NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY 2 TRANSCRIPT

WAYNE E. KOONS
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is October 15th, 2004. This oral history is being conducted with Wayne Koons in Houston, Texas, for the NASA Johnson Space Center Oral History Project, continuation of the October 14th interview. The interviewer is Rebecca Wright, assisted by Sandra Johnson and Jennifer Ross-Nazzal.

We thank you for coming back today and continuing where we left off yesterday, [when] we had just started talking about the beginning of your transition from working with the STG [Space Task Group].

KOONS: Of course, there was a period of time there that was pretty much taken up with learning to be a civilian and learning how to work with the people in the Space Task Group. Other than that little project with the long-line retrieval, I didn't have any specific assigned duties.

I think at some point there I got assigned to do a paraglider operations assessment, and we formed a committee that included Jim [James A.] Lovell and some other people that I don't remember right now. John [G.] Zarcaro was on that group. The proposal was that the Gemini spacecraft would deploy a paraglider at ten or twelve thousand feet and glide to a land landing. People were anxious to get out of the ocean environment.

Maybe the reason I was assigned to chair that was that somebody figured out that the paraglider flew about like a helicopter in autorotation, with a power failure. It had about that sort of glide characteristic. I don't really remember any of the specific things. I think one thing we concluded was that the crew's visibility out those little windows on the Gemini hatches was going to be pretty poor—not like a helicopter, where you have all kinds of visibility and you can readily assess what the winds [are] doing to you and look for a landing spot and so forth. The Gemini crew, on the other hand, was pretty much looking through a peephole. It didn't give them a whole lot of visibility. In particular, it didn't give them any visibility downward.

We noted also in most anywhere in the United States, if there are not infrastructure obstacles like telephone poles and bridges and things like that, then there are natural obstacles like rock outcroppings. It was pretty hard to find a sizable area that would compare to the area where the Soviets land their spacecraft now, which is pretty much just unbroken prairie. That was one of our observations.

I think our work there was pretty much overtaken by the assessment of whether the paraglider was really feasible to put in the Gemini. There were some people who were working very hard to get it in. The contract was with North American Aviation [Inc.]. They were contracted to provide that paraglider. We had a bunch of people here at the Center who were very involved, including the Center Director, who really wanted [the paraglider] to work.

As we looked at it, we concluded there were a bunch of things [to consider]. I remember Pete [Peter J.] Armitage observing that the paraglider is great while it's stowed, and it's great once you get it out, but the problem is getting from the first state to the second state. There [are] just a lot of things that have to happen to get that paraglider out of the canister and deployed. It was a pretty large wing. It had inflatable booms and keel, and the first problem was generating enough gas to inflate that boom.

Then you had to be concerned about what if you've got a small rip somewhere, that the boom's going to start to lose pressure and your flying characteristics are going to go to pot. You may not get it deployed correctly. Even if you do get it deployed correctly, then [there are] some fairly heavy little winches that are required to maneuver the spacecraft. You have to actually shift the length of the suspension lines to maneuver. Your vertical velocity is like thirty feet a second, which is enough to spoil your afternoon if you hit going that fast, so it was necessary to flare, which involved a line payout sort of thing. It was all just pretty complicated.

Then the overlay of the crew not being able to see very well and practically forcing you into a deal where you had to have some kind of ground guidance, some sort of a ground control function to give them guidance and help them with energy management, wind alignment, landing spot selection, and so forth, it was really getting pretty complicated.

All that was complicated further by the fact that this was a non-redundant system. The paraglider had to work. If it failed, the only option then for the crew was to eject. I've never met a pilot who was anxious to leave his airplane. So the crew was not very enamored of that idea either. So it was a pretty difficult thing, and we worked pretty hard at it, but a lot of the hard work we put into it was consideration of "Maybe this isn't going to be such a good idea for this series."

The other complication was you had to fly with—or a good possibility was, that you'd fly with some little rockets that would trigger to attenuate the vertical velocity just before you touched down. That was another thing that was looked into. Anyway, at some point, the decision was made to abandon the paraglider, and we went back to parachutes. That all happened in the early sixties, in the formative years of the Gemini Program. As it turned out, we stayed with the water landing for all the Gemini flights.

An interesting thing that happened during that time, and it sort of impinges on the paraglider, was that the medical people were becoming concerned about the effects of extended weightlessness, or no gravity, on the crew, and the phenomenon [in Earth gravity] is called orthostatic hypotension, which just means that they've been in a weightless condition so long that their arteries and veins become essentially deconditioned and allow the blood to pool in the lower extremities when you stand up in 1-G. This is not unlike what happens to a pilot when you do an accelerated maneuver like a pullout from a dive or a hard turn in a dogfight or whatever. So there's a body of knowledge about that, but there was no experience with this extended [duration] thing.

So that sort of bore on the paraglider question, because the crew coming down in the paraglider was seated bolt upright, and this was just immediately after being weightless for some period of time. So if the blood draining away from the head was going to be a problem, they were going to experience it at a very bad time. But that was also a concern [regarding] their ability to take care of themselves post landing wherever they would come down, whether it was water or whatever.

So in cooperation with the medics, we set up a series of tests, and we actually combined weightless simulation, which was done by just having people stay in bed for two weeks. We put them directly into a—we [called] it the egress trainer. It was a boilerplate spacecraft that had crew support couches, and they went from the bed rest directly into that. Then we had a mechanical agitation system that simulated motion in the open ocean, where the objective was to find out if we had a critical problem here where the crew would literally go unconscious immediately after landing.

The medics were quite convinced that we had a problem, although we hadn't proven it yet, and we'd even gone so far with spacecraft design to look at things like providing some sort of [air] pressure [bladders] in the suit, similar to a G suit, that would actually squeeze the lower extremities and cause the blood to be pushed back up toward the head and neck. There was another consideration that said, if you've really got a problem here, the easiest way to do this would be to just flood the suit, just pump water into the suit, which would balance the [blood] pressure, and the suit, in fact, would become the support.

I never thought that was a very good idea, because if something happens and you have to jump out, having a suit full of water is not a good condition to be in if you have to leave the spacecraft. So I voiced some objection to that idea for that reason.

As it turned out, the testing, I think, indicated that it was a sort of a problem but it didn't persist very long. People readapted within a few minutes, or if they could get themselves into a [near] horizontal position for a little while, then pretty quickly you overcome the effect of the weightless period. Anyway, that was sort of an interesting sidelight.

Another thing that I was given responsibility for was to come up with the shipboard retrieval equipment. These were basically cranes that we used to lift the spacecraft out of the water, the cradles, and all the other accessory things that it took to get the spacecraft out of the water. This was happening at a time in which the Gemini and the Apollo Programs were both ongoing. At that point they were pretty much in parallel. Gemini was using technology that was going to permit it to be ready for flight much sooner than Apollo, but we had the two [spacecraft]. The two spacecraft were—one was just about as well defined as the other at that point.

So I [set] my design guys the objective of saying, "Can you come up with a set of retrieval equipment that can be used for both?" In other words, we'll design, basically design [it], size-wise and weight-capability-wise, to handle the command module, and then we'll adapt down to the smaller Gemini spacecraft. That was not only for the lifting and handling equipment, but it also was my responsibility to provide the deactivation equipment for the propellants, the reaction control system propellants that were on board.

So [to] the people who were doing that work, I gave the objective of, "Come up with your deactivation equipment that will work for both spacecraft so we don't have to produce two sets of it." At the rate that the agency was spending money at that time, that's probably a fairly minute savings, but I thought it was worthwhile to pursue that if we could.

On the retrieval equipment, the cranes, there was very good reason there to use the same crane for both programs, because it took modification to the ships. These things went on destroyers, the old World War II[-era destroyers] (and I can't remember the class name), but those ships had to be modified. They had had so much topside gear added over the years that they were bordering on unstable as far as the propensity to turn over in a rough sea. So, years ago, the Navy had found that every time they added topside equipment, they had to add ballast down at the keel in order to maintain the [center of gravity] so that the ship was stable and would remain upright when it was agitated in a really rough sea. So, having the same equipment and then adapting these cranes to fit on the destroyer required quite a bit of structural change to provide hard points that could take the loads.

In addition to all that, there was the expense of building the cranes. If we could use the same thing for both programs, it was going to be a savings. The training would become similar. There were just a number of factors that led us to conclude that having the same piece of equipment for both programs was going to be a good idea. So that turned out to be a sizable design activity.

By this time, I was a section head. I had several designers devoted to that. In an attempt to ease the problem, this [stability] problem for the ships, we tried to make the equipment as lightweight as possible, and that led us to use a material call T-1 steel, which is a higher strength than standard cold-rolled steel. I think it had been originally developed for bridge-building. Of course, aboard ship, you have a big corrosion problem, so we used a process called Dimetcoat, to try to make our equipment as corrosion-proof as possible.

We made the control box as simple as we possibly could. We put a lot of effort into making the little control box so it was intuitively obvious to the sailor that was running it what the switches were going to do, or the controls, so there was a minimum training [time] for him. He didn't have to learn a maze of switches. It was something that was natural to operate.

One of the problems that were more apparent with the Apollo spacecraft, since it's quite a bit larger, was that in order to get the hook engaged into the lifting bail, or the lifting loop on the top, you would have to put somebody on the spacecraft to actually engage that hook. And the hook was pretty heavy. So we tried to figure out how to do that without having somebody try to scramble up the side of the spacecraft. We came up with two gadgets which were unique, at least as far as the Navy guys' experience.

We had a tool shaped sort of like a very long-legged question mark, and we put a lead line on that, and then there was a little shuttle in it. Then we'd snap it around the bail, activate the shuttle, and it passed the lead line from one side of the question mark to the other. So then when you pulled that tool back, you had the lead line threaded through the loop on the spacecraft. The Navy guys who used that thought that was just terrific, and they all wanted some, because every time they had to tie up to a buoy or a lot of things they encountered in small-boat work, they thought that would just really be handy to have.

The other thing was we spent a lot of time on the design of the hook. We were deliberately using stretchable nylon line for the lifting. Riggers flinch when you talk about stretchable nylon, but that was the right thing to do here because it avoided high snatch loads if the spacecraft happened to be going down on a wave and the ship happened to be rolling away from it. As the line came taut, you could get a really huge snatch load and probably just yank the loop right out of the top of the spacecraft, which would leave you with a real problem with no way to handle it. So we were using this high-stretch nylon line that really had a lot of spring to it to avoid that.

Also, as that hook was being taken aboard a spacecraft, in order to avoid damage as much as possible, we made the hook as light as possible. We used a material called 17-4PH, which is a very high-strength steel, and it allowed us to make it just as light as we could. Then the design became this pretty unique design. I don't know if there are any of the things around [still]. It sort of looked like a hook, but it didn't look like any typical hook that you've ever seen. It was designed specifically to fit the lifting bail on the spacecraft.

Rockwell had come up with a very novel design there. Instead of having a large loop of cable or whatever on top of the spacecraft, they had come up with the idea of using a number of small cables which were bound together by a sheath. Then when you started lifting on it, the sheath would break and these small cables would spread out on the hook. So instead of having a large cable bent into a tight radius over the hook, [where] you take quite a penalty as far as the strength of the cable, you now had several small cables laying over the hook, and your net loss of strength due to being bent was much less. It was a clever design, and it worked well. We had to make the hook with a flat bed in it so it comported with that particular action.

The other thing, still in order to avoid putting a swimmer on the spacecraft, in order to engage the hook into the bail, [was that] we had to figure a way to get the lead line to actually pull the hook through the bail so that it was engaged, and we did that. We solved that problem with a tapered neoprene snout on the [tip of the hook]. The way that worked was, as you pulled the lead line, the narrow end of the neoprene would start around the loop. If, say, it was in a ninety-degrees-out-of-whack position, then as you got more and more of the snout through, it became stiffer and stiffer as you worked it toward the hook. Pretty soon, then, it would actually flip the hook around to line it up with the bail and snap it into place. It would also work well if the hook was as much as 180 degrees out-of-whack.]

That also worked very well. It was pretty slick. I've watched the training a number of times in the movies. It was very seldom that you got fouled and couldn't actually engage the hook into the bail.

Anyway, all this work was going on. About that time I had responsibility added. I was a member of the Landing and Recovery Division and the head of a section there. [That was] a line division which was part of the Flight Operations Directorate. My supervisors, I guess, concluded I didn't have enough to do, because they created a negotiated new position with the Apollo Spacecraft Program Office. I think my new additional title was Recovery Systems Manager, if I remember right. This was a dotted-line relationship with the Spacecraft Program Office.

