ORAL HISTORY TRANSCRIPT

GEORGE C. FRANKLIN
INTERVIEWED BY KEVIN M. RUSNAK
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RUSNAK: Today is October 3, 2001. This interview with George Franklin is being conducted in the offices of the Signal Corporation in Houston, Texas, for the Johnson Space Center Oral History Project. The interviewer is Kevin Rusnak, assisted by Sandra Johnson and Jennifer Ross-Nazzal.

I'd like to thank you again for coming by this afternoon to share your recollections with us.

FRANKLIN: Most happy to do that.

RUSNAK: Good. As I was explaining, can you tell us some about where you grew up, the kinds of interests you had as a child in going through school, and any other experiences in industry that you might have had before coming to NASA that led you down your particular career path?

FRANKLIN: Okay. I was raised in Phoenix, Arizona, and spent most of my summers somewhere in the mountains. I was lucky to be able to get away from the heat of Phoenix, so I did a lot of fishing and exploring and hiking and things of that nature as a child. I had my own horses. We rode out in the desert. We lived north of Phoenix, where I could ride anywhere I wanted to ride. It was a lot of freedom.

I went to school at Phoenix Junior College for my first two years, as a pre-med [medicine] student, and then I went to Tulane University [New Orleans, Louisiana] for the remaining two years of pre-med. After that, I was drafted into the army, so I went into the

service and served with the 40th Division out of California, which was a National Guard outfit. Most of the draftees at that time were from Arizona and Nevada, and what was remarkable about it, the particular group we were in, this regiment we were in, 80 percent had either three years or four years of college, draftees. So we all felt we were pretty smart.

The cadre we had working for us, or was working us over at that time, were seventeen- to nineteen-year-old National Guard kids playing soldier, so we had a lot of fun with them.

Anyway, we were shipped over to Japan and we stayed in Japan for several months until… the attrition of the National Guard [took place, and] were taken home, because they didn't want to send California's finest National Guard into Korea. So then we went on into Korea and we arrived there, I remember, on an early morning at 17 below zero, and traveled out up to the heartland.

I served with [a] forward medical group in Korea, where we would be the first ones to bring in the wounded and treat them and then helicopter them to the MASH [Mobile Army Surgical Hospital] units. So my event there was uneventful, other than you get scared a little bit and you do your work and you get done with it.

So, coming home, I spent my two years and I refused… a commission at that time. They were offering commissions to non-coms [non-commissioned officers]. I was a first sergeant at that time. Because that says you now get a tour of duty again for another two years, so I said, "Go on home."

So I came home, and the job that I [could] get at that time with a degree in biology, with minors in chemistry, I [could] clean out rabbit cages somehow. So anyway, I decided I ought to go back to school.

I had an uncle in New York, who worked for G.E. [General Electric]. He was head of the Turbine Division of G.E., and he was the one that had developed the coal-fired turbine locomotives, held a lot of patents there. But he told me, "Why don't you be a mechanical

engineer. A mechanical engineer, they're always wanted, there's always a job. You'll never get rich, but it's an interesting field to go into."

So I said, "Well, I'm of average intelligence. I ought to be able to do that."

So I went to Arizona State [University]. I was living in Phoenix at my folks' house then. I said, "Well, I'll go over to Arizona State and brush up on my math and take any other courses I need to take before I can go into engineering." So I went over there and I brushed up on my math and drafting and a few other things.

Then I went down to University of Arizona at Tucson to take my engineering. I got out of the service in October of '52, and I entered university in—I'm trying to remember now. That's a good thing to remember. I guess in that fall of '53.

So I went through engineering relatively easy because I had all my credits. I just needed the base courses and took those. I joined a fraternity down there.

Actually, to back up, at Arizona State at that time I was a founder of a Theta Chi fraternity chapter there, and then when I went down to University of Arizona, of course, I just joined the Theta Chi organization down there. I became later the president of that organization, and I ran the house. That was the way you kept your income. I was on the GI Bill of $110 a month, so I got my free room and board by managing the kitchen and the house, which was a breeze, because I like to eat. [laughter]

I graduated from University of Arizona in the spring of '56. In January of '56 I got married, a wonderful woman from Tucson that I met down there, and off we went to Convair [Division of General Dynamics] in San Diego [California], where one of my fraternity boys said, "They're really hiring people over there," and with my background they needed somebody in their Human Factors Department.

It was an interesting, fun thing in a way. I had a firm offer from Shell Chemical over in their Torrance plant, which I had visited because of my background in chemistry, and in engineering. So it was a pretty good offer. So anyway, when I heard of this one at Convair

opening up, I asked them, I said, "Well, what's your salary?" And they said something, and I said, "Well, that's not enough."

And they said, "Well, what do you think?"

So I thought of this Shell Chemical job, so I doubled it and asked them, and they got back on. I was called out of class, in my mechanical systems class, and they said, "Don't sign with anybody. We got you." So here I went over there with a great job of $4,800 a year, and all the overtime I can take.

So off we went to San Diego in that summer, and that fall we bought a house, $1 down, $99 a month for a big house, big three-bedroom, two-bath house, brand new.

And I settled down at Convair. I was in the design requirements area, which was called the Human Factors, headed up by a guy by the name of Woodson. They were supposed to set the requirements for the [CV-]880 and the [CV-]990 aircraft at that time and the [F-]106 aircraft that Convair was building. So we were working on ejection seats, trying to have a supersonic seat that would come out of the 106. We ran a lot of tests on that. I remember going out to Alamogordo [New Mexico] and doing a lot of sled tests and picking up the pieces around the track after it blew up.

Then we were starting to design the 880 cabin and cockpit, so I decided that I didn't want to be in the requirements; I wanted to be in the design group. So I requested to go over to the design, and proceeded then—I hate drafting, but proceeded there with doing the design of the cabin and the controls displays and the seats and the consoles and the rest of the stuff in the 880.

Knowing I didn't like the drafting that much, and I'm not a great draftsman anyway, and remembering a professor at the University of Arizona who taught metallurgy, he spent about half his class telling us about what we ought to do, that we ought to be dentists, we ought to be something else, and then he started telling us about the facts of life of going into a company, and he says, "Get acquainted with your boss, the one that you're really working

with in that drafting room." He said, "Learn to drink his coffee and offer him coffee, and never miss a schedule, but never do perfect work."

I said, "That's crazy."

He said, "What happens is that there's a promotion coming up in another department and he likes you, but he's afraid that you might let him down, so he's going to move you. He's not going to move his best guys. He's going to move you."

But anyway, remembering that advice, I said, "Hey, I'm going to go into drafting." But anyway, I went into drafting and then I worked my way up to where I was finally in charge of thirty draftsmen. Designers, I call them; they're not draftsmen. They're designers. For all the mechanical systems in the cockpit and the passenger cabins. We did the seats, we did all that.

There [were] two other [lead] people there. One of them was [in charge of] the avionics and the other was [in charge of] electronics. It was divided in that fashion.

Well, we got our first experience there of computerized systems. Remember, up until that time, a slide rule, if anybody remembers a slide rule, is the way you did your work, or you had one of those hand calculators that looked like an adding machine, that you put a lot of numbers in and turn the cranks and you watched all the digits come up and you thought that was the right answer.

But they decided to put a computer system in, which was going to computerize all the designs by number and the ships and what have you. Well, if you think about an 880 program or any commercial aircraft program, you have about seven or eight airlines with their different configurations, and everybody wants a different configuration. They don't want the same thing, because they're used to what Boeing put out or they're used to what somebody else put out.

Well, we went through this computerized thing, and I had a call from one of the buyers. He says, "You know, we're buying 100 more eight balls [attitude indicators] for the cabin than we have ships that are on the market."

I said, "That can't be. You take them off the drawing?"

"Well, that's the way they come out of the computer."

So I said, "Well, there's something wrong."

So we asked for printouts of all the computers, and the three fellows, myself and the other two leaders of this group decided that what we'd do, because we worked with these numbers all the time, you kind of memorize, we'd go through the book just at random and pick out a number and see if it was right or wrong.

So we went through the stack, which was probably about six, seven inches thick of computer printout paper. After you work with these numbers, they're ten-digit numbers, after you work with them long enough, you know the dash numbers and the sub-dash numbers and you know what the part is, you know what airline it's going to be, and you know what it goes into. You just keep it going.

So anyway, we went all through this, and each one of us came up with there wasn't a single page without an error. We asked about how was the computer program set up. Well, the drawing or the bill of materials sheet was sent down to keypunchers, and there were two keypunchers, and what they did, one of them punched in the numbers that they saw on the bill of material, and the other one took that paper and punched in again, and that was supposedly double-punched, and if there was any mistake, they had to go back and fix it. So Quality [Control] said, "There's no way that that can be wrong." It had to be the bill of materials.

So anyway, long story short, we finally found out that there was something wrong with the punch or the computer program, so they had to revise all that. Nowadays in the

computers you do all that on a desktop computer, but those were pretty neat stuff. Our first introduction to the computers.

Well, anyway, Convair went on through and they lost a lot of money on their ships. It was costing them 2 or 3 million dollars to deliver one because of the way they ran their production line. Every step of the line was a new ship because it was a different configuration than the previous one.

So we went up and did a study real quick to see what was Boeing doing, and we found out what Boeing was doing, was they were selling the basic to the airlines, like you normally do. You price out a basic and then you put the options in, or the changes. And that's the way we priced. You price that right on down to the drawing levels.

But what Boeing did, they built the basic. They ran the basic airline through their system and then they took it over into the customs shop where they took things out and put things back in, and they controlled the costs then to that airline for those options, where Convair was sending them down the line and doing the options on the line, so every group station along the line had a new ship to work on each day. It wasn't the same routine, so consequently, it was costing too much money.

[Howard] Hughes was the one that got Convair into the job in the first place. Howard did that. He conned them into building this plane for TWA [Trans World Airlines], which was a little bit smaller than and a little less capability than Boeing's planes. He held up shipment for some of them because he didn't want to pay for them for a while. Anyway, it led Convair down the path where they went to the 990s, which was probably one of the best aircraft ever built, commercial aircraft, but wasn't successful because it only filled a small niche. It was one of the first ones that went supersonic—accidentally, but it went supersonic [during test flight].

