ORAL HISTORY TRANSCRIPT

CARROLL H. "PETE" WOODLING
INTERVIEWED BY CAROL BUTLER
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BUTLER: Today is January 19, 2000. This oral history with Pete Woodling is being conducted for the Johnson Space Center Oral History Project in the offices of the Signal Corporation. Carol Butler is the interviewer, and is assisted by Kevin Rusnak and Rob Coyle.

Thank you so much for joining us today.

WOODLING: You're welcome.

BUTLER: To begin with, if maybe we could talk a little bit about your background and how you came to work for Langley Research Center [Hampton, Virginia] and what you were involved with there.

WOODLING: Okay. Sure. I went to school at [College of] William and Mary in Virginia and decided, after graduation in 1950 with a degree in physics, that I wanted to stay down there [in the area]. I had a little girlfriend from New Jersey and she was a freshman at William and Mary, so her sophomore year, after I graduated, was coming up. I was kind of serious, we were kind of serious about that, but her parents, of course, weren't serious about having her not finish school. In fact, they moved her out—she didn't come back for her sophomore year, so that kind of put an end of those plans. Probably good. I certainly wasn't ready to get married. I was ready to work for a living, but wasn't ready to get married.

I taught school for a short amount of time, high school, and that was a lot of fun. Didn't make much money, but had a lot of fun with those kids, because that was in '50 and

'51, start of '51. That was during the time of the Korean War. The kids didn't have the worries that the adults did, and I was young enough that I could relate to most of the stuff that they worried about, about dates and how they looked and all that stuff. So that was great fun.

But through a co-worker at the high school, he said, "You're not making much money, Pete." He said, "You might want to look for a job at NASA," at NACA [National Advisory Committee for Aeronautics], at that time, at Langley Research Center. This was a fellow teacher, and his wife worked out there [at NACA]. I said, "Yes, I might do that." I said, "Do you know whether they take people with physics degrees?" He said, "Well, as a matter of fact, the person that maybe you'd be working for has a degree in physics from William and Mary." That was a coincidence, too, because it turned out to be a gentleman by the name of Ordway Gates, who was a cousin to my then future wife. That's how we got dating, through Mr. Gates.

So I went out there and made application. This was before my first school year was up teaching high school. So I went to the principal. They wanted me immediately. It was probably in early June or early May, so I had another one or two months to finish high school and fill out my contract. He says, "I don't know how we can let you go. You're under contract."

I said, "I understand that, but I thought I'd—" I was talking to the principal of the high school, a really nice man.

He said, "Well, I'll tell you what, if we can get a replacement, I'll let you out of your contract." He said, "Do you really want to go out there?"

I said, "Let me tell you, they offered me $3,100 a year."

I was making $2,000 from the high school. After all the withholding tax and teachers' retirement stuff, I made $161.88 [per month] or something like that. And we weren't eating too well. [Laughter] I was living with another teacher, and we always had fun those times,

but we weren't eating all that well. We accepted a couple of invitations to go eat with the students, and then the principal informed us that that wasn't proper. He says, "You can't get commitments like that."

I said, "Yes, but we don't get food like that anywhere else either." [Laughter]

So I ended up signing on with NACA at that time, in April of 1951, before the school term was out. Someone did take over the class. When I told the class, I'll never forget that, when I told my home room class that I was leaving they all applauded, and I said, "Okay, I'll remember that." [Laughter] They had heard I was leaving before that, but they had that set up. I had a heck of a lot of fun with those kids.

So I went to work for NACA, and, like I said, I ended up working for Ordway Gates, was his name, and his cousin was Milly Johnson, Mildred Johnson, and I ended up marrying Milly in 1952. She also graduated from William and Mary a year later than I did, and got a job at Langley. So we both worked there for—I forget when she retired. She must have retired in '55 when we had our first child. But we both worked there and I enjoyed that very much.

I ended up, fell into a lot of these things just because the timing was good, but I worked in a dynamics group there at Langley Research Center. As a result, we ended up doing simulations of high-speed aircraft. There was some things that were coming in, some problems that were coming into analysis of a lot of people at that time, which was called roll coupling. The airplanes were such high performance and they could roll at rates that were extremely high, a lot higher than normal, because they had short wings and slender bodies. You could actually get into a horizontal spin, an uncontrolled horizontal spin, as opposed to a vertical spin, through this roll coupling.

Ordway and I did some original work and analysis of that maneuver and we talked to quite a few jet pilots, some of them back from Korea, that said that they were using those things in evasive maneuvers. We kind of said, "Well, you don't intentionally get into those."

They said, "No, but once you get into them, why, it's pretty good. The other guys kind of back off, you know." But there was a lot of pilots losing control and having to bail out or even being killed.

But that's how my first—we ran simulations of that, as well as computer analysis. From that I got into the X-15 program, the high-speed X-15. [It] was flying flight test out at Edwards and [I] stayed the total time out at Langley, but did get into what we called a closed loop simulation of the X-15 with the naval centrifuge at Johnsville, Pennsylvania.

The idea here was that through the computer tied to the cockpit of the centrifuge, and we simulated most of the primary instruments in the gondola of the centrifuge, the pilots, the X-15 pilots, we invited them there and most of them had a turn at flying the centrifuge, they were able to fly reentries, which is the main task of the X-15, and experience the G forces. But their inputs from their control sticks and rudders and what have you, were fed into the computer, and through the equations of motion of the dynamics of the aircraft and the environment, the results of their inputs, control inputs, would perform as much like real time that we could make it. If they started to lose the airplane or came in at too high an angle of attack, or experienced large angles of side slip, those kinds of things, why, then the airplane, it was difficult to control the airplane on top of the reentry Gs and they would benefit by that kind of training.

It was experimental, certainly, in a large degree, and we had a lot of difficulty in getting it to work, but it finally worked pretty well. None of the pilots ever said that that was much like a real airplane. [Laughter]

There is where I first met—I decided that if I could, later on when I went into the space program, if I could work with a flight crew and astronauts in any way, I really wanted to do that, because those guys—well, I met Joe [H.] Engle and I met Scott [A.] Crossfield and Joe [Joseph A.] Walker worked for early NACA, and Neil [A.] Armstrong. So all those guys were out at Edwards [Air Force Base, California]. Met a couple very nice pilots from

the Air Force side, Iven Kincheloe, who was famous and really neat guy. He got killed not too much later than that.

But those people we invited them in and had them wear pressure suits and did some of the early simulations along with North American [Aviation, Inc.], who is doing probably the higher, certainly the higher fidelity simulations, but without the dynamics, without the feel or the centrifuge to give you the extra Gs [forces].

But [as] I said most of the comments weren't too favorable. I remember Scott Crossfield said that—I asked him how much this felt like the X-15, and, of course, he hadn't flown many flights at that point in the X-15. He hadn't flown the design mission. The design missions were up to 250,000 feet and then that's where you got the higher entry decelerations. But he knew enough about the airplane and how it handled, and I said, "How does this compare to the X-15?"

He says, "It compares very favorably to like if I was sitting on the front of a locomotive and trying to keep it on the track." [Laughter] He said, "It doesn't fly like an airplane at all."

I said, "Well, we appreciate your comments." I said, "I had to ask."

He said, "Well, I gave you an answer."

So he wasn't very impressed with the thing. But I think they all felt that that was a good piece of experience. They had some confidence that they could handle the decelerations while they were trying to do a very difficult control task. So it added to their other training activities.

That was in combination with the Navy. I was probably still working—well, I was, I was working in simulations in late '61, I guess, when the Space Task Group—Space Task Group, I guess, must have been formed earlier than that. Oh, I'm sure it did, because the Space Act was '58, so the Space Task Group shortly after that came into being.

But they got talking, and a couple times I thought that I wanted to join the Space Task Group, and it was right there at Langley. A lot of the people that I respected, and really hadn't worked with them much, but I knew from editorial boards and stuff like that, that they were great engineers and people that, if they were going to undertake a project, that I really wanted to be part of that—Chuck [Charles W.] Matthews, Chris [Christopher C.] Kraft [Jr.], at that time, and a lot of people I'm sure I don't remember their names. But I kind of put it off.

Milly, my wife, had parents in Petersburg, Virginia, and my parents were in Milton, Pennsylvania, a little town in Pennsylvania. So we weren't too far from both of our parents. They were all living and expected us to come home frequently, which we loaded many a car up and went up there either to Virginia or took turns at Christmas time going to Virginia or Pennsylvania. So I knew that it would be difficult for my wife to leave that area, as well as myself. I liked the area, I liked Virginia, and we had developed quite a few friends in that area. Still had some people even going to William and Mary, going through law school, some real close friends that we used to go up and see quite often.

But there came a time when the Space Task Group announced that they were moving to Houston. Through the X-15 simulation program, why, I came to know a real good friend, my first boss at NASA in Houston, and that was Warren [J.] North. Warren was from [Lewis Research Center] in Cleveland [Ohio], but he was working closely with the Space Task Group, and I think he was probably part of it at that time. But he talked to me one time, it must have been early in '61, about going to Houston, after they announced the group was going to move to Houston. I said, "Well, I don't know about that."

He said, "Well, you're branch chief here. You certainly can be a branch chief down there." And he said, "Think about. You'd probably be in a simulation group. Initially it would be probably called—" I think at that time he was even thinking about crew procedures, certain details of in-flight task from the crew's standpoint, defining those, helping build

handbooks and what have you. And that was while we were flying Mercury. We were flying the final missions of Mercury. I don't know when John [H.] Glenn [Jr.]'s flight date was, but—

BUTLER: February '62.

WOODLING: '62, okay. Well, we had decided to come to Houston. I made up my mind with Warren, and I said, "I'll try to sell this to Milly." He knew Milly, he had met her, and we had them over for dinner. But he says, "That isn't going to be a problem, is it?"

I said, "I don't think so." I said, "It depends on how much she feels about moving away down to Texas and with all those uncertainties."

But I said to her—I came home, I think the day he offered me the job, and I said, "Warren wants me to move to Houston. Would you consider that?"

She says, "Let's go."

So that was real easy, and that always makes it easy if both of us wanted to go. I said, "We're never going to get an opportunity like that. It's really going to be—" Even at that time we realized it would be something. Of course, we weren't thinking about the moon. I don't think [John F.] Kennedy had made his speech yet. I'm sure he didn't.

Near that time they were still flying [Mercury], they were flying Glenn, and I got a little bit of experience with that, because the control center was at the Cape [Canaveral, later Kennedy Space Center, Florida]. Part of the organization that would end up under me was also at the Cape for crew training. They had Mercury and the Gemini mission simulator down located at the Cape, but the management and the organization showed it under Houston. I didn't assume those duties when I first moved down there [to Houston], but later on for the entire Apollo project, why, I had a branch under Riley [D.} McCafferty down at

the Cape, whose responsibility was to manage the simulators down there, among some other activities like crew quarters and what have you.