[My job], generally speaking, was to look at all the equipment and systems and how they functioned from the time of main parachute deployment through landing, through the retrieval and through getting the spacecraft and the crew back. It was looking [at] hardware and procedural interfaces. [Will] the way we're going to do it work right with the hardware we have? Is one aspect of the hardware going to work right with another? This turned out to be a very interesting and challenging [effort].

Some of the people involved with different pieces of this, [like the] electronics people, who were generating the location aids, didn't really talk to the mechanical people who were doing the retrieval loop, who didn't really talk to the reaction control system guys who were dumping propellant during the descent, who didn't really talk to the parachute guys who were popping off drogues and then dragging main chutes off the upper deck. It wasn't that they ignored each other; it's just that they didn't [always] understand the intricacy of how those things had to work [together].

We had a number of problems. One thing, and it's easy for designers to do this, they tend to think, "Oh, the spacecraft is coming down. It's like this model that sits on my desk, and it going straight down, so the parachutes are going to go straight up." Well, no. In fact, it may be over the other way around, and the parachutes may be dragging their lines over the structure or whatever, and it may give it a really nasty yank when the chutes inflate.

So we had to talk about those kinds of things. We had to look for things like sharp edges on the structure that might cut the parachute lines. Incidentally, we found a bunch of sharp edges. That got to be a major witch-hunt on the upper-deck design, because there were lots and lots of sharp edges, and every time we looked, we found some more.

It was a nuisance to the upper management to have to keep going back and cleaning these things up, but the potential for real harm was there. You could really have a problem due to this. So we just stayed persistent with it and kept saying, "We've got to make all this stuff work right."

Rockwell [International Corp.] tended to think of post-landing as—as near as I could tell, [the] mental image that they used was Long Beach Harbor [California]. They didn't have any experience with open sea, didn't really have any appreciation for the wave action and so forth. They were just virtually opposed to the idea of doing any testing to see how the spacecraft would perform in an open sea and what kind of ride it would give the crewmen.

When we said, "Look, our studies indicate that in some [contingencies] the crew may have to stay in that spacecraft for three days," this was just all totally new to them. They had never thought of that. They assumed we land, we get out, and go have coffee in the wardroom. It was not something that they had ever really thought about. When we noted to them that in a rough sea state you're not going to be able to open the hatch, the crew's going to have to stay inside buttoned up, then it became apparent we were going to have to have ventilation, which meant not only a fan with a motor to run it, but it also meant that the [battery power] had to be [budgeted] so there was power to run the thing.

Now we get into the phenomenon that I ran into, that I'm sure a lot of people ran into again and again, you know, they say, "You mean we've got to take that all the way to the Moon and back just to run a fan?" It was like, "Surely you guys can figure out some other way so we don't have to do that." The design was very, very critical, and the very most weight critical thing you were designing was the command module, because that ultimately was the piece that got back. So whatever weight you put on it affected everything from liftoff all the way through every mission phase, with the exception of the lunar excursion.

It affected everything, so we had to be extremely careful, on the one hand, making it so it was safe and appropriately designed for the landing and post-landing. But on the other hand, everybody was motivated to keep the weight down. So we were in a balancing act there trying to get this done.

We had to provide a post-landing beacon so that the search aircraft could locate it if it was in some remote location. At that time our planning model said that this or that or whatnot may happen, and even though we're planning to land somewhere west of San Diego [California], we may wind up somewhere off of South America if we were forced to come back at some different [time] on the Earth orbit missions. Or on the lunar missions, people were pretty jumpy about being able to control that entry. It's a very, very precise thing to capture and not overshoot and not undershoot and control the heating and everything. So there was the potential for some significant miss as far as landing point on the lunar returns, at least as those early studies indicated.

So we were involved in making sure that the spacecraft was designed to land and be self-sustaining for a good long period of time. In a contingency situation, we were looking at three days before we might get rescue people to the spacecraft.

Let's see. I'll have to come back later to two things. One is the search-and-rescue aircraft and the work that was involved there, and some other things that are slipping my mind right now.

The landing itself, when the spacecraft hit the water, was another thing where the loads were not [initially] appropriately accounted for. Rockwell made a test in which they used a double trapeze sort of a rig. They'd made a boilerplate spacecraft with a flight lower heat shield, the spherical part of the heat shield, and they used this trapeze rig to drop it so that it hit at a certain velocity vertically and horizontally in a little test pond. Their intent was to demonstrate the spacecraft was strong enough to withstand the landing at sea.

They did the test. There was a major structural failure, and the spacecraft sank in a few seconds. So obviously we had some work to do on that. There was a structures group formed to work on that, and I was assigned as part of that Tiger Team to work with Rockwell.

I think Rockwell reacted very well to that problem. As we got involved in that, we found that they had not really written their loads analysis to account for things like the shape of the wave as they hit it. They were pretty much looking at flat water or a sinusoidal wave, whereas the actual surface of the sea is a myriad of different shapes and angles as you hit it. I think their reaction was very appropriate, because as they looked at that, they said, "You know, if we had a worst case of swing on the parachute, horizontal velocity due to wind, vertical velocity," which has to account for a single parachute failure (you're coming down on two instead of three), orientation, the orientation relative to the direction of the motion, which is not controlled, and then stack up the worst kind of sea, side-of-a-wave kind of thing that we can think of, it's probably not possible to make this thing so it'll [survive landing] in that condition.

At this time, computers were still pretty green devices. This was in like the '63-'64 time frame. For the most part, the only computers available were what today you call mainframes, the big machines that take up a room or two. They proposed to do a Monte Carlo analysis of the landing loads, at which they'd take all these factors that I just mentioned and randomly, or with appropriate statistical distribution, have them occur. Then you'd run a whole series of combinations of these conditions on a computer. The product would be a single set of velocity and orientation and whatnot, and you would statistically combine these things so that you didn't combine worst case on worst case on worst case, because the probability of worst cases all happening simultaneously is almost zero.

So there was some substantial opposition to that from people, particularly within NASA, who were used to doing slide-rule analysis, you-stack-up-all-the-loads-and-design-for-it kind of approach, and they were not at all enamored of this Monte Carlo analysis. I think maybe the name put them off a little bit. So we had a substantial tussle about whether or not to concur with Rockwell taking that approach.

My part in that was that I actually believed that Rockwell had a good approach, so I kind of took a beating from time to time when I would attempt to represent that as being a satisfactory way to do the job. Also in my job I had a couple of dynamicists in my section, and they got very closely involved with the modeling of the sea surface.

It all turned out to be a very highly technical kind of thing, but as it turned out, we came up with a relatively low-weight modification to the spherical heat shield that resulted in—of all the landings, we never did have a problem. We made some more tests that combined loads in a way that this computer analysis indicated was appropriate that was close to the worst case, and it [withstood] the loads all right.

One thing that became apparent as we went along was that the [center of gravity] of the spacecraft had grown up away from the spherical heat shield, and we got into the condition where the spacecraft would float stably in either of two positions or two orientations. One was, as you would think of it, with the conical area up and the spherical heat shield down, and that was called Stable One. But it was also stable standing on its head with, actually, the main hatch out, but all the upper deck down [under water].

There were some guys at Rockwell who attempted to prove that was okay by taking a boilerplate out into Long Beach Harbor and running back and forth inside it to try to show that three guys dashing around inside throwing their weight back and forth could bring the spaceship upright. That wasn't hard to discredit, because, first of all, their boilerplate didn't have any installed equipment and by the time you got all the control panels and storage lockers and couches and struts and everything else in there, there wasn't any room for people to dash around at all. They could just really squirm around, was more like it.

Also, the thing that could happen in an open ocean, as we proved with [a] test spacecraft, [was that] you could be in Stable One and get flipped over into Stable Two if a wave hits you just wrong. This really was a design penalty. We had to penalize the spacecraft in order to correct for this problem. It was not feasible to move the center of gravity down so that the metacenter was above [the center of gravity] and only have one stable flotation position. So we had to undertake some active method of making this thing float upright.

The solution was actually proposed by Rockwell, and I thought it was a very clever solution, even though it was relatively heavy and nobody really wanted to do it, but it had to be done; and it was the three uprighting bags that you see on some pictures. You'll see these big balloon-like things. I think they're maybe three and a half feet in diameter or something like that. These were stowed under the main parachutes or beside them so that they were available, and then they were inflated by little compressors immediately after landing. We had to, of course, find an intake place for the compressors to suck air that was going to be above the water in either stable condition.

It took two or three minutes to bring the spacecraft upright when it was in Stable Two, but it really had to be done that way. You couldn't leave it in Stable Two, because the crew was in a very awkward position. They were sort of hanging in their straps and not really able to move around without stepping on the control panel. All the location aids were under water. The intake vent for the ventilation fan was under water in that condition, and the lifting loop was under water. So even if you had it in that condition, this loop was four feet under water and pretty hard to get [to] to go ahead and pick the spacecraft up. So it really was necessary to fix that.

The design was these three bags, which were, in themselves, a very clever design, because they were each supported or tethered on one cable, but the cable actually ran to the far side of the bag through a little tube that was through the bag, so that the bag, as it inflated, actually crawled along the cable and tightened itself up against the spacecraft. So it made it possible to stow the bag somewhere else and then, as you inflated it, have it crawl into position. It was a really innovative design, and whoever at Rockwell came up with that should have had a good pat on the back, because they did a good job with the design.

One of the jobs that paralleled all this that was going on was that we were designing both Gemini and Apollo egress trainers, and we did that design in-house for Gemini. The designers who worked for me had done a number of boilerplate spacecraft for training, like for the Navy to use for practicing open-sea pickups and whatnot. The helicopter people were still involved, and they were a backup at this time, not to pick up the Gemini, but they were used to deploy swimmers and to pick up the crews in some conditions.

Anyway, we needed a number of boilerplate spacecraft, and we had designed a low-cost boilerplate steel spacecraft to use for handling and retrieval training, and then we made one of aluminum because we needed to check out the flotation characteristics, and we had to get the moments of inertia right. In the steel, all the weight was concentrated in the skin of the steel boilerplate, which was not characteristic of the spacecraft. It had most of its weight internal, and the skin was relatively lightweight. So we made an aluminum boilerplate and then put a combination of ballast and flotation devices in it to make it float the same as a flight spacecraft and to get the inertia as close—we never got it exactly, of course, but to closely match the inertia so its behavior in an ocean environment was good.

We ran some tests with that to check it out—how's it going to behave, what's it going ride like. We had some [couches and] restraints in it so the crew could experience what that was like. We actually, then, converted that spacecraft into [the Gemini] egress trainer. We improved the fidelity of the couches. We redesigned the hatches so that they worked very similarly to the flight hatch, and we used that thing for crew training [for] egress.

We used it to develop the flotation collars. The flotation collars were designed by the guys in my group on sort of an outline basis, and then all the details were worked out with the shops over at [Naval Air Station] Pensacola [Florida], which is where those things were actually built. They were actually built in Navy shops over at Pensacola. That was true of both the Gemini flotation collars and the Apollo flotation collars.

So we had made that aluminum spacecraft and did a lot of testing with it. Then we actually did a long-duration test, in which we put some people in it and left them out at sea—I don't remember how long, but it was quite a while—just to make sure that it was going to be satisfactory.

For the Apollo command module, we took a little bit different approach. Rockwell actually made the egress trainer. It had a spacecraft number, a hull number. It was Spacecraft 007, which everybody got a big kick out of because the James Bond movies were big at that time. We ran a series of tests on that, and we actually ran the formal qualification test of that spacecraft for the post-landing environment, did it out here in the Gulf. We sat around and waited for a while until there was some pretty rough weather available, and then took it out and tossed it in the ocean and dumped it into Stable Two and went through the whole [sequence], you know, upright it and make sure all the location aids work and make sure the fans work. The guys weren't very happy about it, but they had to stay in there for a while.

WRIGHT: And who did you use? Was it NASA employees that were your test subjects?

KOONS: It was just crossing my mind as I was saying that, I remember that Walt [Walter] Cunningham always gave me a rough time about that because he did not appreciate getting stuffed in that egress trainer and doing that, although he was just kidding. So I know Walt was involved. I don't remember who we used for a crew in the longer-duration testing. Milt [Milton L.] Windler's section actually ran the tests. I provided the hardware and worked the procedures, and my people were involved in it, of course, but I don't remember. I just didn't set that up. It was Milt Windler's people who actually conducted the test.

