represented three consoles in the Control Center, and we were doing all that stuff getting ready for it and then how to do rendezvous and how to do guided entries and how to use the Agena to burn the engine and propel the Gemini spacecraft other places and other orbits.

So we worked on all that kind of stuff and putting all that into requirements for displays and so on that ended up being what the Control Center used. I mean, we had never done any rendezvous before. We were just making it all up as we went along as to how you would do those things, and the Flight Dynamics Branch had to put all that in the computer so that we could then execute the things that we had to do during the Gemini Program.

But along about '64, I was named as the fourth flight director. Chris was the first one, and John [D.] Hodge and Gene [Eugene F.] Kranz were named when we had to do—[L.] Gordon Cooper's [Jr.] mission was thirty-some hours long, so we had to have three teams. So those three were named. And then in the interim between that and really starting to fly Gemini, I was named as a flight director, and I was the fourth. Then later on, Cliff [Clifford C.] Charlesworth was named and Gerry [Gerald D.] Griffin.

But I was also tasked to take care of some of the early unmanned Apollo testing. We were doing boilerplate testing of the Apollo spacecraft, abort testing of it out at White Sands. As a matter of fact, they have some versions of it over here in the rocket part, the Little Joe vehicle that was used. It was designed to take the Apollo spacecraft up to severe max dynamic pressure conditions that it would experience during the Apollo launch phase and then test the escape system, test the escape tower that pulled the spacecraft off it. I was involved in a number of those tests out in White Sands, kind of as a flight director. I had a couple of people who looked at it, and we actually had to send the command to blow up the vehicle and trigger the abort sequence when it got to the right conditions. So that was our job to do.

BUTLER: Interesting job.

LUNNEY: Yes. Then we had a couple of unmanned flights, Apollo-Saturn 201 and 202, that were unmanned vehicles, and then 501 was the first Saturn V. It was unmanned. So the team of people I had in the Flight Dynamics Branch I had worked with in getting ready for Gemini and so on, and they were all at their consoles doing this stuff, and I was still their branch chief for a while, and I was also then named as flight director. So I was also sitting, actually, on console for the flights that occurred out at White Sands and the first three unmanned Apollo missions that were flown—Apollo-Saturn 201, 202, and then 501 was the first Saturn V.

By that time, I came back to the Gemini Program as a flight director on Gemini IX. So I was on for IX, X, XI, and XII, and Chris Kraft and John Hodge and some others moved over to start getting ready for Apollo. That, of course, slowed down and was interrupted by the fire that occurred in 1967, but—let's see, I guess it was '66 that we were flying the last of the Gemini Program—'66 or '65? The fire was in '67. I think it must have been in '66.

So I came back, and several of us, Cliff and Gerry Griffin, I think, were the primary players, primary flight director team that operated on the last number of Gemini spacecraft when our senior leadership, represented by Chris, went over to start getting ready for the Apollo thing. So I was able to come back to Gemini. Of course, I followed all the Gemini flights by being in the Control Center, even though I wasn't sitting on console.

Again, the Gemini Program has still yet to get credit for the contribution it made to the success of Apollo. I believe I talked about that before, but it can't be said too often, that the things that we got to do in Gemini really prepared the total operations team—the people in the Control Center, the astronauts, and then the engineering team that supported that—that whole team of people came together doing the Gemini Program, and we did almost everything you could do in Earth orbit.

We had a digital computer on board, so we have these two ways to steer the launch vehicle. We had propulsion on board the spacecraft far beyond what we had in Mercury, which was just retrorockets, so that we could change the orbit, we could do rendezvous, we could open a hatch and do EVAs, we had two crew members and not one. We docked with the Agena stage. We then used its propulsion system to change orbit of the dock combination and go to other altitudes and so on. So we experienced all of that stuff that you could do in lower Earth orbit, including then guided entries down to specific landing points, and we got pretty good at getting very, very close to the carriers, the recovery carriers, with the Gemini system.

It was a big step up from where we were in the Mercury program, but the experience that we got in dealing with problems—the Gemini spacecraft, we still had not yet incorporated all the knowledge and experience that we were getting, so it had numerous problems as we went along in flights, compared to what we then had by the time we got to Apollo. The industry had learned how to do a lot of things that ultimately got reflected in a somewhat more reliable Apollo machine compared to the machines that we flew in Gemini and earlier in Mercury.

But the Gemini spacecraft was very sophisticated, and everybody that participated in it would tell you, I think, that we had a wonderful time and did all kind of things. And some things we just invented. You know, we'd invent them two weeks before the flight and figure out how to do it and scratch it on a paper, and then we'd go try it in flight and see how it would work. It was a great training ground for the total operations team. So that by the time Apollo came, this team was absolutely ready to take Apollo to the moon in as quick a time as you possibly could. And without that experience, I think Apollo would have gone a lot more slowly, a lot more slowly, than what it did.

We went to the moon on the second Apollo manned flight, Apollo 8. We'd never have had the courage to do that if we didn't have the experience that we had in the Gemini Program, both the flight crews, the ground crews, planning teams, the engineering teams. We were ready, and as soon as we got the launch vehicle and the spacecraft that could go there, it was a very courageous and bold decision that became Apollo 8, but the teams of people were ready for it. They were ready for it, and it was a result of what we learned and what we matured through the Gemini experience. I mean, it was a real training ground for us.

BUTLER: Gemini was a very crucial program.

LUNNEY: Very crucial, and it doesn't get full recognition, I don't think, for how significant it was. It enabled the Apollo Program to be successful in terms of schedule, to be successful and to get there within the decade, which was the original goal. I think we would have gotten there, but it would have taken longer. As a matter of fact, I've also observed that it probably would have taken us so long that we might have experienced Apollo 13 before we ever landed on the moon if we did not have the Gemini Program, and who knows how that might have changed the history and the dynamics of things.

It was great, and it was great fun. I mean, we just had a wonderful time doing it. We just had a wonderful time.

BUTLER: It wasn't all that hard work, like you said before.

LUNNEY: No, it's not work. My father did that. I didn't have to work.

BUTLER: Gemini was crucial, and so I'd like to talk some about each of the missions and what involvement you did have with it. I know you said you didn't have a whole lot of involvement on the earlier programs, but you were in the Control Center?

LUNNEY: Yes. Gemini III was the first manned flight, John [W.] Young and Gus [Virgil I.] Grissom. I think I had the sequence—I mean, I never can remember exactly what the sequence was, but we were just bringing this Control Center over here on line. So I think the first mission, the Gemini III—although I could be wrong about this and flip the locations—but I think the primary team went to the Cape, and we operated the Control Center back here as a test. So I was a flight director running the Control Center back here, following on to the thing at the Cape. And then on the next flight, Gemini IV, the primary flight team was back here running this Control Center, and I went down to the Cape in case something happened to this one because it was our first one. So I was involved in the first two flights in that way, and I saw it was Gemini III and IV, but—I think so.

BUTLER: I think that's correct.

