

NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT

ORAL HISTORY TRANSCRIPT

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INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is May 23, 2008. We are honored today to be with Dr. Christopher Kraft, former Flight Director and Center Director for the Johnson Space Center. He is speaking with the JSC History Office staff of Rebecca Wright, Sandra Johnson, and Jennifer Ross-Nazzal on the topic of what he calls the gutsiest and most important decision of the entire space program, Apollo 8. He begins today by providing the background of what led up to the decision for Apollo 8.

KRAFT: Now in thinking about what you wanted me to talk about, I reflect in my mind that you cannot appreciate Apollo 8 unless you know the situation we were facing in the summer of 1968. Not to belabor the early part of that, but as you recall, in January of '67 we had a fire, we killed three people, it was very traumatic to all of us, particularly to me because I was very close to the astronauts involved in the operations. I was a pallbearer in two of the funerals. That was very tough on us. However, I think it was without question the turning point in the lunar program because had we not had that event take place I think it's a strong possibility we wouldn't have gotten there in the '60s, and a strong possibility we wouldn't have gotten there at all. Now I say that without knowing that, of course.

But the condition of the hardware that we were working with, because we had a whole group of people as I described in my book [*Flight: My Life in Mission Control*] in the Apollo Program Office who were inexperienced in manned spaceflight, we had everybody working on

Mercury and Gemini, the President [John F. Kennedy] said we're going to the Moon, and we had about maybe, at that time, 350 to 400 people at most working on the program, as far as the government was concerned. Maybe in the industry—I don't know what that number was, but it wasn't a large number. At the height of the Apollo Program we had 400,000 people working on Apollo. So there was a tremendous management challenge to build this monster program and a tremendous number of unknowns. [A big] difference between going from Alan [B.] Shepard [Jr.], which was a 15-minute flight [Mercury-Redstone 3], to leaving Earth's gravity and landing on the Moon. The magnitude difference there was indescribable. At that time it was indescribable.

So we took on a whole bunch of new people without a lot of manned spaceflight experience. A lot of good people, a lot of smart people, a lot of very highly motivated people. But they were running too fast. As a result, those of us that were doing Mercury and then Gemini, both in Operations and Engineering, had a hard time getting these people to recognize the implication of the human in the design of a space vehicle, because most of these people that came into the program were from the unmanned programs. They were from the Air Force black [classified] programs. They were people from the rocketry programs who built Atlases and Titans and other rockets for the Department of Defense. Frankly I think they were used to cutting corners to get the job done. I don't know this, but I think that they applied some of that experience and thinking to the Apollo spacecraft. So that's the background that we were faced with.

Myself and a number of others were trying very very hard to impress the new people, particularly the upper management, that they were running too fast, that they were ignoring the lessons learned from previous programs, and we could see the results of their labor—not just

them—but see the results of the contractors who were all also, most of them, new to manned spaceflight. That's the situation we found ourselves in in the late part of 1966. We were coming off of Gemini and beginning to be able to put our best experienced people onto Apollo.

The reports from Cape Canaveral [Florida] on the quality of the hardware that was being delivered—and I could see it myself, because I'd been spending some time in North American [Aviation, Inc., later renamed North American Rockwell Corporation] in California—the Thompson Committee [also known as the Apollo 204 Review Board, chaired by Dr. Floyd L. Thompson, Director of the Langley Research Center in Hampton, Virginia] which reviewed the fire described it as shoddy workmanship and that it was really a disaster waiting to happen. Our people were saying the same thing internally to the program. John Bailey, who you don't know, was my boss back at the NACA [National Advisory Committee for Aeronautics] in the 40s and 50s, and he was a very good friend of Bob [Robert R.] Gilruth's. He had sent him to the Cape as our special representative down there in the '66 time period. He was living there.

He kept writing these memorandums back to Gilruth, which he distributed among the top management at the Manned Spacecraft Center [now known as Johnson Space Center]. He said, "This hardware is not very good. The cabling is being stepped on when they work on it in the spacecraft. There's no protection for it. The people are really not very good at checking this thing out. They're not very good at trying to maintain some semblance of the fact that a human being is going to be in this machine. I'm telling you, it's not good." So that's the situation we found ourselves in, which I tried to describe in my book.

On top of that, the management of the program from both the [NASA] Headquarters [Washington, D.C.] point of view and the Center point of view was such that Gilruth, who was an extremely great man to work for, but not very aggressive in protecting his fanny or protecting

the Manned Spacecraft Center. He was a brilliant man, but he wasn't a Chris Kraft, somebody that was willing to speak up, fight the battle and take the consequences. So what happened was that the program manager he brought in here was appointed by George [E.] Mueller in Washington, who was the head of the program. As a result, they began to be the program management runners. They managed and ran the program and bypassed Gilruth, therefore bypassing the top management of the Johnson Space Center, literally.

I spent, which I describe in my book, a lot of time trying to convince Joe [Joseph F.] Shea, who was that manager, that he was ignoring our inputs and that he needed to take advantage of the tremendous engineering experience and talent that we had at the Johnson Space Center, and he was not. Frankly at the end of 1966 I think both Max [Maxime A.] Faget and I had gotten to him, and I think he had begun to realize that he needed a lot of help and that he could get it from us. I think our relationship was changing. Unfortunately that had very little effect on the hardware at that point. The thing was cast in concrete so to speak. That's the situation that we had at the Cape in January of 1967. That created death. It killed three men. It was a tragedy, not only from the standpoint of loss of life, but from the standpoint of the program itself, because it was a situation that did not have to be that way. That's what we all felt.

Now I won't go into the fire. You can read all about that if you want. But I wanted to give you that background because that's what we were faced with on the 28th of January 1967. I think I described in my book where Floyd Thompson, who was brought in to review the accident, who was at that time the Director of the Langley Research Center. Now all of us worked for Floyd Thompson at one time or another, all of us management at the Manned Spacecraft Center, including Gilruth. Gilruth took his place in flight research where I started, and so I knew all these people as a young engineer. They knew me as a young engineer who

knew nothing, and all these people saw us come up together. So we were all well versed in each other's capabilities and each other's traits, et cetera. Thompson called me on the phone. He said, "Are you going to be at Cape Canaveral?" This was two or three weeks after the fire.

I said, "I'm coming down there," on such-and-such a date.

He said, "I want to meet with you." So I met with him in his motel room. First question he asked me was, "Where does Gilruth sit in this management chain?" Naturally I told him he doesn't sit at all.

I said, "He's being bypassed. There's a straight line between Shea and Mueller, and so the Center has been bypassed in this thing," and we were trying to fix that as it happened, as I described to you.

He said, "Thank you." That's the only question he wanted to ask me. He said, "That's exactly what I suspected from having watched and looked at this thing for the last three weeks, and you don't have to say any more." So he knew, from having known us, what had happened.

Now we're faced with we've got to build ourselves out of this phoenix. It was obviously both a tough road technically, a tough road managementwise, and a tough road politically, because you can imagine that the [United States] Congress at that point was not very happy with NASA. Particularly as they began to hear what Thompson had to say, because he didn't mince any words, and he wrote it, if you read the report. He just flat wrote what was wrong. So we had a lot to overcome.

Fortunately for NASA, we had George [M.] Low. I can't emphasize [enough], besides Gilruth, how extremely important George Low was to that situation I just described, from every point of view: from the technical point of view, from the management point of view, and from the political point of view, because he had experience in all of those. I think Gilruth could see

that, and he insisted that George be made the Program Manager, and George at that point was the Deputy Director of the Johnson Space Center, and he had been in Washington from the beginning of manned spaceflight. He was very much involved in convincing Kennedy to go to the Moon. He was a part of the decision-making process. Convincing is not the right word. I think Kennedy convinced himself and us. But at any rate, I think he was the ordained man for that job. He, having been appointed the head of the program, he knew what was wrong. I'd been telling him what was wrong for months. I'd go to his office and complain bitterly to him about what was going on. He appreciated what I did. He said, "You've got to do it yourself." He said, "I appreciate your telling me, I'll do my best to help you do what you've got to do, but you've got to do it," and I knew that. I just wanted him to know what I was up to.