I came to Houston, and that was a big deal for us. I came down in, I think, maybe late April or early May, and spent, I'll bet I spent eight weeks easily, two months, at the YMCA where I stayed. I think they were giving us five dollars per diem at that time, and I think the YMCA charged two dollars or three dollars a night, so that fit with that, and I had a little bit left over to spend on eating.

But the thing that I remember more than anything else was that it was not a happy time. It was hot and they did not have air-conditioning in the rooms. [Laughter] We didn't have an air-conditioner in our car when we came down there. I said, "Milly, I'm not sure we made the right decision." [Laughter] So the environment was already testing us, but we made it through that summer.

We were in temporary quarters when we first came down here. They hadn't built the center yet. We were up at the HPC, Houston Petroleum Center, off of I-45 there. That's where we ended up. They were some of the better quarters. They put the E&D [Engineering and Development] people over in…[buildings on Telephone Road], which were not too hot. [Laughter] Max Faget used to complain about that, that the other guys always got the best quarters.

That was in the early days of Gemini. They got thinking about, I'm sure long before I realized that, but with Jim [James A.] Chamberlin, who headed up Gemini, and, later on, [Kenneth S.] Kleinknecht, got thinking about Gemini and how well that fit into a build-up capabilities, hardware, pilots, everything, or astronauts and everything, how it would fit in to leading up to the lunar program.

Then it wasn't long after that that President [John F.] Kennedy made the challenge to the country and to us to land a man on the moon. We thought that was way out of sight initially, but then it was a real—that's the motivation and that's what you needed. That's what

we needed. Everybody was glad about that, because the country was behind us, Congress was behind us. Everybody was focused down here.

BUTLER: So when you came in, Gemini was really getting up to speed. Had you been at all involved in any of the Mercury simulation stuff?

WOODLING: No. I had seen them, I had visited at the Cape, I had met Riley McCafferty down there, and they had a Mercury simulator that was built by the spacecraft contractor, McDonnell [Aircraft Corporation, later McDonnell Douglas Corporation], and they had started to convert that one, as well as we may have gotten a completely new one down there from McDonnell. I think they delivered two Gemini mission simulators.

We had part-task simulators that would—we ran quite a few simulations of reentry with Gemini, but the full-up mission simulator, and almost from the very beginning the concept with the mission simulators was to be as high a fidelity, to include as many of the flight tasks as possible. The very challenging aspect of the mission simulators was not to provide not only the nominal missions, but all the malfunctions that were possible. So we had to go into a great degree of fidelity on simulating the systems. They had to be as close to representing how the system, spacecraft systems, would work and how they'd interface with the astronauts as possible.

So we spent a lot of time in the development of those simulators on the malfunction capabilities that had to be built into them. Then in the same sense, the flight crew spent a lot of time on malfunctions and "what ifs" in their training. If we only had to do the nominal mission training, it would have been like 20 percent of the time, maybe 20, 25, 30 percent of their time. But the fidelity in those was very much related to the malfunction capabilities.

The Gemini mission simulator that I started to talk about those, they were built, and I think there were two, there was one located in Houston, I'm sure of this, and one at the Cape. They were built by McDonnell Corporation in St. Louis [Missouri].

About that same time they were planning to bring new astronaut groups in. I don't think I participated in that second group, which consisted of nine crew members, but the third group, I played a part in that. It wasn't a big part, but that was interesting and added to my insight and to the selection of these unique individuals. They were all really great people to know as pilots and co-workers and engineers.

In those days—and I'm not putting any of the present-day pilots down, certainly, or crew members, whatever their title may be—but most of them in the second and third group were engineering test pilots. They were all pilots. They were all qualified pilots through the third group, maybe through even later groups, but they were engineering test pilots. A lot of them had been through Air Force Flight Test Center or the Navy had their Patuxent Flight Test Center [Maryland].

So they were not only good pilots, but they also had the engineering drive to understand what they were doing and what the airplane was doing and how they could learn more from each flight by planning what the objectives of the flight were going to be and running the airplanes through its maneuvers. So they were very interesting from an engineering standpoint, very interesting to be associated with, because they were inquisitive. They always wanted to do more on a flight than you programmed for them, and that was good. I mean, they kept us on our toes.

So I had that benefit of having to know some of those people from the very start. We got into the Gemini mission flights, and we had our simulator support those flights in that we tried to put it in the configuration of the present spacecraft and the mission that we were going to fly. The way we ended up, both in the early days of Gemini and all through Apollo—Shuttle, carried on through Shuttle, was that the early training for the flight crews

would be done in Houston, and they would be the first one to step up to a new flight or a new spacecraft configuration. So there was quite a bit of development time and checking-out time associated with the simulators and the training devices in Houston.

Then about a month—it depended on the flight and the launch rate and a number of other factors, but about a month prior to the actual flight date or launch date, why, the flight crews would transfer down to the Cape and they were quartered down there and spent all their time down there in the final days of training with the mission simulator supporting them. It would be tied, I think—I don't know what mission it was, but it was one of the early missions that the control center went to primary in Houston at the new MSC at that time. We tied the mission simulator to the control center, so we had the whole flight crew in the mission simulator, we had all the ground controllers, flight controllers on their consoles in the control center, and we did an all-up mission simulation.

Now, that didn't come easy and we had a lot of doing it in real time, making sure everything was synched, understanding—everybody was learning through this process. The flight controllers were learning, the simulation people were learning how to do that kind of a complicated simulation in real time. You had to make it certainly realistic. You wanted to do it. You didn't want any computer delays or things that looked artificial. Then the flight crew's doing their thing. We all learned, and that was the whole premise behind Gemini then. I mean, we were learning to do all these things that were necessary to get us into Apollo, in flight, on the ground, and everything else.

That was a fun time, too, because these pilots had a large input into what their training schedule [and content] was going to be. I had some responsibility through what we called training coordinators. We'd assign a person [when] the flight crew [was] announced [for a specific flight]. I had a group called training coordinators that we would assign one individual that they would keep track of their schedule [and progress]. One of his responsibilities was to work with the flight crews and our training people that operated the

mission simulator consoles. We had the training console people, too, simulator instructors, to work with them at an early date before they really got into their scheduled training, what their training scenario or schedule was going to be and what defined in fair detail what the makeup of it was going to be, how many hours on part-task simulators or how many hours on mission simulators, or all those things.

In Gemini we had what was called a Dynamic Crew Procedure Simulator [separate from the mission simulator]. That was the first motion base simulator that we had. Now, Apollo, we ended up with all the command module simulators had a motion base, the one at the Cape, as well as the one up here in Houston, that borrowed a lot of the technology from aircraft simulators. They were getting into some pretty good sophistication at that time. Those two things fed each other. They learned from us, we learned from them.

Let me back up a little bit. The mission simulators in Gemini were provided by McDonnell Douglas. Early in the Apollo program we realized that we were certainly going to have mission simulators, and we decided that we were going to fly flights with just the command module, but we were also going to incorporate the lunar module spacecraft later on and then fly the all-up lunar landing missions. So we developed the simulators along those lines.

The first Apollo simulator was just a command module, with the propulsion module, of course, but the lunar module was not part of it. We wrote the specifications for that, and that had to be competed. Link, the old Link Trainer outfit [Link Group of General Precision, Inc., Binghampton, N.Y.], won that competition to build the command module stimulator. Later on we competed also the lunar module simulator, and Link won that for probably good reasons.

I was part of those source boards and they [Link] were the logical ones, but there were other competitors that at that time had large capabilities. McDonnell Douglas was one

of them, not only with their Gemini experience, but they had started building large simulators for their aircraft, and very high fidelity, combining both motion and visual.

But Link was also doing that and they sold—they were probably the leading Air Force contractor in simulators at that time. So that's how Link got into the things that I was interested in, or required.

We ended up with—I was trying to remember that this morning—we ended up with two command module simulators and one lunar module simulator in Houston. There was a very ambitious flight rate we were looking at, at that time, and we were even thinking about additional simulators, but that never materialized before the program was declared over. At the Cape we had a lunar module simulator and a command module simulator. So the cycle again was, we'd do the early upcoming mission early in the cycle in Houston and develop all that software, check out our simulator and get it up running, debug the whole system there, [perform the early training in Houston,] and then we'd go with the flight crews down to the Cape and transfer all that simulator load and software down there, and they'd finished out the training for the nearest close-in mission. Then as soon as the astronauts transferred to the Cape, we'd pick up the next upcoming mission in Houston and we'd cycle, kept cycling them that way.

We had some real challenges as far as changing flight schedules. I remember Apollo 8, when we decided to fly Apollo 8, and that was the first one with the big booster [Saturn V] and the first time we were going around the moon. There was some difference in the—our systems were probably simulated well enough, but for everyone it was a big step. We had not a whole lot of time to do that. The crews were very well trained in not the translunar mission, but they were very well trained in the operation of the command module. They didn't fly with a lunar module at that time, on that mission.

So we made the switch and everybody got on board as to the new mission with a lot of enthusiasm, because it was a great idea to fly at that time of the year, and fly [Frank]

Borman and his flight crew. Everything turned out just perfect on that thing. So that was a real morale-booster for everyone and I think for the country and for the program.

I probably missed—well, I did. I didn't say anything about—when we were trying to [support] Gus [Virgil I.] Grissom and, I guess, John [W.] Young, and [the back-up crews]—who flew the other for early Apollo flights? When we were trying to get our simulators up for that, we had just a lot of trouble. We had new computers. We had, of course, new simulators out of Link, and they were working very hard. Grissom was constantly begging us to bring them up before we were probably ready. We would tell them that we still had some problems. He was getting quite frustrated by the lack of performance of the simulators. He wasn't too kind in his comments about the simulations, but we finally got him where he was pretty comfortable with the simulator. Then the fire happened there and he never got a chance to make [an Apollo] flight.

We got a lot more attention than we probably wanted because of the comments from the flight crew earlier that we weren't working as hard as we ought to be, or at least the results indicated that we had to be further along than everybody else was. Well, our answer, you know, it wasn't much of an excuse, was that we were the focus of a lot of the firsts. It was a place where the flight crews for the first time could try out how they wanted to operate the aircraft or systems, spacecraft, and how the flight software was going to work and the flight computers. It was the one place where a lot of that got focused together at the same time.

So everybody was debugging both procedures and the simulator software and the flight software at the same time, but that was good. I mean, you know, we were going to operate it the way the flight crews wanted to, the way the systems experts that built and designed the systems, spacecraft systems, wanted them to. So we were all learning through that process. Yes, people were anxious. The flight crews were particularly anxious.

But overall we got real good marks out of the debriefings of the flight crews after their flights, and we got a great deal of satisfaction out of that. They would talk about our fidelity of the systems simulation being very good, and we had the out-the-window views, including the lunar terrain. I'm sure you've seen some of those. We had the motion base to simulate the dynamics during launch and the vibrations and what have you there. So the flight crews were very nice and complimentary about our simulators. Of course, that made it, from our point of view, made it very worthwhile.