LUNNEY: So I was involved in that way. Then I skipped a couple of flights, went off and did this Apollo unmanned testing out at White Sands in the desert and the three flights that I was involved in that we flew unmanned, and then I came back for Gemini IX, X, XI, and XII. My involvement in the intervening flights, or the interim flights, was not on console, but I was around and observing it, and of course the three console teams that we had represent the three console positions were involved in every one of those flights. But at that time I was thinking more along the lines of what I would have to know and do as a flight director. So I was watching over those guys, but they knew what they were doing, so I was really learning as much as I could about stepping up to being a flight director when the time came.

BUTLER: We'll start with Gemini III, then, a little bit. You mentioned that was Gus Grissom and John Young, and this was the first manned Gemini, and it really tested out the spacecraft. How was that different than the Mercury Program and the Mercury missions?

LUNNEY: The spacecraft was—first off, there were two modules to it. It was a reentry module and then an adapter module. I can't remember what we called it, the thing in the back where we housed the propulsion. I think the fuel cells. The Gemini Program was the first time we used fuel cells as a powering device, electrical power for the spacecraft. We had to use cryogenic hydrogen and oxygen, which we'd never used before, which are the fuels or the supplies for the fuel cells. You mix them and you get electrical power and water out. We had a digital computer on board. We had two people. We had hatches that you could open. You could change the orbit.

There was also this back-up way to take over from the launch vehicle if something went wrong with it. You could switch to the spacecraft computer, and it could guide the vehicle into orbit, could guide the launch the launch vehicle and take the whole stack into orbit. The guidance computer, of course, was used for entry, and it could steer the vehicle, modulate the lift so that it would steer right down to the right kind of place. Two people on board. EVA. I think they were the primary—the docking system, of course. It was capable of rendezvous and docking. We did that a number of times with the Agena stage.

Compared to Mercury, I mean, it was a big step up. Mercury was batteries, so it was more limited in terms of duration and power. It was nondigital, so it was mostly an AM kind of a system. It was packed. Looking back on how we constructed it, I mean systems, subsystems were just sort of laid in the spacecraft, almost in sort of a stacked kind of a fashion, and if something went wrong and we had to repair it, it was a major job to get something out and put it back in and then put all the rest of the stuff back on top, all the boxes. And we used hydrogen peroxide, and it was kind of a fussy, delicate kind of a system in a way that took a lot of special care.

In Gemini, we went to the hypergolic system where you just mix fuel and oxidizer in the combustion chamber under pressure, and you get the ignition that you want, a much more capable system than the attitude control system we had in the Mercury spacecraft.

In a sense, although a lot of things that we did for Apollo got bigger, like the propulsion, it kind of was a step up to the digital kind of systems, the propulsion kind of systems, the fuel cell kind of systems, and the communications of all the above, that Apollo was to become, and that was represented by this Gemini vehicle. So, in principle, it had all of the innovations that we were going to employ when we went to the Apollo spacecraft, even though the Apollo spacecraft was bigger and so on, probably a little more complicated, but certainly all the systems were a little bit bigger, but mostly of the same type that we used in the Gemini program.

So it was a big learning experience for the industry that had to build all that stuff and test it and get it flying. It was also a big learning experience for us, who had to learn how to operate it, because with all these more capabilities that we had, I mean, we just introduced more and more variables to mission content and variables to what could go wrong and variables to what are you going to do about it when it does, and on and on and on. So we began to step up to a lot of the complexity that was going to be built into the Apollo spacecraft. We were stepping up to all of that with the Gemini vehicle, and in kind of a principle way, the Gemini vehicle was much closer to the Apollo vehicle and a big step removed from what the Mercury spacecraft was.

BUTLER: A big step in the right direction.

LUNNEY: In the right direction.

BUTLER: When Grissom and Young tested out this new spacecraft with all these different systems, and you said you were working in the mission control here as the back-up to the one in Florida, do you remember how the mission went, both from—

LUNNEY: It was very short. All I remember is it went fine.

BUTLER: And everything in the Mission Control, then, tested out fine as well?

LUNNEY: Yes.

BUTLER: The next mission, then, was a very big step, too, with the EVA.

LUNNEY: Yes, it was. Again, you know, the context—sometimes we lose track of the context of these things because we're so focused on what we're doing internally, but by that time the Russians had been off doing a number of things, and they'd already done at least one EVA and maybe more than that by the time we flew Gemini IV. So the idea of adding the EVA to Gemini IV was kind of a bold, big step to make at the time. It seemed like a bold, big step to make. It went fine, although I think we learned quite a bit about the fact that—there wasn't a lot of room in the spacecraft, and just getting a big person like Ed [Edward H. White II] back into the spacecraft and stuffed down into this hard balloon suit, because he was in a vacuum—get him stuffed back in enough to get that hatch closed and get it sealed up, I mean, was kind of a major thing.

The other thing, I think, that misled us was that Ed's flight, he had this little almost a squirt gun kind of a maneuvering system that was probably just nitrogen gas, and Ed floated around, propelled himself with this little thing and got back in. In retrospect, it probably seemed to all of us easy, that is, the EVA seemed kind of easy except for the crunching-down part getting back in, but it turned out that later on, when we started to do the EVAs and put people out, they were having trouble keeping themselves in a position, so we didn't go out on Gemini V. We didn't go out on Gemini VI and VII. I don't remember us doing an EVA on VIII, because we cut the flight short, it came down. So Gemini X, when I returned to the Control Center as flight director for Gemini, was probably the first time we did, from Ed's flight. There might have been one in between. I just don't remember. I don't think so.

BUTLER: I think you're correct on that.

LUNNEY: So Ed floated around. He was comfortable, and it didn't seem like any big deal, but then we started to want to have people go places on the spacecraft and do things, like work in certain places, and we hadn't thought about securing the astronaut to the place where he was going to work. So we found, really in the next three Gemini flights that I worked on, that crews were spending an ordinate amount of energy just to stay in one place, let alone do anything when they were there. The fact that they were struggling to stay in one place because we didn't have handholds and footholds and so on like we have today, and again, we didn't think we needed them because of how easy the Ed White thing was, we found if you want to keep somebody someplace and have them work on something, though, you really need to give him a way to secure himself in place or he just floats away. Every time he tried to do something he floats off.

So they were spending a lot of energy to do that, and as a result of that, they were overloading their air-conditioning systems, the little chest pack that they wore, and their visors would fog up. They would be working like the devil, very strenuous, to complete any of the missions that we had, and we didn't complete some of the EVA mission objectives that we had early on, for that reason.

We started to realize, hey, you know, we're a long way from having figured this thing out. By the time we got to Gemini XII, people had thought through it quite a bit more, and we'd installed the handholds and footholds and ways for people to move back and forth on the spacecraft with rails and so on. We finally, I think, began to figure out what it was going to take—we, the whole system including the flight crews. And by the time we got to Gemini XII, we figured we knew how to have somebody floating around on the vehicle and doing what we had to do.

