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EDITED ORAL HISTORY TRANSCRIPT 2

RICHARD KOOS
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is August 24th, 2023. This interview with Dick Koos is being conducted for the NASA Oral History Project. The interviewer is Jennifer Ross-Nazzal. Thank you again for persevering and making it through to our scheduled interview.

KOOS: Thank you. You asked last time if I remembered anything after our meeting that might fit in what we talked about. One of them was when I first came to Space Task Group. I think most times down at Cape Canaveral [Florida], we roomed together, Carl [R.] Huss, Harold [G.] Miller, and I. They took me around to all the places, drove all around Cape Canaveral. There were all kinds of antennas for different kinds of radar, and telemetry, and whatever signals. I remember we were on top of the IP 709 building looking around. It's one of the computers that they used to track all the missiles, what the trajectory was and where the impact would be. IP stands for impact predictor.

I was talking to them. I said, "You know, it's really sink or swim around here." Carl Huss says, "Yes, we don't have time to teach you how to swim either." I just somehow or other remember it because that's certainly the way it was. We learned the mission rules, procedures, and the systems to make up and simulate problems we called faults. It was all based on the what-if question; as [Walter M.] Schirra said, to "*stimulate*" the flight control team to think.

There was another time back at Langley [Research Center, Hampton, Virginia] that I came down the hall, and this guy with a blonde crew cut came out of one of the doors in the

offices. He was huffing and puffing. I asked, "Who is that guy?" And I think Stan [Stanley] Faber said, "That's Gene [Eugene F.] Kranz. He's the flight controller lead." I just remember that image of Kranz coming out the door. That's what he is. Whenever he goes around, he's always busy and huffing and puffing.

Let's see. You asked what the flight control people thought about simulation. I put down a bunch of the rules that the simulation went by. It was early in the simulations, because flight controllers were complaining, "That's not realistic." They were using that as an excuse to not take it so seriously. Not really an excuse, but they couldn't make sense out of what the situation really was. Which was true, because the simulation had its troubles, and things happened that just went awry, not because of anything we could do about it. It was the nature of what the Mercury Procedures Trainer [MPT] was at the time. Whatever system we were simulating, that sort of thing happened occasionally. Chris [Christopher C.] Kraft made it a rule, I think before the team would become frustrated with sims and possibly develop a negative attitude. Whatever the data showed, however not realistic, they were to respond as best they could.

ROSS-NAZZAL: Can you explain that a bit more? Give some examples?

KOOS: The simulation is unrealistic. You treat it as if that's real data, and then act on that, and do the best you can. He just wanted to get that question cleared up. They were all trying to make some sense out of the data, as messy as it might've been. That happened in simulation.

ROSS-NAZZAL: Why would they go awry with the procedures trainer? Was that ever clear to you, or was it just a kink in the system?

KOOS: Well, yes, I can give you an example. Chris Kraft called me up to his console one time. Walt [Walter J.] Kapryan was there talking about something with Chris at his console, and I was thinking, "Oh, no, what does he want?" This was during the Redstone flights. It was the pitch attitude profile during the launch. I thought he was asking me what the profile looks like, but he knew what it was. Kraft said, "What he wants to know is how do you simulate it?" I had described how it goes from 90 degrees pitch, goes back over, slowly goes down to 60 degrees. Kraft says, "How do you do that?" "Oh, that's what he wants to know," I thought. "Well, I have a knob and a meter. I turn the knob manually." I would keep it as close as I could. It was not one of the parameters simulated by the MPT. You can't do what the computer could do, but it was one of a few parameters that couldn't be simulated by MPT, so we just had to manually, as we would say, "Fake it." Other things happened to distract you. One person at the telemetry console couldn't fake everything and put faults also. That was asking a lot, anyway, but we tried. There were a number of things like that that happened. Those kinds of situations are what prompted the complaints and Chris Kraft's ground rule.

ROSS-NAZZAL: Did you feel overwhelmed? You mentioned that quote by Carl Huss. "We can't teach you to swim," we're so busy. Did you feel overwhelmed those first few years when you were working on Mercury and even later in Gemini and Apollo?

KOOS: Somewhat. I didn't have much time. Well, the only studying that I could do, really, was to go through the flight control manual that McDonnell wrote with all the schematics that showed the way the systems work. I learned quite a bit that way. Otherwise, yes, it was

somewhat overwhelming, because that was my first job, really. Everyone was super busy, and we felt the pressure of the race with the Russians although it didn't influence us directly in our work.

ROSS-NAZZAL: Were there other ways besides looking through the manual that you learned about things?