We were planning to do more than certainly the Apollo 17—I guess that was the last—and we were even thinking, as I said before, about additional simulators to keep up with the flight rate. But that got sorted through and we realized that that program was going to reach a logical ending there. We had to start thinking about the Apollo-Soyuz mission and the Skylab. We used most of our Apollo hardware, as a spacecraft did, for those missions. We used the Apollo simulator hardware.

Let me go back to something important, that is extremely important. In the simulations we were always looking for additional fidelity. In Gemini, we simulated the on-board computers, the spacecraft computers, went through a digital simulation, kind of a bit by bit. It was a pretty high degree of fidelity, but there were still things that the spacecraft computers in the simulator didn't work precisely like they did in [the real world or in] flight.

We made a decision in the early days, along with IBM and [with] the flight controllers' help, to incorporate the actual [same hardware configured] flight computers, tie them in directly to our simulator and the environment of the simulation and the simulation systems on the ground. We had the same number of computers. I think there were five total; there were four primary and one backup. We had the same number of computers. We used the flight software in those computers, and that helped a lot of people, IBM in their development and check-out and debugging of the flight software. Certainly it made it the

best possible simulation of that important part of the spacecraft operation that we could provide for them.

That turned out to be a good approach to take. We've, as far as I know, continued with that ever since. The flight computers for Shuttle were included as part of the actual flight computers provided to the simulations for the Shuttle mission simulators. So that was a good thing. Then to interconnect with the flight control and with the control centers over there [in Houston] and everything were as precise as we could make it, as realistic as we could make it.

After Apollo, we had one additional simulator. We had the Skylab simulator for [spacecraft systems activation and for] the crew quarters and to carry out their experiments and so forth. Let's see. Who built the Skylab simulator? It was probably Link, but I can't remember that exactly. We still used the command module simulator for the transportation…system to orbit and what have you.

Then Apollo-Soyuz, we flew that mission which was an interesting one because Deke [Donald K. Slayton] got his first assignment to a flight and Tom [Thomas P. Stafford] was the commander there, and that was a good flight crew. We always had fun with those guys.

Then during that time we had to start thinking about—well, right after Apollo, there was already some simulations going on for Shuttle, just part-task simulations and some of the people that were later going to build the Shuttle, they were doing engineering simulations. But we had to start thinking about developing the specs for the Shuttle mission simulations, and that was a big undertaking.

As usual, we started out with the systems experts as they had in the Engineering [and] Development directorate, as well the flight controllers. We would try to get with them. We would sit down with them and start writing down what the requirements were going to be for operating the systems and how many malfunctions we wanted to try to incorporate, and develop these specifications that we could after we ran a competition to who was going to

build this thing. We'd give them the design specs, because we had to have a certain degree of design specs when we went out with our competition. We had to define to them what they were supposed to build and what it would cost to build those.

WOODLING: But they changed very rapidly, those specifications, as we got smarter on how the systems would really operate and how we wanted to operate them. So there was, like the spacecraft, a very large task of configuration control of knowing where you were against the requirements at any point in time. That was identical to the spacecraft [world], because as they would change the spacecraft, we had to tag along and change our simulation capability accordingly. So we tracked the spacecraft evolution and configuration [and mission design] change[s] very closely, and then would incorporate those changes into the task for the mission simulator manufacturer. Well, Link won that also. That was a very good competition. We had other very qualified bidders on that.

Because of my assignment in that mission simulator area, I was fortunate, as I look back, it was probably a good assignment for me to be a part of the…Source Evaluation Board that ran the competition for the [procurement of the] simulators. There were several large boards for that. The earliest one that I was the chairman of was for the Shuttle mission simulator computers, which UNIVAC won. We got to work with some great people from the procurement group. The one in particular, it was Bob Klein [phonetic], he was a procurement specialist and just a super guy and a very colorful individual. He got us through some very difficult things in the way of procurement and kept Link on their toes.

IBM became an associate kind of contractor because they were providing the computers, and he had some past experience with IBM. They weren't especially easy to work with from a procurement standpoint, but they were always of the right motivation and wanted to do the best for the project, like everybody else. So there wasn't any of that wasting

time or anything, it was just that they had their way of doing business, like most companies do.

But he was an extremely large amount of help in the procurement and the development of those mission simulators, Bob Klein, and other people in the procurement end of it who knew contracts and knew what we could do and what we couldn't do and how to run source boards. We were also, we like to think, helping with the development of those source board and procurement procedures, too. We did some things that were unique and first time.

They set up a Senior Advisory Board that was made up of top officials from the center. Bill Kelly I always remember—but always a director was a member of that, too. No, I take that back, he was not a member of the Senior Advisory Board, the center director wasn't. He kind of stayed out of that, but the next level down in center management, they had members on that [Board] and Bill Kelly was one of them. A lot of help. Sig [Sigurd A.] Sjoberg, [R.] Wayne Young, those kind of people, [Clifford E.] Charlesworth was in there.

These were difficult things that we were doing. To make sure that we did things in a fair way, did things in a competitive way, had to be super careful that we did not pass manufacturing secrets and proprietary stuff between contractors, both in the competition and after they got the [contract]. So we were very anxious that that all was clean, and I think we did it pretty well. We had some complaints that we worked through, but nothing major that drew a halt to the competition or the development of the simulators.

Now I start to forget precisely the dates, but I retired in late '83. I think my retirement papers showed actually January 3rd or 4th of '84. But after the Apollo missions and while we were developing the Shuttle mission simulator, I was promoted to the directorate staff. I still did Source Board work and still took a very active interest and role, of course, in the mission simulator and Shuttle mission simulator development.

I worked for four people in succession that I reported to that were outstanding people and I benefited by it. I mention them as both friends and people that helped me in my career. The first one, of course, that I worked for was Warren North, as a division chief. Then I became a division chief under Warren.

After a short period there, we reported to the director, who was Deke Slayton. Deke was, well, he was the kind of guy that would—he didn't mess a whole lot with what you were doing. He just told you what you had to do and he gave you a lot of freedom. He stood back, and if you messed up, you'd find out about it. But it was a way that most of the people that worked for him wanted to work, and he realized that, including the flight crews. That was always an interesting part. We went to all his staff meetings. More than once he reminded those flight crews, they'd get maybe complaining or crying a little bit, and he'd say, "Hey, this is an all-volunteer group. There's the door." [Laughter] And they got off of that pretty fast. If they didn't like something, he had to remind them that they were in there because they had volunteered, because there was plenty of guys waiting to step in if they'd have walked out that door. They knew darn well they were in a privileged position.

Likewise, his division chiefs, he gave us a whole lot of freedom. That was kind of him, yet he was respected at the center. I think Deke did a terrific job. He was director of flight crew operations. That was the same period and most of Apollo that Chris [Kraft] was director of flight operations, flight crew under Deke and flight operations under Chris. Those guys worked well together. …Later on Chris was director of the center, and Deke worked under him, and I still reported to Deke.

But then somewhere along the line, it was after Apollo, well, I guess when Deke got the assignment with Apollo-Soyuz, I moved ahead, a reorganization, and I moved to a new directorate. I moved to the Data Systems and Analysis Directorate. At that time it was under Bill [Howard W.] Tindall [Jr.]. Bill was probably the smartest engineer in what we were doing with [designing] the flights that I ever knew and ever worked with. I consider him a

friend. He was very…nice to me. I worked as an assistant under him, had various assignments, but I always learned from Bill. He was extremely focused on detail…

But that's probably the single most thing that I remember from Apollo, from Gemini all through Apollo, leading into Shuttle, that the leaders, Dr. [George M.] Low, Dr. [Robert R.] Gilruth and Dr. Kraft, [all] those people, and down through the directorates, were attentive to the detail. They knew a whole lot more than normally you would think that they needed to know to do their job, but that's what made them good. They knew the spacecraft, they knew the missions. They spent a lot of time with crew safety, as you would hope and expect them to do. That all turned out to be a large part of the success of the Apollo mission and Gemini, also.

Back to the people that I reported to directly. After Bill Tindall, I guess he retired at the time that Lyn [Lynwood C.] Dunseith took over. Lyn was a very good manager and director that I worked for. Then…for a short time…after Lyn also retired…I worked [for Jerry C. Bostick].

…When I retired, I was still assigned [as] the assistant director in the Data System [and] Analysis Directorate. I got to know, when I made the change from the flight crew ops to data systems analysis directorate, I'd worked with a lot of people in the MPAD, the Mission Planning and Analysis Division. We had worked with them in developing flight plans and what have you, but I learned to know a lot more of the people in that directorate, and [was] very impressed with the technical level and their dedication to making everything work as it needed to work.

So, again, back to the people. I got to know a lot more people as a result of that reassignment. I didn't want to do it at the time, but it really made the last few years of my job worthwhile. I made a lot of new friends and got a larger chance to participate in some of the missions. I didn't really participate, but I was over at the control center and they gave me

some headphones and I could listen in on those. That was a good ending to that career. I liked that, also.

I talked pretty long there, didn't I? [Laughter]

BUTLER: You were doing just fine.

WOODLING: You didn't ask any questions. [Laughter]

BUTLER: You were doing just fine. Well, I'll ask a couple now.

WOODLING: All right.

BUTLER: As you were starting out with Gemini or with Apollo or the Shuttle, you mentioned that you would sit down and talk to the systems people and go over the systems and find out what their specifications would be and such. How would you then build to where you could then sit down with the crews and do the simulations? How would you decide what problems would be most useful for them to test on? What would be the procedure, I guess, that you would work through?

WOODLING: There's quite a few steps that I didn't talk about there, but in between those, the flight crews were assigned to certain mission phases and certain parts of the spacecraft, too. Those people, through that interface, we got a lot of feedback through the flight crews, how they were defining or developing the spacecraft systems, and what we needed to include in the requirements for the simulation of those systems, through the flight crews. But we also got probably more of those requirements and how to operate the systems through the flight control people, because they were assigned by—their disciplines were [also] by spacecraft

systems or by mission phases, or through both. We needed their input and their expertise to end up with the right requirements for the simulators.

The program offices were involved in that they would, I think, mainly—well, maybe Apollo also, but I was going to say mainly in Gemini. But it got started in Gemini that the program offices ran [mission planning] under a senior individual. They would run rendezvous planning every week, or launch under Jerry [Jerome B.] Hammack, launch operations and procedures. Entry was—I forget who chaired those.

But that was a focal point where everyone would get together with the flight crews and ground controllers and our simulator people, and we'd decide on how we wanted to run that particular phase, whether the spacecraft system that was being developed could handle that phase. We would go off and define some of the malfunctions and run those by both flight crews and the flight controllers, whether they were sufficient. We were always changing those. We were always adding to that.

But through that process, the simulator was evolving along with the spacecraft and our capability, understanding of what missions we wanted to fly to build up this capability during Gemini and then Apollo that led to the lunar landing. So the process of development meetings or planning meetings, they were quite essential in keeping everybody together and doing the important things or the right things or the next things that were in line to be looked at.