That, by the way, was a slightly different kind of EVA than we had when we had when we went, of course, to the moon, because there we had gravity to help. Even though it was one-sixth of what we had on the Earth, people could walk around on the moon and it was like being on the Earth except they could bounce higher and maybe hit a golf ball further than the Earth orbit experience or just free-floating. In the latter Apollos, we had some missions where we had cameras and stuff that were in one of the bays of the Apollo service module on 15, 16, and 17 Apollos, and we had to have an EVA for people to go out and get the film and retrieve it because we separated the service module for entry and lost it.

So our Gemini experience helped us a great deal with that. The Gemini experience, I think, helped us think through a lot more as to what the lunar surface was going to be like, what we had to do in the way of having tools made that people could use and having equipment designed so people could handle it and so on. So the Gemini stuff contributed a lot to making the Apollo EVA work, spacewalk work, moonwalk work, as trouble-free as it really was. I mean, the Apollo moonwalks, those guys would rocket all over the place and jump up and down. I was always worried about those suits springing a leak, but the suits were good, and they got very confident, the crews were very confident in them. They just had a good time to the limit while they were there. As a matter of fact, then they got that little buggy, the little dune buggy [Lunar Rover], and, oh, my God, they'd drive that thing too fast. You know, they're all Corvette drivers, and it used to just make me nervous as the devil. They'd be hot-rodding that thing around the moon. I was thinking, "Oh, can't you go a little slower, please?" But they did fine with it. A lot of what we learned in Gemini on EVA and the suits and so on really turned out to pay off when we got to Apollo.

BUTLER: Absolutely. Well, I think those astronauts had the kind of confidence in you that you had in your trench team.

LUNNEY: Oh, yes. It was completely mutual. It was completely mutual. Really, almost this whole contingent of astronauts that went through the Gemini experience were the guys that were flying the Apollos. So we had a lot of time to work together and a lot of time to build confidence in each other and so on and build a good relationship between the flight crews and the Control Center and the way we interacted with each other. It was a nice, smooth operation.

BUTLER: Talking about the EVAs on Gemini, you mentioned how they would be working so hard and they would overheat their suits beyond the limits. What concerns for the astronauts did that raise for you?

LUNNEY: Well, they're very real, because, you know, on the first one I was on, Gene [Eugene A.] Cernan was out on Gemini IX, and the way these two-man EVAs were organized is one guy would stay inside—in Gemini IX it was Tom [Thomas P.] Stafford, the commander, and Gene would go outside. Well, you know, his job was to go back to the back end of the Gemini spacecraft, and we had a maneuvering unit that he was going to try. But Gene was working so hard to keep himself from just floating off and to get back to where he was, by the time he got there he was overloaded in terms of heat, and his visor was fogging up. I felt it was dangerous, because he couldn't see where he was.

As a matter of fact, Gene tore his suit to some extent, tore a couple of layers of his suit on Gemini IX on some antenna or other that was in the back end. We didn't know that until after the flight, but that was an example of how kind of dangerous it was to have people not be able to see what they were doing and not be able to secure themselves where they wanted to work. I guess in his moving around, Gene bumped into an antenna—I think it was an antenna—and tore a couple of layers. We didn't know that until afterwards. But then getting Gene back into the spacecraft, you know, he kind of had to work his way back up the umbilical and hang on best he could to places where we didn't really have handholds and then get back in and get the hatch closed, again with not being able to see too well because he worked so hard that he overloaded the air-conditioning system and got a lot of condensation inside the suit, all showing up on the visor. So he was not in a good seeing condition to help with Tom. I'm sure he could see some through it. But that was kind of scary for us and left us kind of spooked.

Gemini X was more of a free-floating EVA where John Young stayed inside. Mike [Michael] Collins was trying to retrieve some things from the Agena stage, and he ended up losing them because I think he was having some of that same problem. I mean, it looks easy just to float around, but if you're trying to get somewhere and do something and get back, he ended up losing some of the samples that he was trying to retrieve from the Agena stage, stuff that had been up there for a while that people wanted to see what the effects were on, space effects on. So again, that kind of said, "Hmm, you know, there's something going on here that we don't really know too much about and how to do very well."

Then we flew Gemini XI, and Pete [Charles C.] Conrad [Jr.] was the commander, Dick [Richard F.] Gordon [Jr.] was outside, and Dick—we were doing something with a tether, where we were hooking this tether between the Gemini spacecraft and the Agena, we were going to sling them around once we got separated, which we did, kind of a hair-raising thing to do, but, nevertheless, Dick was having this terrible time staying somewhere. The front end of the Gemini spacecraft had probably, I don't know, three-foot diameter cylindrical section, and Dick, bless his heart, you know, was trying to climb on that and hold himself with his legs like you would in a saddle, and he was just struggling.

I can still remember listening to him breathe. It sounded like he was running at high speed for hours and hours. It was a terrible noise and sound coming from him, obviously struggling like the devil to hold himself in place in order to secure the tether and some other things he was trying to do. Again, we were left with this, "Oh, my God, this stuff is a lot harder than we though it was." His breathing still sticks with me thirty-some years later. I remember how hard he was working and how hard he was breathing just to keep himself in place to do the work that he had to do.

In parallel with that, we began to recognize that we needed to do this thing with handholds and so on, so that by the time we got to Gemini XII—and somewhere in there, frankly, I don't remember where, maybe it was Gemini XII, we realized that using the swimming pool neutral-buoyancy thing, swimming pool with people in suits was a good approximation of what they were experiencing in flight. So that began to be used. I can't remember which flight crews used it first, but certainly we were using it by the time of Gemini XII, and it may have been just coming on line about the time of that flight or the preparations for that flight.

So Buzz [Edwin E.] Aldrin [Jr.] got a chance to use the new swimming pool as a training device, and then, of course, a tremendous amount of augmentation for him in terms of station-keeping and keeping himself in one place with handholds, footholds, etc., and he was able to navigate the spacecraft, traverse it to the back because we had handholds, and then keep himself in place and do a set of tasks at the back end, making connectors and so on, disconnecting them, that people thought might be applicable to the lunar surface work. We understood enough by that time so that went reasonably smoothly, but the couple flights we had, Gemini IX, especially Gemini IX and Gemini XI, were scary from an EVA point of view because the crews were in some degree of jeopardy out there because they overloaded their systems and they couldn't see very well. It was pretty spooky.

We used to have big arguments with the program managers, Charlesworth and I. Cliff was one of the flight directors at that time, and Chuck [Charles W. Mathews] was the program manager, and these guys had designed this little chest pack to do the oxygen and the air-conditioning job, or cooling job, for the crews, and they used to just insist that it was designed according to spec, and we said, "Look, we don't care if this thing's designed according to spec. That damned thing's overloading, and we're having a hell of a problem with it." So we had ongoing fights and debates for some months about this chest pack and the capability of it to cool the people so they wouldn't overheat. The engineering team kept insisting that it was designed properly, and it was, you know, but it was designed assuming that the crews would not have to work so hard to do what they were doing. So, ultimately finding a way to not have the crews work so hard made the air-conditioning system and the cooling system appropriate for the task, but it took us a little while to figure out what we had to do to make it work right, and some of it was spooky. Some of it was spooky.