KOOS: Other ways were just participating and doing. Things were pretty simple comparing it with later programs like Gemini and Apollo. We shared info and pointed people in the right direction to find out about things if they couldn't give direct help. Everyone was very open to help and tolerate of a newbie.

For example, Mort Schleer was the first environmental control system controller in Mercury Control. I'd call him on the phone back at Langley. I'd say, "What happens if this particular valve fails or sticks?" He'd have to figure it out himself. They just weren't thinking in that failure mode, if this fails or that. But they did have mission rules, and that's the other thing that we went by, exercising flight rules in various stages of flight. For example, if something happened in launch phase, it might be a different thing to respond than if the same thing happened during orbit phase. That's true. That was a big consideration all through the whole Apollo Program.

Let's see. Where were we when we left off?

ROSS-NAZZAL: We were talking about Houston, but you seemed to think your story was getting a little boring, so I did think of a couple of other questions. You were near the water when you

were at the Cape and also Hampton. Did you do any sort of water activities? Was that a way to socialize with your coworkers? Or did you not have much time?

KOOS: No water activities at Hampton. Beverly came down to the Cape with me a couple times—I think it was two or three times—until she got bored with it while I was at the Cape. Anyway, we did that. The Polaris was right on the beach, so we spent some time on the beach. We'd get up at two in the morning, we'd finish, then I'd come home, and we'd go down to the beach a little bit. We weren't completely without spare time, but we did planning and studying. Most of our free time was eating out or spending time on the beach. Otherwise, it was bars.

ROSS-NAZZAL: Lots of drinking?

KOOS: Yes, for some. I was so naïve back then hadn't been involved much. Let's see. I must have been 24, 25, not very much experience in the world. I wasn't a teetotaler but just didn't drink much. When I was younger, I remembered the family of German relatives had their beer at gatherings for sure.

ROSS-NAZZAL: Very different world back then, for sure. Were there any activities that you belonged to at work or outside of work when you were working on Mercury? I know at JSC [Johnson Space Center, Houston, Texas], there were a lot of clubs once the center had been built. Was that something that was the case back in Virginia or out in Florida, or was it just bars, like you said?

KOOS: Not Virginia but the Cocoa Beach was lined with motels and bars. Never were involved in binge drinking, which is usually in places like that. While in Hampton, Bev and I drove around Virginia sight-seeing. There is lot of history to see and gorgeous scenery. Through those years, it was Beverly and me. We both went to church and were involved there, and that, in fact, has been a major part of our lives in the various communities where we've lived.

ROSS-NAZZAL: That's interesting. You mentioned your hours at the Cape, which seem very challenging, getting up at two a.m. to work. What were your hours like when you were working out at Langley? Were they more your typical eight to five, or were they also different?

KOOS: At Langley, no, they were pretty much—I think somewhat long, but not a lot. Bev got tired of me going to the Cape and stomping around Hampton where it was all new to her. When we moved to Hampton after getting married, she started working as Carl Huss's secretary. She finished at the regular time. That's what most people followed, those hours. A lot of the guys, they had meetings afterward, not all of them. Some of the people that worked on computers, I think, they had regular hours, unless they were making runs, and it went longer than the normal day. Hal Miller and others and I, after a busy day, would talk about what was ahead, what we should be doing, informal strategy sessions.

I remember one meeting that was about requirements for the new Houston MCC [Mission Control Center]. It was close to the time when we would move to Houston. Harold had me go with him, and they were talking about some of the requirements and things that would have to be in the new Control Center. That's when he came up with the SCATS [Simulation Control and Training System] acronym for the simulation system in the Houston MCC.

Anyway, we were having a meeting. It was after the normal hours. I was thinking, "Oh, Beverly's waiting for me to drive her home." So I just stepped out of the meeting. I turned around from my chair, and there was a door, so I opened the door, and it was a closet. I looked, like, "Oh, wow!" And there was Kraft grinning at me. He was sitting at the other side of the table, and he was just laughing at me, because I guess I looked a little embarrassed. And I was.

The other thing that I was thinking about—that goes along with some of the other things we talked about. There was a simulation rule that came from Gene Kranz. It was early on in Mercury sims. It seems to me I remember Houston more. I don't know when it really started, but I got the impression that he told Harold about it and then he told me. The last simulation you do, do a normal one. That became strong rule through simulations going forward. He thought the last thing flight controllers should have in mind from the sim is what should be looking like normal.

ROSS-NAZZAL: Can you explain what you mean by normal? Was he asking you not to throw in any malfunctions or was it just things that were much more realistic versus something like the crewmember has a heart attack.