Bill Tindall chaired one of those Gemini mission [phases], and he was known for his reporting and minutes keeping of those meetings by "Tindallgrams." You probably heard about that before, but he very accurately recorded all the arguments—not arguments, but discussions about pros and cons of doing things different ways. He did that weekly.

But there were others, like Barney [Wyendell Bernard] Evans, he may have had the entry one, but I think there was an entry, there was an ascent, or launch phase, and Bill's on-orbit phase, including rendezvous. Those were necessary meetings, and everybody realized

how important it was that we continued to operate that way. They led to the way we operated in Apollo mission [planning] and in building the capability [on] the ground to how we wanted to fly the missions and how the spacecraft ought to work.

So we benefited by that in that they drove our requirements, because we were always adding to, making something higher fidelity, or add to the capability to look at different simulations of different malfunctions. We depended on them and tried to go do the thing that we felt we could do best.

BUTLER: When you were running the simulations, were there ever any surprises that came up that would then result in changes being made either to the flight hardware or software or flight planning or anything like that?

WOODLING: In the check-out of the flight software, there were some things that we ran into there, probably not a big surprise, but about the same time there was a software development lab that IBM used to check out their flight software to a point where they said, "Now you guys can have it, and it looks fairly clean, and start using it. We're ready to make sure that the flight crew can work with it and there aren't any surprises from the interface with the flight crew."

A couple of times, and I don't remember the specifics, but we found some things when the flight crews got to using it, it didn't work as it should, or it didn't work as IBM expected it to, or the flight crews expected it to. So that was a double benefit, too. Then we'd go back and IBM would look at that and say, "You're right. That's something that shouldn't be that way." It needed to be corrected. They were always quite anxious to get to the point in their check-out where they'd turn it over to the mission simulators and the flight crew interface would be the next level of check-out with their flight software.

I can't remember any real surprises. We were very much concerned with a lot of questions about the makeup of the lunar surface before we landed with Apollo 11, and we were quite concerned that we had done an adequate job with that. Of course, it was a lot of people's guessing as to what the lunar surface was going to be and how it was going to look when we got close to it.

We had, from a landmark, or a landing site, information, we had some very accurate simulation out the window through digital simulation [that is incorrect, actually we used a scaled lunar surface model] of what the craters looked like, which ones they would key on for Neil's first lunar landing. Except for the dust, which we didn't have much of, I doubt if we had any, and for the first lunar landing, they said it looked very much like a simulator. So he [Neil] was pleased. Everybody was pleased about that.

We then incorporated the dust from…the descent engine, and added that to the visual simulation. We kept tuning our simulators. Of course, the more flights we had, the better we understood how things really were going to work.

We didn't simulate Apollo 13 too well. [Laughter] But after the explosion aboard the spacecraft, we got very much involved in that. We got Ken [Thomas K.] Mattingly [II] over there, who was originally assigned to that, and he was a good—I think that's well that it worked out that way, because he was on the ground in the simulators working with the lunar module and how it was supposed to work and the command module, rationing the systems and the consumables and figuring out with the flight control people how we ought to end up flying that mission to save that flight crew. He did an extremely good job. He did. Thank goodness we were able to provide him with some pretty good simulations of the mission and the systems. That was [a] rewarding flight after it was over.

BUTLER: Do you recall where you were, what you were doing, when you found out about the accident?

WOODLING: I was on a mission control loop. I had a speaker in my office, and I heard the first call that, "Houston, we have a problem." Then monitoring that conversation, I went over to the control center and stayed over there pretty much in one of the support rooms. I forget which one that was.

The guy that I need to mention that really ramrodded the simulator operation was a gentleman by the name of Stan [Stanley] Faber. From the simulator end, he was there a lot of hours. Things would come up where Ken would say, "Let's try this," or, "Are you certain of the simulation of the consumable? Is it accurate enough to phone up some procedures to the flight crews? Can we bank on that?" Of course, the flight controllers had a large say in that, too. But Stan did an outstanding job, along with quite a few other people on the ground for that mission. Getting that flight crew back was quite an achievement.

BUTLER: You mentioned that you hadn't done a simulation that exemplified what happened with Apollo 13, but would you ever have really even imagined that all of that could happen?

WOODLING: No, I think that the extent of that was—it was something that we probably wouldn't have even tried to come up with a simulation of that.

You know, Dr. [George M.] Low said the reason that we were successful in Apollo was that the [spacecraft] systems that we had were so forgiving. And that's right. They had been designed with the idea that if something went wrong, you still had a way out. One failure wouldn't end the mission or be a problem from crew safety standpoint. So the spacecraft were extremely well designed and they were able, with the flight crew, to live through malfunctions…we tried to make certain that one thing wouldn't get you. Well, what you worry about is the one thing that you didn't think about. But I don't think no matter how much planning and so forth, I don't believe that we would have thought that we could have

lost the complete service module capability, [a part of the] command module with it, and still live through that mission.

But the lunar module was a lifesaver and it was a lifeboat. What if that had happened on Apollo 8? We didn't have the lunar module, see. That's why that was such a gutsy call [for Apollo 8] and we were lucky through all the programs. We really were. The problems that hit us, hit us at a bad time, I mean, it was never a good time, but it was also something that we learned about.

The fire. Everybody regrouped. There were a lot of things that we did better after everybody going back through the Apollo hardware and looking at it, what was wrong, where we were headed. We were headed down some bad paths. So that fire, we probably wouldn't have succeeded if we continued the way we were before the fire. So we were very fortunate, with a lot of extremely dedicated people at the top that kept us focused on the right things, details.

Dr. Low said one other thing, he said the reason that we were successful in Apollo was not only the hardware and the spacecraft and the forgiving aspects of that, but also it was an extremely well-trained flight crew.

BUTLER: Absolutely.

WOODLING: And I was part of that, so that was rewarding.

BUTLER: Absolutely. That is very rewarding. They certainly did do a good job.

WOODLING: Well, thanks. It was a lot of good people.

BUTLER: A lot of people had to bring it all together.

WOODLING: Oh, yes.

BUTLER: Going back to Gemini, you mentioned the Gemini mission simulators and the dynamic crew procedure simulator. The Gemini also was doing a lot to train for EVAs. They had a lot of problems with the EVAs at first, not realizing the intricacies of working in microgravity.

WOODLING: Yes. That is a good point.

BUTLER: What did you work on there?

WOODLING: Probably very little from the actual training aspect. Under Warren North, and then later on [after] Dean [F.] Grimm became the division chief there, he had people in a mockup group and an EVA group. They were another main element in the crew training. With the help of full [scale] spacecraft mockups they would run through the EVA procedures, the foot restraints, and trying to get a better handle on the time lines. I guess, well, there was a real learning process in that, in EVA, too. I remember being pretty close to the EVA that Ed [Edward H.] White [II] and Jim [James A.] McDivitt did on—what was that, Gemini III, IV? Yes, that's right. That's right, IV.

We learned a lot from that, but one of the comments was that things took a lot longer [at zero-G] in doing than we had practiced or trained for. Just moving things around that seemed very easy in one G were difficult, keeping track of the umbilicals and the tethers, that I think indicated to us that we needed a better way with the underwater facility, to get into something that we could closely, more closely simulate zero G. That turned out to be a major step for the Apollo missions and the Shuttle missions. But most of those things for the

mockup designs and how we used them in training and development of the EVA procedures was under a different group or organization than my mission simulators. It was still under Deke Slayton, and under a gentleman by the name of Dean Grimm.

When they reorganized the Warren North division, we became three divisions, one under Jim [James W.] Bilodeau for procedures, mine was training, meaning mostly [the] mission simulators, and third one was—what was [the name of] Dean's division? Don't recall right now. But he had the full-scale mockups for EVA.

When Ed White flew, he used a jet gun that one of the guys that retired pretty early in a program, [Harold] Johnson, designed. That worked out real neat. That mission was one of the—are we running bad on time?

BUTLER: Well, we're getting close to changing the tape, but you could go ahead and finish this.

WOODLING: I just wanted to say there's three, I guess, really touch-and-go times that I think about when we were flying a mission, and the first one that I recall was the Gemini IV mission, where they couldn't get the hatch closed [after the EVA]. Couldn't very well simulate that, so the training there was minimum.

But with them in their pressure suits, Ed had just finished the EVA and they were trying to close the hatch, and the pressure suits were working against them trying to push them out, and McDivitt and Ed were trying to close the hatch. They were near exhausted. It was really, I think, if Ed hadn't been in the condition he was—and he was the strongest man that I ever knew. In his training, he was a real hard-training physical condition person, and if he hadn't been in the condition he was and as strong as he was, they would not have been able to close that hatch. Of course, that would have been really bad; we'd have lost both of them. That was the number-one flight that I remember.

The other flight during Gemini was Neil Armstrong when his thruster stuck and the spacecraft went out of control before he realized what was going on and he'd lost a lot of consumables in trying to arrest the rolling. The rolling rate, the motion rates got so high that he was hanging in there from a standpoint of knowing what was going on and thinking and being able to do anything about it. That was touch and go, and that was very close to have lost a flight crew and a mission, too.

BUTLER: Had his training been able to help with that?

WOODLING: Well, we were, as we should have been, closely scrutinized on that. We probably didn't run as good a simulation as we should have on a stuck thruster. We looked through all the records of how much training he'd had and it turned out to be probably minimum. He had some training in that area, but the fact that he didn't immediately recognize that he had a stuck thruster, and before the thing started getting out of control was an indication that we probably didn't do an adequate job there, and we accepted that. Thank goodness we lived through it and benefited by all that, although it was not too rewarding to know that we could have saved him a lot of anxiety and risked his safety.

BUTLER: He'd had enough other training to be able to keep his cool and figure out the right thing to do.

WOODLING: You bet.

BUTLER: Well, if we could go ahead and take a break here.

WOODLING: Sure.

BUTLER: We'll change the tape out.

Working in simulations, you worked very closely with the flight crews, and you had mentioned you'd like to maybe tell us a little bit about that and working with them and some of the astronauts and how that all went.

WOODLING: Yes, that was a fun part of our job always. They were so gung-ho of doing things, and always looking for new things to do and better things to do and ways to do their training better. So they were always adding to our training schedules, as well as they were very active in doing the flight planning. I had some flight planners in the early [Gemini] missions that worked for me under Tommy [W.] Holloway and those kind of people. The [flight crews] wanted to do much more in the flight than we initially would plan on. So it was good working with those people, because they kept you on your toes. They were quite good people from the standpoint of what made sense.

Of course, we'd bring up questions about crew safety, and that was foremost in their mind, too, although they seldom mentioned that, but they'd say, "Is that doable," or, "Does that make sense to you? Are we putting at risk anything that we shouldn't do unnecessarily?" And we'd make opinions on those.

I mentioned, I think, earlier that Gus [Grissom] was very critical—all the flight crews were critical [of] simulations, and that was to our benefit. We didn't like it at the time, the way some of them handled it, but when they were unhappy about something, they made it known to not only us, but to a lot of people. So a lot of people watched us, what we were doing. Again, that was good, because it kept our people moving and doing the right things and realizing that even though we probably were pretty good at what we were doing from the [past] experience, that we still could do better.