BUTLER: With the Gemini missions and the EVAs, did you plan for or train for a situation where something went so wrong that maybe an astronaut couldn't come back?

LUNNEY: Not really, no. I don't remember doing that. I don't remember doing that. I remember Gemini IX was an interesting thing. We haven't talked about it, I don't think, on any of this, but the Agena had been launched, and the Agena had—it was called "alligator jaws" because the thing didn't open up all the way to expose the docking system. It opened up a little bit. There was this cover over the docking system, and it was supposed to come all the way off, and springs were going to push it. Well, it came partially open, and it was sitting up there like that, and I think we knew about that before we flew, I think. Boy, my memory is not what it used to be.

Anyway, we flew up there, and we had a big argument about—"we," a couple of us young flight directors—we did not want the crews to go out and mess with this thing, but the successes that we'd been having were making other people bullish about things, and they thought it would be a good idea to demonstrate that we could recover from this partially opened adapter cover that was over the docking system. They thought that would be a good demonstration, which it would. They were right. It would be a good demonstration if it worked. But Cliff and I were concerned that we had this thing half open, and we weren't entirely sure why it wasn't open all the way—there were a variety of theories—but there was a lot of energy left in those springs, and if they went like that, who knows what those panels would do if they hit anybody.

So we argued a long time not to do that, and it turns out that the bullish opinion about demonstrating this won the day, and so there we were, going to do this, and it turned out that the rendezvous with the Agena stage sort of came towards the end of a day. By the time the crews got there, Tom and Gene, they called down that they were too tired to go ahead with the EVA, which was a giant relief. [Laughter] A giant relief for me and some of the other fellows in the Control Center who had argued against giving the crews this assignment or this task, to go try to make this thing right. I never have really asked them how tired they were. I don't think they wanted to mess with that thing either. [Laughter] Then we went on and tried the other EVA at the back end of the Gemini spacecraft with Gene later on.

I can't remember when we became aware of the thing being half open. It might have actually been in flight or soon before the flight, because the Agena would be launched in close proximity of time to the launch of the Gemini. So we didn't have a lot of time ahead of time to talk about it, but somewhere very late in the sequence and in flight, Cliff and I were arguing that we should not do that. We felt kind of awkward, too, because here we were being sort of conservative, maybe even chicken, and all these smart guys were thinking that this was such a good thing to do. [Laughter]

But in light of the way that flight went and in light of the experience that we got with EVA and the difficulties of being in one location, in retrospect, we were well advised not to mess around with that thing and let it pass. We'd have plenty of other opportunities to show that we could do things that weren't planned, and we did. So that was one that we avoided through a combination of circumstances that I'm glad we did. I'm glad we avoided it.

BUTLER: Absolutely. I think it sounds—

LUNNEY: Because Gene's experience in EVA was very difficult, and if we'd run into that with him out there with this spring-loaded thing about to pop, doing something to get it to pop, and had a problem holding himself or a problem with his air-conditioning system and smoking up his visor, steaming up his visor, who knows how that would have turned out? So that was one we missed. We missed that bullet.

BUTLER: A good miss.

LUNNEY: Dodged it, I should say. Dodged it.

BUTLER: We've talked about the EVA, but another major part of Gemini was the rendezvous and the docking, and you had been involved with the trench and the trajectory. What can you tell us about that?

LUNNEY: Well, the rendezvous was a big challenge in terms of figuring out how to do them and then figuring out how to train for them and all that kind of stuff, because it was all new to us. People do it now, it's fairly routine, but at the time it was not, and we were actually—from a trajectory point of view, we knew how to figure out how to maneuver all these things to get them pretty close together, but we never really thought very much about the final stages of the approach to it, to the rendezvous, and what that would look like to the flight crews and what kind of cues they would have that things were either going well or not going well.

In the middle of all that, Buzz Aldrin, prior to being selected as an astronaut, had worked on—let me call them terminal phase approaches, the very tail end of the rendezvous, and he had worked on the concept of how to approach the target vehicle from below and then in front so that if done at night, the target vehicle would look fixed against a star background so that as long as the crews kept the target vehicle fixed against a star background, which they could see very clearly at night, then they knew they were closing on the right line as long as the range and range rate were behaving themselves, then they would get there okay. And if the vehicle was moving with respect to the star background, then they knew they had to make some corrections back on.

So, Buzz had studied, and I think he did his [doctoral] thesis on approach techniques at the tail end of the rendezvous, and so while we were struggling with all the other maneuvers and how best to arrange them, we then married all that with the idea that Buzz had about the best approach quadrant and the best lighting, that is, star background, for the crews to see and then use that as cues to help them with the final stages of the rendezvous. We were able to marry those two things together and then start experimenting with different, really, paces of approach. We used to call it "[unclear] revolutions," but we sort of started the rendezvous and then it would take like four revolutions and a series of maneuvers to come in, ultimately getting to two orbits that were concentric. That is, the target vehicle would be at altitude, say, 150; the spacecraft would be at altitude 140; and that would allow the spacecraft to slowly close on the vehicle. Then we would do a terminal phase intercept, and then we would get into this quadrant of lighting that I talked about that Buzz Aldrin introduced.

But we found ourselves doing rendezvous at various speeds. Some of them were very deliberate. If you allow yourself three or four revolutions for everything to null out so that you get there, that's one thing, but we even experimented with rendezvousing and docking within the first orbit on Gemini XI. We call it M equals 1. And everything had to go right or else it's kind of going away from you. If you're not getting it done right, it goes away from you, and then you have to reestablish. But we experimented with a variety of those kind of things in order to find out the various lighting conditions, the various conditions that the crews were facing as they came in, and the best approaches, and what was the best kind of pace for a rendezvous set of maneuvers to occur at so that it always felt comfortable and stayed under control.

We also even experimented with what we at that time called the "standoff rendezvous," where, instead of the orbits being concentric, maybe ten miles different in altitude, which results in closure, we talked about being in the same orbit ten miles apart so we're kind of fixed with respect to each other going around [unclear] and then we just do a little maneuver and kind of coast in. We experimented with that on Gemini XI. As a matter of fact, we invented it after the Gemini X experience, where we ended up using a lot propellants in the final phases of the approach, for reasons that I can't really remember. We ended up using a lot of propellant. But that sort of compelled us to ask if there was some even more slow or more deliberate way to approach the vehicle so that you didn't have to try to chase it, and that's what caused the expenditure of the propellant. If things get sort of outside of the normal, the crews would have to chase it, and more propellant could be used.

So we used one of these standoff techniques, and we did one of those. We invented it after Gemini X and tried it on Gemini XI, and it worked pretty well, too, but we had all of our equipment working, the radar and so on. So it was easier. So we did rendezvous every way that you could imagine, coming at the target vehicle from different angles and different altitudes, different concentric altitude differences as to what was a nice terminal phase to arrange. We did this standoff, and we did a variety of things.