KOOS: They were usually instrumentation problems, something that you could sort out really quickly, and say, "Well, that's not to worry." Another one on what flight controller reactions were. You still get this feedback. It's like trash talk on a basketball court. That went back and forth between the sim people and the flight control team. That made it fun. Cliff [Clifford E.] Charlesworth, he was flight director; I was on his team. He would always say, "Sim? That's not realistic. You can't have all these failures. That's too many." We planned what was an

important part of the sim that involved one or two members of the flight control team. For other flight controllers to keep busy, we'd give them smaller, not really consequential, faults. Mostly that would have been instrumentation or something like that.

The other rule was that we never focused on who the person was at a given console. We never singled somebody out with picking a fault based on the individual. It was always on something technical or a system of the spacecraft. The relationship with flight controllers would be a little bit better that way, because the fact is we didn't always know who was going to be on a console that day.

ROSS-NAZZAL: Was there someone that you enjoyed doing simulations with more than other folks or a team?

KOOS: No, I never thought of what teams might be in the MCC on a given day. Sometimes the whole team wasn't there that day, because of meetings they had or something else. No, I can't think of anything like that. I had a lot of respect for Glynn [S.] Lunney as a flight director. He always seemed to be unflappable, kept a perspective; it created a mood of no panic for the rest of the team.

ROSS-NAZZAL: When they would tell you, "This is not accurate. You would never see this on my screen." Would they show you, and then would you work with their consoles to come up with better scripts or training sessions?

KOOS: Yes, in many instances like that we would check out why. In some cases the simulator didn't have the capability, or we didn't have full knowledge of it. That turned out to create awkward situations. The Sim Sup [simulation supervisor] would explain the situation during the debriefing of the sim. This sounds like it might be a poorly implemented simulation system. However, the simulators couldn't be developed with the same resources or programmers as the mission computers that had extensive validation and verification during development using job shop offline before each fight. It was a little different for the flight simulators. The scope of what they simulated was smaller than the simulation provided by the Ground Support Simulation Computer. The Apollo Mission Simulator (AMS), for example, was programmed for training the flight crew who had far fewer displays or needed to simulate far fewer data parameters than those monitored in the MCC. The MCC used the data from the spacecraft telemetry, which delivered far more parameters for more extensive analysis.

We did have a lot of exchange with the flight control team. Our guys would go down the hall and talk with flight control team members, especially in the systems area because that's where the failures mostly originated. They would talk about what they were doing and what their concerns were. Some of the individuals might not have been on a console, but they would say, "We're worried about this sort of thing or that sort of thing." We would pick up on it, and our guys would try to work it into a simulation somewhere. Failures usually came out of the flight control team's work on developing flight rules. They were to determine exactly what the response should be for a problem. If something should happen, what would they do? So, we found out a lot from that. We pretty much understood what was going on in the planning.

ROSS-NAZZAL: How familiar were you with the flight rules? Were they like your Bible?

KOOS: That wasn't the only thing. But yes, flight rules documented the Bible for what to do if. They addressed the possibilities of what could happen. There were other procedures that we exercised in some appropriate manner. We would look into the performance of ground systems, radar installations, etc.

I'll just go into the Apollo 11 story a little bit if you want. I can do that here. I can tell you how that came about. I was not working on Apollo 10 in the spring of 1969. Jay [F.] Honeycutt was the supervisor, and that team was busy. Either the flight was in progress, or the simulations were. Some of us were back in the office and not over in the Control Center. We had two Grumman guys with us. Rockwell and Grumman were working with us so that if we had some questions on how something was going to work, we could use them. If they needed to, they could go back to the plant, and they could find the data on the spacecraft we needed.

One of the guys for the Lunar Module, Jack Niebauer came to me, and he said—this is the other thing we did. We'd go over to the engineering side of MSC and ask the guys for the different systems. We did the same thing that we did with the flight controllers on the given systems, to try to sort out and see what's going on, what they were concerned about, what and how it would work. He said, "You know, I go over to those engineering guys, and they say, 'That computer—this is not going to fail.'" Jack was trying to ask, "Is there any way we can cause a guidance computer problem?" I knew that it was rope memory, and it was hardwired. I said, "Well, that's probably true; it's supposed to be very reliable. There are inputs and outputs to the computer. There are inputs from a stable platform, displays, and the computer entry device for the crew and there's uplinks from the ground, and then there's event parameters

coming into the computer. That would cause the computer to do crazy things if wrong." He went off on a quest for something along those lines.