Another thing we were involved in, talking about contingency landings—the Air Force was at that time deploying some long-range search-and-rescue airplanes which were called the HC-130H. These were C-130s which were configured with additional internal fuel tanks. They'd actually taken some KC-97 fuel tanks and adapted them to fit on the pallet system in the back of the 130. They were able, by a combination of shutting down engines deliberately to conserve fuel as they burned off fuel, and careful altitude profiling, to [stay] up well over twenty-four hours aloft without refueling.

These guys were deployed, or were to be deployed; they were used for a number of things. The Air Rescue Service used them for [rescue], of course—they had an extensive mission because [the United States was] operating principally B-52s. During that time frame, there was lots of Cold War stuff going on, and we frequently had airplanes up over the North Pole and ready forces in a near-combat mode at a lot of times. So Air Rescue Service had a real job. They had lots and lots of crews to cover and try to provide rescue service for.

We got involved in two things that went on with the HC-130H airplane, and I was assigned as liaison to the Air Force for that effort. We had two things. One was that we wanted to have a very sensitive receiver on board that could really reach out from a high altitude and hear that little 2-watt or 5-watt, or whatever it was, beacon on the spacecraft, so that if we had a wide miss of some sort, say, on the Apollo reentry—this is the kind of modeling we were doing, the sort of thing we were trying to anticipate. We said, "If they really miss widely, we may have a cross range as well as a downrange discrepancy. So there's a pretty good chunk of ocean, like several thousand square miles, that they might be in, and we're going to have to cover it pretty quickly, because we've got to figure out where they are and get some aid to them." So we wanted a really sensitive directional receiver in the HC-130H.

Their avionics people, as I remember, were in Orlando [Florida] at an Air Force base there, and we worked with them quite a bit to figure out what kind of receiver could go in there. If you look at an HC-130H, it's got a little smooth hump up on top right behind the cockpit area, and that houses that special receiver [antenna].

They were glad to have it, because they could also be used for the personal beacons. If a pilot ejects, he's got a little mini-beacon as part of his survival equipment. Later, just a few years later, that became also a two-way radio, but at that time it was just a little locator beacon. So the Air Force was glad to have this capability, and we worked with them and shared costs with them on equipping those airplanes with that [receiver].

The other thing that was really interesting was, they wanted the capability to pick people up with the 130, which sounds kind of far-fetched. But actually they were running tests with a company called All American Engineering [& Manufacturing, Inc., which] had made the hook-and-winch combinations that were used to snatch the returning camera modules out by Hawaii, which didn't get a whole lot of publicity because they didn't really want [the public] to know what they were doing, but it still got reported in that time frame.

The surveillance satellites that we had aloft would eject a camera module periodically. This is in the days before we had broadband, and we could transmit a better picture electronically than you could on film. They were actually ejecting film capsules and recovering them in the air. I suspect the reason they wanted to recover them in the air was they didn't want them down where anybody else could get a hold of them, because it wasn't too hard for the other guys to figure out if a spacecraft or satellite had ejected a device which was going to make an entry, it wouldn't be too hard to have a submarine there waiting.

So they did this air-to-air retrieval, and that was a pretty foxy maneuver. You tried to smack the parachute of this thing with the belly of the airplane. As it went aft, then, there were some hooks hanging over the rear end which went into reinforced shroud lines and snatched the thing and began to pull that camera pod along. Then there was an energy-absorbing winch inside that paid out line that allowed [the pod] to be accelerated up to where it matched the speed of the airplane. Then you'd just reel it in, and you had your camera pod. It all worked pretty well.

So the Air Force was working with the—the way they stated requirements was they didn't say anything was a requirement until they were sure they could do it. So they were tinkering around with a requirement to pick up people from the surface, and they, quite naturally, had turned toward the All American Engineering device. They were looking at take a couple of bamboo poles and rig a line up and have the airplane fly low and drag his hooks through the line and take the guy on the ground, who'd be in a parachute harness, and just snatch him and take him. It worked fairly well.

We had some real reservations about it, [though]. We had a term that we called man-rating. All the handling equipment and just anything we did, before we put a person in it or used a flight crew in there or whatever, we wanted to make sure that it was man-rated. I never heard that term defined. I think our understanding of it was, you want to make sure that the man that you're working with is still going to be alive when you're through, this is all over and that you haven't done any harm to his person.

So we had some real questions that that system was going to be man-rated. If you started analyzing potential failures, there were a lot of things that could happen that weren't too classy. Just the slightest malfunction on that winch and you could pull the guy up and smack him back into the ground at 100 knots or so. It was easy to get a partial engagement and then just flat drop him, have him come off the hooks. It was [also] a pretty violent thing for the guy to experience. I mean, he really got a good yank.

They were doing this with dummies. I don't think they ever did it with a live person, but the dummy got a real—it was a real snatch-and-go kind of thing, even with the energy-absorbing winch and whatnot, because you still had to accelerate that winch drum and all that massive cable or nylon line or whatever you used. It was a pretty violent thing to do.

There was a competitive system. It was a really unique experience to get acquainted with a fellow named Robert Fulton, who happened to be the grandson of the guy who invented the steamship. Robert Fulton had an engineering company up at Danbury, Connecticut. He had bought the old airfield there, and his office was in the control tower. I was up there one time, and it was really a neat place to have an office, just windows all the way around.

He had three or four really good designers working for him and a couple of shop guys, and he cranked out novel gadgets. That's what he did, and he did it very well, and he made a lot of money at it.

One of the things he had developed was a system to retrieve the frogmen when they would go in and, say, do a mission in an enemy harbor. He used little boats with no transoms in them, and he'd set these two boats so they were facing each other, maybe fifty or eighty yards apart with a line between them. The high-speed powerboat that came in to get them would make a high-speed run in and it would simply grab that line with a hook or something midway between these two boats, and never slow down. So the speedboat would make a swing into the harbor in this [clandestine] mission and snag that line.

The geometry effect was, as the speedboat moved along, these transomless boats with our frogmen in them would slowly come up out of the water and start moving with the boat. The effect was that over a period of a half a minute or so, they'd come up to full speed, the water would drain out of the transom, and they'd be being pulled along by the speedboat back to whatever mother ship had originated all this activity. That was one of his basic inventions.

He had then conceived that this could be done with airplanes to pick people up off the ground, and he had, in fact, demonstrated that several times. The basic way you did it was to put a fork, like a Y or two legs of a Y, sticking out at the front of an airplane. At the base of that Y was a device that engaged the line. The way you picked people or an object up off the ground was that the people on the ground would send up a balloon on a 700-foot line. The airplane would come by at 500 feet and engage the line and snag it. The device that snagged it was just a pair of points that twisted so they engaged the line. Then as the airplane continued, the load on the ground would first go straight up because that's the way the line was, and as the airplane continued to pull on the line, the load from the ground would gradually swing into motion, and gradually rise and accelerate and finally wind up in a tow position behind the airplane, being pulled by this Y on the front of the airplane.

Then the chore—and this is where things sometimes got dicey. Then working either out of the side of the airplane, out of a hatch, or off a ramp at the rear if it were an air-drop-style airplane like a 124 or 119 or something, you had to get a hold of that line and pull your load in, whatever the load was. This had several advantages.

By putting fending lines on the tips of that yoke in the front, you could actually have a miss and not be catastrophic. You just simply pushed the line aside as the airplane went by, and you could come around and try again.

Secondly, it was actually not a critical flying job. It was not really particularly difficult to hit that line, and usually the guys would hit it within a foot or two of the centerline of the airplane. Lockheed [Aircraft Corp.] had a test going one time for the Air Force, and I got to ride along. They let me fly one. This was in a [C]-130. It was not particularly difficult to get lined up and hit that line dead center, so it was pretty reliable from that standpoint. It was graceful, in that if you did miss, you could fend the line off and not cause some kind of problem like yanking the guy fifty feet in the air and then dropping him.

The other advantage it had was that it was very gentle for the guy riding. The person you picked up got a very gentle ride. They hardly ever saw more than about 2-Gs acceleration. They just simply went straight up and then sped up and wound up in a tow position behind the airplane. The line transfer was what was truly tricky, to get the line transferred and hooked up to a winch and bring the guy on board.

So we took the view with the Air Force that they really ought to start learning about this particular system because it had a lot of inherent reliability. It had the advantage, if the guy that you're trying to rescue was in a bunch of trees, you could take him out of the trees. You could literally take him straight up, right out of the trees. So you didn't have to have a big open area in order to operate it.

You could do it at night. You'd just string some little lights on the line and power them with flashlight batteries, and it made plenty of light. If it was foggy, you couldn't do it, but if it was just dark and you were under the cloud cover, why, it was not difficult at all to get lined up and hit the line at night.

It had the capability of being done with more than one person, just depending on how you sized the lines and materials and everything. Plus, the advantage was, if, say, you had sized it for two people, if there was only one person on there, it didn't make a bit of difference. It still worked exactly as it did with two people, whereas with the snatch system, where you'd fly down close, you had to even know pretty well what that guy weighed before you picked him up, because you had to adjust that winch pretty carefully.

So we saw a lot of advantages in what we came to call the Fulton system. There ensued a months-long discourse with the Air Force, because they were trying to get their [C]-130s configured and get their H-models on line and deployed with Air Rescue Service. Eventually, they came to our point of view, and the Fulton system is what was installed. We sized it for two people at a time.

The Air Force provided the capability to do long-range search, very long-duration searches. They could stay airborne over a day and then actually go down and deploy frogmen, [and] the Navy normally provided the guys who did that. Say you were out in the South Atlantic somewhere and there weren't ships anywhere around—put a flotation collar on it, stabilize the spacecraft, get the hatch open so the crew could have some fresh air, and then if the situation warranted, we could actually pick them up from the sea or land or wherever, and get them back. So that was very interesting.

The utilization of that system has never been publicized. It's just not. And part of the reason for that is some of the applications were classified. So I don't know. Fulton told me, as we were working with this early on, that the Navy had actually used it a few times and adapted it on different airplanes. He said that the first man that was ever picked up was a guy who had died at one of the Arctic listening stations. I don't remember what airplane they used. I think maybe it was a B-29. They flew up and picked the body up that way. He said, "That's the first time we actually ever picked up a man." It was a guy who had been in a snowdrift, and they dug him out when it was possible to send him back. That was the first time, but it has been used a number of times to do actual rescues.

By and large, the events over the years have [caused] helicopters [to] become much more capable, with longer-range and higher speed. [So], the need to have this capability [in the C-130s] is much reduced.

Can we take a break for a minute?

WRIGHT: We sure can.

[Tape change]

KOONS: The next thing that happened turned out to be a significant chunk of effort in the Apollo Program for the recovery people and for the crew people. What happened was that one day Pete Armitage grabbed me and said, "Come on. We've got to go to a meeting." It was that kind of a thing.

I was amazed at what we got into. The full title of the organization that we met with was called the President's Interagency Committee for the Prevention of Back Contamination. So help me, that was the full title. That's what this group called themselves. It was a collection of scientists. We had veterinarians from some office; Department of Agriculture, I guess. We had biological warfare specialists from the Army's Fort Dietrich [Maryland] facility. We had people from the communicable diseases centers [Centers for Disease Control and Prevention] in Atlanta [Georgia]. The chair of this committee was a fellow named Dr. David Sensor, [and], as I go through this, you'll see it was really good that he was the chairman, because he was a very reasonable guy to work with.

The first meeting with these folks was truly an eye-opening experience. I mean, it was amazing. These are literally laboratory scientists. I remember at that first meeting one guy showed up for the meeting, wearing his white lab coat. We're in the ninth floor conference room [that's coat-and-tie territory], and here's this guy in his lab coat. There's another guy in there with a full set of whiskers, smoking [a Sherlock] Holmes pipe, a great big one. It had a bowl about that size [demonstrates]. These guys were laboratory people. They had no idea of what goes—other than what they'd seen on TV, they had no idea what goes on with getting a spacecraft back from a mission.

The [stated] concern was that we would pick up something on the Moon and bring it back and contaminate the Earth's biosphere. That's the best way I can express it. What that something might be was not known. It [was] just that it might be something.

Of course, you immediately say, "What in the world could that be?" That was not the issue. The issue was that it was possible. Somewhere beyond your imagination, this kind of thing might happen.