Then on the last Gemini flight, the rendezvous radar failed. The rendezvous radar helps us know range and range rate to the target vehicle. It's very important to getting it all done right. And it just failed somewhere along the line. We didn't have it at all, so the final phase, which was mostly where you were dependent on the rendezvous radar data, we set it all up and put the crews in the final phase, and they were able to accomplish the terminal phase without the radar based on all the cues and information that would be available to them in this technique that Buzz Aldrin had brought to the program. As a matter of fact, Buzz was flying that time. So it just kind of tooled on in and worked fine, and there we were, and said, "Gee, we know how to do that." Even if the rendezvous radar failed, we get into a certain point from the ground, vector them in, and then the last couple of miles, the crew was able to pull it off with the cues that were available to them. So that gave us a lot of confidence in the rendezvous and the docking.

I didn't mention the word "docking," but at the tail end of every one of these rendezvous we're docking with the Agena vehicle. So that gave us a lot of confidence that we kind of tried it a whole bunch of different ways, and sometimes—this one time at least we got into a place where we were spending a lot more fuel than we wanted to, but, by and large, we felt pretty comfortable that we could pull these rendezvous off. Of course, the Apollo mission was completely dependent on being able to rendezvous the lunar module back to the command ship in order to come back to Earth.

So we kind of felt good about that, and the Apollo rendezvous went fairly smoothly and fairly routinely. Most of the crews that flew, of course, had flown in Gemini missions where we'd done a variety of that kind of stuff. So we were all kind of comfortable with setting up the rendezvous phase from any one of a number of different starting points and getting finally to a sort of specific set of standard conditions at the end where we could put them on an intercept and then the crews could monitor it very well and take over if they had to without rendezvous radar or whatever. We all felt pretty good that we knew how to do that, and we were comfortable that we could do that when we got to the moon, and they all went well.

BUTLER: They did all go well, every one.

LUNNEY: They all went well.

BUTLER: Luckily, you didn't have as many learning steps as you did with the EVA.

LUNNEY: Well, Gemini was probably the learning experience. When we got to Apollo, we liked to keep it on track, nominal, kind of don't deviate. Once we got to the moon, we weren't into doing tests with how to do this, because we had to get them there to the command ship to get home. And they all turned out that way. As a matter of fact, Apollo 11, that was the shift I was on, the ascent from the moon and the rendezvous back to the command ship, and it just went by the book. Everything worked just fine.

BUTLER: And luckily it was all—not all, but a good portion, due to the success of Gemini.

LUNNEY: Successes in Gemini, and, of course, the Apollo hardware worked greatly. It was great stuff, worked great most of the time, and, you know, everybody was ready for it.

BUTLER: I have a few more questions before we wind up for the day.

LUNNEY: Okay.

BUTLER: You were beginning to work as the flight director in these missions that we've talked about in some detail. I'd like to go back one step to talk about Gemini VIII briefly, if we could. Were you in mission control at the time?

LUNNEY: I was around, yes. I was sitting around watching it, but I wasn't assigned a shift or anything. I was there, and when the vehicle started to spin up and when the crew separated, that was, I think, the first time we really landed in a contingency landing area. I may have my oceans wrong, but we were planning for the Atlantic, and we ended up landing in the Pacific, terminated the flight early, and so on. Yes, I was around watching all that.

BUTLER: Comparing that to when you were around for Apollo 13, which was another big event, what was the seriousness of Gemini VIII?

LUNNEY: Gemini VIII was very serious because if the crew—and I think basically Neil [A.] Armstrong responded to this problem on his own—if they hadn't gotten themselves separated from the Agena and back under control, had they stayed attached to the Agena, it just would have kept spinning up more and more. They thought it was the Agena stage that was causing the problem, and it was really the Gemini stage, and so did the ground. The ground thought there was something funny about the way the Agena was behaving, so they walked themselves into a mental trap thinking the problem was on the Agena.

But the crew separated from the Agena, and then they found that they were continuing to spin up, coming to the conclusion that that was being caused by the Gemini spacecraft. So they shut down the primary system and they opened up the entry control system. We had a separate propulsion system just for entry, and the rules were, once opened up, we had to be looking for the first closest place to come home. But they got off the Agena, they recognized it was still spinning up, they stopped the spin by going to the entry control system and shutting the other one off, and they got it back under control. Had they not gotten it spun down, it would have spun up enough to cause them to be unconscious, and there would not have been any recovery from that if the crews had passed out, because there would be no way to get it to stop spinning. So that was pretty dangerous. Pretty dangerous.

Probably the difference between that condition and the one we had on Apollo 13, it was sort of like a single problem, and the single problem could have had dire consequences, but the single problem got handled and then the worst result was we shortened the mission and came home at a contingency landing site, which, by the way, had recovery forces and so on. The difference between that and Apollo 13 is that Apollo 13 went on for a long time. We abandoned one ship and got in another and had to use it in a way that we hadn't really used before. So we had a tremendous number of various problems that had to be solved, as opposed to the one that Neil solved here, and it went on for a much longer period of time, during which time any screw-up could have undone the work that we had already performed and might have ended up again in the loss of the vehicle.

So Gemini VIII happened very quickly, was resolved fairly quickly, the mission was terminated and it came home, but it was kind of like a single-problem sort of an event. Apollo 13 was a much more pervasive kind of a problem in terms of moving them to another ship, powering it up, and then having to conserve all the consumables to get all the way back to the Earth. So there was a lot more opportunity for us to screw it up than Gemini VIII. Gemini VIII, though, had to be solved, and Neil Armstrong separated the vehicles, found out what was going on, solved the problem. If he hadn't done that, we'd have lost the vehicle and the crew. So that's the difference in the two flights.

BUTLER: We've talked now about some of the flights, the EVA and the docking and rendezvous experience, but Gemini also had other experiments that you carried out on the various missions, and you mentioned briefly when you were talking about—I can't remember which one it was.

LUNNEY: Gemini XI, the tether.

BUTLER: Gemini XI, the tether experiment, yes. Can you tell us about that?

LUNNEY: Well, yes, that was interesting. I can't remember how that came about, but there was this idea floating around, or this concept floating around, that one way that we might keep vehicles together would be to put a tether between them and spin them up, and then if they didn't dock with each other, they could stay in close proximity that way. So, as bold as we were, we said, "Well, okay. Why don't we try that."

Of course, then there are other problems associated. You want to be sure you can unhook from this tether once you got going, and also, how do you even steer the vehicle? You know, the tether had a little give in it, so you've kind of got get the vehicles apart and get the thing a little bit taut, and then how do you use your thrusters to start swinging this thing around?

At any rate, we did it, and there probably wasn't a whole heck of a lot of theoretical studies done about tethering and spinning up and so and so on, but a little bit of trial and error ahead of time and some studies, of course. And then in flight, the crews got it going, and the tether worked pretty well. We kept the two vehicles together until it came time to—there was a little post or something that the tether was looped around, and that was pyrotechnically released, as I recall. So that allowed the vehicles to separate and us go on our way.