But anyway, so Convair started to shut down their engineering, and their engineering was peaked out at around 7,000 engineers, and it was going down about 10 percent a week,

and that was one of the things that was very distasteful, was I had to come up with a 10 percent [cut] every week in the personnel I had working for me. You'd turn those [names] in on a Thursday, and on a Friday at 3:00 o'clock in the afternoon they would get their notice and out the door they'd be escorted, with their two weeks' notice, and that was it.

So anyway, [engineering] went down and down and down, and they opened up some opportunities over at the Atlas [missile] program up on the hill in San Diego, and so they asked me what I knew about structures, and I said, "Well, I can do structures. I'm all right. I'm smart on that." I didn't know a thing about it, but I'm smart on that; I can run the numbers.

So I went over there, and they were increasing the capacity for the Atlas program at that time, so we were working on Super Atlases [Centaur]. I was having a ball with that, because the manager over there was real nice to work with and the troops, we can kind of think outside the box when we're trying to do some design work.

So I was asked to do the proposal for the lunar module [LM] and do the internals, so I said, "Well, fine. I'd love to do that." So there was a group of us went off into the think-tank world and sat there and we would look at the proposals. The first thing that really got me was, remember we were trying to figure out what was this lunar module, you know.

We watched the speech by [President John F.] Kennedy when he said, "We're going to go to the Moon and back in a decade," and behind him was a mockup of what purported to be was the lunar module. It puzzled us, because it looked like there was more glass on there than there was spacecraft, and we said, "We can't understand why anybody would put glass on a spacecraft." It was more Buck Rogers than anything else, because everybody knows glass is heavy, aluminum is light. We couldn't understand. We tried to dissect it and we tried to think of it, and as we were doing our design, we wondered, "Are we missing something that we don't know about?" because of this picture.

It puzzled us and it puzzled me for a long time till after I got to NASA, and I'll tell you that story hopefully sometime here, where I finally met the two guys that I think did that mockup, that were, quote, "designers," but non-reality-type people. They can draw beautiful pictures about what things should be and do all kinds of things, but no consideration for cost or doability or function. Just nothing. So I finally figured out that that's the kind of guy that did that, but that took years later.

But anyway, during the proposal, the other thing that bothered us was the weight. The weight that NASA gave us on the vehicle, if you run the calculations out, equal the fuel weight to get that fuel up, and we said, "Where is the structure to hold the fuel?" You had a machine here that something was wrong with it. So we worked on that for probably six months or more. Everybody was working at it, and the more you worked on it, the more fascinated we became with the idea of the lunar module.

We came up with some pretty good designs on it. We thought we had it wired when you go in to the [NASA] people and they talk to you about it and everything else, and our manager was pretty good, our leader. We were still trying to get the weight down all the way through the proposal, and I think everybody else was. When the proposal came out the next morning, miraculously, the weight had been reduced and we couldn't understand why, except the manager said, "Well, we reduced it."

I said, "You just arbitrarily—?"

"Yes, we arbitrarily reduced it. We don't think NASA knew what they were talking about."

So anyway, we find out later that Grumman [Aircraft Engineering Corp.] did the same thing. Everybody did that, because the calculations just weren't there.

So anyway, I had made a vow when I got through with that, that whoever won that contract, I wanted to work with it. That was going to be the fun thing, to work with that lunar module. So when it was announced that Grumman won it, I said, "No way am I going

to New York. It's cold up there." I'd been raised in the Southwest. "I don't know whether I can even speak that language."

But Johnson Space Center had been announced to go to Texas, and I said, "Well, I went to school in New Orleans. I ought to be able to handle Texas all right." So I said, "That's where I'm going to go."

So I applied and I waited and waited and waited. Finally got a letter saying, "Well, we'll try to get to you pretty quick."

Meanwhile, I went back. They wanted somebody to work on the Little Joe II, which one of the models is sitting out here on the park, which was going to be a test vehicle for the command module [CM] separation system, and it was to be built cheap and reliably. That was the only two requirements. They didn't care about weight, nothing else.

So I was given a couple of tasks. One is to design the fins on the machine. The other was to design the dummy payload, which is nothing more than a piece of iron, command module shape, but with the proper weight distribution. We were going to build it down at the experimental shop, which essentially we were able to do sketches and just pass them down to them, and they would build as we made the detailed drawings, because you always had to have detailed drawings.

NASA came around for the preliminary review one day, which we didn't know what was going to happen, and they wanted to review the drawings before it went to production. Well, the thing was half built already down there. The unit was already in—I mean, it was all put together. They came to me and they wanted to know what my layout—because it was supposed to be a preliminary review for layouts—of the fins for the control system. I said, "Layout? What do you mean, layout?"

"What is your layout? We've got to look at that."

Well, the only thing I'd done on a layout was a point-to-point location for dimensioning. I laid out my big drawing. I said, "Well, there's the apex and there's the other apex, and here's the shape of the thing." It was in a sketch, is all it was.

He said, "That's a layout?"

I said, "That's a layout. You want to see the production drawing?"

He says, "Oh." So I showed him the production drawing. He said, "Well, that's what I want." So I gave that to him.

So anyway, the next day we got a go-ahead to go to production, which we already had. But we made some contribution there; at least I made some contribution there. One of them was, there was a whole bunch of JATO [jet-assisted takeoff] bottles all put together between two big rings, and they needed a skin. Well, I had just put a patio on my roof, one of these aluminum patios, you know, with the thing, real cheap from Sears. I said, "Go down and buy some of that and wrap it around it. You don't have any loads there." What you want to do is just keep the wind loads out.

"Yeah, that's a good idea, but how are we going to draw that?"

I said, "Go to Sears and buy it and make a sketch and put a ten-digit number on it." So we did that. So that was riveted in.

The top was fun, from the standpoint that I drew all that up and then the boss says, "Now go get it built."

And I said, "Built? Where am I going to get it built?"

Well, because of this thing, we weren't bothered too much with competitive bids and all that other good stuff. So I heard about a shipbuilder up in—trying to remember now, I think it was Boston, an ironworks up there. So I talked to him on the phone and I described what I wanted. They said, "Yeah, we can do that."

So I went up there with this big roll of drawings, you know, all the details and all the military specs, the whole bit. I went into the foreman's shop and he looked at that. He got an

8-and-a-half [by 11”] piece of paper out and he sketched something, and he said, "Come on," and we went on down. And there was a fellow down there, with a big brake bending and rolling steel. I mean, he was rolling inch-thick steel back and forth, and he'd throw stuff in there to eyeball it. So he stopped the guy and he had him look at the sketch. The guy said, "Yeah," nodded and jotted something down.

So we went on back in. He said, "Yeah, we can build it for $10,000."

I said, "You've got to ship it to San Diego so we can put it together."

And he says, "Well, you pay for the shipment. We'll build it."

So I said, "Well, that's close enough." And I said, "Now, you've got to have it painted. You've got to have a certain paint."

He said, "Well, you furnish me the paint, and we'll fix it."

So anyway, I left him with all the drawings. I said, "Do you need any of these drawings?"

He said, "Nah, I don't need any." [Laughter] But I left them there anyway.

Sure enough, it came on, on a railcar, and it was just what we wanted. We put it on and we sent it out to White Sands [Test Facility, New Mexico]. The first test was very successful to demonstrate the separation of the launch pad separation system. It wasn't designed to do that. It was just to test the Little Joe II itself. But during the design phase, NASA came in with a change, and they wanted to put moveable fins on the bird so they could do some controlling. We said, "What do you want to do that for?"

"Well, we want to have this moveable thing on the controls."

So we put that on. They furnished the control package and the motors as GFE [government furnished equipment]. They furnished that. So we put it in. They did the testing on it.

So when we fired it and off it went, the control system went haywire. So what it did, it put excess loads in, and one of the JATO bottles came through the side of the corrugation

because of extreme loads, which set off the release mechanism to shoot the tower, to take the command module off the top safely, and landed. And the astronauts are watching all this, said, "Hey, that works great." So the test program was cut short out there when they proved what they wanted to prove, with the JATO bottle work.

So anyway, then I went out to working on the Atlas for a while, until my application was in, and I finally heard from them, says, "Yeah, you can come on out." That was about the time John [H.] Glenn [Jr.] was trying to get off the pad down there, and what I found out was, my application was sitting on the desk waiting for a manager down there who was trying to direct his part of the launch down there. So everything was kind of held up.

But they told me that they're going to get me, and "Come on down," so I thought, "Well, housing is really tough to sell out here in California. Convair's gone down, Ryan's gone down, everybody's gone down. You can have any house down there you want." So I said, "I'd better put mine on the market while I'm waiting for this final approval, because it may take months."

So I put the house on the market on a Friday, and I jacked up the price pretty good, I thought, about 10 percent over what I paid for it. And on Sunday I had a firm offer, in cash. I said, "Mmm." The real estate dealer said, "You mean you can't renege now. You really wanted to sell it and you've got what you want. You even got more than you want."

I said, "Okay," so I signed that off and I told my wife and kids, "Well, we're out of a house. I don't have a job down there yet." So we found a fellow over in La Jolla up on the mesa that had lost his job at Ryan and he was working up in Rockwell, up in L.A., but he couldn't get a house up there because he had a house down below. So I made a deal with him that I'd pay his mortgage for him and I'd give him a month's notice before I left. I wasn't going to sign a lease or anything else. So we moved into that house and we stayed there exactly one year before they finally turned us loose down there to come down to Houston.

So we went to Houston and found out that the space program hadn't been built yet down here on the center. We even drove down through here, and they were under construction and the cows were out there. We went over to Seabrook and tried to make a phone call to the guy I was going to work with, and the operator kept saying, "You can't get that number from here. You can't get that number from here." So we drove back over to Webster and tried again, at that little corner. I think it's a nightclub today, that was a pizza and a gas station at that time. They had real good pizza there, too.

But tried to call him again, and we couldn't get out. So we drove on back up to Highway 90 and got in a motel for the night. I mean, you've got two kids and you're in a station wagon and you've driven all the way. That day we drove all the way from, I think, El Paso or somewhere up there.

So we finally got a hold of the guy, and he said, "Oh yeah, we work up at Office City. That's up in town."