As we discussed this, we said, "What would you do? What would you expect to do to prevent this from being a problem?" Of course, their concern was some kind of plague which would run away and destroy the Earth's population, or some kind of plant disease that would wipe out all the green stuff on Earth. At the outer limit, that's the kind of worst-case catastrophe that they would mention. I never did get a real thorough feel for how any of this was going to be possible, but these folks were all convinced, and they had a lot of clout because somebody had persuaded the President to appoint them to come down and tell us what to do.

We engaged in some discourse that day. We said, "What is it you think we should do?"

It was things like, "You have to absolutely isolate the spacecraft so that nothing can get away." At this point, now, of course, you're familiar with the mission profile. The lunar module has been abandoned and left in lunar orbit, and the service module was pickled off a couple hours before we came into the atmosphere, so now it's just the command module.

They said things like, "We have to decontaminate the command module. We have to make sure that nothing gets from the command module into the ocean when it lands."

One guy sat there and literally said, "You know, the best thing would be if you could have a big flask on the deck of the carrier and maneuver the carrier under the spacecraft so that it landed inside that flask and then slap the lit shut and isolate it." That was beyond anybody's imagination, how we could ever do that. This fellow was describing a laboratory solution in the real world. He, of course, had no idea how you would ever maneuver a carrier or the fact that that was probably impossible. I mean, you could probably try that a hundred times and never do better than hit the carrier somewhere, [and certainly not in the flask].

Pete and I mostly tried to listen and ask questions and say, "What have you really got in mind here? What is it you think we really need to do?" We came back from that first meeting just kind of incredulous, saying, "Do we really have to do this? What is it we have to do?" It was a very nebulous thing that we were confronted with.

They had vaguely outlined laboratory concepts again. The way they contained highly pathogenic organisms was with double containment. They have two barriers around it, and the space between the two barriers is pumped down to a lower pressure than either the inner or outer environment. Then they do either incineration or very careful filtering of the air that they pump out of this inner space.

So they were talking about things like double barriers and decontamination and whatnot. So we did just some rough work and concluded that they really needed an education on the realities of what you have to do in order to retrieve a spacecraft. We also [decided] we'd better give them some realistic talk about what you do in secondary landing areas and contingency landing areas, and all the sorts of things that have to be addressed in order to ensure crew safety and ensure that you get the spacecraft back.

The kinds of things that these guys were talking about had a very high potential for being really dangerous. Aside from being really difficult to do, it could be really dangerous to the crew to do this. So we went through several iterative steps with these people. We gave them a pretty thorough briefing on how we deploy forces, the fact that we always had to be ready for the spacecraft to land not only five miles from the ship, which, as it turned out, was fairly typical, but it also might be fifty miles or it might be five hundred miles, and we had to be ready for all those kinds of contingent situations.

Once we finally got enough idea of exactly what they had so that we could do some hard conceptual work, we created a cost model, which frightened us. It didn't seem to bother them, but it was a real big number. But the thing that we wound up that conversation with, that part of the briefing, was, "Whatever it cost, you're talking about doing something here now that is going to cause us to compromise the safety of our crew and to compromise the reliability of getting the samples back to the Lunar Receiving Lab. So we think we should keep talking about this, because we're not positioning ourselves so that we're very comfortable with what we're doing here."

So we went, again, through several iterations, and we proposed some ground rules. We proposed that, "Okay, we will provide the maximum level of containment, whatever that is, only in a nominal prime landing site, where there's no spacecraft anomalies, no weather anomalies. In other words, we're looking for pretty much a blue-sky day [when] nothing goes wrong. Then we'll do the maximum amount of containment and prevention, whatever that turns out to be."

Another ground rule we proposed was, "We will never do containment at the expense of crew safety. If anything happens that we've got a problem that we may lose a crewman or a rescue person or recovery people or anything else, we're going to abandon containment right now. We're going to quit that, and we're going to concentrate on keeping our people safe."

Third was that we would provide reduced levels of planned containment for contingent situations. In other words, the further you get off nominal, the less containment we're going to provide. We had talked with them enough about how we do it. We'd shown them some movies and gone through some briefings and shown them force deployments and that sort of thing, and they readily agreed to those ground rules. So at that point we pretty much felt that we had something we could work with. We said, "Okay. We'll go start talking about what we might do and come back to you with a hardware and procedures briefing."

I remember in that meeting—this is a little vivid aside. Of course, it was going to be my job to do this design, whatever it was. I was going to have to get this done. I remember sitting there thinking, "What an absolute nuisance. The probability of this ever being a real problem is just so low that I really hate to spend the time on it."

So I privately concluded a couple of things. One was, I was going to try to do this so it had a minimum interference with the ongoing program. I didn't want to turn this into an obstacle.

Secondly, I concluded that whatever we did here, the virtuous side of it was that it was going to help us in preserving the integrity of the lunar samples. Forward contamination was the technical term for that. Whatever we did here was going to be an aid in ensuring that those samples that we got back from the Moon were just as pristine as we could keep them. I think everybody understood the real need to do that. If you're going to do science on those rocks, they'd better be just exactly like they were when they were on the Moon, or your science is not valid.

I asked a question which sort of had a humorous little outcome. I said to these fellows, to the committee, "I would like to ask a question." I said, "You know, when we start in doing design work, we like as much as we can to have specific things that we're designing for." I [asked], "What would be the representative thing that we should design to protect the Earth against?"

Some guy answered, and he said, "You should design to protect against the most virulent known Earth pathogen," whatever that was.

I [asked], "What is that?"

And he answered me. He gave me an answer which didn't mean anything; it was a big long name. It was some really nasty bug they had in a bottle up at Fort Dietrich.

So then I [asked], "Could that thing live on the Moon?"

"Oh, no."

So we kind of got everything in context at that point.

The solution that we worked up for this problem was, first of all, we did have to make one spacecraft modification, and that was to provide some filters on the air that was exhausted from the spacecraft when you ventilated post-landing. They were really anxious that we not get stray bugs or Moondust or whatnot scattered out in the ocean. So there were some filters added to the spacecraft. So that, as far as I can remember, was the only thing that actually impacted spacecraft design.

Of course, anybody who's watched the movies or whatever of the landings knows basically we wrote a spec [specification] for a house trailer, what it amounted to, a box that would accommodate the three crewmen and one recovery guy (as it turned out, one of my people) and a doctor. So we said, "We're going to button up five people."

At that time, the target isolation time was six weeks. We had to keep everybody buttoned up for six weeks to make sure no illness or whatever developed. This box that we developed wasn't any [one] thing that was really a technical design challenge, but, rather, the challenge was to have it do all the things it had to do. It had to be able to sit on the ship and condition its internal air and whatnot using the ship's power, which is one kind of electrical power. The basic thing this thing did was it had to be sealed up, and then we provided a fan on it which held it at a negative pressure so that any leaks were inward. Then we had a very tight, thorough filtration action on the air that was exhausted by this ventilation fan.

We had to have the communication equipment in there so the crew could talk to the press. That's a necessary part of the deal.

We had to be able to handle the lunar samples. They were initially taken into this box—I'm talking now about what we were doing spec-wise—and then cleaned up, and they were hustled back to the Lunar Receiving Lab here just about the fastest way we could get them back. The crew in their box came along later.

But anyway, we had to be able to seal up and decontaminate the sample box containers and get them out of our quarantine box. Then [the quarantine box] had to be capable of being hoisted to get it off the ship. It wasn't really convenient to provide a great long extension cord to keep it powered while it was coming off the ship, so we put a self-contained power unit on it and a little generator.

While it was dockside and then being transferred to the—you know, if you're talking a typical mission, say, where the ship docks in Guam or Hawaii or somewhere, you dock the boat, the ship, and transfer the quarantine container to the dockside, get it on a truck, take it over to the airport, put it on an airplane, fly it back to Ellington [Field, Houston, Texas], put it on a truck again, take it down to the Lunar Receiving Lab, and dock it. Then it stays there.

One of the challenges was, you have all different kinds of electric power that you get from these. Onboard ship, you have one kind of electric power. On the airplane, it's different. Different places you might wind up dockside in different parts of the world, you may have different kind—you may have 220 volt 50 cycle or 60 cycle, or you may [have] 110 volt whatever. So we had to be able to—I think the ship's power was 440 three-phase, 60 cycle, and the aircraft was 400 cycle power. So that turned out to be the most complicated thing to design, was the power-conversion equipment that we included on the thing. Then the recovery engineer, who was in there, had to know how to do all the switching to keep all that working. That conceptually was what we did.

So we promulgated a request for quotes. Our initial cost estimates had been up in the several million dollars, and then we had been able to whittle it down, and we thought we could probably bring this in for under two [million], just based on our on estimates. But anyway, we put out requests for quotes. We got several bids from people who were in the two-million-dollar range for this. This was an acceptable cost.

But we had a really innovative approach proposed by a consortium of Melpar [Inc.] Corporation and the Airstream Trailer Corporation. So that's what we wound up with, was an Airstream trailer. We visited their factory a couple of times, and those people were really proud of what they were doing. They made those trailers without any wheels, of course. They built them onto a pallet which was compatible with all these handling requirements that we had to meet, and they sealed it. They did an extra special job of sealing all the riveted joints. Then the internal configuration was somewhat different from what they were used to doing. The big picture window that you remember, seeing the pictures of the crew looking out through this picture window, that was a unique thing. Of course, then we had a [pass-through] lock that we used to get the [lunar] samples out. That all worked out very well.

We had a lot of peripheral equipment. It finally worked out that the normal way to egress the crew was to pick the spacecraft up from the ship and set it up on the deck and then set up this plastic tunnel and have the crew egress that way. That was one way to do it. Another way, as I think John [C.] Stonesifer described to you, was to actually put containment suits on the crew and spray them down with a disinfectant and then move them to the quarantine facility, and then later, set the spacecraft so that the plastic tunnel was set up. The recovery engineer then went over to the spacecraft and retrieved the samples and brought them back into what came to be called the Mobile Quarantine Facility, or MQF. The samples then were wrapped up and decontaminated and passed out through the lock so they could then be handled just like ordinary cargo.

It was interesting. As this all went along, the people we were working with kind of got into the spirit of how we were trying to accomplish this. These laboratory guys got more and more [involved]; an example of the thing we always tried to do was to try to get the people you're working with, whether it be Navy guys or Air Force guys or whoever, to see the problem your way and to try to help you solve your problem.

These people on the quarantine committee got pretty much into that spirit, and we were able to do some fairly simple things that were satisfactory. We used ordinary household Clorox for the decontaminate. That's what was used in the lock to wash down the sample boxes before they were passed out. There was some other agent that they used at the spacecraft. But basically, they accepted some really ordinary procedures.

… I know that everybody saw this as a big nuisance. I know the crew certainly saw it as a nuisance. But it was something that we had to do, and we pretty much accomplished what we set out to do, which was, let's get it done with a minimum of fuss and bother and make sure we don't hurt anybody. So we were able to get that done.

Probably in some respects it was a real relief for the crew, because they could control their immediate environment. If they wanted to sleep, they could just close the curtain on the window and go to sleep and whatever they needed to do. We were able to control the press access quite readily, since it was only through the window that they had access to them for a while. So that was probably a real blessing for them, to not be expected to endure endless interviews and whatnot.

WRIGHT: You mentioned you had a recovery engineer that was with them. Did your immediate employees have any concerns working with the materials because of possible contamination?

KOONS: No. No.

WRIGHT: What were their thoughts?

KOONS: Actually, you should ask John Stonesifer, because we had this thing pretty well designed, and it was coming down to the point [where] we were beginning to work with the ops [operations] guys to write procedures. I had put out a call for volunteers for the people who would staff this, who would actually go into quarantine. I remember John [K.] Hirasaki was one of those, and he may have been the one who did the first mission. He still works here somewhere at the Center. I don't recall who the other ones were. [Anyway, John Stonesifer took over my position well before the first lunar landing.]

But, no, as we were working on that, everybody said, "It's absolutely just near impossible that we're going to have any kind of pathogenic thing come back from the Moon." The real task was to preserve the integrity of the samples, to keep everybody safe and healthy, and get through this as best we could and not be any more of a problem than you just had to be.

WRIGHT: The approximately ten years you had been working with the space agency culminated in the Apollo 11 landing. Could you just stop for a second and share with us what that was like for you, of being able to know that everything you'd been working for, from the day that you walked into that field, now had come true?