But for a while, I mean, it was really kind of funny. Pete Conrad is one of these ebullient guys where everything is funny to him and everything is a riot and just being around him is like that, but he got this tether going, he and Dick Gordon, and they just got to laughing and chuckling, talking about how it was going. Sometimes it would go in and out on them, and it would go around like this. So they had a lot of comments about how wild a ride it was on that tether, but it worked well. Then we never used the technique for anything. Maybe some day somebody will use it for something, and they'll go back there and look at the Gemini XI stuff we did. But it was kind of fun, and Pete was the perfect character to pull off something like that. He had a good time with it.

BUTLER: I'm glad he had a good time.

LUNNEY: He did. He did.

BUTLER: I know ideas are still being bandied about with the tether.

LUNNEY: I think so, yes, and there will be applications for it. I don't know what they are yet, but there will be. But it was exciting.

BUTLER: I guess at the time you were just trying everything you could think of that might apply to what you could need.

LUNNEY: Right.

BUTLER: You've talked about Gemini being such a vital step between Mercury and Apollo and making it happen and achieving the goal of landing on the moon by the end of the decade. There was at one time, though, some talk to go straight from Mercury to Apollo. Had you heard of any of that at all?

LUNNEY: Well, it probably was discussed, the concept of the Gemini Program and then getting that introduced and approved and so on. I wasn't involved at that level in discussions in NASA. It came to me as kind of a given that we were going to do it, and probably in the beginning—probably in the beginning, I don't really remember exactly, but I could easily imagine that some reaction would be, "Well, why are we even bothering with that? Why don't we just get on with the Apollo." And there probably were proponents for that point of view. I wasn't involved in any of the debates, and I'm not sure I would have been wise enough to know this going in, but in retrospect, it clearly was a tremendous boost to us to have been through that experience.

I'm sure some people viewed it as a financial drain. They could have put all the money into Apollo rather than that, and also an attention drain because the focus of the astronaut corps and the flight ops people, a lot of them, anyway, was very strong in terms of focus on the Gemini Program. It turned out that within Chris Kraft's outfit we also had a bunch of people off doing this lunar landing planning, the planning for it, and a lot of them had and a lot of them had not been involved in the Gemini Program. So they had a nice mix of people and did a lot of the planning.

So when the time came for us to consider something like Apollo 8, you know, out came another group of experts who had figured out and knew all this stuff about how to route the trajectories to the moon, how to get them back, and what the navigation around the moon was going to be like. It was almost as if the management had this set of people off doing this stuff on the side while we were doing all Gemini, and when the time came to need the information and the experience and the expertise, the whistle blew and out they come, and they were just great. They knew everything that you could know about that stuff, and they were ready to do it. So we added that complement of expertise to what we had built and learned in Gemini, and the sum of it all was plenty adequate for us to do the Apollo job.

BUTLER: In my research I found that there was some question, also, or maybe only one or two voices suggesting that maybe Gemini could do an Apollo 8-type mission.

LUNNEY: Yes, yes, there was. There was a name for it. I've forgotten what it was, but there was a thought that maybe we could take one of the Gemini spacecraft all the way out around the moon and back. Again, I wasn't involved in the discussions of that and the pros and cons, but it did not come to pass. I am not aware of what all the tradeoffs were, and I'm sure you could have fixed this, but one obvious one that comes to mind is the Gemini heat shield was designed for reentry from Earth orbit. It would have taken a considerably different and better heat shield—I mean it's not just a little bit, it's a lot—to deal with the speeds that you would have if you came back from the moon and reentered. Now, I'm sure the people who were proposing knew that and had some solution to it. I just wasn't aware of it. But again, discussions I was not personally involved in, that didn't come to pass although I heard that it was being talked about and considered, and we then moved on to Apollo.

It might have been—somebody could tell you this—it might have been that it would have cost considerable amount of money and probably taken some amount of schedule time, both of which by that point were getting close to bumping into the Apollo schedule. Because we finished the Gemini flying on XII in, what, fall of '66, and then the fire occurred in '67, but the fire occurred in a flow of what otherwise would have been a launch of that vehicle probably several months later. So the two programs, without the fire, would have been very close to being end to end of butted together, but it didn't come to pass that way.

So, probably considerations like that led people to say, "Well, let's skip that, and let's skip this extension of Gemini-out-to-the-moon idea and get on with the Apollo because it's at hand." Then when the fire occurred, everybody's attention was turned to getting the Apollo Program back on track. It probably would have been something of a diversion to still be carrying along a Gemini-to-the-moon idea. And that's all the Gemini-to-the-moon would have been able to do. It would have just been able to go around the moon probably. Maybe there was an idea of adding a stage to it and putting it into orbit or not, I don't know, but it wouldn't have gotten us to land on the moon. It wouldn't have gotten us to land on the moon.

BUTLER: Which was, of course, the ultimate goal.

LUNNEY: Right.

BUTLER: At this stage I'd like to ask Kevin and Summer if they have any questions.

RUSNAK: Yes. I have two. They are kind of going way back to the beginning of your career at NASA. I believe you started as a co-op at Lewis. Would you describe that experience?

LUNNEY: Oh, yes. Boy, I went—I was eighteen years old, had two years of college by that time, and I was going to go to the University of Detroit and then three months and work three months for the last three years of my college. It would have been five years to get out. That's what it was. When I was eighteen, I went in probably, oh, August or September of '55, to work at the Lewis Center. I think my first period was not a go-to-school period, it was go-to-work period.

So, after the summer of my second year of college, my first assignment was to go and spend three months at the Lewis Research Center. I remember it was August, about, because it was hot, and I was a newcomer to town, and I didn't know what the bus schedules were, and anyway, I had a ride or a bus drop me off at one end of the airport. Well, the Lewis Research Center was over at the other end, probably a two-mile walk. It was two miles' distance, so I ended up having no other way to get there, so I just walked over there. By the time I got there, I was kind of dripping wet. [Laughter]

Cal Weiss was the name of the guy who ran—among other things, but he was sort of the godfather for the co-op students, and he took me in and laughed about it. He was fine. But I was very embarrassed because I was late. I mean, I thought I was going to be on a bus, and I had to walk all this way, and I was sweating, and first day at work. I was thinking, "Boy, what an impression I made here."

But being a co-op student was interesting because I had some kind of oddball shifts that I ran, and then I would—for example, on one assignment I was the engineer in charge of the ten-by-ten wind tunnel, ten-by-ten supersonic wind tunnel. It was a big, state-of-the-art kind of a thing at the time. So they would let me run the tests, or be the nominal engineer in charge, but there were two or three technicians that, of course, really knew what was going on, and they would get me through the night.

But through all that, I got acquainted with a lot of the technicians that really actually run a lot of the laboratories or the test cells and so on at the Center, and I always had the feeling like I was seeing—I would know where the card games were on Friday night, payday night, which, of course, you're not supposed to do, but I would know where they were. I played on the softball teams, and it was just a fun time.

It was like being in a place when you knew you were at the bottom rung of the ladder. I was at the bottom rung of the ladder, but I had a lot of interesting things, little interesting assignments, and they kind of put me in a number of different jobs around the Center over the three-year period when I came back every three months. Every six months, I guess, I'd go to a different job somewhere in the Center and work with a different group of people, and I had a chance to work in wind tunnels and engine test cells. Jet engines were not very reliable in those days. The cells were constantly being destroyed when the engines didn't work and blew up. Cooling devices. One guy that was there had some of the original designs for thrust reversers for jet engines, which, of course, every time I see one now I think of him, and they had various kind of nozzles that they put in the back end of engines to control the speed, and then they had all these studies for how you cool them and so on.