My father had a cousin that was up in town, a distant cousin. I'd never met her before. So I got a hold of her and she had a garage apartment that we went to for about a week, until we found a brand-new house out in Westbury that we can rent. So we went out to Westbury and rented that, because they said the center wasn't going to be ready for a year, so we signed a lease.

I worked at, Lord have it, Franklin Apartments, and I remember the vendors used to come in and say, "Franklin. You own this place?"

And I said, "Of course not. This is my brother's place." We had a lot of fun with that.

But anyway, it was there that we started the program, working on the lunar cabin, and that's where you always remember, you know, where were you when Kennedy was killed, well, that was it.

So anyway, we stayed there, and a year to the day when we signed the lease at the place [in Westbury], that's when we moved into our new house down in El Lago, and we

moved into the center for the first day. I moved to the office for the first day and the new house at the same time. So things worked out all right.

I spent, I guess, the early days still working on the cabin. Of course, Grumman had the program up there. I became the lunar module subsystem manager for the cabin, for the crew station. I worked under Warren [J.] North, which was Flight Crew Operations Division [FCOD] at that time, and he was under [Donald K. "Deke"] Slayton, so we worked pretty good, and that was a good bunch to work with.

There was a lot of innovation that went on in there. The first air-bearing floor was developed by one of the guys that worked for Warren, that he developed that so Ed [Edward H.] White [II] could do his EVA [extravehicular activity] experience with his gun [hand-held maneuvering unit, HHMU], which that was a fun program to work with, too. The other Gemini activities I worked out of there because in addition to the lunar module thing, I was working the Gemini cabin. So I really had two hats for a while, because the lunar module wasn't going that fast at that time. I'd go up to Grumman occasionally and they were still in the preliminary design.

Although in September of '63, I went up to Grumman, they had their first big mockup review of what the thing looked like, and everybody and their dog from NASA were up there to review this, because it was the first time we'd seen what Grumman was going to do. Grumman always put on a very good show, as far as a program. The mockup was—we looked at it and said, "Well, it's pretty big," because that's the first time we see something 3-D in the LM, and it's not unusual to see it down here at the museum. It's big.

But anyway, we went in there and we looked at it, and they had the crew working in pressure suits of the Gemini type at that time, with backpacks on, trying to get in and out of the cabin, because at that time they had two docking ports. They had one in the front and one up at the top, and the one in the front, of course, was the egress to go to the lunar surface. So they had Peter Pan rigs to offload some of the weight and get them in and out.

After looking and reviewing that mockup, about the first day I came to some very startling conclusions that I wrote up in chits. One, I told them to get rid of the seats. I said, "There's no reason to have these big old seats in the lunar module," and they're huge seats. They look like big Stratoliners in there. Well, they had to be, because these guys in these pressure suits, they'd break them if they didn't.

Then I said, "If you get rid of all those seats, you get rid of those big windows up front, because those windows have to be big if you're sitting down, but if your face is right next to a window, it can be fairly small." I said, "Get rid of that. And the other thing, now that you've got him standing up, because that's the right way to do, is get rid of the forward docking thing, because that's only a backup if the command module guy is incapacitated. Since the command module docked with it originally from the top, he ought to be able to dock back to it from the top, and it would save a step of moving drogues and probes and all that stuff." [The LM crew can look up while standing and dock as well, if necessary.]

So they said, "Well, that's kind of shocking to do all that."

And I said, "Well, just do it."

He says, "Well, how do we know people can stand up?"

I said, "You're less than 1/6-G going down. As a kid, when I was out in Phoenix, we used to ride in the back of a pickup across the desert, standing up, shooting jack rabbits. And that's far worse joggling around in the desert on the back of one of those things than it is what they're going to ride on this nice smooth trip. They can stand it."

"Well, okay."

So anyway, they said they were going to do that, but they wanted a whole bunch of studies done on restraint systems, on all kinds of other things, the feasibility thing and what have you. So that went on for about a year to do all the safety harnesses and things of that nature that they finally put in.

Grumman did the design on all that. We made our suggestions. You've got to remember, I guess, in all this, when NASA says they design, they don't. They make suggestions on design, the contractors make the design, and it's the guy on the table where he draws his pencil, that's what it becomes.

Well, I found out as a subsystem manager for crew station, I had a lot of ideas that had to be done on that thing, and when you get a bunch of New Yorkers together, they're hard-headed and don't like it, "not invented here," you have to be so diplomatic as to nudge them in the right direction to get things done.

I had two wonderful guys up there to work with. One was Rigsby, John Rigsby. He was in charge of the design group which did the actual drawings for the cabin. And the other was Howie [Howard] Sherman, who had the Human Factors Requirements Group, which was my counterpart. Well, both of them were my counterpart, although Rigsby had to talk to several [other] people because of various subsystems in his group, like the environmental control system and the other kinds of systems that were in there.

But those two guys, we'd get together and I'd say, "Look. My job is nothing more than to see if I can keep as many people at NASA off your back while you're getting your job done, so you guys, with my help a little bit, can make a consolidated, integrated cabin," so that's what we did.

We did all the displays and controls in there. A fellow by the name of Chuck [Charles] Wheelwright, who worked for me, did all the lighting specifications and requirements. The storage requirements, Ray [C.] Malone, who worked for me, helped work on all that. He'd worked a lot of the Gemini stuff. He was what I call a super tech kind of a guy. We worked all those kinds of things together.

I constantly had to work with all the subsystems people, cajole them, twist their arm, do whatever I had to do to get them to make their part compatible with the rest of the parts that we were putting together in the cabin. Controls and displays, that was typically in

avionics, but we had control of the requirements and the placement of those things, and we held onto that very tightly.

The avionics people didn't want an eight ball. The crew wanted an eight ball, and there's a good reason for that, that if you look at it, the crew at that time that were flying, in flying their aircraft, had eight balls. They had been trained on them. They knew what they look like. They were experienced with those things. So it stands to reason, if you're going to go into another new vehicle, you want the same thing that they're used to. Now, flat-panel displays and everything else came by later in the aviation world, and the new aviators who came out using those kind of things, that's why the Shuttle now has been changed, because they had a new group of flyers that had already had the experience and training on those things coming in to use them on the Shuttle, but on the lunar module as well as the command module, we had trouble with the command module, too.

I had to work on those displays. I had a counterpart in my group that did the command module. We had to make things compatible with existing crew, because we didn't want to add to their training and teach them a brand-new machine to operate, but to operate it the same way they operated other machines. So that was our goal throughout this thing.

So we had a lot of fun with that. I spent a lot of time at Grumman. I would leave here on Monday morning on the plane, and come back on Friday night on the plane for two solid years. You'd be up there working, going through testing, evaluations, assisting in design, other things.

So we had the total integration done on the lunar module we got through. I think giving Howie and Rigsby the same credit for getting that done up in Grumman, and we got that done. We got rid of the large windows, got the small windows. It was one of the best weight savings that are ever done on the lunar module.

There's kind of a side note here. It came out in *Popular Science*, there was a review in *Popular Science* on it, when they interviewed [Wernher] Von Braun, and Von Braun said

what had happened up there. There was a picture of myself and Lou [Louie G.] Richard, who ran the mockup shop in my group that did a lot of the mockups for the restraint systems and those kind of things, so we kind of coordinated our activities on that.

Anyway, Von Braun. We had our picture in there [*Popular Science*] and our name in there, and we said, "Look at that." I'd showed my boss, and he said, "My god, look at that." Well, guess what he did. He put me in for a suggestion award, and I got $25 for that. I mean, big money.

Later on, I remember—this is many years later, but when [John W.] Kiker, who worked in my group later in life, had put in the suggestion to fly the orbiter on top of 747, he got a $10,000 award for that, which was right. I mean, he deserved every dime of that, because he proved it. He went out and did the design. We built the models for him and he went out and flew those models at Ellington [Field, Houston, Texas] and showed all that work. That's a side note.

Anyway, so that was my first award, big $25 for doing all that. There was another article in *Life* magazine that was an interview with Pete [Charles] Conrad [Jr.], that he went through it, because Pete was a [astronaut] counterpart that I had to work with at that time on the lunar module and restraint systems and what have you.

Pete, God bless him, he's one of the best guys I ever worked with. He always used to say something about—you know, every once in a while somebody would crash out at Edwards. I said, "I bet they lost another good pilot." He said, "No, the good pilots are still alive." And I'll never forget that. We were sitting over drinks up in Bethpage [Long Island, New York], and he never drank up there. He always ordered a ginger ale while the rest of us drank a beer or whatever, but he always had a ginger ale. He said, "I'll never drink, because I know tomorrow I'll have to jump in that plane, in my hot rod, and go home." So he was an excellent, excellent man to work with.

Neil [A. Armstrong] was excellent to work with, too. [David R.] Scott and the rest of them. I got real close to Scott and Neil during their Gemini VIII program. I was assigned at that time to be their point engineer during their integration, which essentially meant that I had to go to all the testing up at St. Louis, had to follow everything down at the Cape. I went down to the Cape for four months down there to follow and make sure that all our stuff that we had to check and everything would always be put in at midnight. So we had to be up there at midnight working on that, Malone and myself and two or three others.

You had to do that, because there was a tendency to fix things in a tidy fashion in the cabin and where the crew was concerned. It was just the inherent cleanup that crews do when they're putting things together.

On Gemini VIII, there was a flying backpack that the Air Force had furnished, that was to go on the back of the vehicle, that Scott was to get out and go back there and put that thing on and fly around. He also had some tool things he was going to do. There was a torqueless tool that he was given. That was an interesting story on design, too.

But anyway, when we went down there and we watched this, we had done a lot of studies and a lot of mockup reviews with him on this thing, and we had that backpack when he went in, we had the straps put into certain places all the way along. Just before I left, I said, "Now, before you close that up and dock the modules together, I want a photograph just before you close it, just before those things come together." So they took the picture.

We looked at that picture the next morning, and somebody had gone in there and taken all the straps and tucked them way back in there. Well, there's no way that Scott would ever be able to get those out in the pressure suit. So we went to the manager down and there said, "Undock it. Pull it apart."

He said, "Well, that'll set us back a day."