As I said, I was working with Joe very hard. I learned to play squash so I could play squash with him at night. I went to dinner with him and his wife on occasion, to try to get to know him, and him me. I was in his office quite a few times trying to explain to him what he was doing wrong, what he should do to do right. We became very close as a result of that. It was improving immensely when the fire took place....

So all these things are going on, and George Low comes in the middle of that and brings order out of chaos. I can't emphasize how important that was. He immediately appointed a board, which he called a Configuration Control Board, and appointed all of the top managers at the Manned Spacecraft Center as board members. You could not send a representative to that meeting. You personally had to go. It was Max Faget, myself, Deke [Donald K.] Slayton, one of the doctors, one of the scientists at the time, and a couple others.

He had a meeting every Friday with that top management group. He had a meeting every day at noon to review the program. He began to then go see the management of the

Command/Service Module [CSM] at North American and at Grumman [Aircraft Engineering Corporation, later renamed Grumman Aerospace Corporation], and he fired half their top management or had them fired by going to the presidents of those companies, and had them removed, including Harrison [A.] Storms, who was a cornerstone at North American. But at any rate he forced him out and brought in a lot of new people into the management at North American, and same is true at Grumman.

He appointed his own people, began to get ahold of the program, solicited our advice—the top management of the Johnson Space Center—and brought the program back up into a place where I think it was obvious that it was healing, and that what had to be done with the hardware—we had a meeting shortly after he became the program manager and listed all of the things that everybody wanted done to fix the vehicles, to fix the management, to fix the rockets, to fix everything that had to be done. We made a list of all those things. They were there by the hundreds. There were 125 top ones. We characterized them as absolutely required. We had names for all the stuff, all the names escape me, but we listed the importance of all these things and then categorized them. We ended up at the end of the program, a year later, doing every one of them.

Now that's the background that we were dealing with. Let's jump to the Saturn V, because it's also important to Apollo 8. You've seen it over there in that building [Rocket Park at the Johnson Space Center]. Stand it upright—at that time, here I am looking at a Redstone rocket, which is over there—compare the size of those things. An Atlas even, compare that to the Saturn V. So the Huntsville [Alabama] Marshall Space Flight Center under [Wernher] von Braun is building the Saturn V. They're rocket people. They know the rocket business. So we fly the first Saturn V. Actually we flew some stages before that.

But then we flew the first Saturn V, and it went fine. We put a big load of sand on the top to simulate the weight of the vehicles. We were going to fly 100,000 pounds. It flew pretty well, except it had a lot of technical issues which did not really surface very well in that flight. It looked like it was a great flight, but it wasn't. We had problems on all three stages, problems on the first stage, second, and third stage. They were not serious problems on that flight because it made it. It did its job.

We flew the second flight, and it was a disaster. I want to emphasize that. It was a disaster. That doesn't come out anywhere, but it was, I want to emphasize, a disaster. The first stage had pogo. The second stage had pogo so badly that it shook a 12-inch I-beam, it deflected that thing a foot. You can look at an I-beam in a building. This building has an I-beam across here as a joist. It deflected a foot as it was flying in the second stage. The third stage ignited and then shut down, and it would not restart, which was a requirement to go to the Moon. It had some vibratory problems associated with it also. I could describe that to you, but I won't.

I gave you the background of this crummy spacecraft that we're faced with in the beginning of 1967. I mean crummy. You go read the Thompson report: shoddy workmanship, poorly designed, checkouts terrible, et cetera. Here's the Saturn rocket that everybody thinks is a wonderful piece of hardware that almost busted itself into pieces in all three stages the last time it flew. As a matter of fact, Gene [Eugene F.] Kranz and his flight controllers saved [us] when we flew the second one by what they were able to do with the spacecraft that were on top of it by some marvelous flight controlling.

Now let's go to July of 1968. I wanted to set that stage for you. July of 1968, the Command/Service Module had recovered. It was now becoming a fine, good-looking piece of

hardware. We had delivered it to the Cape. It was being checked out. It was planned to fly by itself for 11 days the first time we flew it in orbit with three men.

But that part of the program was really progressing well, and I think we all had a great deal of confidence that it would fly and fly well, and we were going to fly that on the Saturn IB, not the Saturn V. In other words, it was a two-stage rocket, but it was made up of a previous Saturn I and Saturn II stage which had been flown quite successfully. The Lunar Module had just been delivered to the Cape. It was also a mess. Now it was a mess because we were using these very delicate pieces of structure because we had to. It had to be light. The wiring had to be light. It had to have very small and probably inadequate insulation. It was fragile. When they got it to the Cape, they just had a time getting it checked out. Just everything was going wrong with it.

George Low could see that in July of 1968 he was going to have trouble meeting the schedule which we wanted to begin to hold to, in that it was supposed to begin to fly on the second flight with the Command Module. I should have said that, when we had these early meetings we set out these various categories of flights, which I suspect you've read about, Categories A, B, C, D. We said, "These are the objectives we want to accomplish in each one of these flights." None of us thought we'd be able to do that in one flight. We thought it'd take us two or three flights. Turned out it took us one flight to do them all. But we did stick to the flow that we wanted, how we wanted to prove to ourselves that the hardware was satisfactory and it would accomplish the operational capabilities that we had set out for it in terms of rendezvous and docking and heat reentry capabilities and control and navigation and guidance, et cetera, et cetera. The Lunar Module just wasn't cutting it, and the Cape was just driving us bananas telling us the hardware wasn't good enough.

So George could see that happening. He was trying in his mind to come up with something that would advance the program, at the same time giving him some time to get the Lunar Module corrected from both a structural and a management point of view and a checkout point of view at the Cape. So he called me in his office one day, and he said, "I'm thinking about trying to do something with the Command/Service Module after the first flight, assuming that the first flight is very good, if not perfect. I was thinking about a circumlunar flight."

Now that leapfrogged the program over these early orbital operations that we wanted to do with the Command/Service Module and the Lunar Module in Earth orbit, proving their operability with each other. Whenever George had a problem, he gave it to me. He had already given me the software problem. I was in charge of the ground software, but he couldn't get the software out of the MIT [Massachusetts Institute of Technology, Cambridge, Massachusetts] people. So he put me in charge of that. For me it was an easy job because all I had to do was get the stuff out of there, which was easy for me to do. Not easy for MIT to do, but easy for me to do. So I knew the status of all this stuff. I knew the status of the operational capability. I knew pretty much the status of the hardware, but George knew that a lot better than I did. I told him, "I have to think about it a while. I can't give you an answer," I said, "We had all the stuff laid out according to our game plan and that [ruins] our game plan, and we'll have to go back and look at that."

Now it turns out, however, that I was doing my best to get us to the lunar program in my management mind. George [Mueller] and I used to fight about that. He wanted me to concentrate on the early stuff, and I was telling him I was doing that, but I wasn't. I thought we had that pretty well under control. So I was trying to leapfrog the program into the lunar stuff also, both for the Command Module and the Lunar Module. So I thought we could probably

hack that, if we worked [hard]. I didn't know about the [Mission] Control Center, though, because we had a lot of problems in the Control Center with the magnitude of that software and the fact that we had a lot of new display systems, et cetera. But that was coming along. But asking us to go to the Moon on the next flight after the first flight of the Command/Service Module was quite a chore. So I didn't jump on that.

However, we got together again, and I started thinking about cottoning to the idea. He called me into his office again. He said, "What do you want to do?" He said, "I've been thinking about it some more, and I think we ought to seriously consider it." So he said, "Let's go down to see Bob Gilruth about it." I describe that in my book, where the four of us, Deke Slayton and myself and George Low and Gilruth, used to have—when we had some serious problems, we'd all have a bull session about it around Gilruth's table, a round one. So off we go.

We talked, just the three of us, talked to Bob about it for maybe a half an hour. He liked the idea. We were talking about a circumlunar flight, just sending it up there, going around the Moon. We knew—they knew—I didn't know as much about it as they did, because I didn't like to know what the Russians were doing. I was with the press too much and I was afraid what I would say. So all these secret briefings that Gilruth and George Low were getting, and I don't know who else, which I was asked to get, to participate in, I would not.