Anyway, I got to do a lot of things—shock tubes, wind tunnels, and propulsion systems. I never did work in the rocket lab, but I worked on jet engines, compressors, turbines, and all that stuff. So it was a lot of fun. I got the chance to do a lot of different things and always kind of at the bottom rung of the ladder looking up.

Then when I graduated, I went to work in a different unit than any of the ones that I'd been in before as an entry. The branch chief at that time in this branch was George [M.]

Low, who was down here eventually as the deputy Center director, ran the Apollo Program after the fire, went to Washington, was the deputy administrator, a wonderful guy. But it was interesting, there I was the first month out of college working for George Low, who, as branch chief, was kind of remote to us on the floor, but that I had an association with him for so long over all those flights, and there were a lot of times when he was the program manager and I was the flight director. We were doing this or that or telling them why we were doing this or that. So it was kind of fun.

But I loved being a co-op. I loved being a co-op student. I think it's a good thing, because it gives you a chance to see how this thing you're working on in school really gets applied, at least in this one area. And for me it was a motivator to get through school, get out, and get on with doing what I wanted to do, which at the time was work on airplanes. There was no such thing as space flight until the month I got out of college. There it showed up on my desk, this Mercury drawing, which I still have a copy of at my home. I guess you could say it changed my life, and it did. But it was a lot of fun. I enjoyed being a co-op student. They often ask me here at the Center, and we did this over where I worked at Rockwell, I often get a chance to talk to the co-op students. I guess I'm one of their examples of something or another. [Laughter] But I've enjoyed it.

RUSNAK: Also from that time period, what was your impression of the group of Canadians and Englishmen that came from Avro?

LUNNEY: Oh, yes. Did I talk about that in the last interview?

BUTLER: No.

LUNNEY: Listen, that's another untold story. Let me see. I don't remember what year that happened in exactly. Probably '59-ish. I was in Space Task Group, and we had a set of senior leaders, Bob [Robert R.] Gilruth, Chuck Mathews, Chris Kraft, Max [Faget], a bunch of senior leaders like this, and the rest of us were all kind of like entry-level upstarts, you know. In military terms we had a high command with generals, and then we had G.I.s, sort of, maybe corporals.

There was a group of people in Canada working on a supersonic airplane called the Arrow, that was canceled. [Maurice] Harold Macmillan, I think, canceled it, the prime minister of England at the time canceled it. It was being built in Canada. Somehow or another, Bob Gilruth and people knew about that, and I don't how the connection was made, but they went up and interviewed a bunch of these folks, who, it turned out, a lot of them came down and worked for us, and what was wonderful about it is we had this set of generals—I'm exaggerating a little bit—sort of general staff and then us G.I.s, and they were experienced. They were ten years older than we G.I.s, and they filled in all the rest of the chain of command. They had experience. They were experienced airplane designers and builders. They knew their way around the technical subjects, the business of flight, and they were a great contribution to the—let's see. What's the right word? Sort of for the filling out of the Space Task Group team. The Space Task Group, really, was missing some ingredients, but they brought the expertise that just filled it out just so well.

As a matter of fact, one of my bosses for many years, who has now died, was Tecwyn Roberts. Tec was from Wales, and it was first chance, you know, a lot of us young American kids had to work for somebody and to meet people—all the rest of them, too, from Canada and England, but Tec was marvelous. He had a wonderful knack for getting people to get along. He had a wonderful reasoning ability to take emotion out of it and to bring people back on track and keep them on track. He was so skillful that Chris Kraft had a tremendous amount of confidence in Tec, and Tec was our leader for a number of years, not very many because he ended up—he came down here, but I don't think he stayed very long. The weather was just not good for his health.

So for a number of years, a couple of years, Tec was our direct leader and mentor and kind of a—not quite a father, but maybe an uncle figure to a lot of us young fellows in the Flight Dynamics Branch and so on, and he was a tremendous help to Chris in putting together the Control Center concept. Tec was the original flight dynamics officer at the Cape in the Control Center when they operated out of the Mercury Control Center at the Cape. But he was such a gentle and yet demanding kind of a guy—those two words don't go together, but he was that. He was kind of gentle with people and he was kind of demanding of their performance, and because of his talents he evoked a tremendous amount of confidence that people had in him, management had in him, and it was like he was a perfect match for us. We were a random group of young engineers that arrived from all over America and kind of a little brash and a little hasty at times and sometimes a little emotional, and he would kind of gather us along.

As a matter of fact, after he died a couple of years ago, I wrote a note to Doris expressing my appreciation for all that Tec had meant to me personally, and I told her how much I and the rest of the men that worked for him had learned from him and how I felt that I used a lot of what I'd learned from him raising our family. So I wanted her to know that there was some of Tec Roberts floating around down here in Houston, Texas, in the next generation of Lunneys. But Tec was one, and I felt blessed because Tec was just a jewel and he got to be our boss, and we had a wonderful time learning from him, and he had a hell of a time dealing with us, I'm sure.

But there are a number of other people. I don't remember how many exactly, but my impression was it was about two dozen people or so, twenty-five, so, pretty close. About two dozen people showed up, and they brought all kind of talent to it. As a matter of fact, Jim [James A.] Chamberlin came from Arrow, and I believe—I may not have this exactly right, but I believe that Jim Chamberlin was one of the champions for Gemini Program. As I have testified here, I think it turned out to be a great decision, but there were others—Dick [Richard R.] Carley, John Hodge—I'm going to forget people, but there was a bunch of people who came in and just filled in the ranks just tremendously, and the Space Task Group profited enormously from their talent and their experience. I don't think Canada or England or Wales, I don't think any of them really had a chance to know how much those people contributed.

I had some visitors one time, friends of ours, their family background is from Wales, and people from Wales cam over to visit, and I had a chance to talk to them about Tec and the whole thing about the two dozen or so people from Canada that came down. They came from Canada, but some of them came originally from England and Wales and so on. John Hodge was from London, but he was in Canada at the time of the Arrow being canceled.

It was interesting because they were there and they worked on this airplane, which was—you know, it's a work of love to do something like that. It was quite advanced for its time, and they were all there when they actually took cutting torches to it and cut it up because they didn't want it to be resurrected. The government wanted to make a point, so they took cutting torches and cut this thing up, and that would have to be the low point of one's technical career, to put your heart and soul into something like that. I mean, they had a flying machine. It was built, and then to see people torch it to nothing, to scrap, and then within probably a week or some short period of time, this whole other door opened up for them. I don't know how many were interviewed or had the opportunity, but the two dozen or so that came to the Space Task Group was a tremendous addition and a great success story that has never really gotten much publicity, hardly been told, I expect.