I said, "Gonna have to do it. You've got it wrong in there. Somebody fixed it."

So they pulled it apart, fixed it. We stayed up all night watching them. They closed it back down again, and they recovered the schedule. Well, you know what the mission was. Unfortunately, they had a stuck thruster and never got to do the mission. But I remember I had my mother come down to the Cape and we'd gone out to dinner, and that's when we heard about it. So we rushed back to see what was going to happen. We were happy to see that they got down all right.

The other things that happened in this thing is, the designers' philosophy—and I think one that illustrates it is on that mission there was a—I call it a play box, that was set up on the outside of the vehicle, and it was to see whether or not an astronaut in zero-G can torque bolts. So somebody had developed the torqueless motor. I don't know whether it was Black & Decker or somebody, but they had a torqueless motor. It was an Air Force experiment. They wanted to see if man can work in the thing. They also wanted to see how much torque you can put on it with a wrench.

So they came in this day, set it [the experiment] on the table. We're in kind of a mockup review and here was this thing sitting there. The box was sitting here. Dave Scott was sitting there and I was sitting there. These vendors that had put this magnificent job together. Dave kind of went through the motions of it. Then Dave took their wrench and he grabbed a hold of the nut, and it broke. It broke the wrench.

Dave says, "What's this?"

He [the experimenter] said, "In zero-G, it would work. You put too much force in 1-G."

He said, "Think about it. I'm as strong up there as I am here. Go down to Sears and buy a wrench. Don't design one."

But that's one of the things we found out all the way through the program in Apollo, in Shuttle. People wanted to redesign existing equipment. They wanted to redesign wrenches. They wanted to redesign vacuum cleaners. They wanted to redesign all kinds of

things that are well known today, will work up in space if you make them compatible with the materials list. That's about all you have to do. And we fought that continually.

The lunar surface experiments were an excellent example of that, because the interfaces there, people tried to design something better than already existed, and we had to go through that. That was one of the jobs that I had, was to go through and keep letting people know that the designs are already there. Just implement them. Just do them. So we had to do that.

You know, you kind of wonder about people's thoughts sometimes. I remember one guy I argued with. He was a Ph.D. I'm not going to say what Ivy League school he was from. But we argued about forces that a man can exert up in zero-G, and he says, "But there's no gravity up there. Therefore, 'F equals MA' doesn't mean anything."

And I says, "What? F equals MA anywhere in the world. It's basic engineering. Force equals mass times acceleration."

He says, "But there's no acceleration up there. There's no gravity."

And I says, "Forget about that. That's a value, and there is." I never could convince that guy. He ended up, incidentally, with the post office for a while later on, and then he went to *Consumers Guide*, and he's a test guy at *Consumers Guide*. So when you read some of those things on the thing, that's—-when he went to the post office, he was working on standards for the post office, and I don't know what that was, but weird. Anyway, side issues.

We did all the cabin integration then for the lunar module. It turned out very successful. I was going to get in, when I got into the mockups, to talk about Apollo 13, but let me talk about Apollo 13. We always had big mockups for Gemini and Mercury, and we got into Apollo, the cost of the mockups furnished by North American [Aviation, Inc.] and by Grumman were high, and the program office was short of money and didn't want to really produce those. But they produced some.

We finally got them to produce the basics for us down in Houston, and then the mockup group that I had working for me at that time was very innovative and very capable. We had our own little shop, plus we used Tech [Technical] Services [Division]. Tech Services would come in, and if we furnished them the materials and the money and the design, they would hammer it together. Jack [A.] Kinzler worked with us very well on that. He didn't like us having our own shops, but he tolerated us, because we had some excellent machine shops, but he had the better ones.

But anyway, the mockups were used for training, engineering evaluations, and mission support, and I guess the best place that that really showed its mettle was in Apollo 13. I went to see the movie, by the way, and it was very, very good, very well done. As soon as we got word what happened, I had pretty close relationship with the environmental control people that were over in Crew Systems [Division] at that time, and they worked in our mockups a lot. And I hollered at them and I said, "We got a problem with those square canisters and those round canisters." I said, "We're going to have to figure out something quick."

And sure enough, we got a call real quick from the [Mission Control Center], "Hey, how are you going to figure this out?" Because the command module people said, "We're not going to have enough lithium hydroxide."

So I got the environmental control people together, I got all my storage people together, and since we put out the storage drawing for everything on the cabin, we knew where everything was, and before the flight we always stow the mockup with everything that they had at launch. So I got those guys together, and I sent them down to the mockup, and I said, "You guys, sit on the floor there till you figure that out." And the same thing with the command module, which was right next to it down on the floor. And they went down there, and they worked and worked, and pretty soon, they hollered back, and they said, "We got it."

And I said, "Take it on over there [to Mission Control]. I don't even want to bother seeing it. I know you did it right." And they'd come up with the cardboard covers from the flight plan and the duct tape and spare hoses that were in there and put it together, made a square-peg-in-a-round-hole kind of an operation. They wrote up procedures and sent it up. I don't think that took them more than six, seven hours to come up with that, including the procedures, because I said, "Whatever you come up, make sure you have the procedures when you go over to mission control." And they went over there and they showed Deke Slayton and the mission control people, and [Eugene F.] Kranz said, "Send it up."

So we were very happy, you know, that that solved that problem. We couldn't solve all the problems. We'd solved some of the others of wires back and forth for power and storage of things and what have you. But that was where the mockups really came into being. They came into use other times, too.

We also worked on crew interfaces with the Marshall [Space Flight Center, Huntsville, Alabama] rover [lunar roving vehicle]. When the rover came in, we had to make sure that it was compatible with the crew. Well, we had had, always had, very poor relationship with Marshall. They didn't want to do business with JSC, and vice versa.

But anyway, we went over there, and they had a big mockup review of the rover, and they didn't have anything on it except, you know, "Here's the rover." Well, I looked at it again and looked at the seats, and I always think of things that, you know—why make them spacey look? Look at something else. I said, "Why don't you make them look like a lawn chair, only make them strong, and then they can just fold down. You don't have all this contraception of pulling pins and other stuff you have."

And they said, "Okay. That'll lighten it," because they had a weight problem.

And then we put in a whole bunch of chits. There must have been forty chits about where to put this tool and that tool, and the camera, and something else, and something else on the rover. So we went through the whole review, and they read off the chits, and they

dispositioned them, and then they got to his set of, I call them crew-related chits. The manager there handed them all to me and he says, "You take 'em home and work 'em. We don't want to mess with them. He says, "We're gonna build a rover."

And I said, "Well, wait a minute." I says, "The rover's got to carry all these stuff."

He says, "We don't have that in our requirements."

So I said, "All right. Give me two points on that vehicle for tools." I said, "Just two sockets on the back, back of the seat somewhere, and define them to me where I could put something in, and a pit pin in and it'll hold something."

And they said, "All right. We'll do that for you."

And I says, "I need a place for an antenna." I said, "Give me an interface on top."

He said, "Okay."

And I said, "The other thing you ought to do is add fenders."

And they said, "We're not gonna add fenders."

And I says, "You're gonna add fenders because it's too dirty and too dusty." So they agreed to add the fenders.

And the steering they had on that was terrible. And I said, "Wait a minute." I said, "Why don't you just go back, get a LM controller or a command module controller, they all look the same, and plant it up in the middle up there." And I said, "If you turn it this way, the wheels go that way, you turn it that way, the wheels go that way. You push it forward, it goes forward, you pull it back, it stops."

"Oh. Okay."

And I said, "Then either crewman from either side can run that machine, and it's easy with that big glove hand just to do that. They don't have all kinds of other stuff." So they agreed to that one.

So we came back with all our chits, and we made a pallet that had all the tools on it, that were racked up, that would interface with their sockets, and we got Grumman to build

that pallet with all the interfaces and to stow it on the descent stage. There was another place to put it on the descent stage. So we got them to do that. So the process then was the rover was pulled out, it was unfolded, and the crew can go over there and pick up this pallet full of tools and stick it on and drive off. And that was going to be it.

Well, when I got back, there was a discussion, a change meeting. I had to go to the change board every day whenever they had one. They were talking about the navigation on the rover and what kind of gyros they're going to put on, or which stabilization system, or whatever else. And I got to thinking, I said, "Hey, you don't need it." I said, "You got the sun coming from one direction. Put a sundial on it." I said, "Then you guys on the ground figure out what the angle means as they drive around, and you can tell them, 'Go to this angle or go to that angle,' and you can work all that out, because you know the geometry, and the crew doesn't have to worry about a thing, and no moving parts, no electricity, no power, nothing."

So they said, "Uh-huh." So they put the sundial on, and it was right up there where they put the little antenna that they had to turn around to line up the TV system and the communications. I worked with the TV people to get the TV onboard and how to handle it. That was fun. I went on a proposal with them, or a proposal evaluation, and that was interesting. We worked with the TV people on it, and we got through with that. Somebody had run the calculation of how much popcorn we'd eaten during that, that review. It was tons of it. I mean every day somebody would have a big bowl of popcorn there. They'd bring it in in fifty-pound bags, you know. It was something.

Early LM, I was wondering why there was no cameras on board. So I had to work through a project office at that time, NASA was set up almost like a government bureaucracy. You had to work through offices. So this one office said, "No, no, we're not going to put cameras up. They're too heavy. We don't need those. We don't need those."

So I got to thinking. I said, "We're going to have cameras." So I called up [George W. S.] Abbey, who was working for George [M.] Low at the time, and I told Abbey, I said, "We've got to have a camera." I said, "I'm getting resistance here from even putting any kind of camera up there, and we're going to have to have a camera, because when you go on a vacation and you take a picture of something new and bring it home and show people, say, 'Look at that. I was there.'" And I said, "We don't have any of that."

So he said, "Okay."

So the next day, I had a call from Abbey. He says, "Low says get a presentation together and come to the [Change] Board to how to put some cameras on." He says, "Talk about putting a motion camera on and a Hasselblad."

And I said, "Okay."

So the next change board, I went up and I made this presentation of a camera and where it was going to go and the weight and all this stuff that goes with it, and everybody at the table, the managers, they're all moaning. "Nah, you can't do that. We don't need that. That's too much weight. That's this and that and everything else."