So they knew the situation with the Russians better than I did, and they said, "It would also give us a leg up on the Russians, because it appears that the Russians may be trying to do the same thing." Well, that was in *Aviation Week* anyway, so I knew that was general knowledge. He said, "Besides the fact it would give us a leg up on starting improving our game plan and ability to get to the landing flight in this decade, if we fly the CSM around the Moon, we would do a lot of things." He didn't know how much he would do, really. He was thinking

about the hardware. I was thinking about the total operation. So Gilruth said, "We ought to call Deke in." We did. We got him on the phone. He came in. We talked about it for another half an hour or so.

We went out of that meeting with Deke going to see what he could do in terms of crew training, and what he would have to do in terms of crew assignments, and how he'd have to shuffle crews. Because he had them all going in certain directions to do certain things on this game plan that we laid out of rendezvous with the Lunar Module, et cetera. So we only talked briefly going out, and I told him, "You go do your thing, I'll go do mine." I called in my top guys, and we sat around a table, and they were excited about it. I didn't expect that from them. I thought I'd hear all this doom and gloom, and I got nothing but, "That's a great idea," which improved my health a great deal. So particularly Bill [Howard W.] Tindall [Jr.] and John [P.] Mayer went off out of my office where we'd had these discussions with John [D.] Hodge, who was head of flight control, and Rod [Rodney G.] Rose, who was my special assistant, and Sig [Sigurd] Sjoberg, who was my deputy. I told them generally what the situation was.

Now I have to interject here that we did not want this to become public. We knew if this thing got out to the public, we'd be in deep serious trouble. It would spread like wildfire. Because we knew that would be a change to the press, it would be a change to the Russians, it would be a change to the politicians, because they knew pretty well also what we were trying to do. I'm talking about the oversight committees in the Senate and the House, and as a matter of fact the science group in the White House under [President] Lyndon [B.] Johnson. They weren't very friendly to us. Never were very friendly to us.

We didn't want to spread this out as to what we were attempting to do here. In fact, we didn't know what we were attempting to do when I first got this group together. But I was

limited, as all of us were, in the people that we could talk to about it. So I had to do it in a makeshift manner of telling them we were doing something rather than doing what we were aiming for. Nor did George Low talk to Sam [Samuel C.] Phillips about it, his boss in Headquarters. Nor of course not talk to Mueller about it. Mueller would have gone bananas. By the way, Mueller and I are very very close friends today. In those days we were archenemies.

So overnight my guys went off and looked at this thing, and when I got back to my office the next morning, I couldn't get into my office, and they were there. They wanted to talk. They came in, and they were excited, and they talked about, "Yes, we think it's a great idea, we don't know whether we can do it or not, but we think it's worth a try, we think we ought to do it." But they said, "There's one thing we want to do which you haven't mentioned and which you probably are going to be upset about, and that is we don't want to just go to the Moon, we want to go in orbit around the Moon." Now frankly that's an order of magnitude difference in risk right there.

Of course my reaction to that was, "Why would you want to increase the risk?"

They said, "We've been looking at the data from the tracking of the Ranger [spacecraft] and the Lunar Orbiter around the Moon, and we cannot do the orbital mechanics to determine the orbit in the first place and to predict where the spacecraft is going to be from the back side of the Moon to the front side of the Moon. Every time we do it with the gravitational models of the Moon that we have, we miss by about two miles. We can't figure out why that's happening. But if we were to put the CSM in orbit around the Moon, and measure it at the same orbit that we're going to fly to land on the Moon, we could develop an empirical set of formulas which would allow us to do the right orbit prediction around the Moon."

I don't remember exactly what my reaction to that was. But I didn't know whether that was a good idea or not. Frankly, I didn't know whether I could convince George Low to do that, because as I said now, the engine has to work. You can go on a circumlunar flight without the engine at all operating no matter what. You can go at what we called a free-return trajectory, which means you could send this thing out like leading a bird, send it out around the Moon, you have to shoot it out here to be where the Moon is coming, go around, just go back to the back side, the Moon slings you back, and brings you back to the Earth no matter what you do. You only need small midcourse corrections, and you can do that with an attitude control system. But you have to have the engine to put you into orbit around the Moon, and you have to have the engine to get you out of orbit around the Moon.

So that really increased the risk probably as I said an order of magnitude, if not two orders of magnitude, at that point in time, recognizing that we haven't flown this Command/Service Module yet. We didn't know whether that hardware was good hardware or bad hardware. We thought it was good. All the engine tests were wonderful. But we didn't know. Anyway, I cogitated on that for about 12 hours or so, and then George called wanting to get together again I think two days later to see what Deke and I had come up with.

We met and started talking about it, and I threw this thing into the punch bowl that said, "Well look, if we're going to go, my people—and I think they're right—want to go in orbit around the Moon." There was dead silence in that room when I said that because they were shocked by that. But they listened for a while, and I did my best to convince them because I wasn't convinced totally 100% myself. But I told them what we wanted to do, why we wanted to do it. George, just thinking about it a few minutes, said, "Well." I don't think Deke liked it too much, but he didn't say much, I don't think. He just reported that he could change the crews, and

what he would do, and how with training, and yes we think we could get the software together. We get the trainers because I was in charge of the trainers. I knew they could do that.

So we got pretty excited in this meeting, if you can get Gilruth excited. He was so excited, as I said in my book, he said, "If we're going to do this--," and George had described to him the problem. He reiterated the problem with the Saturn V from the get-go. He said, "You realize if we do this, the next time we fly the Saturn V it's got to send us to the Moon." Last time it flew, all three stages had major problems.

So Gilruth immediately said, "Well if we're going to do this, we got to get Wernher on board." He and Wernher had become pretty good friends. So he called him Wernher.

At any rate, George said okay, and he said, "I'm probably going to have to talk to Phillips about it," his boss in Washington.

So Gilruth said, "Well,"—he went right to his phone, picked up the phone, and said he wanted to speak to Wernher. She said, "He's in a meeting." Told you that in my book. "Can he call you back?" He said, "No, I want to speak to him right now." That shocked the other girl on the other end. But he had it on the speaker system there. I don't know what she said, but she said, "Just a minute." So about five minutes, he came to the phone. So he told him, as I described, that he had me and George and Deke in his office, and that we'd been talking about a change in the program that we'd like to discuss with him, and it would require his okay and his rocket. He didn't tell him what we were talking about. He said, "We'd like to come talk to you about it."

I think Wernher said, "Well, I can probably see you tomorrow."

Gilruth said, "No, I want to see you right now."

He said, "What do you mean?"

He said, "We'll fly over there right now and talk to you about it." I'm trying to make this sound exciting because it was exciting.

So after we hung up the phone to von Braun, Low said, "I better call Phillips, we can't go any further in this thing without getting Washington involved in this." So it turned out Phillips was at Cape Canaveral at a meeting with Rocco [A.] Petrone on the problems they were having at the Cape. So he called Phillips, and George told him we were going to the Huntsville [Center], and he said, "I'll join you." So I don't know what George told him. I don't think he told him, because I can tell you when I told him, when I talked about it—or we talked about it—in Huntsville, he was pretty shocked. But at any rate, he told George that he'd meet us at Huntsville. He said, "When are you going to be there?"

Said, "We'll be there in two hours." So we got on the Gulfstream, didn't have a jet then, never had a jet while I was with the agency, we had to fly that prop thing, which ruined my ears. We got on the airplane, flew to Huntsville, they had a special car meet us into Wernher's office. So they were all gathering. Phillips had gotten there. Shorter flight from the Cape up. We all met in von Braun's office—either his office or a small conference room right off of his office. I think it was his office. At any rate, we all sat down, and I think Gilruth said some words that we had a plan on flying to the Moon on a flight after the Command/Service Module test in October. We'd like to tell you what we want to do.

So George told them what the problems were with the Lunar Module, what we thought about the Command Module, what he thought the hardware could do, what he thought we could do, said he hadn't talked to the Cape about it. Rocco's sitting there. He said, "I haven't talked to Sam about it, but here's what we want to do." Then he looked at me and said, "You tell them what we want to do."

So I got up and described this mission. I don't know whether Deke said anything or not. He may have in answer to a question about what he would do, what about the crew. I could tell by the looks on the people's faces that they were surprised, but they began to become quite elated about it. That's how Phillips responded immediately. He responded saying he thought it was a great idea. He was proud of us for bringing it up. He recognized, he said in so many words, he recognized what a boost to the program it would be if we could pull it off. But he recognized the risks involved, the risks of getting ready to do it, the risks of being able to do it, the risks of having an almost perfect flight on the first flight of the CSM that would allow us to do it. So we had not too long a discussion following that.