KOONS: Yes. By that time, I had been moved. I guess it was an upward move. I had been moved over to be Technical Assistant to the Director of Flight Ops, who at that time was Chris [Christopher C.] Kraft. My job was to [coordinate] all the operational planning and initial conceptual work to fly the Apollo Applications Program.

The Apollo Applications and Apollo-Soyuz [Test Project] were both getting cranked up well before we made that first lunar landing, because those were the follow-on efforts, and the work had to get started in order for those things to be ready to fly after we concluded the series of landings on the Moon.

Bob [Robert F.] Thompson had been moved sometime before that to become the Program Manager of the Apollo Applications, and we had a new Division Chief named Jerry [Jerome B.] Hammack. I got moved over to Kraft's staff as Technical Assistant for Apollo Applications. John Stonesifer took over my branch. He was a section head in our Operations Branch. He moved over and took over my Systems Branch. So to go back to your earlier question, he would be the one to really talk about how did the people feel about doing this. He was the one who actually followed through and developed all the detailed procedures, took the hardware that we had laid out and went ahead and worked up the procedures. It would have been his guys who actually did the job of being in the quarantine with the crew.

Now, to answer your question, by the time we actually landed on the Moon, I had been working on Apollo Applications for a year or so, but I was on the Kraft staff, and I was able to get a Control Center pass. So I was in the Control Center when the landing took place. That was a really significant moment, to watch that happen, to hear the voice loop, to realize that for the first time in human history we had actually gone to another celestial body. I did not, at that point, think about are we going to keep doing this or whatnot. It was, we had done *the* step. We had done *the* thing that President [John F.] Kennedy had identified as a national goal back in, I think, 1959 or somewhere in that time frame. [No, it] couldn't have been. It had to be '60 or '61. But he had identified a goal and stunned us all when he said, "We're going to do it in this decade," because we didn't really expect that part of his speech.

But no, it was tremendously fulfilling. I remember I stayed in the Control Center a good long while, and as I went out of the Control Center, the Moon was up, and it was quite a feeling to stand there outside of the Control Center and look at the Moon and say, "There you are."

WRIGHT: Those years were extremely intense, with everyone working.

KOONS: Oh, yes.

WRIGHT: Could you share with us what it was like with the team members and how important it was to have the people that you were working with there so that you could accomplish as much as you could, and how managers like yourself were able to hire in the people that were needed to do the work needed to be done and even then some of the traits that you were looking for when you were hiring in some of these folks.

KOONS: From the time I first became a supervisor, I took as sort of my personal attitude was, there isn't anything that I personally can do unless the people who are working with me are properly motivated and appropriately encouraged and given the right kind of technical direction and encouragement and that they feel that they're the ones doing the job. Because they truly are. You know, the guy out in front is just that; he's just out in front.

Sometimes you have to do supervisory things like discipline people. I felt [that in] my job as a supervisor, it was much more important to develop the talent of the people who worked for me than it was for me to take any kind of personal credit or seek to get myself in the spotlight. I wanted the people who worked for me to feel that sense of accomplishment that I did. If they felt a sense of accomplishment, then I could. That was my basic attitude toward leadership or supervision or whatever you call it.

I think it worked well. I think we had a number of people who came into the organization, and as I would interview them, it's a personal chemistry kind of thing. It's a combination of body language and response and attitude and whatnot, much more than what their technical background might be or what their test scores might be or anything like that.

For the most part, we were hiring people coming fresh out of college. We hired—maybe a third of the people that I brought on board were people who were experienced to some degree, but for the most part, they were new grads [graduates]. I took it as a real responsibility to nurture these young people. As it turned out, there weren't any women involved then; they were all these young guys.

I've had the satisfaction, looking back, of having seen some people who were—there was Frank Janes who came, and he really had a difficult time adjusting to the working world. I had to work pretty hard to get Frank up and going. He's not alive anymore, but he would tell you that the first three or four years of his work here at NASA were probably really tough, because I was giving him personal objectives that he needed to work on that he was not comfortable with. But Frank went on and later became the head of the Crew Procedures Branch over in Flight Crew Operations, a pretty significant job. Considering his ineptitude when he started as a new grad and where he got, I felt a lot of satisfaction in that.

Jim [D.] Shannon was one of my section heads, and I think that he developed into a real management talent during the time that he was at the Center. He became, I think, a Division Chief. I think he's still around somewhere. There are two Jim Shannons, by the way, so you have to be careful with that.

Randy Stone was one of the people that I hired. Of course, we all know he went from Landing and Recovery, went into Flight Director's Office and became the Chief Flight Director at one point and then was the Director of Flight Ops and wound up Deputy Director of the Center.

Milt Heflin was another young fellow I hired. He's now the Chief Flight Director. I've had a lot of reflected satisfaction from seeing these people really develop and do well in their careers.

Qualities that you look for: alertness, interest, innate intelligence, motivation, people who are not a bit indifferent, they're really focused and really want to understand what's going on and be a part of it and do everything they can to make it go. That was always what I was looking for.

WRIGHT: Getting a man to the Moon and returning him safely was quite a challenge. The attitude on the Center or every place that you worked, was there ever a doubt that it wasn't going to happen? Or did you feel that everyone—

KOONS: Not on the Center. I did have the experience of several times as we were staffing it up, we were having difficulty getting enough people to get the work done. I went on several recruiting trips. When NASA would pull in, and as a typical deal, we'd advertise, and we'd have people coming in Friday night, Saturday to interview. I interviewed a number of experienced engineers and very often ran into a doubting attitude. I think it was probably, on their part, "Why would I leave a good job to go do something like that?" Or they were coming to find out what we were talking about.

But, of course, we had one disadvantage—our salaries were not fully competitive. We did not offer the same level of compensation that they could get with aerospace, because a lot of defense companies were really operating full-out, building airplanes and whatnot. So we were not competitive in that regard. But I encountered a [few] people who basically said, "I don't want to get involved in some crazy deal like that. I didn't know what you guys were doing, but now that I understand it, no thanks." So I encountered that a few times. But basically I think that the people who worked on the Center were all very focused. I can't think of anybody I ever ran into who doubted that we were going to get it done.

We had some real crushing setbacks, like the Apollo 1 fire. That was really, really tough. For me personally that was tough because Gus [Virgil I.] Grissom was a friend of mine and Roger [B.] Chaffee was a friend. It was truly difficult to go to work for a few days after that happened.

But as it happened, one of the things that came out of that was that they finally recognized the need that the hatch had to open outward. The Program Office agreed that they would take the weight penalty, and they set up a Tiger Team to work with Rockwell to get that hatch redesigned in an accelerated fashion. Kenny [Kenneth S.] Kleinknecht was assigned to head that Tiger Team. I was on it, along with Jim [James M.] Peacock and Bob [Robert D.] Langley, Jim Peacock out of the Project Office. Bob Langley was the Mechanical Subsystem Manager. There was one other party.

We practically lived on the airplane for a long time as Rockwell developed that design. We were then back here working on details of, how's that going to work as far as the crew? I'm sure there was somebody from the crew on that, but I can't remember who it was. How's this thing going to work? The controls, the interface. What kind of pressure is it going to be able to handle? What kind of leak rates are acceptable? Just a myriad of questions that had to be sorted out, and it all had to happen really quickly in order not to mess up the main schedule and slow down the spacecraft. But I think across the Center there was a real resolve on the part of most people that, "We're just going to have to do it better."

WRIGHT: After the fire and the missions became scheduled and people felt that you were going to be back on track to make this, again the intensity must have heightened and the workload was such. You did mention earlier in our interview that you had a young family that was here.

KOONS: Yes.

WRIGHT: Could you tell us how they coped with the fact that you were not home so much and you were spending so much time—

KOONS: Pretty much I tried to isolate my work from the family. We had young children, real young children. For most of that time, I was living up toward Houston; I was not living locally. So I had a good long commute, and I used that driving time to kind of switch gears, and I would be with my family. Then very often, if the workload was really high, I'd have a bunch of stuff packed in my briefcase, and after the kids went to bed, why, then I'd get in couple of hours of reading.

When I was in flight school, they taught speed-reading. The reason for that in flight school is to help get your brain to really go fast and be able to pick up bits and pieces of information and integrate it and act on it. It's just part of the conditioning and training that you need if you're going to be a good pilot. But that speed-reading really held me in good stead, because we had huge volumes of printed material that we had to keep up with, and lots and lots of memoranda flying around.

When I had that dual assignment as a section head and, later, Chief of the Recovery Systems Branch, and at the same time I was Recovery System Manager for the Apollo spacecraft, I had a double dose of reading. I got lots and lots of paperwork that crossed my desk, that not necessarily caused me to do anything, but I did have to screen it and see, "Do I see anything here that I need to act on or I need to get somebody to look at," or whatever. So the speed-reading held me in really good stead, because I could really zip through the work. In fact, I [recommended] it to several of my people. I said, "You know, go down there and spend a few bucks and take a speed-reading course. It will help you. It'll help you a lot."

One of the problems that we ran into with a lot of engineers was they were not well educated in communication skills. They had limited ability, particularly in written communications, to write letters and memoranda that were orderly and coherent and led you where they wanted you to go when you read it. I had guys take time off work and go—they taught some courses in—they called them creative writing. I think it was really remedial writing that the Center taught. I wasn't the only supervisor having that kind of problem. We had some people [who] did [the courses]—and I think it benefited them some.

WRIGHT: Looking back over the days that you spent in Apollo and prior eras, could you pinpoint a time where you felt was your most challenging time, the time that you felt that you'd look back on as a memory of this was a really momentous time in your life?

KOONS: I think probably if I were going to pick a period, I'd pick the decade from '59 to '69, that period of time. That was really exciting. All the things we accomplished in that ten years were pretty heady stuff. We went from the first manned flight to the first landing on the Moon in just a little bit over ten years—no, eight years.

WRIGHT: From what you described to us, it's like there really wasn't any stop and go. It's just you had one intense time level there.

KOONS: Yes. No, there weren't any break times in there. For me, I had two times when I kind of had enforced breaks. One of the Gemini missions, and I can't tell you which one it was, I was sent out as the Recovery Coordinator for the contingency area, which included all the Mediterranean and Equatorial Africa and Saharan Africa in the Eastern Atlantic, and I don't know what else for sure geographically. We had a few people deployed for that when we had some—it was more that we had some Department of Defense people in a ready condition, rather than that we had so much deployed.

The DOD had established a command station at San Pablo Air Force Base in Spain, and I was deployed to that, which gave me a really nice break. I actually took about three days of leave and spent a little time in Germany and the Amsterdam area, the Netherlands. My family originates in the Netherlands, so it was interesting to be able to do that.

Then later I was sent out on [another] Gemini mission. I was the Recovery Coordinator in Hawaii, and we had everything from all of the Pacific and right up to South America and clear down to Australia. In that entire area, I think there were seventeen of us that deployed in either shore stations or shipboard or whatever for that particular mission; seventeen guys from the Landing [and] Recovery Division. I was with the Commander of [the] Task Group, whatever they called him, at the command station in Hawaii. That's the one where they had a—it was a rendezvous mission. They had a target vehicle failure on launch, so I wound up having to stay in Hawaii for six weeks waiting for the next launch.

WRIGHT: If you have to be somewhere, that's a good place to be.

KOONS: That was all right. Yes. I was right on the break point. The people who were further out were told to stay, and the people who were closer in than I were told to come back to Houston and get back to work. There were three of us there. "You guys in Hawaii take your choice." One guy had a daughter graduating from high school, and the other two of us stayed.

WRIGHT: We're at a stopping point. Before we move on, I was going to ask Jennifer or Sandra if they had any questions for you about the time frame that we were talking about, or if you have anything else you want to add about the work that you did in the recovery.

KOONS: I thought of a few things last night, but I don't think any of them are really significant, but [I'd] have to go back and try to piece in [things].

WRIGHT: Okay.

KOONS: I did want to say—and I forgot to ask my wife—when I told you that George Cox and I went to New York to be on a TV show. I said it was *I've Got a Secret*, [and that was correct]. …

WRIGHT: If you'd like, we can stop and pick up when you come back, about the meeting that you were involved in about the beginning of the Shuttle operations, or we can start on that now and take a break when you're ready to go. So you tell us what you'd like to do.

KOONS: Why don't we talk about the period of time that I was on Kraft's staff, which was about two years.

WRIGHT: Let's do that. Okay.

KOONS: It's not going to take long, because it was all pretty much routine stuff.

WRIGHT: You can give us some insight about working with Dr. Kraft.