So I saved my last slide until after they got through moaning, and I threw it up, and I says, "We need to record what we saw and tell the folks back home what we saw."

And that's when Low made one of his statements that was very good. He says, "We have this board here to get everybody's opinion and everybody's input." He says, "But I'm the only one that has a vote. Approved." And they all agreed that that was the right thing to do.

So anyway, we got the movie camera that was set up, up in the window. We worked with that so it would view the landing. You can see the probes coming in and the dust flying. And we put the Hasselblad on. I guess it's fortunate or unfortunate, one of the two, that Neil Armstrong had the Hasselblad on. He had it on a bracket that was on his suit, so he was taking all the pictures on the first mission, and there's no still pictures of Armstrong on the

Moon except when you look at Buzz Aldrin's shield on his face, there is Neil. It's the only [still] picture of Neil on the surface.

Later on, we got more cameras on board as we kept saying, you know, "You've got to have more and more." But we also thought that, "Hey, you got to have a movie picture."

The TV people wanted to get a TV. They came over to me one day and said, "Got to get a TV on. Got to get a TV on, George." They didn't like to go to the board. I don't know why. They didn't like the board. Since I usually had a presentation once every day, I guess, when we went up there, I said, "I'll get it on board."

So I proposed that we put it on board so we would record his first steps off the Moon. And everybody else said that we ought to do that, but I stuck my neck out to the board, and board said, "Well, how are you going to do that?"

And I said, "We're going to get Grumman to mount this thing on the outside such that when the crew gets out there, they can turn it on and put it down."

"Oh, okay."

And we had some other things we had to do. So what we finally did was get Grumman to make the MESA, or the modular equipment stowage facility, which was on the right front quadrant of the lunar module descent stage, to hold all kinds of equipment, extra film, experiments, tools, anything else that we may want to use on the surface so they wouldn't have to bring them out of the cabin all the time. There was a lot of things we didn't know what we needed on there yet, but we said, "Put it on it. Make this device as big as you can and as strong as you can."

And I said, "That's where we're going to put the camera, and the camera will be focused so it looks at the ladder and ground when it comes in, and the crewman then, very simply, when he backs out of the cabin, he pulls the lanyard, this thing drops down, and they turn the switch in the inside, and the camera comes on, and we take his picture. Great.

Wonderful." Well, it turned out okay. We got a picture of him stepping down, scratchy, but wonderful.

I guess I want to mention a little bit of the other managers besides George Low. George Low saved the program, by the way, Low did. I don't remember the guy's name before him. I remember in the background that before they [the subsystem managers] went up to the Change Board, they wanted to know what this guy wanted as an answer before they could pitch, and they would make two or three different proposals and wait until they heard what he wanted, and then that's what they'd get him. They never went up there with the idea of giving him an honest, straightforward answer, or an argument or a controversy, because he was so autocratic that he wanted what he wanted. He didn't listen.

When Low came in, Low listened to all the subsystem managers and all the experts there, engineers, and would reach what I call a real good decision based upon what the inputs were. And the inputs, because the guys knew that he was listening, were very good. They were well thought out, they were well detailed, they were very honest in their beliefs or what their background was. So Low did that.

Well, Kenny [Kenneth S.] Kleinknecht was that way; Owen [G.] Morris was that way. Bill [William A.] Lee, who was lunar manager for a while, especially right after Apollo 1, I remember him right after Apollo 1, they knew they had a fire, he said, "You know, we're going to have to go look at the lunar module real quick to get the [combustible] stuff out of it. We know we're going to be delayed at least a year." He had all the subsystem managers together and he said, "Let's just get started now before they tell us what they're going to do on the command module."

So we were doing that in parallel before they had the full investigation with Rockwell and the command module. A lot of the things that they were to implement was starting already up at Grumman. So we got a little a head start on it, but Bill Lee was, you know, he wasn't an engineer, he was, as I recall, a psychiatrist or psychologist, one of the two, but he

was able to listen to his subsystem managers and technical experts, and deduce very quickly what was the right technical answer, even though he himself was not technically qualified in any of that stuff. So to me, that's a true manager when he's able to take the people that are the experts and bring it down and get the right answer.

Low was technically qualified, but he also was able to take these other people. And Low was not—I have seen him reverse decisions based upon new inputs, and he was not reluctant to do that. He would say, "We have new inputs. We're going to not do this. We're going to do this." So he worked with things that there going in there.

But they're all excellent managers. [Aaron] Cohen later on came into being. Kenny and Owen did mostly on the command module, but we worked together with them for a long time.

And another little side issue. I keep running into people that say, "You know, we didn't go to the Moon." I ran into one of them over the golf course the other day. He said, "Ah, we didn't go to the Moon." He says, "You can tell that because the flag's flying up there, and they know there's no air about there."

And I said, "Well, let me tell you about the flag, because I'm the guy who put the flag on board through Mr. Kinzler." I said, "I had a call from Abbey. He says, 'We haven't got a flag up there.' He said, 'We got all these in the cabin. We don't have a flag up there.'"

I said, "Let me get on it. Let me go down there and see Kinzler and see if he won't build us a flag."

Kinzler would never come to the Change Board, but I would go down there and others would go down, too, and ask him to do some work, and he'd get the work done. He had some excellent, excellent people. The technicians he had in that shop were fantastic. So I went down there and I said, "Jack, we got to get a flag up." I said, "I'll furnish you the guy to do the drawing," because you always had to have a drawing for the R&QA [Reliability and Quality Assurance] guy to sign off on. I said, "We'll do the drawing. You do the design."

And I said, "Your end points, you're going to be fitted on to the ladder of the orbiter, right?" And I gave him the dimensions of that. And I said, "You come up with the clamps and everything else, and I'll get Grumman to get the interface."

So he went off and designed this thing, which the flag is rolled up in a tube, and it's got a—he said, "Hey, this thing won't fly up there." So they put a bar on it.

Well, when it's deployed at the Moon, they raise the bar up, and because this flag has all been crumpled up and folded, it comes out and it looks like it's waving, you know, and it's the most beautiful thing when you look at it. Why is the flag waving on the Moon? Well, that's the reason. It's a wrinkled flag that's held up with a bar. And I tell these people that, and they say, "You really didn't go to the Moon."

But Jack's office I used an awful lot for various things. Later on, we used him for things on the Shuttle. In the mockups there was another thing in the big mockup in the Spacelab. The Spacelab mockup was furnished by Marshall, and it came by barge up Clear Creek and into the dock down at the end of the street down there by the Hilton [hotel], and I think it's the only thing that ever came in on that barge. But when they built that dock there, it was to take large spacecraft parts and bring them into NASA for testing over in the big chamber. And even the streetlights going down the avenue would fold down. So anything that came in can go down that street.

Well, anyway, the big mockup came in on the barge. We went down there and watched it, and we floated on in to Building 4, and we floated it in on air bearings in the floor and put it up vertically.

When Skylab went up and they had the problem up there, they didn't deploy one of the arms and it was all tangled up, the heat shield was not deployed, they thought they would lose it. So there was immediately a flurry of activity on all centers. How do we fix the problem quickly? Because the guys are going to launch. We can hold the launch up to X

number of days, and the heat is going to destroy that thing up there unless we figure out how to go fix it.

So everybody was scrambling around the different ideas. I know my group was working on an idea. Kinzler's shop was turned on with the idea, and he finally came up with the right one, but it was an umbrella kind of thing. It was very unique. It was folded up into a canister that fit through the scientific airlock. They would use the mockup then to check that out, because here we had a high-fidelity mockup, the only one in existence, and we'd check it out and check it out, and the crew would check out what they're going to do. That was put aboard, it was sent up, it deployed properly.

The crew, meanwhile, had been training on how to get rid of all the tangle around the arms. We built up some special tools for them in the water tank and sent it up. And so that was successful. So, mockups, training, and evaluations on the ground get the job done very quickly.

Neutral Buoyancy Facility, let me talk about that. That's a fun one. When we first started out, we had an egress trainer down in 10 Building down in the back. It was nothing more than an old oil tank, or water tank, I don't know which, that was used during the Mercury program to teach the guys to get out of the spacecraft and into life rafts. It was used during the Gemini for that.

When we decided to go EVA on Gemini, to see if we can do an EVA, and that was with the Agena docking module. Armstrong's mission was going to be one of them, but the others did them as well. They were trained down there in the water tank and do that. We got to thinking that we needed a bigger water tank, because there was Apollo coming along, and we knew we were going to do a lot of EVA. There was Shuttle in the future that was coming up. We knew we were going to have to do EVA on that. So since my group was running the water tank, I said, "We got to go build a water tank."

So we had a design plan with this swimming pool that we were going to put in. We went to the facilities people, and the facilities people said, "Well, it's going to be big, but you know, that centrifuge, that's not used for anything anymore. It's a white elephant. Why don't you put it in that building."

Bob [Robert O.] Piland—it wasn't Bob, it was Bob's brother. [Joseph V.] Piland said, "Use that building."

And I said, "Well, you're going to take that central core out."

He said, "Nah, that's too much work. See if you can build one in there."

So we came up with the idea of what we wanted, and we put it in the budget. It went to Washington and it was rejected. And we said, "Why it was rejected?"

"Well, use the one at Marshall." Marshall had a bigger tank. We didn't know much about it, but they had the bigger tank that they'd use for Skylab, and it was built with small tool money that Von Braun scrounged together to go build this tank, see.

So anyway, we put in the pitch again to go to Washington the next year, and they come back, says, "No, go to Marshall." Well, the trouble with going to Marshall was that the flight crew had to go up to Marshall, all the suits had to go up there, and with the suit crews as well, and they had to go by commercial. They couldn't go by T-38s or their aircraft. And then the crew, after they went through the tank, couldn't fly home for twenty-four hours because they're higher pressure. So we kept saying, "That's no good."

Well, they said, "Move the training there. Move the suits. Move everything." Marshall said, "Hey, you know, just come on over here and do all this stuff." Because Skylab was most of that work, not all of the EVA.

So we said, "No, we got to build it here."

So anyway, several years this kept going through, and I finally found out that the chairman of the subcommittee was from Birmingham [Alabama]. I said, "Guess what?" I said, "We're being outfoxed."