Gus told us one time that the simulators weren't worth a darn and if we didn't get on with it, why, he was going to go elsewhere for his mission simulator training. We said, "Well, I didn't think you could do that, Gus." But that didn't mean that we weren't thinking bad things there. I mean, we realized that we had to really improve them, had to come up with some things.

At that time that the simulators, when he was particularly unhappy, we couldn't run without having a computer interruption. We couldn't run a total entry, or we couldn't run a total mission phase without something bombing on the [simulation] computer end. Then, of course, we'd get all kind of phone calls as to when we'd have the simulator back up. Well, you know, that's guessing when your computer problem's going to be figured out. We weren't very definite on when we could do it. But he was probably one of the most vocal in criticizing the simulations, but yet very complimentary after mission simulations, after he flew Gemini there and everything went well from that standpoint.

One of the other fights that I think was certainly ironic, but I think about, was Jim [James A.] Lovell's flight on Apollo 13. For a number of reasons we changed mission schedules there real close to his mission [and] with Apollo 8. He didn't get a lot of malfunction training that he thought he ought to have, but yet he was confident of his flight crew. Then they changed a flight crew member; they changed out Mattingly with [John L. "Jack"] Swigert. I'm sure that bothered him from the continuity of the crew standpoint. But I talked to him down at the Cape maybe a couple days before his launch and I said, "How do you feel, Jim, about your training and your readiness?"

He said, "Well, we'll be okay if nothing goes wrong." And I thought about that when the accident occurred in mission. What could have been worse? He meant he didn't have a lot of backup training for systems not working the way they were supposed to and he couldn't assist the flight controller on the ground as to sorting through these things. Not in his wildest dreams would he ever have believed that he'd blow the back end out of the spacecraft. But,

man, I'll tell you. But Jim was a good commander and he was obviously a good pilot, and the other two guys on that mission worked to bring everybody back safely.

BUTLER: Did you talk to him about that afterwards?

WOODLING: Yes, I did, I mentioned that to him one time. I said, "Do you remember you said it'd be all right if nothing went wrong?" [Laughter] Oh, man, that was awful.

BUTLER: Well, luckily he did have enough. He might not have thought it at the time.

WOODLING: Let me tell you one other funny thing. It was kind of typical of the relationship that Deke had with his flight crew members. But we were talking in a staff meeting one time with—this is when Deke was the head of the astronaut office, while he was also—no, I guess, Tom Stafford might have been the head of the astronaut office at that time, but he [Deke] was director of flight crew ops. We were in a staff meeting of Deke's and we got talking about how we could better or more efficiently cycle the flight crews down at the Cape.

It was always kind of a difficult thing for us to send a flight crew down to the Cape, have them finish their training down there, from the standpoint of that was a lot of resources. They provided T-38s for them. Of course, they were available both in Houston and at the Cape, but also the simulators, that was a pretty big operation down there to provide that.

The flight crews liked it because they were down there, the phone calls tapered off to practically nothing, because they didn't have people calling them, like they did in Houston, and they liked that. They liked that isolation to concentrate completely on their final days of training down there.

So we were talking in this staff meeting about how we could provide an easier way for flight crews and Deke said, "Maybe we could get to the point where we suited everybody up here in Houston, had them train, all ready to go, and we even suited them up up here." Because the suiting facilities and the make-ready facilities were down there, too. He said, "Then just send them down there on a NASA airplane, have them walk off the airplane, get in the spacecraft and go."

Halfway through that conversation, Tom walked in and he had his "white scarf" on and he'd just come back from a [T-38] flight and those guys were—at heart they were jocks. But he comes in and he hears this conversation, fly down, suit up, load on, walk off the airplane, get in the spacecraft and blast off. He says, "Who in the hell came up with that weird idea?" He was about to sit down, he was in the process, Tom was, and Deke says, "That's my idea," and Tom never sat down. He stood up and he says, "Think I'll go out and come in again, Deke." [Laughter] Deke said, "That's probably a wise idea, Tom." [Laughter] He never came back in. He went out and Deke said, "Well, I guess that's enough on that subject." I said, "Yes, I think you better line up your lieutenants there, they're not thinking like you are." He said, "Well, it was kind of a stretch on a funny idea." Everybody agreed with him that that was right. But Tom went, "Whoa, your idea?" [Laughter] They all had different personalities. Very nice.

BUTLER: They used to work together pretty well?

WOODLING: Oh, yes. There was difficult times, but those people I think kept the program running, because they were as interested as anybody, obviously, in making it successful.

BUTLER: Having talked about your relationship with the flight crews, how about your relationship with the flight controllers and working with them in the simulations? You

mentioned that the flight crews said that when they came back that things were pretty realistic.

WOODLING: Yes.

BUTLER: What was the flight controllers' relationship?

WOODLING: Real good. I would say that during the Apollo program when we got into all the simulations with the flight controllers and the flight crews and our simulators, I would say that that whole relationship improved immeasurably. We realized our training instructors and our people that wrote the specs for the simulators and had to do the upgrading through all the flights, they realized what benefit those flight controllers would have. They were very good systems people and procedures people. I mean, they knew how to—had to know, were directed to know how they were going to use the systems and how the systems would operate both in a nominal way and in problems, how they would work if there were malfunctions.

So I would say that my people finally realized there was a degree of competitiveness there, I think—well, I'm sure there was—about maybe even how a system worked, and that our simulation was correct and maybe the other people didn't realize something about how the system worked. But that whole relationship improved immeasurably over the Apollo program. Going into the Shuttle, why, it was very good. That turned out to be a very good team effort.

IBM was an integral part of it because they had a large part of how well our simulation was going to work out with the flight software and the flight computers. But we, in turn, provided them with a lot of insight into how that—when somebody starts working with their flight computers, why, you know what things you might get into.

Let me digress. [Charles] Pete Conrad, one time, we were giving him some elementary insights into the Apollo program, and they were in the process of flying some of the Gemini flights. It may have been early in the Gemini program. But anyhow, Conrad was on board and I think he probably already had an assignment, but we told them that the flight computers in Apollo were going to be the actual flight computers and the computer itself, in case they hadn't already had the time to look at it, the Apollo flight computers, was quite different than the Gemini flight on-board computer. The on-board Gemini computer wouldn't tell you anything unless you [tell it, and wouldn't tell you anything unless you asked it.] [Laughter] …[Pete] ended up by saying, "That sounds like my wife." The Apollo computers were entirely different.

BUTLER: I hope he never told her that. [Laughter]

WOODLING: No. I'm sure about that.

BUTLER: Quite a character.

WOODLING: Yes, he was quite a character.

BUTLER: The transition from Gemini to Apollo, you mentioned that the computers were different, and of course, you're going to multi-vehicle spacecraft and so forth, and you mentioned earlier to try and get the simulator up to speed. Were there any major changes that as you were making that transition that either you hadn't anticipated or that caused any difficulties in transitioning from Gemini to Apollo in the training and simulation aspect?

WOODLING: I guess to answer that question, one of our biggest challenges in Apollo was creating the out-the-window scenes with the large amount of infinity optics and the importance of the out-the-window for scenes, not only on lunar landing, but for on-orbit operations, rendezvous and docking with the lunar module. The out-the-window scenes were very important and key. I mean, it was something that the manned part of the missions were going to use to make certain that everything was going right and that that was real, and what I'm seeing feeds into his other sensors and information of the on-board systems and how they were operating.

So to provide that, yes, that was an order of magnitude. We had out-the-window simulations for Gemini, but it was a minimal kind of thing. But it—we learned from those simulations, as well, to give us some leg-up into Apollo, but it was an order of magnitude higher. The stars had to be simulated, the images of the spacecraft. We used models for lunar module and integrated those in with star backgrounds and horizon Earth backgrounds and then the lunar landing part of the lunar module simulator. At a period of time I would say that that probably paced our simulator development [and checkout] more so than anything else.

I don't recall that [we, the simulators,] ever caused a space launch delay. We had some that we wished we'd have had the simulator up earlier so that they could have logged their plan, preplanned hours earlier. Like Lovell's, in his case, why, he wished he'd had more time and our simulator would have been available more time so we could have covered more spacecraft malfunctions. But I think, yes, the visual simulation that was moving up into Apollo from Gemini was a big challenge.

It probably didn't occur to you, but on the command module simulator we had, those were motion bases. So we had the large window simulators also that had to survive the motion simulation. So they were rugged as well as being optically correct, you know. So there was quite a high set of requirements for those windows. The people, Stan Faber, again,

along with a couple of other people, were very instrumental in making sure that all went right, went together right. Good man. Good engineer, Stan.

BUTLER: Sounds like it.

WOODLING: [Richard G.] Dick Snyder was another one. Did you talk to him, by the way?

BUTLER: No, not yet.

WOODLING: I'm not sure of his whereabouts. Dick was an assistant to Stan in mission simulations. When I retired, he was at headquarters, so you might start there if you're interested to know his whereabouts.

BUTLER: Sure. We're always interested in adding to our projects and always looking for new people who are interested in participating. We depend on you guys a lot to tell us.

WOODLING: Have you talked with Tommy Holloway yet?

BUTLER: Not about the early days. We did talk to him in conjunction with the Shuttle-Mir project [International Space Station Phase I], I believe.

WOODLING: Oh, yes. Great man.

BUTLER: Yes, we'd like to go back and talk to him some more about these days.

WOODLING: I bet he'd like to do that.

BUTLER: I'm sure he would. You mentioned the visuals and the pictures for the landing. Were you involved with the lunar landing training vehicle at all?

WOODLING: Not really. We followed that pretty closely. Our training coordinators would schedule the crew's time on it and so forth. I got a little bit more interested in it after Neil had to bail out of the one out at Ellington [Field, Houston, Texas], and I watched quite a few of those flights. I had some good friends that worked out there at Ellington and worked on that project. But on the support of it or the mission control or anything like that, no, we did not.

I take that back. We had an LLTV [Lunar Landing Training Vehicle] simulator that we provided, sure enough, under Wayne [K.] Williams. We ran that as long as they were flying LLTVs, that's correct. I'd forgotten about that. That was an almost oversight. It was a fair simulation of it [the LLTV mission task and dynamics]. It was a kind of a minimum simulation [from the standpoint of the LLTV instrumentation], but we had to simulate the lunar rocket [motor] that took up [five-sixths] of the G of the spacecraft and then [correctly simulated the dynamics] when it went into a lunar mode. So we simulated that, the [operation and dynamic] environment [of the LLTV] in our training vehicle [simulator]. I think it was useful. There was a certain number of hours required on that [simulator] before they flew the actual vehicle.

BUTLER: From what we've seen, it was a useful thing, although it was challenge.