Afterward, I realized what he had done. He had talked with the simulation guys that run the simulator, and he talked with flight control guys, too. I don't know if he talked with Reddy Kilowatt, Jack [John R.] Garman, or who, but I know he went off and did that sort of thing. I never heard much about it. I thought that he couldn't find something, or he would have been sure to use it. I thought that was really a good idea, basically, at the right time. Then, of course, the last simulation did have the rule about no anomalies.

ROSS-NAZZAL: He violated that rule.

KOOS: The fact is, during the last Apollo simulation for Apollo 11, he wanted to put it in. I quizzed him about it some. I said, "Are you sure this is not going to cause an abort?" He was insistent, so we went ahead. It was a program alarm, 1202, or 1201. Then Steve [Stephen G.] Bales called for the abort. Kranz wasn't happy at all with it being the last simulation run for the landing. Good grief. Somebody wants to get me bad. Anyway, then it came to the debriefing. Debriefings were a confessional, going the way it always does. It was very open. So, if you did something wrong, say that you did it, or if you made a bad choice, say what you did. It was a situation where it wasn't clear it wasn't correct to abort the landing until it came to me. Simulation was last. If they thought the simulation wasn't realistic, the flight control team didn't put it in negative language, staying away from the rule about taking the sim data for real if they thought it wasn't. They'd talk around it but the Sim Sup would have his turn for "confession" or critique eventually in debriefing.

I can't remember what Steve said in the debriefing, but I could tell Kranz was upset. And then it came around to us. I said, "You had two cues, and you didn't use them. You had the Abort Guidance System that had some of the same parameters that the primary guidance system had. They both agreed, and they were normal. It was the program alarm by itself. It was the only cue you had to abort."

That was really an error, however it happened for Steve. Kranz told him to go back with MIT [Massachusetts Institute of Technology, Cambridge] Draper Labs and go through all the program alarms and determine which ones would cause an abort. So that's what was done. They weren't in the flight rules. There was nothing about if those alarms might occur incorporated in the flight rules before the simulation. But we didn't have a chance to simulate again, because it was the last one for Apollo 11. There wasn't time for more. They button up the Lunar Module days before the launch. The flight control team had some time for thinking through before flight day what to do if it occurred during landing. Steve Bales, the Guidance officer, Jack Garman, and people from MIT Draper labs worked on the mission rules that said what to do. Draper Labs knew what could cause of the alarms; they programmed the LGC [lunar guidance computer]. That's about it, I think, about that incident. I don't remember any other circumstances that we didn't have a normal ending on the last sim. That rule was begun early, back in Mercury, I think. We tried for a normal sim. We didn't think we had broken the rule. Sometimes we don't know what action will be taken.

ROSS-NAZZAL: Did you feel vindicated when you saw what happened during Apollo 11?

KOOS: Yes, I do remember saying to myself, "Why that's the same alarm in our simulation!" One other clue to the alarm not being of any major consequence was the "seat of the pants of the pilot." Neil [A.] Armstrong had already demonstrated his skill using his feeling of vehicle performance to actually save himself: once during a flight in the X-15 and also in the lunar landing simulator.

There are some other similar circumstances like that that didn't question anyone doing anything wrong but the simulation was responsible in either giving the team practice on something not expected or pointing out something new to the flight control team. We ran other cases when something happened in the flight that we deliberately simulated. In the Apollo 11 case, it was the exact same alarm in flight it was certainly a coincidence.

Some, I think, mistakenly, think that the simulation saved the landing from an abort. "You guys saved the Apollo 11 flight." Someone actually told me that. Realistically, the Control Center doesn't have the "seat of the pants" in simulation that the crew does in a flight. Of all the astronauts, I think, Neil Armstrong probably had as close a relationship to the vehicle through his physical feel of the vehicle. I read someplace that he knew all the mathematical computations of vehicle movements. Basically, he could tell how the vehicle was performing physically, relating its movements to the flight dynamics equations he knew. If you just go to the time when he ejected from a lunar landing simulator out at Ellington [Air Force Base, Houston, Texas]. That's attributable, basically, to his understanding that the vehicle was just not moving or working as it should, the way he was commanding it or trying to control it. So he got out, fortunately. For those who may have thought that simulation should take credit for saving the flight from aborting by running the computer alarm situation, Armstrong continued the descent while hearing the alarms, asking about them later simply because the Lunar Module was

doing well. One of the Apollo books has the story; it has a copy of chart printed in the book. But yes, we did. I think simulation can take credit for bringing complete awareness of the alarm situation and possibly avoiding a confusing situation between the crew and ground crew during the real descent. We did some other simulations that were also helpful.