BUTLER: We've been in contact with a gentleman named Chris Gainor, who's been talking with a lot of the Avro folks and some others, and he's hoping to put out a book on it, from what we understand.

LUNNEY: Really.

BUTLER: So I think in the next few years, hopefully.

LUNNEY: That's a story worth telling. And they brought a mix because, well, one, we were all American people, but most of them had a NASA-NACA—all our management all had an NACA background.

By the way, as part of that background, Bob Gilruth, for example, actively cooperated from Langley Aeronautics to England, whatever the research organization was called over there, I've forgotten, with all the World War II stuff. So he was actively involved in helping to orchestrate the best of both of us in terms of aeronautic research and aeronautic applications. But those men had a different kind of experience and a different kind of background and so on, so they brought just another mix to the soup, or stew, that was becoming the Space Task Group. A tremendous addition. A tremendous addition.

RUSNAK: Thank you.

LUNNEY: I'm glad you brought it up.

BUTLER: Summer, did you have any questions?

BERGEN: Yes, I have a couple of questions. The first is, you mentioned that the Space Task Group mainly had a NACA state of mind, basically, which, from my understanding, is more pure research than—

LUNNEY: Right.

BERGEN: So how difficult was it to make that transition from that research state of mind to a functioning program or work crew?

LUNNEY: That's a good question. I don't know. I guess I'd have to say that it was made just because of the talents of the people involved. I don't know that there was anything, other than having to do it, that was forcing it, but probably the people at Langley thought Bob Gilruth might be crazy—really, I'm serious—for getting involved in this, because, looking back on it, it looks one way, but looking at it from the beginning's end, this could have just been a flier idea that wasn't going to go anywhere or could have ruined a lot of reputations in failing and so on. And probably a number of his colleagues thought Dr. Gilruth might have been putting it all at risk to do such a thing.

Some of the other people who came, Chris Kraft and, I believe, Chuck Mathews—I'm not sure of Chuck, but I am of Chris—had been involved in flight test work at Langley. Chris was involved in flight control systems for the F-8 *Crusader*. As a matter of fact, the airplane that John Glenn few across country and made the talk show, whatever it was, was sort of one of John's opening rounds at being famous. But Chris had worked on the control system for that, and I believe had interacted with the people at Patuxent [Naval] Test Center up in Maryland, where the Navy tests airplanes. Chuck Mathews was, I think, involved in flight tests, too, although I'm not as sure of that.

Max, of course, was always—Max Faget was always in the conceptual design kind of business, did some of the early work on entry vehicles that I believe affected the way the United States chose to design weapon reentry systems early on, and then, of course, had a big influence on the Mercury and Apollo spacecraft and the Shuttle system, too, for that matter.

So they just had a unique mix of—I'm beginning to see this thing in terms like this, and this may be true of a lot of places in the world, but like in America, it's sort of like America has this problem and this need, and kind of the whistle gets blown, and out of somewhere come some people who turn out to be very nicely matched in terms of talent and skills to respond to this problem or need or call that the country has, and there they are. I mean, you look at them after a while and say, "These guys are perfect for this job."

I watched Dr. Gilruth, Chris, and George Low. I couldn't imagine anybody pulling off what was done here in this Center in that program in any better fashion than those guys did. I mean, I just can't imagine it. It perhaps could have been done better, I don't know, but I'll tell you, it was inspiring to me as a young fellow to watch all this go on, but we had the greatest leadership before leadership was even a consultant management guru kind of a word. We had it in spades. There it was, right in front of us every day. But America had a call and a need, and out came these folks, and they're absolutely perfect for the job.

BERGEN: And you got it done.

LUNNEY: Got it done.

BERGEN: My second question relates to Gemini. You talked about it being a learning phase, and it seemed like every mission accomplished so much more built on the mission before, but yet it took four missions at the end of Gemini for you to get a handle on EVA. Why do you think it took so long to grasp the complex things of EVA?

LUNNEY: I guess I haven't thought much about why it took so long, but it sure did. On the other hand, the problems we had on Gemini IX were like in May, and Gemini XII, when we think we had it figured out, was like in October or November. So it was a six-month period that the real trigger of the fact that we had a real problem response and then closure on a solution occurred over about a half a year. So, in those terms, that wasn't a long period of time, and the flights were coming six or eight weeks apart. So it was difficult to take a lot of lessons from one flight and get them in place.

For example, the idea of the swimming pool, which, I believe, got really implemented fully on Gemini XII, I don't know where that came along, but just having an idea of it and then being able to get it in place and get the crews trained and take some advantage of it, etc., is just going to take some physical amount of time measured in at least weeks or perhaps a month or two or three. It did seem to take us a while in terms of the sequence of flights, the four flights. In terms of time, it wasn't that long a period of time as these things go. But why it took that long, I'm not sure I could tell you. I'm not sure I could tell you.

BUTLER: As we wind up for the day, is there anything that you can think of from the early part of your career that we didn't cover?

LUNNEY: Well, you asked about the Avro contingent. And it's a good thing which we spent a lot of time on the Gemini Program. This is not the kind of forum where going over the stories of what various people did at various times is appropriate, but there's some wonderful characters involved in this whole thing who contributed in different kind of ways, but the force of their characters contributed to a lot of this in different ways, and sometimes it was funny. A lot of times it was work and solid and good, and sometimes it was funny, and sometimes we probably did dumb things. We were learning a lot.

We assembled a group of people, at least on the ground, to do this that was not done the way we selected astronauts. When we selected astronauts, we went out and got the best pilots America had to offer, screened them all down through a million tests and got the bunches that we got. In the case of the people who did the work, for example, the people who did the work in the Control Center and the people who did other things, I mean, they showed up. There was this thing going on, and I was there very early, but after that, people showed up. They heard about this and it sounded exciting to them, and they showed up. So the only screening that was done was sort of like a sort of a self-screening thing where people almost volunteer, or they're motivated to come do something, the success of which was far from assured. At the beginning, nobody would have guessed—I don't think anybody would stand around projecting how this thing was going to turn out. I don't think we would have been able to do that. So people showed up, in effect, kind of volunteered. It sounded like a lot of fun, and I guess as a result of that, we got people who wanted to do this work.

As I said about my branch, people came to it with different levels of skills and talents, but they all came to it with, I would say, about the same desire and the same attitude, and that turned out to be a pretty significant factor in how well they did their job; that is, attitude overcame in some cases not being as skillful as some people at other things. Attitude carried.

But there are a zillion stories about the people involved that happened and antics of sorts that went into it, but it was a great team of people. It was a real pleasure, a real honor, to be part of it. A real honor to be part of it. As a matter of fact, it's interesting to do something like this and think about it thirty years later, reflect on it thirty years later. In some ways it reminds me of how long ago it was, and yet in other ways it was just yesterday. There's still a real comradeship amongst the people who recognize themselves as being contributors and players in that time frame, and there's a lot of satisfaction, a lot of reward in it. I feel good about it. I feel good about it. America called, and a lot of us answered, and mostly we got the answers right.

BUTLER: It certainly turned out very well. I want to thank you for joining us today.

LUNNEY: You're welcome.

[End of Interview]