Rocco Petrone said he thought it was a great idea, but he didn't know exactly what they could do at the Cape. But he said, "We'll do the best we can, and we'll bust a gut to get it done."

Now Phillips, in answer to that, said, "Look, this is a pretty serious change, it's a serious risk, it's a serious thing in terms of convincing our own management and the politicians, so I don't want to talk about this outside of this room until we've thought about it, and see if there are any showstoppers under the things we have on the control, and we'll have a meeting two days from now."

So two days later we had a telephone conversation, and everybody reported, and everybody was going on for it. Sam said okay, after we got through telling him what our problems were and what we thought we could do. He said, "I've got to expose this to Mueller and [James E.] Webb [then the NASA Administrator]." He said, "I can't not do that." Now as I said again, they were in Austria at an international space meeting, and he said, "I'll have to call George Mueller and Webb." I don't know whether he had a conference call with them or not.

But he talked to them and then described that call to us, and he said they were livid. That here they were out of the country a few days, and here we were reshaping the whole program.

Mueller was deathly opposed to it. "Can't do that. That's craziness," is what he told Sam. I'm paraphrasing. I don't know what he said. But I can imagine what he said, because I knew George Mueller. So Sam reported all that to us, but Sam was a very competent human being, he wasn't the greatest technical guy in the world, but he was a great manager, and a great representative. He said, "We're going to continue on because I think it's a right thing to do."

Then we brought [Thomas O.] Paine into the [discussion]. Paine was the Deputy Administrator, and he acquainted Paine with the situation. He could tell that Paine liked it, but Paine wouldn't react. But he did approve of going ahead with it. Now then, Sam, he says, "You got to keep this secret." After a couple of days I went to see George, I said, "We can't keep this thing secret anymore," I said, "I've got to have at least seven or eight more guys that know the whole game plan here." Deke had the same problem. We've got to start laying this thing out if we're going to do it. So they agreed that we could get a few more people involved. But they couldn't talk about it. We had to do it as if it was a general game plan.

Mueller came back, and we had meetings. The meeting man had meetings in Washington. He was still very cold to the program, and he got recommendations from other people, and they were cold to it. He talked to Webb about it, and he was cold to it. But it turns out that Paine, who was Webb's deputy, very favorable internal to NASA. So we proceeded. Finally we convinced everybody that well look, we're not saying we're going to do it. We've got to fly the Apollo 7 first, that's number one, it has to be practically perfect. You can continue to work on it.

Webb says, "I'll have to announce that to the press, that we're doing this sort of thing, and I will couch it in the terms that it is a possibility being considered that we might do this for the various reasons that you guys have given me from the standpoint of the Lunar Module." I don't know who else he talked to. Webb was a politician, so I'm sure he must have talked to the heads of the committees at the Congress. Probably talked to the White House. I'm not even sure he didn't talk to Lyndon Johnson about it, because he knew Johnson very well also as a personal friend. I assume he did. But I don't know that. George told us that all of that was going on, but I didn't pay too much attention. I had too many things to do, and it wasn't my job, and it didn't worry me anyway.

But at any rate, we all decided that was the game plan. So here we had the flight, and it was perfect. Apollo 7 was about as perfect as any spaceflight could be. As a matter of fact, for a first flight, it was uncanny. Nothing failed. Nothing. Now, we had a failure in the pilot. But it didn't matter. Technically as a test pilot he did a [good] job, and so did the other two guys. So here we are one day after the flight, and now we're faced with fish or cut bait. We've got the success we were looking for, things were going pretty well, and now we got to go do something, we've got to make a decision.

So we got to Washington, and Mueller says, "I've got to call in the presidents of all the companies and see what they have to say. I've got to talk to Webb about it." I could tell he was getting a little warmer to the thing, but he wasn't too happy about the fact that he didn't invent it. Wasn't invented here. He had a lot of advisors, including Bellcomm, who was his technical group in Washington, tell him they didn't want to do it, that there was too big a risk.

Anyway we had all these presidents come into Washington. Gilruth and George and Deke and I and Bob, we're going back and forth to Washington like rubber balls to get this thing

approved. Gilruth is telling Mueller, "You're meeting us to death." But Gilruth was not, as I said, as aggressive as I was, as I am. But at any rate, we had this meeting. I described that. I even described the words that all these people said. Presidents of all the major companies—and I guess there were 11 or 12 of them—that were involved in Apollo. I and others all made—I was the major guy to make the presentations, along with George Low. He gave the program management description, and I gave the description of what we wanted to do and why we wanted to do it from an operational point of view. They hadn't heard anything about it, and George asked all these guys what they thought, and with one exception all of them thought it was a good idea. They all admitted that it was a high risk, they all said it was a very gutsy thing to do. I don't think they used that word, but similar words. But they thought, just like we did, that it was a [big] step in the program, and that if we could pull it off it would really be a step function increase in both the morale and the confidence that we would have in doing the job.

So we came out of that meeting, and Mueller wouldn't make a decision of course, said, "I have to think about it," and they had a separate meeting with their top management. I guess with Webb and Paine. I reported in there that Paine had later told us in a private meeting that we had had, previous to that meeting, that he thought—he really praised us highly for having the guts to do what we did, and that we were willing to do something that wasn't planned and had the management and judgment to do that. So we knew we had a friend in Paine.

Now in the meantime, Webb says, "I quit." I don't know what forced Webb to quit. Webb had a terrible experience from the Apollo fire with the Congress. If you've read about that, they were on him because it turned out that there were some internal reports that had been written to Sam Phillips which had not been reported to Webb; he didn't know they existed, which described his dealings with North American previous to the fire where he had read them the riot

act, and after the fire threatened to kick them out. That was all written, but confidential reports, but the Congress had the things, or the Congress's staff had gotten hold of these reports, and confronted Webb with it, and he didn't know about it. He refuted them. Came back to his office after that briefing to the Congress and found out indeed they were existent.

He had to go back and eat those words. So he had lost credibility to some extent with the Congress, having had total credibility. So I think he was concerned with what was going on. I don't know whether he just felt like now is the good time for me to get out of here or what. I don't know that he has ever said. There's been a couple of books written. You read that book about Webb, written recently—recently meaning the last five years? That's a great book. Power something.

WRIGHT: *Powering Apollo: [James E. Webb of NASA]*.

KRAFT: *Powering Apollo*. I thought it was a wonderful book. Webb and I were about as close as you could ever hope to get between somebody at my level and his level. He called me by Chris; when I made briefings, he'd interrupt me and make my briefing. He thought the world of me. Sort of like a son to him. But he never told me anything about why he did what he did. I guess that he just couldn't stomach another Apollo 1. I know that's probably unfair to him. I don't know. Maybe he had some other personal reasons. Maybe he had some other political reasons. Maybe he thought that somebody else could do better than he could with NASA. I don't know. I know he was not happy with a lot of things at Headquarters after the fire. He didn't like the management. That's when he brought in Mueller and got rid of a lot of people.

But I don't know how well he even got along with Mueller. So that's all underlying there, which you have to talk to somebody else besides me, because I don't know.

But he left. Now that left Paine as the Acting Administrator. That made it a lot more simple to get it through the works up there. There's a lot of works in Washington. Yes, they had a checklist, I'm sure, that was a mile long of people they had to consult with. Because you don't change something that changes the world. Literally, because it was something was going to change the world. If we killed somebody going to the Moon, it was going to change the world. Which we had the high probability—I say relatively speaking, the high probability of doing. If we were successful, it would change the world. Because it was obvious, if we could pull that off, that the Russians were probably through as far as a contender to going to the Moon. Because we knew pretty well that they were having troubles with their rocket.

So I'm sure they went through their checklist, went all the way to the President I know. Told Lyndon Johnson what we were doing. We got the word that NASA had made the decision they were going to do it, and then they said, "We've got to check with the outside world." So within 48 hours, we had a go decision to go do a lunar operation. At that point it was exposed to the press. As I said in my book, I couldn't believe that the press didn't know it already, because we had said in the original thing before we flew the first Apollo spacecraft that we were considering that kind of a mission. But I never got a question about it. It was amazing to me that nobody in the press smelled that mission out. So boy, when that hit the fan, it was a headline in every technical paper and a headline in most newspapers, that NASA is going to try to go to the Moon on the next flight.