WOODLING: Yes, boy, I'll tell you, that was challenged quite a few times on why we'd taken these risks to fly that. The flight crews wouldn't let go of it, from Deke on down. They just

thought it was the best training you'd get of the final lunar touchdown, landing touchdown, as you could get, and I think that turned out to be the case. It was quite useful.

BUTLER: Well, luckily everything did go okay.

WOODLING: Oh, my gosh. Yes, Joe [Joseph S. Algranti] bailed out of one of those and then Neil. We had some close calls, too. Jim Lovell shut down the descent engine. He was about, I guess, around nine feet off the ground, and so it set it down pretty hard. Another one of Jim's "I hope nothing goes wrong." [Laughter]

BUTLER: He had a few problems here and there. [Laughter]

You mentioned that for Apollo 13 you had been listening to the command loops. Did you do that for most missions throughout both Gemini and Apollo?

WOODLING: Yes, starting off in the ascent phase, I was in my office. I regretted a little bit that when the guys were flying Gemini or flying Apollo, we were working on simulators for the next big program, so very few of us could really take time out of our schedule. We didn't feel right about taking time and going over to the control center and monitoring the flights that closely. We didn't have an assigned task over there, so it would have been just kind of an interest sort of thing and keeping in touch with what was going on. So the ascent phases of most of those.

Now, I saw a lot of Apollo launches. I never have figured out how many of those, but I saw quite a few of the Apollo launches [at the Cape]. In the early part of the mission, when I'd get back to Houston, why, I could monitor those in the command loop there. But a lot of the missions, also, after the launch, why, I'd be over in the control center. I could talk with the flight controllers. Jim [James C.] Stokes' [Jr.] flight control division people, who treated

me nicely, figured I needed a headset, said, "Keep your hands off the console and don't open your mike." I said, "I won't do any of those." [Laughter] And that was fun. Hearing those missions flown first-hand over those ground loops was just absolutely amazing.

BUTLER: Did you get to listen to Apollo 11 that way?

WOODLING: Yes, absolutely thrilling. Couldn't believe it. My mother, I think this is accurate, of course, we'll never know, but I think she died thinking that we staged all that. She was not convinced we landed on the moon. I told her, I said, "Would I lie to you?" I said, "We actually did that." She says, "No." But there were other people than my mother that believed that, that that was not for real. But it was hard being there at the time of imagining what was going on, and then how close we came to blowing off that landing, and working [the problems] through, having the people with the right savvy on the ground to work with the flight crew and saying, "Press on and go ahead and land," and then doing it successfully. All the hardware worked as designed and bringing them back. Great times. Absolutely. Biggest thing of my lifetime.

BUTLER: It must have been quite an experience.

WOODLING: Oh, yes.

BUTLER: Good to know that all that training that the crews had had, the flight crews and the controllers, than even when they did have these problems and what would happen, that they were still able to make the landing.

WOODLING: You bet. You bet.

BUTLER: As the Apollo program was coming to an end, did you think about it much at the time that here was the end of going to the moon, and the end of all this excitement that you had all had working on for so many years, or were you ready to move on to the next program?

WOODLING: I think we were ready. It cleaned up a lot of the uncertainties that we had from the standpoint of do we need more mission simulators. We'd gone through those tradeoffs earlier, so when we realized that the program was coming to an end, why, we were already very hard at work on the Shuttle mission simulators. But we could put all our resources towards that and see what we would salvage from the Apollo program as far as hardware, simulation hardware, and how quickly we could get into some pretty good simulations of the Shuttle mission…, get our people involved with writing the new specifications, working with the flight controllers again. We had already started a lot of that, but it cleared the air. I don't think our group thought a lot about—we were sad to see the program terminate, but we thought it was about time, I believe, because of how it left us with more certainty as to what we did next.

With terminating Apollo, though, our Shuttle mission simulators all of a sudden got a lot more attention. They say, "Where are you? Well, you're not as far along as you ought to be." We took a lot of heat there, as we should have, because we weren't moving. We were always in the position—this is a fact, not a very good excuse—of trying to simulate or write down on paper how the systems were going to operate before they had tested a lot of systems. Furthermore, even more difficult was how you were going to use those systems, writing crew operational procedures for those systems, before we flew anything.

So we were trying to write early requirements on the simulators before we really knew what they were. So it had to be good people sitting down thinking about this is how

they [the spacecraft systems] need to operate for the mission or the program to be successful, and we were able to feed back a lot of that information. I think it [this process] influenced not the basic design, certainly, but how if certain systems had problems or they didn't have the test data to validate that they were properly designed…

Simulations, obviously, they're only as good as the people that writing the software can make them, and then if those people haven't taken inputs from a lot of different people, why, they end up pretty shabby simulations. But [we] had a lot of help. It may not have been easy or asked for help at the time, [however] everybody offered in the right way. I hope we took it in the right way, I think.

BUTLER: It must have been quite a challenge because the Shuttle was so young at that point, and yet here you were trying to figure out how to make it work and begin training on it.

WOODLING: Yes. One problem we didn't anticipate as well as we should have was the landing of the Shuttle, the power-off dead-stick landing and the steep descent prior to that. [Jack R.] Lousma got into a problem of a PIO, pilot-induced oscillation, in the final phases of when he flew during the early Shuttle test. It wasn't a new [aerodynamics] problem. A lot of airplanes, when you [encounter] the ground effects…close to the ground [during] your touchdown, why, you get into a critical part of the landing [trying to make] sure that you anticipate…the dynamics the best you know [them] and don't aggravate those [dynamics with] wrong inputs…of your own…a pilot-induced oscillation.

Lousma had a very critical phase of that landing where it [the Shuttle Orbiter] had touched down and then it took off, and it looked like it was going to be airborne again, and they made the final touchdown. But he was getting into a pretty good dynamics problem there, [however he] was able to get through that. Our simulation wasn't up to snuff on that. We added quite a bit of the ground effects factors to our simulation, we were able to repeat

the problem that he encountered. They were using the Shuttle Training Aircraft also [for training in this critical area]. I guess that maybe [the STA] was a little bit [later]—no, they had at least one airplane configured for that.

I used to like to go out [to] Joe Algranti in aircraft ops [in Ellington Field] and talk to those people, both on the LLTV and the Shuttle training aircraft. I've got a lot of longtime friends out there. Joe was always nice to me, too. [Laughter]

BUTLER: That's always good.

WOODLING: Yes. Have you interviewed him?

BUTLER: We have. We have interviewed him.

WOODLING: I didn't know he was in town. Shucks.

BUTLER: Well, he's not in town.

WOODLING: Oh, you had to go there?

BUTLER: Yes, North Carolina, in fact.

WOODLING: Well, that little sucker, he wouldn't come here?

BUTLER: Well—

WOODLING: You don't mind?

BUTLER: Yes, we don't mind. It gives us the chance to see places we haven't seen before.

WOODLING: Yes, I'll be darned.

BUTLER: Sometimes it's easier for us to go and other times it's easier for people to come here.

WOODLING: Isn't he a neat guy?

BUTLER: Very. Very neat.

WOODLING: Gracious man. I think he started at [Lewis Research Center, Cleveland, Ohio], too, if I'm not wrong. He and Warren North, I think they were both. But I've known Joe [for sometime]—when I was on the X-15 program I met Joe, and then [later] when he was running aircraft ops down here, when I came to Johnson, I had quite a few associations with him, and really good.

BUTLER: That's good.

Actually, jumping back a step to Skylab, were you involved in any simulations or training after they had launched Skylab and they had the problems, the heat shield and the solar panel? Were you involved in any of that?

WOODLING: We provided some of the—see, our simulator, the Skylab's simulator that we had was more how to activate, was used to activate the systems and then deactivate when they were getting ready to leave. But I would say that the bulk of the training of on-orbit

operations and experiments and this heat shield thing that you mentioned and the solar panels and what have you, that was done in the full-scale mockups that were under Lou [Ludie G.] Richards and Dean Grimm as a division chief. We were aware and kept in touch with what was going on there, and made sure that if we ought to be doing something to our part of the ground simulations, that we would fill that square. I would say that the majority of that was done in the mockups, in the redesign of the solar umbrella or whatever, to fix that problem. That was done over in the mockups. Jack [A.] Kinzler was very much involved in that. Good man.

BUTLER: We've been fortunate enough to talk to him, too.

WOODLING: I'll bet he was a gracious man, too.

BUTLER: Very much so. Very much so.

Looking at Apollo-Soyuz, you mentioned that a little bit, and, of course, you've talked about Deke Slayton. It must have been rewarding to see him finally get a chance to fly.

WOODLING: Yes, it was. His whole outlook in life changed. [Laughter] He was so glad to get a flight.

BUTLER: That's great. What was your involvement in the training for that? What were the challenges of training?

WOODLING: Just from the command module operation standpoint. We had the Apollo-Soyuz model in the simulator so we could train for the docking with it. Then the mockup guys would do the transfers and the walk-throughs for the EVAs, for the crew transfers and

that combined operation. I got to meet the Russian crew. Let's see, I guess I met both of them. That was good, too, Deke trying to talk in Russian. They were much better at talking English than our crews were at talking Russian, although Tom Stafford got pretty darn good. He was very good at it. Deke, I shouldn't say he didn't never master it, but— [Laughter]

BUTLER: Well, it's certainly a challenging language.

WOODLING: Deke never tried to fool you. Deke, he was just as straight with you in anything he did. If that was beyond him, why, he'd tell you. But he loved to fly. Well, all those guys loved to fly, but Deke just—when he didn't get assigned to that Mercury mission, that was a tough thing to swallow. Then he worked all through Gemini and they wouldn't give him a flight assignment, and he worked and worked on that, and he finally got a flight assignment.

Then also, Al [Alan B.] Shepard, I think about that, too, because he was grounded because of his ear problem. Then that finally got resolved to the point where—and Deke was very instrumental in getting him assigned a lunar landing mission, and he did good. Al was great, a great pilot.

That first seven—this is bad, I shouldn't do that. The first seven and the second nine were all great pilots. The third group was 16, and they were good, too. We lost a few of those guys, Elliott [M.] See [Jr.] and Charlie [Charles A.] Bassett [II]. Ted [Theodore C.] Freeman ran into a goose at Ellington. C. C. [Clifton C.] Williams [Jr.] was also killed. That was a flight control problem with his aircraft, control surface problem.

I guess that was my attraction to those guys, that they were truly professionals before they came into the program, and flyers, and also most of them, especially through the first thirty, had great engineering credentials. [James A.] McDivitt, Elliott See was real strong in [engineering] background. They were experts in their fields from a technical standpoint and they were some of the greatest test pilots that ever flew. So being around those kind of

people was special. That was a great point in my professional life. How could that ever happen, you know? [Laughter] I just fell into that, see.