ROSS-NAZZAL: Would you talk about some of those? I am guessing there are a lot more. Any in particular that come to mind?

KOOS: I don't know what Apollo mission—they changed the numbers of the flights. Let me go back a little bit. After the fire, of course, there were all these investigations and reviews. Then they started working on what the changes would have to be to update the spacecraft. All that was going on, but the simulations and test flights still went on. Let's see. My mind's a little slow.

ROSS-NAZZAL: There's no rush. It's okay.

KOOS: What we realized was that the Apollo simulator wasn't supporting those unmanned test flights like the first few Saturn Vs, and the first and second; I think there were three S-IB [Saturn IB] and about the same number of AS-500 flights, The S-1B was the smaller test rocket. We weren't going to get support from the simulators for those unmanned flights. It probably was appropriate because they had to make changes to the AMS to keep current with representing the spacecraft changes being made. That was always made simulation difficult, keeping up with changes and having to be the first in a flight's schedule to provide simulations.

It was after work hours, but I went down the hall. Harold, I think, was already gone. I went down the hall and just poked my head in, and Tec [Tecwyn] Roberts invited me into his office to sit down. Somehow in the conversation, I said, "You know, we need to simulate these unmanned test flights for flight control team preparations. They were to have no crew so the CSM [Command and Service Module] was configured for the ground to control in certain situations. It would be unplanned. The simulators were not going to provide simulation of the vehicle for them. They won't be able to support it. They must be busy making changes to keep up with the changes to the real vehicle." Then Chris Kraft walked in, and Tec said, "Why don't you tell Chris what you're telling me about?" I described it all to Chris Kraft, and he understood it, and said, "Well, go ahead and do it." So, I informed Harold, and we started thinking toward adding the CSM to the Ground Support Simulation Computer [GSSC] simulation for the MCC.

It meant that the GSSC, which we used—it was one of the main regular computers that was programmed as a simulation tool for the MCC. The original plan was for the GSSC to simulate the Saturn launch vehicle and the ground tracking systems using the AMS as the Apollo spacecraft. The GSSC would have to add simulation of the Apollo spacecraft. There had been simulation of only one vehicle, the Saturn; now the simulator would have to add the CSM. We had to simulate the onboard guidance and the control system, duplicate the planned trajectory, and everything for the entire flight for AS-201, AS-202, AS-501, and AS-502 and others, that had no crew. There wasn't enough room in the computer, because we had taken on the job of simulating the launch vehicle. That meant simulating its guidance, its control system as well via the telemetry downlink. It was already simulating the radar tracking inputs to Mission Control computers.

By then, I think we were using the 7094 IBM [International Business Machines] computers. That meant the use of two computers to do the simulation for those flights. I don't know how many IBM people we had to do all that work. I can't imagine, but there must have been just a big group of people. They didn't have the rigor in developing the software as on the mission computers. It would have to duplicate what mission planning people, John [P.] Mayer's Mission Planning and Analysis Division were doing, verifying, and testing the software work for the mission computers. It would have been cost-prohibitive. Costs of simulation had just increased. It meant that simulations were developed in increments over several flights. IBM did really, really well under those circumstances. We really owe a lot to IBM folks for that.

As for AS-501, that went perfectly, at least so far as we were aware during the flight. There might have been some engineering things that needed addressing by MSFC [Marshall Space Flight Center, Huntsville, Alabama]. On AS-502, Cliff [Clifford E.] Charlesworth was the flight director. You might remember when I said he was always complaining about, "That's not realistic." Everybody in simulation knew him for that. That's the way he was, a good guy. I think the next guy I liked to work with.

That's a lot of work just to get all the software and systems to simulate a normal flight. It was basically an up and down flight for the CSM, a heatshield test. I think it went far around the world but not a full orbit. We just didn't have that many faults that were programmed yet. It was really early, and the simulation software could do a normal flight but not many faults. But we found some ways as best we could to fail an engine on the second stage. I don't know why we picked the second stage. There were five engines on the first and second stages. We picked the center one, to see what effect it had, then picked another, the left one or the right one, or

whatever, or changed the time of the engine-out to see the different effects on trajectory. There wasn't much you could do about one engine, so we failed two engines side by side.

It caused what they called a "whiffer dill" as the flight dynamics team called it. It's described in Charles Murray's book [*Apollo: Race to the Moon*]. It caused a severely warped velocity vs gamma plot. In fact, Charlesworth asked if we simulated the structure of the vehicle. He was thinking the vehicle would breakup under such severe maneuvers.