But the chairman of the committee was from Texas, and I'm trying to remember what his name was, but he was planning to retire. So I went to [Christopher C.] Kraft [Jr.] and I said, "Kraft, send Kranz up there, give him another pitch, and then talk to this cat from Texas that is going to quit, and have him override it." I said, "He's not going to be around. They can't do anything about it."

So we got the tank approved, and the subcommittee had disapproved it, and it was overridden at the committee level. So we got $750,000 to go dig a hole in the ground. So we got this contractor to go dig the hole in the ground, and they said, "Oh you know that's soupy down there. It may cave in."

I said, "Yeah, what are you going to do about it?"

"Well, we'll put all these pilings down."

So they bored these big old cement pilings down some seventy or eighty feet, in big deep things, and the tank's only going to be thirty, and they had all those in place, they bored them and poured them, and they dug this thing out. I used to go out there every day, because my offices were in that building, and watch the hole being dug. They got it down to the bottom, and just as they got it to the bottom, I happened to be out there at the time, and chief engineer was out there, [John C. “Jack”] Welch, and he says, "The bottom's moving." And everybody looked at it, and the bottom just started to move up, you know, it just looked like a rising cake. And they said, "Quick. We've got an underwater problem. It's heaving it up." You can see these things [pilings] starting to toe in.

So they hollered to the sand company real quick, and they started bringing truckloads of sand just to dump in the hole to put the weight on, and they filled it all up. Well, then they had to sit back and take time to think about, "Now what are we going to do?"

So they went back. They wanted to have the architect go fix it, and the architect says, "No, it's groundwater."

"Well, you knew about it. You didn't design it right."

So that went to court. And the court finally settled it. "Yeah, it was poor design. Go back and fix it."

So anyway, they went back and redug it, fixed it, cost more money, and we got the water tank. And we used it then for some more EVA training and the Shuttle and the rest of it.

Since then, they built the big one out there. That one was started right after I left NASA, so I can't tell you that story, but the ones on that one I guess would be [Vernon C.] Hammersley. Vern Hammersley was kind of instigator of that for a while.

RUSNAK: That may be a good place for us to take a short break so we can change out our tape.

FRANKLIN: Sure.

RUSNAK: If you just want to continue with where you left off. We just finished talking about constructing the WET-F [Weightless Environment Test Facility].

FRANKLIN: Oh okay. Yes, the WET-F. Well, we finished that and then, of course, it's history from there. We utilized it all the way through the system. Hammersley and his group ran that facility, and they did a good job. We had some issues when the Air Force came in. They wanted to make all that as a secure area.

In this day and age, with the New York thing, you kind of wonder that there was a—we had two Pakistanis that were doing our software. They'd been with us for a long time, and they were contractors, but they did the work and did it very well. And they [Air Force] came in and says, "Those people can't come in here."

And we said, "Why not?"

And they said, "Well, because they're not citizens. They're risks. We do work in there that's classified. We got these classified payloads that we're working with."

And I said, "That's not classified payloads." I said, "Those are skeletons of something that we're going to put up in the air, and the only thing we're looking at is how to deploy it manually."

"No, but they got a name to them."

And I said, "Okay."

So I had to go to the two guys and tell them that, "Hey, just be scarce whenever the Air Force is around here." [Laughter] But, of course, they [Air Force] finally left us during that Shuttle program. For a lot of reasons Shuttle was screwed up to begin with.

Yes, I don't think on the Neutral Buoyancy I have anything else to add, although later on, all our mockups were done locally, either local contractors, or we did them in our shops.

The Shuttle mockup, I took that on because it was under the contract with Rockwell to furnish that mockup. Cohen was concerned that they wanted some 3.5 or 4 million dollars for it. And so I went to Cohen and I told him, I said, "Give me a million dollars I will get it designed, and I will get it built and delivered." And I said, "But the only thing I want is, I don't want anybody messing with it." I said, "I'll give you a monthly report on the status and the dollar amount, but I don't want anybody going up to the contractor and pushing them or trying to make design changes or anything else. Just let me handle it."

And so I talked to Kenny Kleinknecht about it a little bit. So he talked with Cohen, and Cohen agreed that that's what he would do. So I had a minority contractor because that way I can give him just the contract, a disadvantaged minority. And I said, "Here's what I want you to design." And I said, "Now, when you design it, make me a ten-scale model."

I had two reasons for that. One, I wanted a tenth-scale model so when I went to production, they had something in 3D to see what they were making, because it's quicker that way. And the other thing, it would prove whatever they were designing, because as they

design, they had to make the part and go put it together. So they'd find out where they weren't making their parts.

Well, he bid the job. At that time he was planning on hiring $15-an-hour designers and draftsmen, but the only thing he can get was $8 designer draftsmen for a short period of time. So the work wasn't that swift, but being mockups and not flight hardware, you know, we overlooked some of that.

So anyway, I told him, I said, "That's all the money I got." I had a fixed budget for him. And I said, "When that money's gone, just give me the drawings. You're through." So I said, "But I would like to keep you as another contractor sometimes. So make sure you finish the job." So that's the way I cajoled him anyway.

So he finished it, finished the model, and I told him, I said, "Well, when you deliver the model, we'll get an audience with Kraft, and you'll get to meet him and you can present the model to him, and maybe you'll get new business." So he did that. We done all that show-and-tell.

But then I put that out for bids, and I got a bid from a guy in California, which was in an area of low, I guess, employment at that time. I forgot the right term, but anyway, an impact area, I guess they call it, for government contracts. And I got one in up in Boston, up in north Boston, with a company. Both of them were about the same bid, and there were some things they were leaving out. And so I asked the one in California what part he left out, and he said, "Oh that'll cost extra." And I asked one up there, and they said, "Well, we'll do it for the same price."

But part of the contract was they also had to figure out how to get it down to Houston and what was the cost to get it to Houston. Well, the one on the West Coast wasn't even going to mess with that, because this thing is oversized. You can't put it on a train. You can't put it on anywhere. So Boston had done a lot of studies in their proposal. One of them was barges and one of them was helicopters, and they finally hit on the idea of a C-5A. They

said, "The National Guard will pull it right into that, and they will fly it down, and you just pay for the gas, government to government."

I said, "That's a good idea."

So anyhow, I went with the one in Boston, and when I took the plans up there and the model up there, I said, "Now, give me the final bid, but I know these plans aren't right, and there going to have to be changes made." I said, "You furnish the draftsman or engineer, whatever it is in your contract, to redline those as billed. And you make the decisions how to fix it." I said, "Because we want a minimum impact on you, and you just deliver it."

So they were off and running, and they built this machine, or built the Shuttle mockup for the water tank. It was all out of aluminum. They got the National Guard. I went up there to get the delivery, and I remember they had a big party up there, a tent and the cake and the cookies and the press and everything else, and I was up there to accept this thing, and the press was talking to me off the cuff, you know, about, "Why we came up here."

"Yeah." I said, "These guys are good guys. They did all the work. They did good work."

So they said, "Well, we'd like to do a little interview with you."

And I said, "Okay." I said, "Well, what are you going to ask?"

They said, "Oh the same thing we just talked about."

I said, "All right."

So they shoved this microphone into my face and this camera about this far away, you know, and they say, "How come you picked this outfit to do that thing?"

And I said, "Well, because they're a low bidder."

"Is that the only reason you picked them?"

I said, "Well, of course, and besides that, they do good work." Good Yankee ingenuity. And it wasn't the answer they wanted. They wouldn't want that answer. They wanted some political answer, which I wasn't about to give. So anyway, they went away.

But it was impressive watch the C-5A come in. If you've never seen one before, it, it is very impressive. It came in and rolled to a stop. The fog was in there that day, and it came down lower and lower into the fog. When it stopped, the armed guards got out and surrounded that thing, you know, and I said, "What's this anyway? What's this war thing we're after?"

So anyway, we went out and we toured it while they were getting the pallets out to load the thing, and they said, "Well, it's National Guard and they follow the procedures of their guard. They guard it just like they go anywhere." The two pilots, one was from Delta and one was American Airlines that were on National Guard duty that week, and they get to fly this thing.

So they invited me onboard to fly back, and they invited me up front in this big spacious cabin. I'd been working 880 cabins, you know, they're little, small things, or the others, but here's this huge deck and a big old nice seat in the middle of it that you could look out and see the world, you know, as you fly by, and watch the wings just kind of raise up. You know, they kind of fly, you know, they flop like a bird when they first take off because they're heavy with fuel, then they take lift. But anyway, they took off and we flew on down, and we came down along the Gulf Coast. And they were looking for Ellington. They'd never come in to Ellington before. And they were looking into Ellington and looking at their maps, looking out the window, and I said, "There it is right down there."

I never will forget the pilot, looked down there and says, says, "Yeah." He says, "That's real small. That's a short runway."

And the other one says, "Yeah, but look how wide it is." [Laughter]

Well, they came in and landed, and we pulled that thing off, and we had to pull it around by a big truck over the tracks, and they took the lights down at the back gate to bring it in. But it was impressive, and I delivered it for the million dollars, total cost. From then

on, when I needed some money to go do a project and I could get a fixed price, project office listened.

What we found out there, what you find out in this thing is, is the cost to the government. They kept wondering during the lunar program, at least from that standpoint, "Got to cut the cost, got to cut the cost." So you try to cut the cost, and what happens is, there's a direct relationship between the number of people you have on the government side and the number of people you have on the contractor side. The more you have on the government side, the more interface you have to have on the other side. And that's money and that's overhead. It's not the guy who's building the machine, those are few, but it's all these people in between. There was me, and I had to have a counterpart up there. Here comes the astronauts along. They had to have an astronaut reception, you know, test pilots up there, to take care of them.

If there was somebody up there—every specification had a corresponding person on the other end, and all the subsystem people had their own little specifications and requirements documents, which nobody paid any attention to, but they always were on the other side and always updated and always back and forth. So there was always that relationship that if you keep the interface down, you keep the costs down. And that's the message I kept telling to Cohen. I says, "Don't have so many reviews, don't have so many people, just pick a few and get it done, and then go back and talk about them." Well, that was one of the lessons that was very evident in there that if you start looking at that.