When I came to Houston I wasn't planning—I was probably going to end up in the—even though I'd worked on the X-15 simulations, why, North put me in a crew procedures development group, which was interesting, backup crew procedures. But I forget [exactly] how things worked out there, but it was shortly after we came to Houston that he asked whether I wanted to take over as assistant chief for simulations. I said, "Warren, I don't know anything about that. You're getting into a phase for Apollo mission simulations where you're going to have to design those simulator specs and work with trainer [manufacturing] people or the Link people," or whoever we thought was going to win that. I said, "I don't have any background for that." He said, "Oh, you can do that." So he was a real motivator and encouragement for that, and it was the best thing that I could have done from my interest, you know. So things have a way of working out.

BUTLER: That they do. That they do.

When you retired from NASA, did you go on to work more in other areas?

WOODLING: Right after I retired, I worked for Ford Aerospace. They were in the process of bidding on the Space Transportation System Operations [Contract], STSOC. I helped write the RFP—[rather] the proposal to the NASA RFP [request for proposal], primarily in the simulator area. So they took me on board, a very, very nice position they gave me, and we worked on that contract, which we didn't win. Rockwell [International Corporation] won that. But we thought we had a good team. I forget who we were teamed with. But Ford was the primary there.

After we didn't win that contract, why, I really retired for, I guess, about a year and a half. In that time period we moved out of Friendswood, had a couple of floods and decided that we didn't want any more floods, so we moved up to East Texas on a hill.

BUTLER: Good way to avoid that. [Laughter]

WOODLING: My son had graduated from University of [Houston] Clear Lake in electro optics and he got a job with Eagle Engineering. I knew most of the people at Eagle. I knew Bass Redd, Barney Evans. So my son called me one day and said, "Bass wants to know whether you'd be interested in working at Eagle."

I said, "Well, if you'd put in a good word for me, I might consider that." [Laughter]

He said, "Well, I haven't said anything bad about you." This is my son answering.

I said, "Well, I'll call Bass. I don't need to put you in the middle."

He said, "Well, if you want me to talk about you, why, I will."

I said, "That's all right."

But I called Bass and I said, "Did you really mention to Steve, my son, that maybe I could work for Eagle Engineering?"

He said, "Yes, I did."

I said, "I thought maybe he was making that up, because he hated to see me doing nothing at home." [Laughter]

Bass said, "Why don't you come in and talk to us."

So I did that, and I started working for them, and I must have worked for them for about a year and a half. I don't remember that either. I retired, I don't remember when. Don't remember those dates. But I thoroughly enjoyed that. Gee, that was a good time, too.

I liked my time at Ford Aerospace right after I quit NASA. The work, even though I was fairly knowledgeable in what I was doing, because it was what I'd been doing at NASA,

but I didn't like the idea of writing proposals essentially. I understood quite a bit of the Source Evaluation Board operation because I'd been chairman of a couple of a Source Evaluation Boards. That was another reason that they'd asked me to work there, so I was able to give them some insight into that. I think that that helped us. We didn't win the contract, and I understood how those things work. There's a lot of considerations that go into the selection of those people, and Rockwell has done a fine job since they got that operations contract, and moved on to bigger and better contracts. So I couldn't argue with that decision.

But then when I worked for Eagle, it was back to some of the old times, because I got a lot of different kinds of jobs, helping people in areas that I sought out and suggested to Bass, that we ought to be working in. I got to work with a lot of the people that I worked with over at the center, Bass and Barney Evans and Charlie [Charles R.] Haines from aircraft ops.

Jim Bilodeau was over there [at Eagle] at that time. Jim Bilodeau, I missed him when I talked about my old bosses. When I came to Houston, he was my branch chief, and then he reported to Warren. Jim—gee, it would have been a real oversight, because Jim helped me immeasurably. He and his wife, we were very good friends socially. Great man. Did you interview him?

BUTLER: We haven't talked to him yet, but we would like to talk to him soon, hopefully.

WOODLING: I think you should. I think you'd enjoy that. Jim, he's quite a character.

BUTLER: We'll look forward to it, then.

WOODLING: Yes. Yes, I owe a lot of thanks in my career to him.

After I quit Eagle, and I'm sorry I don't remember what those dates were, but that was the last time. My wife was still working for Enron Gas and Oil in Houston, for, I guess, four or five months, something like that, but then she planned to retire and did retire at the end of the year. I can't remember what that date was. '87, I think.

Then about that time we moved up to Houston County Lake, up near Crockett, where we are now. We settled into a small house when we first moved, but then got a larger house, have been very happy up there. Been in good health, thank goodness, for both of us.

BUTLER: That's very good. Good to hear.

WOODLING: Thank you. This is a good time recalling a lot of those old things. I thought it would be fun and it was.

BUTLER: Good. I'm glad you enjoyed it. It's been fun for us, too.

WOODLING: Well, good.

BUTLER: Just a couple last things and then we can finish up, if that's all right.

WOODLING: You bet.

BUTLER: Looking back over your career with NASA, what do you consider your biggest challenge?

WOODLING: Well, you know, I think I always felt somewhat limited with my physics degree, because most of the people I worked with were engineers, and that was always a challenge to

me to understand operation of, say, spacecraft systems or the simulator systems as well as I wanted to. I always thought, gee, with a better engineering background out of school, I would have been able to do a much better job there.

I started at William and Mary with the idea of going three years. I was not aware of the school until I got in my senior year of high school, and it was 1946 when I graduated from high school. A lot of the veterans were coming back, going to school, so nobody had any openings. I didn't think I was going. I had a pretty good summer job and I'd almost talked myself into working at a steel factory up there in my little hometown. But I was always interested in engineering and I had my sights set on that.

I found this little school at William and Mary that had a program in conjunction with MIT [Massachusetts Institute of Technology], where you could go three years at William and Mary and then two years at MIT, and get a double degree, one in physics from William and Mary and a degree in engineering from MIT. I thought [this] would really be great. That's the program I started on. I could have gone on to MIT in my third year [rather] for my fourth year, after I completed three years, but the money was kind of scarce, and then I got involved with that girl and thought I was in love, you know.

So I said, "No, what the heck, I'll finish my degree in physics." I almost had enough credits at that time. I said, "But what am I going to do?" I [changed] from engineering to teaching. My mother and dad weren't too happy about that, but they thought if that's what I decided to do. So I changed girlfriends, by the way, at the end of three years. I don't know why, I should have gone back to my original plan to go to MIT, right, because I lost that excuse.

But I finished up at William and Mary and appreciate the education I got from them, but I think the limitation of not having an engineering background and training there, I always thought that that was [limiting]—I admired the engineers I worked with. Not only that they were more rational or had a lot more, it seemed to me, common sense, but that they

were able to look at problems and understand what the solutions were better than I could do. I had to stand back and do more directing than participating in those kind of things, and it didn't always please me. So, yes, that was one thing.

I think as far as organizations that I was allowed to work with, or maybe head up, why, I was given every opportunity. As I said before, the people I reported to were very supportive, very willing to help me with the difficulties that we had, the assignments that I drew. The people from the director's office, they were quite supportive, again, of what I did. So I had a good relationship with them and my bosses. I can't say enough for that. That was just an opportunity that came at the right time, and hopefully I made the best of it.

BUTLER: Certainly seems like you did pretty well. What would you say would be your most significant accomplishment or contribution to the program?

WOODLING: Well, I think it was in simulator development, I think in defining what we wanted to do or needed to do to accomplish there and then to be able to pull it off and then seeing all the results of that through Apollo, the first Apollo landing, especially. I'd like to think that I contributed to that, because it was very rewarding. So it had to be in the simulator area. That was from my perspective.

BUTLER: You certainly had a lot to contribute.

WOODLING: Had a lot of good help.

BUTLER: That's great. Well, I'll ask Kevin and Rob real briefly if they have any questions as we tie off here.

WOODLING: Sure.

BUTLER: Kevin?

RUSNAK: Yes, I had a couple. First of all, I was thinking about the Apollo simulations and I was wondering if you could maybe kind of run us through one of those, like when you go to do a sim with a crew, like an integrated sim with the mission control, who's doing what? I mean, what are you and your people responsible for, and the simulation supervisor, working in the control center, that type of thing. I was wondering if you could just kind of take us through a generic run of one of those.

WOODLING: Yes, I can do that. During Apollo, the training instructors were part of my organization, the guy that operated the consoles and inserted the faults. I say insert the faults, system faults. Those were preplanned, and we got together with the mission control people what particular training scenario we would run on any given day.

But the simulator people would come in a couple hours early, make sure we were doing maintenance. We were operating those things on a twenty-four-hour basis. We were doing the maintenance during the off hours, and then during the regular two shifts during the day, we'd operate the two shifts training most of the time. But on an integrated mission with the control center, on those days we'd make sure about two hours before the liftoff time we were ready and had the right people there and that we had also simulator maintenance people standing by in case we ran into problems or shut down, that we could try to get back up as soon as possible within the continuity of a good training session.

A lot of time[s] we would, early [in the Apollo program], in trying to bring these things up to a level of proficiency, we would really bomb out and the flight crews would have to get out, and they were unhappy about that, and nobody was happy about that. But on

a good day, why, we'd have the mission simulator ready and all integrated with the control center and our times all synchronized and everything.

Then we'd get on to a final-type mission plan, because we used the mission plan and the flight plan that the flight crew for the thing that we were going to train on. You realize it was a check-out of that flight plan, too, because we were going to run everything by the letter and test the flight crew readiness and the ground controller readiness and all the computers at mission control, and at our end, the flight computers in the mission simulator. So that was key to our training and everybody looked at it in that way. The flight crews realized that everybody had to be at their best performance to carry that thing out. I mean, it was a check on how ready they were, too. So it was serious business.

But we'd run a launch with the mission simulator. Training for [Apollo] 11, for example, there would be a period there where we'd change from the command module simulator after we got on orbit and did the on-orbit maneuvers and then the rendezvous with the lunar module. Then the flight crew would get out of the command module simulator, transfer over to the lunar module, or two of them did. The command module pilot would stay in the command module simulator. So now we [had] both simulators hooked in. All the communications [protocol] and flight plan, we were still following [like for the real mission].

If you got that far in the simulations to where something didn't come [up regarding] an inserted problem, you know, to discontinue the mission and do an abort…or whatever, we would continue on. We could run a nominal mission all the way going into [lunar] orbit with the lunar scene out there, the flight crews, two guys in the lunar module, and go through the lunar landing with all the calls from mission control and do the landing.

Then we would skip most of the surface operations, because that was handled as a separate training, as I recall. Certainly for [Apollo] 11, which was a short time on the lunar surface, we'd pick up again with the integrated missions combination when they were preparing for counting down the ascent off the lunar surface. We'd pick that up and insert

back in[to] the lunar orbit, [rendezvous with the command module,] and then back into the Earth return trajectory…

So they were long, for most of them, except for the time on the lunar surface, it was all done and you'd hope, if you did it for a nominal mission plan, without a lot of malfunctions being inserted, it would take the same amount of time as it was all run in real time. So it was quite a demand on the simulations and everybody else, but it was going to be the easiest thing you got to do, because the real one was going to be more difficult. You'd get into some unknowns that we hadn't thought about and maybe things not working quite like they were supposed to, or we thought they would.