That pretty much is the story. From then on it was get it done. Get the operation done, get the software done, get the people trained, get the scientists involved in telling us what they

wanted to see, what they would do if they were inside that spacecraft, what would they look at, what did they want to see about the Moon, what do we want to get out of it, what are our goals, what are our objectives, what are the test things we want to run to make sure while we're there we do this, that, and the other. Laid that out minute by minute.

WRIGHT: Before we get into those, why don't we just take a break for a second.

[pause]

KRAFT: Not confident that we could do it. But there were plenty of stopping points along the way. Not once you light the fire, in terms of the risks now begin to multiply. But there were plenty of places along the operational mission where we could stop and regroup and reconsider, even though we were up there.

WRIGHT: Now that the rest of the Space Center here in Houston knew the plan, what was the reaction from the troops here?

KRAFT: It was total excitement and exhilaration. Everybody recognized what a challenge that was, and what a shock to them, like the rest of us, that NASA was willing to do it. Because by this time we were pretty—what's the word? We were a pretty bureaucratic organization by this point in time. Even though NASA was the best-run group in the government, which even Senator—who was the senator from [Wisconsin]?

WRIGHT: [William] Proxmire?

KRAFT: Proxmire. He invented the Golden Fleece Award. Even though he said we were wasting all this money, he said on the floor of the Senate that it was still the best-run organization in the government. So we were a very great organization, and able to do what we did technically, but we still were bureaucratic at that point from where we had come from.

WRIGHT: When we took just a second for a break, you talked about how it was a minute-by-minute-planned event. Would you share with us how you balanced all those aspects that you mentioned: the scientific goals and objectives, getting the people trained? Tell us how you started putting all this together and were able to accomplish what you did in such a short amount of time.

KRAFT: The planning really didn't happen that fast. The planning to do what we were doing had been in place for a couple of years. We had laid out the plan to build the software in the Control Center, and it's five million words of code, which in today's world is nothing, but in that world took all the computer capacity we had in this country in the bottom floor of that Control Center. We had a computer on board the spacecraft, which was not the epitome of technology at that time because it was hand-wound core storage in that computer, but nevertheless it was state-of-the-art. Because it took that length of time to get something like that done, we had to link the game plans that we had laid out in terms of charts, and this is where we got to be this date, this date, and then we began to measure ourselves against that, and then the operational planning guys were following along with that in terms of this is what we want to do with the hardware,

this is the test we want to run with the engine, this is the test we want to run with the reaction control system, this is the test we want to run with the guidance and navigation system, this is the test we want to run that proves to us that the cooling system works. The pilots, in terms of time plan that they wanted to be able to do this in orbit, and check things out while we're in orbit, and say everything was go before we fire the engine to go to the Moon now—we had been planning that. We were suddenly faced with having to do it, and do it out of sequence from what we had planned to do. But that's the thing we had been working on now for a couple of months.

We asked the scientists, "Okay, we're going to have six eyeballs able to look at the Moon from 60 miles for the first time in human beings' operational capability on Earth. Never been to the Moon with anybody's eyeballs. What do you want to look at? What do you want to see? What do you want them to report? What is the thing you would like to know?"

They began to think about that, "Tell us the color, tell us the shadows, tell us the shape of things, tell us the crater size, tell us how many craters you see, what do you think it looks like compared to Earth." They began to think about that sort of thing.

The other thing we had to do was we had to rendezvous with the Moon and had never done that before. Now, we thought we knew where it was. When I told Mueller that we wanted to replicate the actual lunar mission, in terms of altitude above the Moon and trajectory across the Moon's face, because we wanted to look at the gravitational model from that altitude, he was [angry], because he said, "You don't know that you're that accurate. You don't know that you can hit the Moon within 60 miles as you are aiming at this thing 270,000 miles away. You don't know that your radar is that good. You don't know that your tracking is that good." All correct. But we thought we did, and we had previous missions to the Moon, don't let me kid you.

We had Ranger and Lunar Orbiter that we put up there, and we'd done that very very well. The tracking system, the deep space tracking network, had done that very well. They had told us what we were getting from Lunar Orbiter around the Moon too. So we weren't dumb. The thing we were dumb about was we didn't know that—nobody had come up with mascons yet [mass concentration – region of a planet or moon's crust that contains a large positive gravitational anomaly]. That's what screwed up the gravitational model. You may not believe that, but it did. Just the things that had hit the Moon and left these big core things of iron probably jammed into the face of the Moon had changed the gravitational effects, and that has a perturbation. Generally speaking, it doesn't change things, but when you're trying to get very accurate, it does perturbate the orbits.

We said, "These are the things we want to know." I tried to go through all that. So as we then laid out the flight plan, as we always did, we had their time planned down to the minute, to, from and while there. We gave some time to relax, time to think about it, time to tell us what they saw, time to think about the fact that it was Christmas. You heard my report there of my problem, with the DoD's [Department of Defense] problem with the fact that we were now not going to land in the Atlantic, we're now going to have to land in the Pacific, and we'll need a carrier task force in the Pacific over Christmas when CINCPAC [Commander in Chief, Pacific Command], who was Admiral [John S.] McCain [Jr.], [Arizona Senator] John [S.] McCain's father, had just told all his people they could get off for Christmas. So I had to go convince him because General [Vince] Houston wouldn't do it.

WRIGHT: I thought that was a very interesting part of your book, that whole scene of being in that empty theater and have it filled.

KRAFT: That was a thrill for me. I really enjoyed that. Reflect on it many times. So we had to go do that whole recovery operation. That probably involves 20,000 people in the Navy. They're just on the ships. But it does involve that many people. It involves the planners in the DoD. When you do things with the DoD that's layers upon layers. You've got to train the frogmen; they've got to know where the spacecraft might come down and what the dangers are, what they can do around the spacecraft. You can't touch this, if you do you're going to get burned. You need to get rid of this, and this is how you open the hatch if you have to open the hatch, and here's the tools you can lift it up with, and then you got to crank this thing on board. The astronauts might be sick. This big bubble's on top, the balloons. All of that training has got to be done. That's different than we had planned to do because it's going to be in the Pacific. We didn't have any people in the Pacific trained yet. They were all in the Atlantic. We had to get those people in the Pacific trained.

Flight control team. They're pretty resilient, and they can do most anything. Their "what if" games are so broad that you can't hardly ask them something they haven't thought about. Thank God, on Apollo 13. At that point in time we had maybe, I don't know how many different groups, both Operationally and in Engineering, sitting down saying, "Well these are all the things that we have to have ready, these are the things that we've got to make sure we have confidence will work, these are the tests we're going to run to prove it on the ground and then in flight." When we first began to look at the cooling thing, we realized that we couldn't leave this thing sitting facing the Sun. You can't just go to the Moon and let one side of the spacecraft face the Sun and the other side face the Moon. You're going to have to barbecue it. Got to rotate the thing, and that affects the way you have to do guidance and navigation, the stars you're going to

look at and the rotational rates, you're going to get involved in that. People began to think seriously about having to do all that.

That's in the software, and you have to know where the stars are at the time of day and the time of the season that you're going to fly at, because we put 35 stars into the computer, and what you do is you look at this star and that star and that star, and you triangulate inside the computer, and you do it by hand, you do it on the ground, get these coordinates for what that says, and that'll tell you where you are. You have to be willing to say, "If the computer craps out on you, what is the crew going to do to manually be able to do that?" So we've got to make sure that Borman and [James A.] Lovell [Jr.] and [William A.] Anders know how to do that. Do that in the trainer, but they've got to know what the star charts say and where they are. But you got different groups that had that as a job anyway. Just now you're going to have to do it for real.

WRIGHT: Was there any aspect that you took on as specific details that you took as your personal responsibility?