I guess the Shuttle design, I got into that. Let me give you kind of a feel where I was in that. I had gone from lunar module subsystem manager for the crew station, where I had no people working under me, but I was at staff to Warren North. Then I had access to people that ran the mockups, that ran the systems people. [M. E.] Dement ran the systems world under him, the mockup world, and the training world. So I had those interfaces that I can go

to, and that's where my manpower was that I needed to help, plus the other subsystem managers throughout the center.

I kept that title and I became a branch chief, so then I had a group of people working for me to support my activities on the interfaces for the lunar modules, the Spacelab, the Shuttle, any of the other kind of things we had to work with.

After Apollo was finished and the Shuttle was started, they had a reorganization that took place. The Flight Crew Operations Directorate was broken up and they took the engineering portions of it, which I was one of them, and said, "You're going to go into Engineering [and Development Directorate] now, because it's a switch in budgets," and some other, I guess some window-dressing that has to take place in anything. "The operations has to go down and you're going to go build."

So I took my group of the crew station world with me and the mockup world with me, and we joined in the Spacecraft Design Division. And there I became [a deputy division chief] under the [chief] of that particular one. That's the first time I really found myself in a position of having a boss who had some preconceived ideas of what had to be done that were not consistent what the program was, and I had some hard times with that, because I was in charge of the Shuttle crew station world, trying to work with Rockwell to get that stuff going properly, and the other crew interfaces that we had to do.

So I had the crew I was still working with, I had the contractor I was working with, the subsystem manager I working with, but this boss I had wanted to redesign the world. He wanted to bring in product designers, the ones that design Coke bottles and those kind of things, to design the cabin. He wanted the bathroom certain colors and sleeping quarters a certain color, and eating quarters a certain color, and some of the other kind of stuff.

He had these two designers that I talked about earlier, that I think were the ones that built the early LM model behind Kennedy, making all these drawings, and he was an excellent designer. Don't get me wrong. He was an excellent designer, but he gave up true

dimension reality to make concepts. So he had all these concepts of what the cabin should look like and all these rooms in the cabin and everything else. But you got to remember the cabin is only six feet by six feet, and it's got the bedrooms, it's got the eating rooms, it's got the lavatories in it, it's got everything in it. And you can't make it, you know, a six-room house in a six-by-six box. And I never could make him understand.

Well, he gave me a drawing one day of here's the way he wanted it laid out. I said, "Fine." It was a sketch, a very good sketch. So I gave it to one of my draftsmen, I said, "Put that to scale." So I put it to scale, and I put it back on his desk, and he fired me.

So I called Max Faget up. I said, "I've been fired."

He says, "Just hang in there, boy. Hang in there." So we hung in there and we had mockup reviews, and he wanted things changed. The crew didn't want things changed. So [I] got fired again and fired again. Fortunately, he retired, and I became the chief of the division. So we proceeded. But that was the first time I came close to quitting NASA. But I finally made the decision that there's no way that somebody's going to force me out of a job; I'm going to quit on my own. And so we had fun with him, or had got around him.

But anyway, we went on through and got through the Shuttle program. The name of the program, it was going to be different program. It wasn't going to be costly like Apollo. It was going to be cheap. They weren't going to do a lot of testing. We were not going to use any new technology. We're going to do all these kinds of things. And they resisted right from the beginning to do some basic stuff. Well, sure enough, it gradually crept into the program, and sure enough, it gradually ran the budget up, because one thing it didn't do that Apollo did, Apollo was able to go examine two or more concepts in parallel and develop them and then take the best one. It didn't do that, but it did require some pretty good development of the best concept in somebody's mind.

So it changed as the program progressed, and the price went up. The size and capability of it began to shrink right from the first mockup review. The requirements that

were put on it were requirements from our NASA and from the Air Force. The Air Force wanted to carry a great big humongous something or other that was huge and weighed a lot and stay up there for a long time with it. And to do that, it started to drive the systems to where you exceeded the booster capability that Von Braun was working on, the Saturn V. Not Saturn V, but the total boosting system for the Shuttle.

So anyway, right after first mockup review, they shrunk, and the first place got shrunk was the cabin. It got shrunk where they took out about four feet of it right away. We don't need that for the crew. It was the same guy that wanted all that room. And the payload bay, Max Faget said, "We don't need all that. Shrink it." So the thing was shrunk very quickly right at the beginning. Well, immediately it didn't have the capacity and capability that the Air Force wanted, so the Air Force soon got discouraged and said, "We're going to pull out," which was the best thing for the Shuttle, because, in my opinion, anyway, it was trying to be more than it was ever going to be. It was like the joint services trying to have one airplane that'll do all their tasks instead of having separate aircraft to do specific tasks.

There was an interesting thing in there. I went in there and made that one. The Shuttle controller's first mockup we looked up in Rockwell, they had controllers on both consoles for each crewman. They're similar to fighter aircraft controllers, similar to Gemini. I said, "You know, that's too many controllers, too much console." I said, "Why don't you take one controller for each crewman." And I says, "Well, you don't have to do all the adjustments, because the under G-loads and everything, you're going to have to have armrests, you're going to these controllers in where people can operate them. That's a lot of mechanism." I said, "Put the controller on the seat between his legs." I said, "Everybody can put their hand between their legs. It's just natural, and you can hold a controller there." And I said, "Put the same kind of controller that you put on a spacecraft, because under G-loads, that's what you're going to operate, and it's going through a computer anyway, so you can take out whatever you're going to take out."

And so they said, "Okay. That's fine."

So sure enough, Rockwell implemented that, and, you know, as you raise and lower the seat, the controller goes up and down with you. You know, it's always in the same place.

So anyway, right now I'm in this new group, Spacecraft Design Group. We've designed this controller. The guy I have working for me has done all the studies on it and everything else. Everybody's happy with it. So [Joseph S.] Algranti comes in from the Gulfstream and he says to Faget, he says, "Hey, that controller's no damned good."

So I get a call from Faget, he says, "Franklin, get that controller out of there and go put a wheel in." That was the order that came out.

And I said, "Wait a minute, Max." I said, "You don't understand." I says, "What's wrong?"

And he told me, he says, "Algranti says it's in the Gulfstream, and they're training out there with it, and it's not working in. And he says put a yoke in."

I said, "Let me get a pitch together for you, but let me go out there and look at the Gulfstream first."

So we sent our guys out to the Gulfstream. What they'd done on the Shuttle side, they'd taken this controller and stuck it up in the instrument panel in front of the guy, about eye level, and here's this hand controller stuck up this way, and they're supposed to control that thing going in, you know, and the guy came back, and he says, "It's up there. It's in the wrong place."

So I called Algranti up, and I said, "It's in the wrong place."

He said, "What do you mean it's in the wrong place?"

So we told him. And we went up and gave a presentation to Max of all the studies we'd done, how it works, all the simulators' work, Rockwell's onboard, and what was wrong with the Gulfstream. So he called Algranti, and Algranti said he'll move it. So they moved it, put it on the seat. Everything worked fine. But that's another example of what happens

when you don't have configuration control in the trainers and simulators and those kind of things that they've got to be watched.

We're real proud of the mockup area that I had working for me at that time. Along with the crew station people, they began the full-scale [remote] manipulator [system] facility. They built the mockup, they put the arm in, and they developed the software to operate that arm. And that became, later, the training facility for the full-scale manipulator facility that the crew would go up there and move the big payloads in and out. They were in balloons, and there's another story that goes with that, but if you get Hammersley and that group together, he'll tell you that story. But anyway, we're real proud of that facility and how it worked. The air-bearing floor was another part of the mockup facility that we had and developed.

During the development of the manipulator, I remember the specification that came out, and I looked at that thing, and it just a knob that, you know, just something to grab the knob. And I says, "Why don't you put a foot restraint on the end like you do on a cherry picker so you can move an astronaut around on that?"

And this [that had] boss finally… retired. He said, "Nah, we're not gonna mess with that. Not gonna mess with that. He just want to move payloads. Crewmen aren't going to be out there."

I said, "All right."

So I had some research and development money that I'd gotten. So I went to Grumman, because that was easy to do, and I says, "Get your [6 degree] facility up. We're going to develop a foot restraint or a cherry picker for the end of that manipulator. But I need some data. I need some studies. So then when I get them, I can go back and get the flight hardware." And I said, "We'll probably sole-source the hardware to you, because you'll have the experience on how to do this. So as you develop the facility with this research money, let's develop the prototype," which we did.

So they set up the facility, Six Degree of Freedom facility up there, and we developed the—very simple, nothing more than a foot restraint, you know, the arm or foot restraint the guys use for EVA, on the end of a manipulator, and let the guy in the back run the manipulator. It's just that simple. So we had to prove that, yes, the manipulator operator could move the guy out there where he wanted to go.

So there were some things about, "Well, how do you tell the guy back there to go up to X, or Y, or Z?"

I says, "Easy. You say, go up a little bit, go right a little bit, go left a little bit. Go up about six feet, you know, you don't have to be accurate, just go up about." I said, "That's the way a crane operator works. He doesn't say, 'Go up twenty-five feet and over six inches and two degrees south.' And the guy in the back will steer him there." Sure enough, it worked, and they had the prototype done.

So I went to Cohen, and I says, "We have to get ready to do the EVA," on—I guess it was the telescope mission, where they had the great big boxes and so on to go in and out, and we knew it was a service mission when the telescope first went up. Matter of fact, I worked with them [Lockheed] for a while on some of the interfaces for the hand supports and things of that nature. But I went in there and I said, "We need to go put this manipulator foot restraint on the end of this thing and fly it, because that'll be great for that mission."

And Cohen said, "Well, yeah." He says, "Good. We ought to go do that." He says, "What's that going to cost?"

And I said, "About a million and a half. That'll be complete testing and I'll give you two flight units, and we can do it in about a year and a half," because you can't get flight hardware much quicker than that, even though it's simple.

And he said, "Well, okay."

Well, about that time, there was a group, and I want to use [Bruce] McCandless' [II] name, because he was there. Called me up and said, "We don't want that foot restraint."

And I said, "Why you don't want it?"

"Because we're working on this other thing with Crew Systems [Division]. It's a bunch of bars that you screw together and you crook up and climb up the pole."