I knew simulating structures was too big a software challenge for the computers. He was really saying it on the voice loop so that program management would understand if they were listening in. "Why didn't you abort?" was really the question. During the simulations the team waited to see what would happen. The velocity vs gamma plot went vertical as it should, like normal, and then actually, with two engines out, took a severe dip without the thrust of two engines. It looked like it wouldn't make the planned trajectory. And then it sort of magically started recovering as it burned fuel and became lighter. The problem was, it didn't make it into the planned trajectory at endpoint at engine cutoff. So the backup capability was available for the flight control guys to start the Service Propulsion System [SPS], which is a system of the Command and Service Module. It wasn't planned to be used, but it was a fully loaded with fuel. It was enough to put the vehicle on the right trajectory by the time it cut off. The flight control team would start the SPS from the ground. We did that several times, so it was well rehearsed. By the time for flight day, they could do it with their eyes closed, I think.

A couple of months earlier, I bought a [Triumph] TR3 from Charlesworth. I had gone to a salvage yard and found a red sheet metal top to buy. The cloth top on it was torn and not in very good shape. It was hardly anything, really. Put it on with a few bolts. I didn't make it in to launch that day, because I rolled it. It was dark and difficult to see. It was early and rainy. They

were working on NASA Road 1 and moved the temporary exit lane up from NASA Rd 1. I came up to it suddenly and turned into it. It had hard tires on it yet, and I started sliding sideways. First thing I hit was—I can see this yet—it was a stand with yellow flashing lights, saying the exit lane is moved. I hit that, and then the next thing I hit was this great big, on four-inch posts holding this big sign that said, "NASA Road 1." That's what flipped me.

I just remember waking up with rain hitting me in the face. I don't know how long I was there. I don't think it was very long, but the windshield was out of it, all distorted. So I found a way to climb out of it through the empty windshield. This guy came along. He was driving a truck. He said, "You've got a big hole in your head." It was only a good bump. It must have swelled up. Anyway, he took me into the hospital, Memorial Southeast.

We had a nurse friend that worked at Memorial Southeast, and she called my wife, Bev, and she said, "Well, he's here, and he's okay. But he's, you know, a little bit dazed." Bev came to pick me up, took me home, and I just rested. The next day, I was okay. But I was sore. Every bone in my body, every joint was just sore. I think what probably saved me was the car rolled counter clockwise and threw me across the passenger seat, so it saved my head, basically.

ROSS-NAZZAL: You're very fortunate.

KOOS: I went in to work the next day, and it just hurt to step off the curb and go across the street. Anyway, I went up to Charlesworth's office. Apparently, he heard what happened, and he said, "Well, I thought you were back in the Simulation Control Room that whole flight yesterday. The flight was exactly what happened during the sim." So, I guess we can take good credit for that one. Not many know about it, because there wasn't any crew in it.

I can't think of any other one. There are some. Right now, I can't think what we did. I should go back to where I was talking with Chris Kraft and Tec Roberts.

Later, somehow or other, we began to add the capability to the situation for the unmanned flights. More money was needed for the Control Center to do the added simulation. It started with George [M.] Low's Apollo Change Control Board to approve the funding. Without warning Hal Miller called me and said I should go the 9th floor of Building 1. I didn't know why, but he found out when the simulation software subject came up. I was sitting in a front row of two along the wall as far back from the table as I could get. I really didn't know what I was supposed to say or do. All the heavies were around the table: Chris Kraft, Deke [Donald K.] Slayton, crewmembers, etc. Then the simulation topic came up. I was sort of following it because they were referring to some things I wasn't aware of. Then Rod [Rodney G.] Rose, who was behind me, poked me and prompted me to say something. So, I just said what I knew, the AMS wouldn't support the MCC simulation schedule.

Deke Slayton was sitting on the opposite side of the table across from me staring directly at me. Never knew why. He was the director of Flight Crew Operations. The engineers there had responsibility for the fight simulators. I can only guess that it had something to do with what might cast a bad light on his directorate. It turned out to be fortuitous because the simulation schedules of the AMS and MCC became demanding to both so that a small portion of their schedules allowed combined or as we called them integrated simulations. The GSSC continued to be used for manned flights as well.

ROSS-NAZZAL: Can you explain what AstroSim is?