KRAFT: Personally? I'm a guy that wants to know what's going on in everything. But I don't have to know the details of what's everything. I just want to make sure everybody's thinking right, that everybody was doing their planning, that they had their game plans made out and could show me that they indeed did, both in the hardware and the software. But I'm not a detail guy. I didn't have to know the details of everything. I did know most of them, but I didn't have to. I and George Low and Max Faget, we had the best people in the world that were so extremely and highly motivated that after you see them perform for a while, you know they're

going to do it and do it right and do it well. I never had the slightest doubt that any of the people that were in charge of that stuff couldn't do it. None.

I had the same feeling about MIT. I knew all the managers, and I knew a lot of the engineers because I was running the Configuration Control Board for the software. As I said in my book, I wouldn't let them make a change unless I personally approved it. So I had to know a little bit about it in order to be able to do that. But the MIT guys were brilliant. Brilliant group of engineers. They just needed good management, which they were trying to do, but they didn't know how to deal with the astronauts. They thought the astronauts were God, and so they were going to give them everything they wanted. Which was a good idea, but somewhere you had to draw the line, if you were going to get it done.

Within the industry we had people like that too. We had Dale [D.] Myers and George [W.] Jeffs running the North American Company. They had a bunch of great people involved in it. They had put together a team after the fire, with the help of George Low. Both there and at Grumman. So I think that by the time we got to Apollo 7, I don't remember that we had any doubts about anybody, in terms of management or capability to penetrate the quality of what we were dealing with. I don't remember having any doubts about it at all. Now I don't mean to say that we didn't realize that we could get this thing pointed in the wrong direction off of the S-IVB, that when we got to the Moon we weren't at 60 miles altitude. Or when we got on the back side of the Moon, where we could not see what was happening from the Control Center, that the thing was on its own.

It was like kicking the bird out of the nest when you were on the back side of the Moon for 30 minutes, both putting it into orbit, coming out of orbit. Coming out worse than going in, in my opinion. Bill Tindall, as an example, gave me a presentation of all the things that could

happen when you fire that engine on the back side of the Moon. If the attitude control system did not work perfectly, when the engine stopped burning you could be going into the lunar surface. Or you could be going out into deep space and never see it again, if it cut off at the wrong time in the wrong attitude. What he was going to do about it in the computers, what the flight dynamics guys were going to do about it, the first time we saw it, when it came back around the Moon and it wasn't what we expected, we had thought about that in great detail.

So Mueller was right. It was dangerous. It was risky. But you heard what Lovell said. He accused us. When we got to the Moon, we had computed the exact second we would lose communications with the Command Module. It happened at exactly the right second. Lovell accused us of cutting the communications off. He said, "You can't be that accurate." But we were. The same thing is true about when it came back around the other side. We knew exactly the second. If the engine worked as it should, when the engine cut off and put it into orbit around the Moon, we knew the exact second we should see that vehicle come out the other side of the Moon on the deep space network. Computed that. That was in the press briefing. It said, "We're going to lose communications at this point, we will regain communications at this point. If not, we're in trouble."

WRIGHT: If you would, since we're at this point in the discussion, would you spend a few minutes and reminisce with us about that moment when you heard Lovell's voice come through and knew they were in lunar orbit and the plan was going as you had hoped?

KRAFT: While they were on the back of the Moon was extremely tense for me. I now have heart problems. I'm glad I didn't have them then. Because it was a time of reflection that well, we've

done all this and here we are, and God knows it better work. So I'm sure those thoughts were going through me. But the worst time was when after we'd been there for ten revolutions and come out of orbit, when they went back to the Moon to fire those engines and come out of orbit, now I was really tense and anticipatory. I imbedded that word a lot of times. About what might happen, what could happen, and waiting for it to happen. I was very upset with a lot of people in the Control Center that weren't as concerned about it as I was, inside the MOCR [Mission Operations Control Room]. Matter of fact, I yelled at Chuck [Charles A.] Berry and told him to shut up. I said, "You may not be worried about this, but I am, and I'd like to be quiet for a while so I can pray or whatever the heck I've got to do to make sure that thing comes out the other end." I didn't say that, but I said it in so many words.

George Low and I—I don't know about Gilruth, I can't speak to him, because he was always reflective anyway. But you couldn't tell quite what was bothering him. I know he died a thousand deaths every time one of those things launched. But you couldn't tell it. But I know George Low and I were sitting there looking at each other, next to each other waiting. Not so much going into orbit, although that was exciting, and we'd worried about it, but not a tenth of what I was worried about after the firing to put it back on a return trajectory to Earth.

That's when Lovell said, "There really is a Santa Claus." That Christmas Eve when they read from the Bible, both Borman and I are lay readers in the Episcopal Church. So we had done that several times in our life, quite a few times I'm sure with me. I don't know about him. So that was very impressive that they chose to do that. Teary-eyed, I guess you would say. But it sure was a relief in mental anguish when I knew they were on a return trajectory to the Earth and that engine had worked perfectly both times. Never had any problems.

The first time we fired it, it had a glitch in the thing, and it scared us. As I wrote in my book, on the way out, we had a game plan of let's run the engine for a second or so just to make sure the engine is going to run. My trajectory guys didn't want to do that because the trajectory was so good they didn't want to screw it up. They said, "If this thing burns and it's out of attitude, we could be off trajectory quite a bit."

"I don't [care]. Fire that thing, and I'll get it back on trajectory for you. But I want that engine run before we get there." We did see a glitch in it. We didn't realize the gas was still in the lines. So the startup was abnormal. Took us a few hours to figure that out too. It was okay. But took us a few hours to figure that out. George Jeffs figured that out; he said the engine is okay.

That engine, we had never had one single moment's problem with that engine. That was a fantastic engine. Now you got to recognize that—you don't but I do—that's a pressure-fed engine, as compared to the turbo turbine-driven engine on the Space Shuttle. All you have to do is open a valve—have to open two valves—and it starts burning and giving you thrust. Whereas when you start up the SSME [Space Shuttle Main Engine], you see all that fire and smoke and all that preburning and preshaping and precooling and all that stuff, and then the turbines have to come up to 37,000 rpm [rates per minute] in order to pump 8,000 pounds of fuel per second into that engine. All hell breaks loose when you fire an SSME.

That's not true when you fire the SPS [Service Propulsion System], you just have to open the engines and it puts fuel in the head of the thing, and it burns. That's great. It's easy. That's the right way to do it. They're not going to do that on the next lunar mission, next Lunar Module. I've been giving them a hard time about that. Very hard time about that. I don't like

the way they're doing it. They've been working on that for about a year, on trying to change it, but I don't think they have. Maybe they can't. I don't know. Can't get the power maybe.

WRIGHT: When we first started, you mentioned about designing spacecraft involving or incorporating the human element of it. You had the spacecraft that was functioning well, and you found out that Frank Borman didn't feel well on the mission. Did that give you a concern that you may have to change your plans?

KRAFT: No, I was just ticked off at him he didn't tell us. I don't like secrecy of a test pilot. I don't like test pilots that don't tell me everything. I can understand why he didn't, but I still don't like test pilots that don't tell me everything because if you don't tell me everything, there's not a thing I can do to help him. That's what flight control is all about: how do we preserve the life of the human first, and then how do we accomplish the mission second if something goes wrong. That's what flight controllers are trained to do and ready to do, and that's what's going to make the mission successful. So I'm not very happy with people that are secret. He knew that. But he was anyway because he didn't want to tell us he was sick.

But the first thing is we could have given him a pill. He didn't take the pill, which he should have, and then if he'd have told us we'd have forced him to take the pill, and he would have gotten well a lot quicker. Now was I worried after I found out about it? No, because I knew he would get better. He was a test pilot. He'd been in various gravitational fields before. Not for that length of time, but he'd been in Gemini for 14 days at zero gravity, so I knew he could deal with it. It's just that it ticked me off that he didn't let us help him.

When you get a spacecraft full of vomit at zero gravity, it doesn't tell you where it's going. Or full of excrement. Think about that. Just think about that. We've had that happen. So that's something you don't want to deal with if you don't have to. On Mercury 10, urine got free. One of the bags broke. One of the urine bags broke in [L.] Gordon Cooper [Jr.]'s flight, and then got into the systems, and they were beginning to fail because they had moisture in them. They were not vacuum-sealed. Now at least in Apollo we had vacuum-sealed everything. But still, if you got vomit and human waste floating around you it's not very comfortable to begin with, and it can be dangerous in the second place. So people don't stop to think. You don't stop to think about that....