KOONS: I was again a little bit bumfuzzled when I was asked to consider taking this position. I first talked to Sig [Sigurd A.] Sjoberg, who was the Deputy Director. He explained pretty much what was expected. They were replacing a fellow on staff, and it was a little awkward because he was being displaced. So I considered that for a day or so, and I went back to Sig and said—and here's a little bit of humor. You asked about how was Dr. Kraft to work for. I asked if it would be all right with him if I talked to Chris directly. He said, "Sure."

So I spent a few minutes with Chris one evening, and I told him, I said, "You know, one of the things that I'm not really understanding, you want me here on your staff to coordinate all the planning and preparation of the entire Flight Ops Directorate for the Apollo Applications," which was going to be long duration in the big empty S-IVB as an experiment station. I said, "I'm a little bit uncertain about exactly how much authority you're giving me or what you want me to do. I understand that I should not do anything that would ever interfere with the main objective, which right now is to get the first lunar landing accomplished, but really we've got hundreds of people here working. I understand we need to get going on this. Just to what extent do I have the authority to make things happen?"

His answer was pretty typical, I came to find out, for Chris. He [said], "You do whatever you feel needs to be done. But if you screw up, I'll bite your butt." That was literally what he said to me.

That was easy to understand. I said, "Okay, I'll get with it."

Initially, the major part of the work was to understand the mission plan, to get the trajectory straightened out, understand what inclination, orbital inclination, we were going to fly at, get an understanding of what kind of data coverage we were going to get from the ground stations, just really basic mission planning stuff—this had already been going on in the Mission

Planning and Analysis Division—and to begin to expose this, then, to the Flight Control people, the Flight Support people who ran the network. Landing and Recovery not so much. There wasn't anything unique happening here [for] them.

The flight crew was getting involved. We had a crew representative assigned. The principal way we accomplished coordination was that we had a weekly meeting called a flight operations planning session. Held that every week. Anywhere from sixty to ninety people would show up for these weekly sessions. We'd have a series of presentations principally, initially from the mission planning people.

The unique thing going on here was that the Marshall Space Flight Center [Huntsville, Alabama] was going to be involved in orbital operations, which they had not been before, because we were flying the Apollo Telescope [Mount], which was their project. Then we were going to be going into the empty S-IVB hydrogen tank and using it as a habitation and experiment station. So the liaison with the Marshall [Space Flight] Center was a significant challenge.

There were a lot of things to work out there, because they had no experience with orbital operations, as I mentioned, but they had a lot of desire to do that, and they were doing mission planning. They were designing orbits and coming up—largely, I felt their efforts—you know, I understood why they were doing it, because for one thing, they needed model missions to test their hardware design with and be able to look at thermal profiles and whatnot. But they were not experienced in things like the interface with the network and the fact that you only go—at that time, we didn't have any satellites, so you were only going over a ground station periodically, and you had to accommodate your flight plan to the availability of the ground stations to get the data dumped at the right time, and you had to incorporate the crew cycles. You had to let crew sleep and so forth.

The job also was to be the Flight Ops representative on the Apollo Applications Program staff. Bob Thompson was the manager of that. He left the Landing and Recovery Division to form that program office. So I went to his staff meetings as well as Kraft's staff meetings.

Then I was regularly involved with talking to the people at Marshall. So it was lots and lots of liaison work, just basically plain-vanilla flight planning work that involved the flight plan, the mission plan, all the trajectories, orbit analysis.

We had some really unique things there like the Apollo Telescope Mount, which was a solar observatory. We, of course, had to be able to fly so that we kept that thing stably pointed at the sun in a very controlled fashion. We had [a] new kind of hardware to learn to live with—the solar panels which provided the electric power. Whereas we were used to working with fuel cells and batteries, now we had the solar panels.

For attitude control we had some gadgets called control moment gyros, which Marshall provided. In my experience, those were really unique, and it was a real mind-bending experience to try to figure out and understand how they worked. I don't think I could relate [that] to you very well. They're just some great big gyro wheels spinning in a can that, by torqueing on the [axes] or the axles of those wheels, the reaction torque could be used to change the attitude of the spacecraft. There were three of them. You could actually operate with two. A unique aspect of that particular mission was learning how we would deal with that.

I guess I was there about two years doing that planning work. Then the Shuttle started getting talked about, and they formed a task force for the Shuttle operations. I think maybe it was called a committee or something, but I was on that. I think John [D.] Hodge headed that. I don't remember who else was assigned to that, probably a flight crewman. [L.] Gordon Cooper was assigned. I don't remember who else was on that.

But we basically did some initial discussions of, what do we need to do. This was even like pre-Phase A. It was when just the concept of reusable land-landing spacecraft that would fly multiple missions was first being talked about. Of course, there were people around who said, "Just make it like an airplane. That'll be fine." Of course, the objective would be if you could make it like an airplane, all you'd have to do is service it and fly it again. That would be great. It [wasn't] very realistic, at least for the technology that was available then, to do anything like that.

From an operations point of view, we talked about the landing. We spent a lot of time looking at that. Sperry Company in Phoenix had an automatic landing system that they had developed, installed in a—I think it was in a Twin Beech. We got Cooper to go fly that a few times. I talked with him about it. He's very cocky, not really aggressively cocky, but just very self-confident and relatively cocky in his attitude about his flying. I remember one of the comments he made to me: "You know, I'm the best pilot there is, but that thing can make a better landing than I can." He was really impressed.

But of course, there was a long road to go before that could ever be used for, like, commercial aviation or the Shuttle or anything. The question was, the thing that was conceived of at that time as a Shuttle had a fairly low lift-drag ratio. The weight wasn't really well defined, but we knew it was going to be fairly heavy. As opposed to all our previous experience, which was land on water and if you miss by a mile or so, that's okay; now suddenly you're setting yourself up [to say], "You've got to hit that spot on the runway, and you've got to be going the right direction when you hit it." So that kind of puts a new twist on how you do business as you're coming down through [re]-entry and the [approach to] landing.

Of course, it had a decent lift-to-drag ratio, which meant pretty good glide range and ability to maneuver and manage your energy. We started talking about that. That's why the automatic landing system came into question. There were people who were saying, "Oh, things are just happening too fast, and the penalty for screwing up is too great. We'd better make this thing so it'll land itself and let the crew watch."

The crew's attitude was, "If it's happening fast and it's really critical to do, you'd better let us take care of it." So we had that basic attitudinal conflict to get over, but we worked on that sort of thing.

We were, at that point, just guessing what the payloads might be. The science community was telling us things that [they] might be.

The Air Force came along at this time. At that point, there was active talk that the Shuttle should be a joint activity between NASA and the Air Force. Then I don't know what all politics happened, but it came around to the point that they said, "NASA's going to design it, build it, and fly it. Air Force, you define what missions you need it for." That was a real setback for the Air Force, because they had tried to build the aerospace plane, and it had gotten canceled. Of course, then we picked up their astronauts when that program got canceled. There was still a lot of soreness, a lot of tender or resentful attitude on [the part of] a lot of the top management in the Air Force because that had happened. They felt that they were the guys who were supposed to be flying defense missions, and they didn't really like getting involved with a civilian agency to do that.

So we asked them at some point there to define some model missions, and they did ten. Those missions were classified, and they sort of bounded what the Air Force wanted to do as of where they were at that time, what payloads and what kind of missions they thought they should be able to fly. It also defined some conditions of flight, like they wanted to be able to do a [quick] reaction launch. If something happened somewhere, they wanted to be able to get over it to get a surveillance view of it pretty quickly. So some of their model missions involved a quick-reaction-to-launch kind of thing, which was not really compatible with launches the way we knew how to do them. Of course, in the back of their minds, they'd been doing Atlases and Titans and so forth, so they were always ready to launch on a few minutes' notice. So there was that kind of [wide] divergence of operational attitude as these model missions were being defined.

I remember one of the things I really got involved in. I have to be careful here how I phrase this, because this was all highly classified. Some of the missions that they wanted to do, if you sat down and read them, you said, "You know, I think I understand what it is they're trying to accomplish. I think I could do that a whole lot easier if I had a little latitude with this, that, or whatnot parameter." So I went to the guys who were doing these model missions and said, "Hey, let's talk about this a little bit." They wouldn't talk about it. They would to some extent, but they basically wouldn't give.

I figured out that there was a large influence in what the Air Force was giving us in the way of model missions. There was some influence there from people who really didn't want that to happen. So if we were uncomfortable with some aspect of it, they were comfortable with that, because they wanted it to be tough. They still had in the backs of their minds, "Either we're going to preserve our satellite surveillance capability, or we're going to have our own program to fly manned defense missions," or whatever. But there was some very deliberate but unspoken lack of cooperation at the mission-definition level of things. It was real. At least, to me it seemed real. So that started to take up quite a bit of my time, working with that, trying to get these missions understood.

These missions were driving things. I think it was Aaron Cohen [who] mentioned, when he was discussing this, that the Air Force drove the definition of the payload bay size and the payload weight capability. The Orbiter is built around that big fifteen-foot-diameter, sixty-foot-long payload bay, and that was to accommodate Air Force requirements.

How much different would it have been if it had been ten-foot diameter and thirty feet long, which would probably accommodate almost anything else you could come up with? That would have made a very different program out of it. So that was one of the driving parameters that really forced the Shuttle and the Orbiter Program to take the shape that it did and be what it is today.

WRIGHT: Do you feel that when you entered this phase of your life, that the design of the Shuttle was pretty much complete, or did you watch it become more and more evolved?

KOONS: Oh no. See, we were still—you understand the Phase A, B, C thing. This was still pre-Phase A. There were some Phase A studies going on, and there were some others that hadn't started yet. So this was very much conceptual stuff.

The Shuttle existed in the fact that it was talked about, it was called the Shuttle, and there was an intent to have a program involving a reusable spacecraft. But there was no definition. We hadn't done Phase B yet. So we hadn't had the big competition to settle down on one contractor and actually begin to decide who. This was very much operations analysis, feasibility analysis, mission concepts, very preliminary stuff.

WRIGHT: Being a recovery-retrieval career type of guy that you were, the one thing that seemed to not be changeable was the land landing? Do you feel that that was not an option?

KOONS: How do I answer that? Yes, it was a given that it should be a land landing. You're not going to land a spacecraft in the water and reuse it. Saltwater does nasty things to your spacecraft. So that's a given. You had to land on land.

In fact, for the kind of vehicle we're talking about, landing on water would be a destructive experience. It's going to tear it up. It's not going to survive. For a gliding vehicle that lands [going] well over 100 knots, it's not going to survive a water landing.

So I guess part of the answer to your question is that there was very little in my previous experience that equipped me to deal with the job that I found myself doing.

WRIGHT: That set up a whole new challenge for you, of being able to think in a completely different direction, didn't it?

KOONS: Yes. Yes, I really enjoyed working with a bunch of new disciplines. I had been peripherally involved with, like, the mission planning, that generated the ground tracks that we reacted to with plans for primary and contingency landings. But to get involved in orbit mechanics and attitude control and to work even more directly with the crew and how you develop the flight plan and how their capabilities and their needs interacted with the schedule of what you're trying to do on orbit and how you could optimize your payload—all that was really interesting, to get directly involved in that.

WRIGHT: We look forward to hearing more of those details, and how you were able to get all that accomplished.

KOONS: I think that, if we could break now, that's probably a good point, because the next thing that happened to me was that I got transferred. I was one of the initial forty-one people in the Space Shuttle Program Office. There's a memo somewhere that named forty-one of us and said, "You're it. Go do it."

WRIGHT: We look forward to hearing that. Let's stop for now.

[Tape change]

WRIGHT: I think when we closed out the last part of the session, we were talking about when you were working with Dr. Kraft, on his staff, and we had started talking about some of the first meetings that you'd had with the Shuttle operations and working with the Air Force.

KOONS: Yes. At that point, it became known that they were going to form a Shuttle Program Office. So I talked to Mr. Thompson and Kraft and made it known to both of them that I would like to join the program office. Kraft agreed that I could do that. It was [agreed] that he let me go from his staff, and Thompson took me on. So they organized that office, and I was made the Manager of Payloads and Operations in the Shuttle Program Office.