KOOS: Simulating without a crewmember. AstroSim led to one of our simulators acting as the crewmember. We called him the "AstroSim." The individual, Gene Cheimilewski, became well known because of his dialogue with the flight team in the MCC. It was partly because of his eastern accent, I think, and his quick wit in a lot of his answers given to the flight control team. He could put some humor into the whole thing. It was just a lot of fun.

ROSS-NAZZAL: Can you give some examples?

KOOS: Oh, no. In fact I wasn't the Sim Sup for many of those simulations. They downsized after Apollo 13, because we were all off doing other work. They had a flight hiatus, because they had to do the investigation and make changes and all that. So, let's see. Gerry [Gerald D.] Griffith and I were sent over to the Lunar Experiments Branch. I think that's what the name was. Jim [James E.] Saultz was the branch chief. That was after Apollo 13. So, Apollo 14, they had us work in the Surface Experiments Back Room, SSR [Science Support Room], and just followed the traverse with Al [Alan B.] Shepard and Ed [Edgard D.] Mitchell.

ROSS-NAZZAL: How did you like working in the Support Room? It was very different from being in simulations.

KOOS: It's being like going from the dark side to the light side.

ROSS-NAZZAL: How so?

KOOS: Well, in fact, I thought, "Now I'm going to be on the receiving end of simulations." What strikes you is, when you're over there, you must expect anything. With simulation, they're planning it. There's a little personal thing there, I think, too, probably, with the people that are still in the simulation area. Then after Apollo 14, 15, Gerry Griffith was on console during the EVA [extravehicular activity], and I was in the planning shift during the crew's sleep period. I remember on Apollo 15, the first thing you did was did stuff around the Lunar Module, put out the ALSEP, the Apollo Lunar Surface Experiments Package, get it deployed, and then do a short EVA. Then the second one—this was the Hadley Rille and had the big mountain Apennine Front and Hadley Rille, the canyon. I call it a canyon. I'm not sure if it was that big a thing. They wanted to go down to make a stop or two, as I remember, and then go down to the base of the Apennine Front. It was [David R.] Scott and Jim [James B. Irwin].

EVA's do take more time on the Moon for some reason than they plan. I'm sure they were thinking they'd be success oriented and get more in. They always are in the mode of trying to keep everything on schedule. So, I saw that. Glynn Lunney was on that same shift as me as the flight director, and I told him what we were having trouble deciding. The science guys, they're responsible for planning. But I did try to influence the team about cutting out a couple of those stops and going straight down to the Apennine Front. It was quite a distance from the Lunar Module. They reduced the number of stops. They did that, went down there, and came back. They spent time down there, because some stops were eliminated. As I remember, they didn't stop at any place coming back.

Then on the third EVA, they went over to the Hadley Rille, and they were right on the edge, you know. There was a little bit of concern. I can't remember whether the capsule communicators were Joe [Joseph P.] Allen or Tony [Anthony W.] England.

What we also noticed is that the battery temperature for the Lunar Rover went pretty high. Boeing built that under Marshall Space Flight Center's [Huntsville, Alabama] leadership. They were getting close to the temperature limit, and the limit was like 120 degrees, I think, or something like that. They were very insistent about not using the rover when above the limits, "Are you sure it has to be that low?" What if it goes higher during an EVA? After all, it's a battery. They had an explosive plug, so that if something went wrong inside the battery, instead of exploding, it would pop the plug. We talked with Marshall about it quite a bit, but they insisted. It got worse the longer the EVA and for each EVA. It didn't cool between EVA's as it was supposed to. The problem was with the batteries. They had this reflective mirror on the top, so that it would dump heat into space and charge from the sun, but there was so much dust on the surface it reflected heat back into the battery. The trouble is, they had covers to keep it from getting dusty, and dust still found its way onto the surface. We opened it during the sleep period to cool off, but they didn't cool off very well, because dust still got on the mirrors.

We still had arguments for Apollo 16. It went okay, but it stayed right under the limits. So, on Apollo 17, by the time we got to the beginning of the third EVA, the temperatures are just a couple of degrees over the limit. I remember [M.P.] Pete Frank was the flight director. (Who, by the way was a good guy to work with.) I can't remember how the question came up, but we read out the temperatures and said, "This is getting to be to the limit." Pete just took it on himself to say, "We're go for the EVA." It went over the temperatures, because that was the third EVA, but it worked out okay. Marshall didn't say a word. We didn't have any problem with that.