WRIGHT: There were so many details to have to put in there.

KRAFT: Yes, you better worry about it, because if you don't worry about it it's going to happen, and it's going to give you problems.

WRIGHT: I was curious about a different type of issue that I thought might take a lot of details to think about it, and that's the equipment to photograph the Moon. You had photos that come back from unmanned, but now as you mentioned you were having eyeballs that were going to do that.

KRAFT: Yes, well it turns out that's easy. It turns out that you can do it with a Brownie and get perfect pictures. Because there is no atmosphere, and the focusing is so far away that you don't have to worry about that if you're taking pictures of the Moon. The colors are true because you don't have the atmosphere screwing it up. So if you take an F setting in a Brownie camera, it's

about as good as you can get. Now, we did use the best. It was a Hasselblad. I met him. Great gentleman, [Victor Hasselblad]. He was very very pleased that we had his camera on board. Probably made his company. But we used a Hasselblad camera because it took great pictures. But as I said, you could have used a Brownie.

WRIGHT: That's interesting. It was the first time that the world got to see the Earth.

KRAFT: Now that probably was the most significant picture. I was reminded of that the other day, when I said I was going to do this. Somebody said, "That picture they took of the Earth was probably the greatest picture ever obtained in space," and it is. Taking that picture of Earth was really something, and particularly Earthrise at the Moon. I'm surprised it's not in this office. It's almost in every office in the Johnson Space Center somewhere.

WRIGHT: We'll fix that. We'll get it in here.

KRAFT: But it's a very very very famous picture. Borman will tell you that when he saw that, it was one of the most impressive sights he's ever seen in his life. All three of them will tell you that.

WRIGHT: I found it interesting in your book that you talked about Bill Anders talking about Earthshine.

KRAFT: Yes.

WRIGHT: Can you share a little bit more about that?

KRAFT: Well yes, because Max Faget used to tell me. He said Moonshine is one-tenth the strength of Earthshine. Think about that, because it is. It's about one-tenth. So when you see the Moon shining on the Earth, Earthshine at the Moon is about ten times as strong, it's a pretty interesting thought. So the thing that you have to recognize also, which nobody thinks about in terms of the Moon, and that is what you see on the Moon, because you have no reference.

Depending on what altitude you're at you see craters, and that was particularly important on landing on the Moon, because as you approach the Moon all you do is see more craters, because the smaller craters begin to be visible, depending on the range. So from some altitude you see all these craters, but they're all big craters. Then you get down here, you see more craters. When you get closer you see more craters. But you don't know what their size is. You don't know what the rock size is. You don't know whether you're seeing a big rock or a little rock because you have no reference. There aren't any automobiles, there aren't any trees, there aren't any buildings, there aren't any streams, the mountains you see, you don't know how tall they are. Relatively speaking I'm saying. You have no reference.

That's the reason we had the Sun angle—the one thing we do know is shadow length, right? We do know shadow length as you approach. From a crater you can see the shadow. So in order to give the pilots depth perception, we landed with the Sun at their back at 7 to 12 degrees' angle. That's one of the major criteria in setting the launch time and the launch window in going to the Moon. We wanted the Sun angle to be a certain angle. We wanted the Sun at that angle at the point we were going to land at. We wanted to land in the Pacific back on the Earth.

When you put all that together, you had a three-hour launch window three days out of the month, and if you wanted to do it very well, one day out of the month.

WRIGHT: Amazing. What did the astronauts tell you when they got back? Did you have a chance to spend a little time with them to talk about the mission?

KRAFT: No, I didn't personally spend much time. Well, that's not true. I spent some time with Borman because we were close friends. We went to dinner together one of the nights after he got back, with George Low and myself. But even there, it's still not close. But I was probably as close to Borman as an astronaut flyer, as any of them. I was close to Deke Slayton from a personal friend point of view probably more than anybody else because we spent so much time together. But Frank and I were probably as close too, still are today, more so than any other astronaut. So he had tremendous confidence in me personally, and that was a tough thing to live up to sometimes. We still are friends.

WRIGHT: Did he offer any recommendations or suggestions from his point of view?

KRAFT: Oh yes, sure, they all tell you that. But they didn't tell me that. They are debriefed to a fare-you-well. All these preprepared questions they answer. I think you hit on something that, to me, is one of the most phenomenal things about astronauts, and that is their ability to learn from the previous experiences. It's almost 100 percent transfer of learning knowledge. What do you call that? What factor is that? When you teach people?

ROSS-NAZZAL: Learning curve?

KRAFT: It's a learning curve, but it's some other—transfer—some other word. But it's almost 100 percent. Now that's amazing to me. Even starting in Mercury, it was amazing to me how each astronaut learned from the previous set of experiences. I think that was due to the communication they had with each other. But it was also due to the thoroughness with which the debriefers and the training people went into what they said, and the questions they asked, and therefore the things they put into the trainer from that. Then our training hardware, the systems that we had, were extremely good in replicating what they could see, as well as the requirements to operate the hardware, the systems on board, switch locations.

Look at the switch panel. We got hundreds of switches. I think there were 1,000 switches in the Command/Service Module. You didn't use them all. But if you look at that switch up there—something like 1,000 switches which they had to know what they were going to do. They didn't, of course, because nobody's that good. But we had the people on the ground who did. So between the two of them, they could pretty well do whatever you could do with the vehicle.

WRIGHT: When all the determinations were made that that time period in December of 1968 was going to be the time to launch this mission, and it happened to fall on Christmas Eve and Christmas Day, did the Center receive any opposition from any of the outside forces?

KRAFT: If they did, I never knew it. We had people at the Cape, not so much on Apollo 8, because I don't think they could gather their forces that quickly, I don't think the naysayers

recognized quickly enough what we were doing. But for Apollo 11, we had all kinds of protesters at Cape Canaveral about spending all that money and going to the Moon. You remember the black group, [the Poor People's Campaign]. He [Ralph D. Abernathy] had a big group of people at Cape Canaveral for Apollo 11 protesting—I don't think he was very serious about it, but he was protesting with a whole group of people down there about spending all that money going to the Moon. I don't think we ever had anybody protesting the fact that we were treading on God's world or something. I don't remember anything like that.

WRIGHT: A while ago, during the break, you mentioned about if there was always that possibility if things didn't go well. Of course it'd been around the Christmas holiday. So I was just curious if someone had thought maybe to rethink this.

KRAFT: Until we decided to go, and when we would be ready, and then what were the launch windows, we had no idea that it was going to be on Christmas. We got accused of that, that we did it purposely to do it on Christmas, and we would be around the Moon on Christmas Eve. That's untrue. Just that was one of those happenstance things. I didn't have any idea that it was going to be Christmas. Had no idea. Because we hadn't computed yet what the launch window was. Now we did compute the window for January and February because how many times did we count a rocket down in Cape Canaveral and go?

Even today. Today you don't count that thing down—of course the launch window is a little narrower today because you got to rendezvous, and you only have so much capability. You got to rendezvous with the Space Station. But even then, it was three hours to meet our criteria of getting to the Moon at the right time and the right place with the Sun at the right angle, and

over the landing site that we had chosen. We didn't have to choose the landing site that we were going to land on Apollo 11, we had to do that on Apollo 8. We weren't exactly there, but we knew it was the Sea of Tranquility, Tranquillitatis or whatever it is, Mare Tranquillitatis.

WRIGHT: That's it, and 1968 was such a year for the country. A couple of times in our discussion this morning, you mentioned the political influence and the impacts on the space program. We'd just had a presidential election, President Johnson, longtime supporter, vocal advocate for the space program, chose not to run for reelection. Now you were kicking off a big step toward the Moon. At any point in time did you think that with the change in the presidential seating in the office, were there going to be doubts that we were going to be able to continue this program?

KRAFT: Yes, I think we thought about that. I don't think many people knew [Richard M.] Nixon that well.... But I think we, the management, had some concern budgetwise that we would be supported. But I think Lyndon Johnson was the President or the person in control that assured that that was going to take place, although I don't think Lyndon Johnson [cared]. I don't think that the lunar program was a priority with him. It was only a priority with him because it was Kennedy's idea.