But I had working under me the training [supervisor], initially…[at least], I think, early in the Apollo program, the training supervisor, what we called him, our simulation supervisor, he was out of my group. …For Shuttle we changed, I know for Shuttle, we changed over to where that man was assigned out of the mission control area or the ground control group. But the training people that worked the consoles and recorders and all the data collection from flight crew activities and how they worked through problems and spacecraft systems operation, how the consumables were used, that was all the part of our responsibility.

On site, during the simulation, we had IBM people that supported us on how the [onboard flight] computers were working, and if something developed with the computers that they could assist our simulator people, [they were there]. Of course, IBM directly supported the mission control people from a flight control end, too, so they were directly involved [as a] necessary group that supported those, too.

In those all-up mission simulations, integrated mission simulations, Rockwell or North American had their people there like they would in the support rooms in the actual flight. That was a good check-out of the whole operation. We were much better off doing

those [comprehensive sims] than if we hadn't pressed to get to the point where they were as complete and as high-fidelity as they were.

RUSNAK: Well, certainly you received high marks from the crews. You mentioned a couple instances where, I guess, your area had been criticized for not giving quite enough training on one particular area, or whatever, [unclear]. Who decided what failures to put in there and how did they do that?

WOODLING: That was a combined effort with the flight control systems people. Also, most of the time I left [some people] out, I did not give due credit to the E&D [Engineering and Develpoment] people who were the system engineers [working] with the manufacturer on those systems. But they participated on [system] malfunctions and suggested to our Configuration Board, Simulation Configuration Board, along with the flight control people, and also the astronauts themselves had a lot of say in, "Hey, what if we run into something where it doesn't work that way?" Or, "Have you considered the fact that this propulsion system or something else, [or] computer might not work that way? Have you considered a malfunction along certain lines?" And we'd accept their inputs, too.

That was difficult. That was an always-changing [environment]—we always had more requirements that we could accommodate, because people, in their sincere interest and in their particular area, wanted to do make sure that nothing was overlooked. We always had a lot of things that we wanted to do and had on our list to incorporate. We had to prioritize a lot of that stuff and saying, "Let's make sure we don't overlook the real things that might grab you here and be a serious impact on safety."

So, yes, that was not an easy thing to kind of track, because we had a lot of people making inputs there. The other part of that is that we had to take those inputs and estimate the impact on the simulator. How much check-out time? Do we have the software capacity

to do it? Do we have to trade it off with some other things that we have in there that we haven't been using? How important is it to the training? That was feedback to the person that had suggested it, saying, "We don't really think we can do that at this time."

That was a give-and-[take] thing, too, because they would maybe initially say, "Well, I understand you can't do it." The more…information that they got [from system tests], or if they felt strongly about it, why, they'd come back to the Simulator Board and argue their case again. So there was a lot of compromising and a lot of trying to put the proper priorities to the things that we were trying to accomplish together.

The configuration control [of] the simulators, were a large part of our business, trying to keep track of what we could do and how long it would take to do it, and making sure that we were in tune with the mission objectives to be able to do that.

RUSNAK: Yesterday we were talking with John [W.] Aaron, as I think we mentioned before, and, of course, one of his career highlights as the lightning strike on Apollo 12, where he made the call. He mentioned, of course, that that wasn't something that anyone had thought to simulate.

WOODLING: Amen. Amen. I was out at the Cape and saw that one. That was eerie. That was almost like "X-Files." [Laughter] That thing, yes, it disappeared [into the clouds after a] very nominal-type liftoff, and, of course, those things are pretty—a lot of emotions running through you, anyhow, but that thing disappeared in the clouds and then all of a sudden "crack." And right away I think most people realized what had happened. I mean, the lightning came off the spacecraft and hit the ground. And knowing what that kind of a strike would do to electronics and computers, nobody wanted to say anything. It was deathly quiet, still for, still the roar of the—thank goodness that didn't stop. If that had stopped, why, people would have been running all over.

But, yes, that was a very exciting time. How lucky we were that the people took the recovery actions that they did. Some of the recovery actions were doing nothing and it all worked out right. I remember the debriefing with Conrad and Al [Alan L.] Bean, and he was telling management [what] they were going through [at] that time, and Al Bean said, "We got all these flashes and—"—no, Pete was talking. He said, "We got all these flashes on all the dials hitting stops and we heard the crack and we didn't do anything."

Al Bean says, "Well, I knew I had to do something, but I was afraid to do anything."

[Pete] said, "You did exactly the right thing."

Bean says, "No, Pete, I should have taken better action."

He says, "You couldn't have done anything better than to just sit there on your hand."

Bean finally got to realize[s] that what he did was probably the best thing he could have done, because if he'd have started throwing [switches], getting ready for abort or whatever, it would have probably been the wrong thing. Certainly been the wrong thing from the mission standpoint, because they went on to fly an excellent mission. But it would have put them in [an abort]—aborts are never easy. That's the last problem you want to go through. Bailing out is—you never want to get to the point where you've absolutely got to bail out. Your chute might not work either. That's a bad day [already] when you get to that point.

I was down there at the launch and it was, boy, it was eerie.

RUSNAK: I can only imagine.

WOODLING: Oh, gee whiz. The whole program got more serious about launching during thunderstorms and how to predict lightning. It was a good lesson that thankfully we lived through.

RUSNAK: He was saying that actually as a result of an accident in one of these simulations that he had seen his displays before that there was a low-power situation at one of the Cape simulators that caused his displays to do exactly what they did during the lightning strike, and just because he had been on console a year earlier when that happened, he recognized that and was able to take the proper actions.

WOODLING: Standby, [at least for the flight crew].

RUSNAK: Yes.

WOODLING: Good point.

RUSNAK: Yes, and do the SCE, the auxs, or whatever, just do the Signal Conditioning Equipment because of this simulation that had been run.

WOODLING: See, we always thought we caused a lot of problems when our simulator bombed. We didn't realize that somebody was getting some benefit from that.

RUSNAK: Yes, because of that he was able to make the right call within seconds.

WOODLING: Great. Hey, that's good.

RUSNAK: That's all the questions I have. Thanks.

BUTLER: Rob?

COYLE: Yes, I just have a couple of things. You were talking about the development of these simulators and getting the flight computers to talk to the simulator computers to talk to the mission control computers. All this had to be groundbreaking, and it's hard to imagine this highly advanced technology world we have without somebody having broken that ground. How did you all conceive of this and how did you all figure out, "We're going to need to connect all these systems"?

WOODLING: That was a key to the Apollo simulations, and once we made the decision to go with flight computers, we talked very quickly with IBM to whether they could provide the hardware and the software on a basis that would support that decision and also help us with the design of those interface devices between our Univac ground computers. I guess they were Univac at that time. I think so. But how the actual flight computers would interface with the ground computers or the simulation computers. They had extremely good, high technical help there, we did from IBM. It was great. Yes, it was, it was the first time in that aspect, in that area, for that.

COYLE: Was anybody running anything similar from your office there?

WOODLING: I think probably, to be honest, we looked at a number of different alternative ways of simulating the flight computers. The airlines were into some other ways, but they were also tying in flight hardware with their ground-based simulators. It wasn't to the degree that we were, because again, the malfunction—we made the decision, which was the right one, to put the flight computers in there. But now the next question was, how are you going to introduce malfunctions of those flight computers?

You were asking to do something either with the hardware or software to alter a flight design or a flight computer to output to the ground simulators, and you couldn't necessarily

do that with the flight hardware. So most of that malfunction insertion was done through the ground software, the mission software itself that was a host to the simulation computers. So that got to be a fair amount of the task at hand, to make sure you simulated those things in a way that was real, that you weren't doing something that flight computers could never do that, but that it was a possibility and that it was presented to the flight crew exactly as would happen if the flight computer had a problem, developed a problem.

We had that problem that we ran into on the [computer] overload on the lunar landing [Apollo 11], that the flight controllers called a go for at the last minute and it was an onboard computer overload. We had run into that in simulations. The flight controllers, again, made the right call based on their training experience. They said, "Hey, this is something." The back rooms helped them in it. Said, "This is something we've run into before. The computer says it's overloaded, but if we press on, it's going to clear."

COYLE: Gene [Eugene F.] Kranz, in his lectures or his speeches, says that you guys really kept them honest, particularly when Gene mentions that example of the computer overload on the LM [Lunar Module]. He said that they had not thought of that and sim people kept them honest and then made them better. He's pretty complimentary to that.

WOODLING: That's nice. We hoped we got good marks from Gene, because he was very critical, but he was critical in a constructive way. I mean, he told us at times when our simulators weren't adequate or whether we needed to do higher fidelity simulation or a better job at bringing them up and keeping them online. But he was a real motivator. [Laughter] But for the right reasons. I don't mind hard-nosed people to lead you if they're doing it for the right reasons.

COYLE: My last question is just about the Apollo program or the space program in general. What mission would have been the high point for you? Which one really stands out as one to talk about?

WOODLING: [The first] lunar landing. I have to say that one. There were other times that were exciting, like Neil's problem on Gemini, and like we were having the hatch problem, but I didn't relate too directly to the hatch problem. I mean, I knew the problem and how serious it was. The one with Neil, I was very sorry that we hadn't given them a better insight into what happens when a thruster gets stuck and that it resulted in some very touchy flight actions there that fortunately he lived through them. But we could have done a much better job there in hindsight.

But the one flight that brought it all together, I think, has to be Apollo 11. There was Apollo 12—there was one additional thing in Apollo 12. I mentioned Bill Tindall before, and he had a lot to do with the success of Apollo 12 and landing where we did and the navigation that was carried out for the first time of landing in the near vicinity of that lunar lander [unmanned probe Surveyor III] that was already up there [on the surface of the Moon]. Man, when they landed and looked out the window and said, "There's the lunar lander [Surveyor]," boy, that brought a lot of things together, too. Because just think about that, how all those navigation systems [performed], both on the ground and in flight, and the people making their inputs from the ground to the flight crews, and the flight crews carrying out their part of it. Then landing up there on the moon, 240,000 miles away, and looking out and saying, "By golly, that's where we were supposed to land." Big feather in those guys' hats. That was exciting.

There was a bunch of guys on the ground that I was with over there saying, "Look out the window! Look out the window! Tell those guys to look out!" Of course the flight

crews, they were all keyed to do that anyhow. Pete looked out and said, "Yeah, it's there. We see it, Houston." [Laughter] A lot of fun.

BUTLER: You've certainly had an exciting career and had a lot of significant accomplishments and significant contributions to the program.

WOODLING: Thank you.

BUTLER: We appreciate you coming and sharing it with us today. It's been very interesting.

WOODLING: Like I said, I looked forward to it, and it was even more fun than I thought it would be. [Laughter]

BUTLER: Good.

WOODLING: You're awfully nice people to say those things.

BUTLER: Thank you. Thank you, you're very nice to come share it all with us.

WOODLING: Thank you again.

[End of Interview]