There's also an experiment on that flight. It was hung up on the back of the Lunar Rover. the mylar heatshield on it was kind of flimsy, I thought, but it had the same kind of mirrors to

keep it cool. When I saw a copy of it over in the engineering side of the center, it just looked flimsy to me. I thought, "Oh, there's going to be dust getting into that thing, and it's not going to work." We always asked [Eugene A.] Cernan to dust it off. What it did is took microwave measurements as they drove along. Well, I won't go into all how it worked. [M.] Gene Simmons was the NASA scientist at the time. It was his experiment. We were close to the end of the last EVA. I don't know what struck me to have Cernan to stop the brushing. I just told Tony England in the front room, "Go ahead and tell Cernan not to worry about brushing it off anymore." There's always a crowd of people in that back room, watching what was going on. George [W.S.] Abbey goes back there a lot. I didn't see if Gene Simmons was back there. He was a big guy, bushy hair. I don't know if you know him. He came over on his crutches and he leaned over the console, and he says, "What did you do to my experiment?"

ROSS-NAZZAL: Did the experiment end up working as expected?

KOOS: I don't know the results of it at all.

ROSS-NAZZAL: Did you enjoy working with the experiments? You had been working in simulation for so many years, that was such a change, I imagine.

KOOS: Yes. Yes, I was glad to work on the Control Center side rather than the "dark" side. There was another one on that flight. I can't remember which flight it was. There's a guy at MIT, and he had a thing that was about this big, tall, [demonstrates] about this big around, and it was a lunar gravity experiment. It was supposed to measure gravity in different locations. We'd

just ask him to take a reading in different places. Tony did most all that. We got back to the end of the last EVA, and somebody said, "You could take another measurement." I think what happened was that the commander of the crew took it and threw it as far as he could throw it. I just said, "Well, we need another measurement." And Pete Frank said, "You have to go get it yourself." It was a light moment for everyone in MCC.

ROSS-NAZZAL: Were you working with the rest of the geology team in the back room? How did that work?

KOOS: They were all back there, geologists from the USGS [United States Geological Survey], in particular Lee [Leon T.] Silver from Cal Tech [California Institute of Technology, Pasadena] and Dr. [William R.] Muehlberger from the University of Texas [Austin]. They were a real bunch of nice guys.

ROSS-NAZZAL: You mentioned there were some egos in that back room.

KOOS: Yes. We had an engineering attitude, I guess, as opposed to scientific. Most people were scientific. One of the things we made fun of was—not in front of them—every time you come into a question in science, you open more questions, so we joked about, "Well, that's their livelihood, coming up with more questions than answers." The ego's showed up when we talked during preflight about what ifs and when someone would have to give up something. EVAs were packed with things to do and the awkward suits and environment were difficult to account

for on Earth therefore taking more time. We tried to have then prepared for changes during an EVA.

On Skylab, it was very similar to that. In Skylab, in EREP [Earth Resources Experiment Package], the people were in another building that were in science. They were JSC people, most of them. They said, "We want to run the altimeter over the Puerto Rico Trench, for example. which is in the eastern part of the Gulf of Mexico." We said, "Measure the altitude of the water over the Puerto Rico Trench, what do you mean? Water seeks its own level." And so, we had a little joke about that among ourselves. They ran the pass, and they showed a plot of the water level, the altitude. They could do that measuring from the spacecraft orbit with an altimeter, against the spacecraft orbit. There was a drop—it was 30 feet or something like that over the trench. There is a long canyon on the ocean's floor, and gravity pulls it over to the side and leaves a slight depression. So, they convinced us. Until we saw the plot. we had a little engineering look at it, I guess, and made fun of it.

ROSS-NAZZAL: I wonder if, given our technical glitches, this might be a good place for us to stop. I appreciate your time and, like I said, your perseverance in making it through to the other side of Teams. Not sure what was going on today. Hopefully Tuesday, we will not have these same issues.

KOOS: I think we covered through Apollo. I'll go through it and see if you have some questions in what you've written, and see if we have slipped over something, but I think we've gone through Apollo. Then there isn't much to say about Skylab. It was just drudgery.

ROSS-NAZZAL: That would still be interesting to cover the drudgery, the hours, and things. I look forward to hearing more. We'll move into Shuttle, as well, and maybe Station.

KOOS: I hope most of this is interesting to somebody.

ROSS-NAZZAL: It is. Yes. Everyone's personal stories are important to capture, I think. Those little anecdotes, they're gems for so many people.

KOOS: Well, maybe some of them.

ROSS-NAZZAL: Well, I will let you go, and I hope that you have a nice weekend. I will see you on Tuesday.

KOOS: Okay. You, too.

ROSS-NAZZAL: All right. Take care.

KOOS: Thank you.

ROSS-NAZZAL: Thank you.

[End of interview]