I've never read that, but I think he felt obligated to carry out what Kennedy had said we were going to do. I'm sure he felt that that was an obligation that the country had to fulfill also, because we said we were going to do it. But given his priorities, I don't think the space program was high on his personal priorities. I just don't think so. Frankly, I don't think it was Kennedy's high priority either. By the time we started to do it, I'm sure that he had second thoughts about

the budgetary requirements also. I don't know that at all. That's a pure guess on my part. But his reasons for doing it were as far from being technical or scientific as you could get. He did it to ace the Russians. Flat out, he did it to ace the Russians. I think that was his objective in the first place. Now, I think that having said that's a good thing to do, then he built a lot of folderol around it, about all those flowery words that his speechwriter—who was his speechwriter? Great speechwriter. [Ted Sorensen]

WRIGHT: Can't think of him either.

KRAFT: But at any rate, the words he wrote for him in the two speeches he made in the Congress and at Rice University [Houston, Texas] were about as good as you can get. But somebody put those words in his mouth. Once the words were in his mouth I think he was inspired by it, don't misunderstand me, because he was an inspirational person and he was able to inspire the country. But I have to be callous enough to say I doubt it. But we were committed. The country got committed, and giving up on it I think many times crossed his mind, and he'd say, "Why are we wasting all this effort and time and money on this thing". But when he would stop to reflect on it, he said, "We're committed, and we got to do it." I think that's about the way he would go about it in his mind.

Now, I don't think we felt that way. I think that George Low, myself, Bob Gilruth and Max Faget, Deke Slayton, to say the top, and then lots of layers below it, all felt that it was our duty to do it. It was something that was required of us, and we were representing the country, and we were going to do everything within our power to do it and do it right. I don't believe that it would have been anywhere near possible to do it, had we in the management not had that

commitment. Because it was too hard. I think that the people that were working on the program—and I say this by the thousand—were giving us 110 percent of their capability every day. I don't think we could have done it without that kind of dedication to the program. I think we got from the recesses of everybody's mind that worked on the program, we got it. If they had some talent buried back in those places, it came out.

Now that's what was so wonderful about working on it, is that I think that most of us—now I guarantee you not all of us—but most of the people working on the space program felt that way. Maybe at least 90 percent. There would probably be 10 percent that say we were nuts, overcome, and why are you doing this, and I don't feel so good. The perfection we did it with, the tests run on the hardware, the success of the hardware couldn't have been done without that kind of commitment right down to the working level of the guy on the machine, in the machine shop, or the little old women that put the wires together at North American. I could walk in that room on the Shuttle, and those people would clap. Those old women in that room would clap because they knew who I was. So they had that same commitment. Back then they had that commitment.

Now that probably took a lot of doing. Posters all over the wall, and [Silver] Snoopies [NASA Space Flight Awareness Award], and astronaut visits, and speeches, and myself and others going all around the country meeting with these people. On the Shuttle we had 75 major subcontractors; I was in those 75 contractors at least 3 or 4 times each, some of them 10 times each, and they're located in 48 states. So it took some doing, but I think that was required. Then I think we were rewarded by that kind of commitment from the people in the country. That's what was so impressive about the '60s. Recreating that is probably impossible. I don't know whether we can ever do that again. The Manhattan Project [project to develop the first nuclear

weapon] is something that maybe compares to that. But the Manhattan Project was limited to a few hundred people. The Apollo Program had 400,000 people involved. Somebody had to manage that effort. So managing 400,000 people in all walks of life was no simple task. That's not braggadocios. That's fact, because you couldn't have done it without that kind of commitment.

WRIGHT: As a last question about Apollo 8's mission, you've mentioned to me and you mentioned in your book that you feel that it was the most significant mission that NASA has ever flown. It's going to be 40 years in December, and a lot has happened since then. Do you still feel that that title goes with Apollo 8?

KRAFT: Yes, I don't think there's any question about it. I think the first flight of the Shuttle—manned flight—we did some Approach and Landing Tests—but the first flight of the Shuttle from a technical point of view was equivalent. But not from the total aspect. I was asked after the first Shuttle flight for a statement to the press, and I said, "We just became infinitely smarter." I would agree with that statement today. A lot of the things that happen every time that Shuttle flies still amaze me from a technical point of view.

But not from an emotional or the significant effect on the country and on the world that Apollo 8 had, because man had been looking at the Moon ever since they could see and wondering about it, thinking about it, looking at it from a religious point of view, from an astrological point of view, from a farmer's point of view, then later from a scientific point of view. There were all kinds of scientific theory about how it got there. We still don't know that today, by the way. That aspect of it. But then putting ourselves in the position of doing that for

the first time, of having a human being walk on another planet, of having a man leave the Earth for the first time, being able to look back at the Earth for the first time, realizing the environmental aspects of that, you can just go on and on.

The firsts involved in Apollo 8 almost were unlimited, if you stop to think about it, from an educational point of view, from a theological point of view, from an esthetic point of view, from an art point of view, from culture, I don't know, you name it, that event was a milestone in history, which in my mind unless we land someplace else where there are human beings, I don't think you can match it, from its effect on philosophy if you will, the philosophical aspects of that. Think about the Bible. Last Sunday was Trinity Sunday, and the reading is the first verses in Genesis, that God created the heavens and then he created the Earth and then he created the waters on it and then he let there be light, and he created these animals, both walking and creeping, et cetera. Think about that.

That was all with extreme limited knowledge, which totally changed with Apollo 8. There were religious sects on the Earth that would have never agreed that that could happen. Kicked them in the fanny, didn't it? Scientists have changed their mind totally about the Moon since we brought them back a rock and a handful of sand. On and on. The astronomers think differently. Now they've got a lot of data since then. They didn't have it then. Almost from any point of view: theologically, philosophically, scientifically, engineeringwise, managementwise, scope of capabilitywise. Outside of a war, we have never done anything like that in this country.

WRIGHT: It's true, we haven't.

KRAFT: Outside of a war. It took a [very big] accomplishment. James Webb does not get a lot of welcome for that, but he had a lot to do with it. He sold space to this country as a politician. So he was a great leader for NASA at that time. To have that kind of makeup.

WRIGHT: One word that when we read about Apollo 8, that I think that you haven't said out loud but we certainly have heard a lot, and that's courage. It took a lot of courage to make those decisions with the leadership that you had and the leadership that you worked with. So are there any final thoughts on taking that bold risk?

KRAFT: I'd have to be very egotistical to talk about that. But what I'd say about that, when you go that route, is that it was an opportunity for those of us that were allowed to do it that doesn't present itself very often in any human being's life. So we were extremely fortunate that all the conjunction of the stars and the politics and the money and the technology all came together in the '60s. That was a very extremely unique period in man's history from all those points of view. So those of us that were allowed to do it, and lucky enough to be present, and were given the opportunity to do it—I'm not trying to be godlike or anything like that—what I'm saying is that we were given an opportunity to do it, and we did it. But that's a characteristic of the American human being. That's what makes us great. You hit on the point that recreating that is extremely unlikely, and therefore putting all those challenges together again are not likely to happen. I hope it happens, and if I think about that I'd say well, maybe if we find out that there's a whole human race that exists on Alpha Centauri, that might be an equivalent challenge. But I think it'll take something like that.

Or maybe if we get a message from them. Read that conference that NASA had back in the '60s on what would happen if we got a message from another civilization. NASA put out a paper on that conference. You ought to read it. I can't be any more detailed than that, except they did have it, and they had a theologian, a scientist, an astronomer, a couple of engineers, and some politicians. I don't know how many people it was. It wasn't a whole lot, maybe eight or ten. They all talked about it, about the effect of what would happen on the Earth if we got a message from outer space. It's pretty profound. Pretty profound.

WRIGHT: I'm looking at the clock, and we've had you for almost two and a half hours, and I don't want to take up all your morning.

KRAFT: I told you it would be like trying to get a drink of water out of a fire hydrant once you got me going.

WRIGHT: We're glad that we were able to do that.

KRAFT: I don't do it very often. I don't know why I don't. I don't talk to the NASA historians. Don't ask me why. I just don't feel compelled to do it.

WRIGHT: Certainly you're always welcome to come back on any topic, and we have lots of topics.

KRAFT: I can go on like that about most of them, any of them that I've had any experience with.

WRIGHT: And that's what we would like to have.

[End of interview]