We formed that office up. We only had one or two technical people who actually were members of the office. Most of our staffing came from—I think the term at that time was "co-located" people. We had people from Mission Planning [and] Analysis Division and people from Kennedy Space Center [Florida] and some others. Landing and Recovery, I think, provided one person. They would be in my office area part of the time. It varied by the individual. The Kennedy Space Center guys were there virtually all the time. The Mission Planning [and] Analysis reps were in my office virtually all the time. The Flight Control guy was seldom there. He was really busy doing some other things. But we were able to begin to pull together some of the broad outline considerations for how the Shuttle should be configured and how we would intend to operate it; began to explore what kind of accommodations we needed to provide on the vehicle for payloads, just really some fairly rough stuff. By rough, I mean coarsely defined, loosely defined things.

About that time, things had progressed to the point that the Phase B studies were ongoing. We had four contractors that ran the Phase B studies, which goes through the level of configuration definition. As I recall, all four of them proposed for the final, so we ran the Source Selection Board, which was a major source selection and was housed in buildings—I don't remember the name of the buildings. They were across the street to the southwest of the Center. So we worked out of those buildings for quite a while, evaluating proposals, and selecting the contractor.

At this Center, at the Johnson Space Center, we had two major components of the contract. The one was program integration, where we were looking for a contractor to assist with the integration program across the board, to integrate all the different elements. Second was to be a contractor for the Shuttle Orbiter. As everybody knows, Rockwell won those contracts and became our prime contractor for the Orbiter. They provided the systems integration effort, which was in direct support of the Program Office, which became known as Level Two. Headquarters was Level One. Level Two was Thompson's office, which gave all the direction to the different projects, including the people down at KSC [Kennedy Space Center] who were getting ready to do launch and build the launch equipment and adapt the Vertical Assembly Building and so forth to get ready to do the launches.

The projects over at Marshall were the boosters (solid rocket boosters), the external tank, and the main engines. Those were all separate projects that were run by Marshall Space [Flight] Center, and those projects responded to technical direction from Level Two, from Thompson.

Then here at JSC, the Level Three office was the Orbiter Project Office, which Aaron Cohen was head of.

WRIGHT: You had had some experience, of course, working with Marshall that you mentioned earlier when you were doing the Skylab and also working with some of the contractors, because you had mentioned to us in previous sessions about how you had gone to some of the companies that had invented some of the hooks and things. So tell us how that experience of having worked with the other Centers and having been able to work with some of the contractors, how that helped you in this new job that you had.

KOONS: I was, of course, familiar with working the Marshall Space [Flight] Center. I knew a few of the people who turned out to be involved in the Shuttle projects. I had worked with

Rockwell quite a bit. I knew their facilities pretty well when I was involved in the command and service module, for them. I knew some of the people, knew my way around, and understood some of the attitudinal differences that existed between the Centers and realized a little bit about the kind of things that we had to be aware of as we worked together.

It was a rewarding time. The people who were assigned to me were uniformly dedicated to getting the job done. They were very good at liaison back to their home organization, wherever it was. I think we did some good work in getting things rolling, if you will.

WRIGHT: Can you share with us some of the challenges of being on that Source Selection Board for such a major decision for the agency?

KOONS: Gosh, I was really a small cog in one of the gears in that. I think I worked under Scott [H.] Simpkinson to do the operations element. There wasn't a whole lot to the contractors' proposal. They all proposed something on that, but everybody knew all along that the government was going to do the operation; it was going to be a NASA operation. Even the major tests were going to be conducted by the government. So there wasn't a great deal of significance to the part we played in that.

We evaluated from the standpoint of how well did they integrate the operations planning, how well did they understand the operating environment, and things like checkout and so forth. But I never did feel that what we did as far as the part I did was a big discriminator in the selection of which contractor. It was something that needed to be done, but it was not one of the pivotal or even close to being one of the pivotal issues about which contractor would be selected.

WRIGHT: You had talked to us earlier about the payload bay being designed such to be able to be used by the Air Force. Also, the Shuttle was going to be used by commercial ventures as well. Did this play much of a role in some of the early discussions that you were involved in?

KOONS: Payload accommodation, of course, was on everybody's mind, but I think we realized that the Air Force requirements we were trying to meet, size and lengthwise, were going to encompass anything that would ever be offered up from a commercial [firm] or from any of the other government agencies or experimental payloads. So that was not a driver in spacecraft design.

I think, as things went on, as we got into more detail, [that] how we would integrate and operate a wide variety of payloads was starting to be significant. Things like the big arm that [flew] on some missions, that conceptually came into being at about that time.

I don't really recall a lot of detail about—we weren't really specifically designing for [things] other than the Air Force size and weight requirements. We were doing some very generalized definitions of things like data transmission, how we would take what kinds of volume of data, what types of data we might take from the payloads, and handle that and pass it to the ground, things like what kind of crew station we needed there at the aft area of the lower deck looking back into the payload bay, to what kind of visibility and sort of crew interaction might be involved in these not-very-well-defined payloads. Of course, that's where they work to operate the arm if they're deploying or retrieving the payload, but as far as on-orbit operations, at that point I don't think we got very focused on anything exact at that time.

WRIGHT: Were there customers out there interested in having—at this very early stage, were you already hearing of different types of commercial ventures or even other customers that were wanting to use—

KOONS: Not very much, and at that point we weren't really driving hard to find those payloads, because we were still years away from flight. We wanted to, of course, keep the interest up and make sure that we understood what might come our way and talk to anybody who had any questions, but we had not started advertising for payloads or anything. It was just not time to do that kind of thing yet.

WRIGHT: You moved over to this position at about the same time that Apollo was starting to close its phase. Tell us about that transition for the Space Center as a whole when it was announced that the Apollo missions were going to be concluded and this new phase was going to start generating.

KOONS: I don't know that I have much of a general comment about that. Of course, the Apollo operations people were going right on with Apollo-Soyuz [Test Project] and Apollo Applications, which came to be known as Skylab. So as far as the operations people, it was pretty much an unbroken thing. There was a whole series of missions out there to be flown and spacecraft to be built and provided for and so forth. It was not a big transition for them.

I was not working very closely with the engineering side or the human factors or any of those kind of people at that time, so I really don't have a comment for you on that subject.

WRIGHT: Was it an easy transition for you to move in to working for Aaron Cohen from your Space Shuttle Payloads Operations and Manager into working as his assistant?

KOONS: Yes. I made a move from the Program Office down to become Aaron Cohen's technical assistant. He immediately assigned me as his representative back to the Level Two Control Board, so I was still working Level Two a lot. That was a responsibility that took up basically two days a week, about a day of getting ready and a day spent in the meeting.

It wasn't too long after I came into that position that I was asked to lead a Tiger Team to get a television capability, to televise the approach and landing tests, which was something the Center did quite readily. We used a T-38 and got people who knew what they were doing. They provided a transmitter in the little pod that you can carry, that's an optional pod on the belly of the T-38. We were able to put avionics in there to transmit the picture. We got the cameramen—we called them cameramen—trained to ride in the back seat. They had to be checked out enough to ride and know how to eject and use the mini-camera strapped to the side of their hard hat so that they didn't have to sit there and try to look at it. All they had to do, really, was point their head to get the picture. We worked at that for a while, kind of a collateral duty. There were about a dozen people involved in getting that put together. I was sort of the coordinator that kind of kept an eye on them and made sure that everything was getting done.

I was involved in the planning, to some extent, for the approach and landing tests. The modification of the 747 was done by an element of the Program Office, [which], in turn, relied on the Engineering Division and the Aircraft Operations people to get that part of it ready.

There were a lot of people who really thought this was going to be something, to separate two vehicles that large in flight, particularly when the unpowered one was on top. It was not really that difficult. You just set up a flight regimen so that the Orbiter lifts away from the 747 when you separate. It's kind of like the Orbiter drops the 747, is what you try to do. Then, of course, they fly after separating and go and make the approach and landing.

Of course, we did that out in the desert. I think the last one was done to a runway. It was good. We learned some things about the flight control system. We actually, as I recall, on one flight, got into a limit cycle situation, where the crewman had to change—I think Fred [W.] Haise was flying, and he had to change his control mode in order to regain good control of the vehicle and get it on the ground.

Somewhere along there, and I can't tell you the exact time, Aaron asked me to take the lead for the Orbiter Project Office in the participation we did in the main propulsion test over at Michoud Assembly Facility [New Orleans, Louisiana; Stennis Space Center] Mississippi. What the Orbiter provided—there was a sort of an Orbiter, it was really an aft fuselage, where all the propellant lines and engine mounts and whatnot are, and then a strongback, which was just a steel skeleton thing that could be attached so that the tank was supported. Then the idea was, we would do integrated tests with the three engines of the propulsion system [and] all the pumps, draining the fuel and oxidizer down the lines into the engines. That was a really interesting thing.

Marshall provided, actually, more of the hardware than we did, but we had the responsibility to get it all put together and hooked up, and we had the software responsibility, since the Orbiter, in an actual launch, would provide the software, the control software to make things fly. So we were responsible to do that.

That required lots of trips to Mississippi and lots of meetings and whatnot, and pretty close coordination with the Rockwell people at Downey [California], because as we got the vehicle shipped and got ready to put it all together—that was a huge amount of work, to get this thing over there and get the engines and whatnot installed and to be sure that we were ready to operate it, because it would have been pretty disastrous to the program if we had had an accident at any point with that, because that was a really one-of-a-kind test stand and test article. It would have been a major setback if we had had any kind of catastrophic failure while we were doing that. I don't remember how many tests we ran. There were eight or ten all-up tests where we ran all three engines for a fairly long duration.

We did have one thing happen there. As they were fueling up for one of those tests, they discovered a fuel leak. Their sensors told them that we had a fuel leak in the aft fuselage. So they powered down and drained the tanks and went looking for the leak and couldn't find it. This recurred several times. They were unable to figure out where the leak was coming from. The instrumentation and whatnot was not telling. They were seeing cold spots on one engine, I don't remember which engine. As it turned out, that was misleading.

So as this became more and more confusing and puzzling to everybody, I decided on this end that it was time to get somebody in there to see. Of course, you couldn't put a person in there, so I had a couple of guys put together a collection of television equipment that we could qualify to put in that environment—or certify, really—to put [in] that environment so it would allow us to actually have a camera in there that we could pan and tilt [to] have a look at what was going on and hopefully be able to observe this leak.

After another try, another fueling try, everybody said, "Okay, bring your camera over here. I guess we'd better slow down long enough to put that in." So we put that in and found out that, at least with the camera positions we had, we still couldn't see it. So we then added some polished steel mirrors, and that did let us see it. Actually, the leak was occurring on an engine, not the engine that had all the cold spots on it. The leak was occurring on a different engine. So we were able to see that with the camera. Then everybody knew what to do to get it fixed. We did run that whole test series off without any [big problems]—we had some anomalies, certainly, but we didn't have any significant failures or anything that even came close to causing a loss of the test article or whatever.

WRIGHT: How were your dealings with Rockwell? Were they similar to those that you had had before when working with them, or had they changed?

KOONS: After I had been on Aaron Cohen's staff for about two years, as I remember—I don't remember the exact timing—Andy [Andrew] Hobokan was retiring. He was the head of Manufacturing and Test Office. Aaron asked me to take over that office, which I did.

So as I stepped into that responsibility, that was the first time I really had any extensive direct dealings with Rockwell, and it was at a different level, management-wise, than what I had done in the Apollo Program. So it was not a new experience, because I knew the people, I had been working with them, I had been to meetings and whatnot, but now with a direct-line responsibility to oversee the manufacturing and test preparation process and all the acceptance testing, it put me in a different role. So I had a different set of people and a different set of responsibilities that were involved in my work with them. I found them to be a really good bunch of people to work with. There were very few times that I had any real big disagreements with them.

The first couple of Orbiters coming down the line had gotten significantly [late], largely due to the fact that there were lots and lots of engineering changes being made that were causing the manufacturing people to have to back up and re-do things, and start over. There was some difficulty due to the fact that the job of installing the ceramic tiles had been—I don't know what you would call it—maybe underestimated as to how long that was going to take, how difficult that was going to be. It was a very exacting job that required just handwork, just lots and lots of handwork. Very often, the tile, once they got it installed, would turn out [to not] really fit like it was supposed to, and it would have to come off and a substitute would have to be made.

On 099 *Challenger* there were some 34,900 of these things, and that was a real chore to get that done and get those things on. In fact, when we finally shipped *Challenger*, there were still lots of tiles missing. That had to be done after it got down to Kennedy [Space Center]. There had been even more missing on *Columbia* when it was shipped. It was shipped before I actually got on the job there, during the manufacturing.

But, no, I found the Rockwell guys very—I think we had a good, constructive relationship. I had a fair number of people who were watching closely. What I tried to focus on with the people who worked for me was to get them to look for problems in a helpful way. If they saw anything coming up that the contractor ought to address in a different way, to not bring it up as "I gotcha," but rather say, "You know, I've been watching this," or, "I've been watching that. Have you considered that you might do this? Do you think this might be a problem?" Stay constructive, stay positive, try to keep things moving.

What I found my job to be, once we had worked our way through the detailed schedule and were satisfied that that was an achievable schedule and that I had quizzed my counterparts in the contractor organization directly to say, "Now, can you do this schedule? Can you meet this? Can we do this?" What I found my job to be was primarily one kind of watching the budget sort of thing, but primarily dealing with problems. And we did have some significant problems come up. The crew compartment pressure vessel had a really large flat aft bulkhead that was made, as I remember, in two pieces. It was a numerically machined part and it was kind of like waffle construction; it had lots and lots of pockets. They'd start with this giant billet of aluminum and machine away 90 percent of it, and you were left with a [bulkhead. We] and we were set up, and we were doing this, on what was actually an Air Force mill in Columbus [Ohio], I think.

At some point, the Air Force decided they had to make some new spars for the C-5s. They said, "Oh, by the way, we need that mill. You guys'll have to get off of it."

That caused a major flap. First, we tested the water with the Air Force to say, "Can we maybe help you find a substitute mill? We're all set up and running here. It's going to be a major glitch for us to have to find another mill or change the design or whatever we have to do."

That was not successful. Their attitude was, "That's our mill, and we need it. We've given you fair warning, so move over."

We were able to find another mill. We did have get Engineering to change the design and actually make that bulkhead in a couple smaller pieces and then weld them together. So there was a little bit of a weight penalty involved, but we managed to get that done without causing a big glitch in the schedule.

It was that sort of problem that I dealt with. I found after I'd been there for a while that one of the things that I felt was a little bit uncertain [of] was how well any of us had a handle on what the subcontractors were doing. I didn't really feel that was being adequately monitored by either the government or by the prime contractor. So we just made an adjustment, just called everybody's attention to that and said, "Let's start statusing this on a regular basis." I think we were able, by that, to kind of get people a little more focused on what these subs were doing and to spend a little more time making sure that things were going well there and that we maybe picked up [on] some problems a little sooner than we might have otherwise, so that we were able to maintain budget and schedule better.

One thing I found was that there's quite a bit of government-furnished equipment that flies and was planned to be built into the spacecraft. I found that it wasn't really being managed by anybody in the Program Office. Just a management oversight, probably not a real significant deal, but then some of that equipment could have hurt if it were badly out of date.

So we initiated just a simple process of reviewing that government-furnished equipment every month from the standpoint of engineering or manufacturing status, wherever they were in their cycle, and sort of made everybody focus. "We're really working to a schedule here, now, people. Let's keep ourselves focused on that. In particular, let us know if you think you've got any kind of a problem that's going to impact the delivery of the spacecraft."

I don't, offhand, think of anything else I think that's worthy of commenting on. I retired out of that position.

WRIGHT: Before you did that, you were able to see your Shuttle launch. Can you talk to us about the events leading up to that and how you were involved and where you were?

KOONS: Yes. For the first Shuttle launch, for whatever reason, I was down at the Cape [Canaveral, Florida] and had a blockhouse position, where I could monitor the countdown. I and one of the people who worked for me, named Neil [A.] Townsend, who was our Test Office Manager, were there to just monitor the countdown from the standpoint of the main propulsion system, because that was the thing that was going to be—you know, it was the first time we were flying this system with these three engines. So we were there for that.

But we also agreed that when they got down to minus three minutes, that there wasn't really anything that there was going to be any kind of judgment calls made on. So we beat it up to the roof of the blockhouse, so we were able to be on the roof and watch it about as close as you could get. That was really quite a rewarding experience, to see that launch close up, fairly close. I don't know how far away we were, probably a couple of miles, but it was still close enough that you felt everything shaking when those solid-rocket boosters [and main engines] were building up to full thrust.

WRIGHT: In many, many years before that, you had talked to the astronauts after they had landed. Did you talk to John [W.] Young as well and find out how the—

KOONS: No. No, I didn't. It was not anything that my role put me in position that I should do that.

WRIGHT: And the ones after. You didn't retire till '83?

KOONS: Yes.

WRIGHT: So you were able to see a number of missions launch.

KOONS: Yes.

WRIGHT: Could you share with us maybe how some of your early discussions about payloads and your early discussions about designs, how after those missions returned, you saw that work actually had come into reality and how well those discussions had worked.

KOONS: Yes. I was no longer concerned with payloads at all at that point. In fact, for the last three years, I was very much focused on the manufacturing and acceptance testing and getting that whole process running and keeping it running so that we had a stable environment budget-wise and so that we kept on schedule and got those things delivered as they were supposed to be. That's what I concentrated on.

WRIGHT: When you left, where were you in that progression? You said *Columbia*, of course, had launched and *Challenger* had been delivered.

KOONS: You know, I don't exactly remember; 103 was either finished or near completion, and I don't know the names of them. I always just used the hull numbers. And 104 was being built. We had started a movement in which when they started canceling the Orbiters further out, I kind of became a one-man preacher on a soapbox, and I said, "Guys, we're making a big mistake here. We're cutting this program off without any real way of building more Orbiters."

The planning answer, the program answer, was, "We're going to have all we need. Our studies show that that's enough."

I said, "Yes, but what happens when you do something like you run off the runway and wipe out the main gear, and you've got one that's out of service for a year while you do a major overhaul on it to get it ready to fly? What happens and I hope this doesn't ever happen, but what are you going to do with the program if we actually lose a vehicle?"

We went around and around on that a little bit, and I didn't expect that anybody was going to say, "Okay, let's build a spare Orbiter and put it in the hangar." What they did agree to was that we could budget for long-lead spares. These were things like, surprisingly enough, the big—I think it was aluminum; maybe it was stainless steel—anyway, it was a really large slug of stuff that had to be made for the on-orbit attitude maneuvering system, the OMS [Orbital Maneuvering System] engine propulsion combustion chamber. There was something that was long lead about that, and I don't know the technical details, but I do know that that was identified as a long lead. The wing spars were a long lead, because that was a special billet that Alcoa [Inc.] had to make and ship all the way down the West Coast to Convair [Division of General Dynamics Corp.]. Then Convair [milled] those spars out of these giant things. So we got some billets on order. I don't recall if we actually went ahead and milled them or not.

There [were] just a number of things like that. I think that we got about a $5 million authorization to build and shelve long lead spares. Of course, after the *Challenger* accident, they immediately picked those up and moved forward then to build the next hull, build it into a spacecraft, and that probably saved at least a year, maybe as much as two years, in getting that replacement Orbiter built and ready to fly.

WRIGHT: Is it correct to say that the Orbiters were built to sustain at least one hundred missions each?

KOONS: That was the goal, but I don't know how you'd design something to fly a hundred missions and fly apart on the hundred and first one. I think what you have in the Orbiter is an aluminum-structure airplane which is like any airplane; as long as you don't let your structure corrode and you don't overload it, you can just keep flying it.

The thing that the Orbiter has on it that wears out are engines, and they replace those engines every few flights. Things like the tires only go a few flights, and you have to replace them. So there's a lot of wear-out items on there. As you know, a fair number of the ceramic tiles have to be replaced after each mission for whatever reason. But things like the avionics, all the electronics, that's pretty easy to change. When we built that first Orbiter, somebody ran a rough count and said, "We've got about one million wire segments in there," which meant there were two million wire terminations somewhere.

So that kind of stuff can start to give you trouble, but on the other hand, it's all replaceable. It's all in cables, and you can pull it loose from the connectors and lay new harnesses in if you need. Of course, as you install different avionics or do different kinds of missions, you're going to need to make a lot of wiring changes and a lot of software changes. But for the most part, I don't know why an Orbiter would be something that would wear out. We know that the outer windows have to be replaced periodically, but the nosecone, the carbon carbon—as long as the carbon carbon doesn't get damaged, there isn't any reason it shouldn't just fly indefinitely. I don't think there's any kind of thermal cycling that would wear it out, as far as I know.

So basically, I think the Orbiters—if somebody wants to keep flying them, the basic structure in the system, like the hydraulics and all that kind of stuff, should be reusable and repairable indefinitely.

WRIGHT: Why is it that you decided to retire when you did?

KOONS: It seemed like a good time. I was really tired. I had been going pretty hard for twenty-six years. I had probably taken on more than I should have. The last few years, I was the commander of my reserve unit, and I was also very involved in our church over here locally. I was the chairman of trustees, and we were starting a building program, and that took a lot of energy. So things had just kind of come to the point that it looked like it was as good a time to go as any.

I had an opportunity on the other end, in that my father was ready to shut down the family farm if nobody wanted to pick it up, so I took that opportunity to move from full-time space work to full-time farming, which turned out to be probably more challenging than the space work.

WRIGHT: Wow! Different type of challenges. So you returned to Kansas?

KOONS: Yes.

WRIGHT: We didn't have an opportunity, when we first started, to talk about your early days, because you chose to pursue an engineering degree at a university, and then you joined the Marines. Was there an area specific in engineering that you wanted to pursue?

KOONS: I don't have an engineering degree; I have degrees in physics and mathematics. No, I went from growing up in a small town and went to high school in a small town. I went to a small college in Kansas called Ottawa University [Ottawa, Kansas] and got my degrees in physics and math. That was in a time when the country had the universal military training requirement. Everybody had to serve two years minimum, and some people opted to do that, to serve the two-year minimum. I considered that and concluded I would rather do something a little more rewarding than just being an infantryman for two years, so I chose to go to the Marine Corps.

The time slot [when] I got to actually start Officer Candidate School was several months after I graduated from college, so in that interim I worked for Westinghouse Air Arm [Division]. I had a very small role in the development of the fire control system for the F-4D, which was one of the high-powered airplanes of the day. It's long since obsolete.

I went through OCS [Officer Candidate School] and succeeded there and got my commission. Went to what they call basic school, which really qualifies you for command of a company-sized unit, although you come out a second lieutenant, and nobody's ever going to give you a company. You might get a platoon, or you might get a job somewhere and watch how the people who know how to do it do it.

But I went to flight school and was in flight school a year. Then I think you can pick up from there I got assigned to the Fleet Marine Force. Then they started looking for a [Mercury] Project Officer, and I happened to be there.

WRIGHT: Then your future began, didn't it? Looking back over all those years that you spent doing the work that you did with NASA, is there a time that you feel like was the most rewarding of the efforts that you did, maybe a favorite time period? You had mentioned earlier today that it was that ten years, but was there a certain time in that or a specific issue that you worked on that you feel you were really glad you had an opportunity to be there?

KOONS: Yes. I would repeat, the ten years or so from '59 to '69 were very rewarding, and I was well satisfied with what I was able to contribute there and really pleased to have worked with a team of people who were so dedicated and so hard-driving and so constructive in their approach to the endeavor. It was really the kind of experience I think very few people get to have in their lifetime.

The other period that I found really satisfying was the last three years, when I was the Manager of Manufacturing and Test, because I think we really got some things—we kind of got the trolley on the tracks and kept it there and got the manufacturing operation—I won't say straightened out, because it certainly wasn't broken to begin with, but we were able to establish an environment between NASA and the contractor where there was less finger-pointing and more "Let's get this thing done. Let's anticipate problems. Let's realize that everybody is well served if we get these things manufactured and get them out on time, and if we can save some money while we're doing it, let's do that." Of course, as you save time, you do save money.

I was very gratified with that, and again, the people working for me directly here at NASA were a really great bunch of people, and I really enjoyed working with them.

WRIGHT: Before we close today, I was going to ask and see if anybody had any other questions and if there [were] any areas that you thought of, or if you wanted to take a look at your notes that you made, something that we might have passed by too quickly that you can think of.

KOONS: I'll probably think of that in a week, if there is such a thing. And I did have the right name of the TV show.

WRIGHT: Oh, good. Are there any other anecdotes you can think of or good moments that you want to share?

KOONS: No.

WRIGHT: We certainly thank you for taking time on your first trip back in a long time to spend so much time with us.

KOONS: It's kind of a unique experience to have you all sit and focus on what I have to say.

WRIGHT: We sure enjoyed it, so thanks again.

[End of interview]