And I said, "Bruce," I said, "that's no goddarn good. Wouldn't it be better to sit on the end of a manipulator and just ride up and down where you wanted to go?"

"No, no. We don't want that. We don't want that." Well, he fought me tooth and toenail for the money.

Well, Cohen finally agreed to give me the money, and I went off and got Grumman to develop it, they shipped it in, and one of the things we had to do was, where do you put the tools? Well, I told Grumman, I says, "Give me a post with an interface." And this is when I went back to Kinzler and I says, "You build the tools, and you hang 'em on there." So that was GFE-hung on this thing. So I didn't have a contractor interface to worry about changes. You don't want changes if you're going to a contractor. And this way we'd get two flight units in, you can modify one over at the shop, Kinzler's shop, while the other one's flying, and vice versa. So that's what I told Cohen we'd have.

Well, Bruce kept going after me. I finally got Bruce cornered one day, and I says, "What are you really against?"

He says, "We're fighting for the same funds."

And I said, "Bruce, don't worry about the funds. You're gonna get yours, and I'm gonna get mine. Don't rock the boat." Well, he was over at Marshall in the tank, working over there with these tubes and everything else.

And so anyway, we got the manipulator foot restraint delivered on schedule and on time, on money, and all the other good stuff, and it flew. And one of the best things I ever got was, almost every mission, the crew gave me a colored picture of the Moon, or whatever they did, and this one is McCandless on the end of that foot restraint with this, "Thanks a bunch, George," you know.

And I said, "Okay." If you're fighting for the same funds, that's one issue. If you're really fighting against an object, that's something else. But he was fun to work with and we got it. But that's the kind of fight you have down there. Most of the fights were for funds.

I fought with Walt [Walter W.] Guy all the time for money. We were mortal enemies in change boards and things like that. After I quit NASA and I went to work for Lockheed a year or so later, they asked me if I can be director of their support group for Walt Guy, run his chambers and things like that. I said, I said, "You ask Walt." I said, "If Walt will have me, I can work with Walt," because everybody's afraid of Walt for some reason.

And so Walt said, "Hey, I have no problem."

So he and I sat down when we first got down, and I said, "I'm here to serve you."

And he said, "Well, we never had a problem. We just had money problems between us." [Laughter]

So anyway, we got along good after that one, you know, after my experience with Lockheed and him. Then he went off to set up the Robotics Group and did that.

Space Station preliminary design is just a note. I'll go on that. In about '81 and '82, what surprised me was, here is a brand new group of people were suddenly charged with preliminary design of Space Station. They'd had no hands-on experience with any of the other previous programs. None. Most of them were concept type of people that were thinking in terms of Moon colonizations and those kind of things. I was supposed to go to the meetings to help in this thing, and I kept looking at them, and I says, "You got some problems." I said, "Your rules are bad."

"Well, we got new rules. We're going to do a different program than any before."

And I said, "Yeah, I think so." They were expecting a dedication of the Shuttle for the Space Station to put it in orbit. The way they had it scheduled to go to orbit was that there were no other payloads going up except Space Station for about three years. And I said, "That's unrealistic."

"No, no. That's dedicated. We're NASA. We own them."

I said, "Well, okay."

As you expect and see in the Space Station, it finally got in to where Congress and Washington became the design group, especially after the disaster of the Shuttle. Everything shifted up there. The decision points were up there. The center of gravity was up there. The smarts was down here; it was not up at Washington. The money was spent primarily making studies and proposals and going up there and giving pitches to educate people to come back to go do more studies and educate. So it was real bad.

Now, fortunately, I left that program, or I left NASA about that time, but it started to come back real. I saw that when I was with Lockheed, that it started to come back real when the design responsibility returned to the centers. So management plays a big role in, you know, how things are going. If you look at the kind of management, you go back into Mercury, there was a NASA manager and there's a St. Louis manager, and they got together and say, "We're gonna do it." And there's a very small group of people that work Mercury. And when they did Gemini, it was the same startup except more people were added. And then when we got to Apollo, it was huge. And so therefore the costs go up, but the program was bigger.

I guess, in summary, when I left Convair and San Diego, beautiful country, to come down to the hot hole here, I remember telling my wife, I said, "We're only going to work for the government for five years, and then we're going to come on back here." Here I am, still here. But the lunar program was probably the most fascinating program I ever worked with.

I think when you have a project that is put before people that is unknown, that collectively you have people reaching conclusions and reaching consensus and making designs that are unknown. If you want to do pure research and development without a project, you won't accomplish anything, but if you have a goal that seems unreachable, you're

going to have people pull together that will do the impossible, and I think we did that when we go to the Moon, and I think that was it.

I don't know what else to say.

RUSNAK: Well, if you don't mind, I do have some specific questions on a variety of the topics that you've talked about. Probably the most logical way to go about is just to start back at the beginning a little bit.

FRANKLIN: Anyplace you want.

RUSNAK: And work our way up.

You said when you first came to NASA that things on the lunar module were going pretty slowly. How far in development was the LM, particularly the crew station layout, the things you're working on, when you first started working on that? What kind of concepts were there and what sort of physical mechanism was there?

FRANKLIN: Well, I was assigned to the lunar module as soon as I came, and I got here about April of '63. That's when I moved in to NASA. Had to find my bearings there, who I'm working with, who else is where, what was going on. We started to make the contacts at Grumman at that time. The first true thing that we saw in Grumman was the mockup in September of '63.

RUSNAK: Is it the M-1 mockup?

FRANKLIN: Yes, I think it's called M-1. That's when, I think, all of NASA got exposed to what was going on. People from the Cape were there, Washington, everybody was there.

We saw then what was starting to shape up as the lunar module. So when I say, you know, things hadn't gone too far, I hadn't seen anything until the M-1. I was working not only that program, but I was also working some of the Gemini stuff at the same time. So I'd say slow, it wasn't all that slow, but anytime you're building hardware or designing hardware, it doesn't go fast. It takes years.

RUSNAK: Since you brought up Gemini, you'd mentioned some of the work with Gemini VIII and working a little bit on the crew cabin. Can you elaborate on how much involvement you did have with that program?

FRANKLIN: Well, I'll tell you, one of the guys in the group that was on staff, he was the one that designed the controller that went on Gemini, soon as they wanted to go EVA, he started out with Ed White's flight, I think with Gemini IV, I believe. They knew that they were going to be in pressurized suits, and they had to have something that they can really control that spacecraft very carefully with, while all pumped up in the suit. And so he came up with the controller design.

Matter of fact, he went home in his woodshop and he carved the grips for that, very precisely had the crew of Gemini IV work it over, had all the crews that were going to be assigned to that, work it over. They worked it over in the simulator and gave it to McDonnell Douglas to put in the bird. So that hand controller shape and everything determined the shape of all the controllers from there on. So that's the mother lode to that. I've got to get that guy's name. He's passed away, unfortunately. He passed away about Gemini X. He had a tumor that developed awful rapidly and killed him. But he was a fairly young man but very talented. I've got to remember his name. But anyway, that was that.

The other was, in the cabin was primarily the stowage and all the crew interfaces again. The urine dump devices and so on, the hardware that came out were not working.

And so we had to go back in and help them redesign those things, simple things that would work.

The group I had working with me, and myself, we had worked a lot with human factors where design groups hadn't, so we understood a little bit about what a man can and what he can't do, and we started going into pressurized gloves, putting on pressure suits.

I had some pressure-suit experiences when I was at Convair. We were doing supersonic ejection seats. We'd put on the Air Force full-pressure suit which was the basis for the Gemini one, and I did some chamber work there, and you got some feel for what happens. You know, in a pressurized glove, you can't squeeze. I mean it's big. So the designers, we always had to tell them to put big handles on things. Crews are going to reach and hit things with their fingers or they're going to bump into things. So we had to have them design that way.

So we looked at the cabin, we had to put guards up on the switches and everything, because here's EVA in there. They're going to be bumping around. They're not going to be sitting anymore. We had to work on, in Gemini IV, how do you stow this umbilical again? How do you get it back in the sack? How do you close the hatch? Because now there's always a little pressure in the cabin, no matter what you feel, and here you're trying to pull that hatch down. So we had to devise a lever up there to ensure that that hatch can come closed. We did the velcro. Velcro was invented. We used that throughout. We'd paper that cabin for them to stick things up on velcro.

Gemini told us early, and we had to devise schemes, waste stowage, where do you put your wrappers? And we argued that one a long time, and the argument we went to was, when you bring the groceries home, they come in a small bag. When the trash man comes, it's in a big bag, and, yet you've eaten most of it. How do you fix that? Well, that's where gray tape came in. Gray tape was put onboard to take the wrappers and wrap them up in

small packages so they can stow it back in the box. You can never put a candy bar, after you eat it, back in the same container. It won't go, and especially in space.

So those are the kind of the problems that we were trying to work in Gemini, because Gemini was the first one that people were moving around in and expected to move around in. It wasn't immediately that they were going to move around, but as soon as they said EVA, you know, on Gemini IV, that opened up the bag of worms that we're going to do some work up there. So that's the kind of things that we did in the cabin, how do you make stowage pouches and boxes and other kinds of things that they can get to and use. The interfaces.

Lighting was another issue. Again I'll go back to Chuck Wheelwright. He did most of our lighting for the Geminis and the Apollo vehicles and the Shuttle vehicles. He had a good knack for that, he understood lighting, and that was his expertise. They'd say, "Well, you can only have one light bulb in the whole thing or so much power." Well, he'd come up with how to use that power.

But that's what we kind of did on Gemini, was trying to make those interfaces work better. When we got to EVA, again, the outside EVA, the backpacks kind of things.

RUSNAK: Do you remember Ed White having some trouble getting the hatch closed on Gemini IV?

FRANKLIN: Yes. That was one of the things that we did, was put in the lever up there, that strap.

RUSNAK: As a result of that?

FRANKLIN: Yes, sir. It was the first thing. That was a surprise. I remember Neil Armstrong and his flight checking that and checking it twice, and in the altitude chamber he'd check it again.

RUSNAK: Well, at least he didn't have as much trouble as [Alexei] Leonov did on the Russian flight where he couldn't get it closed without deflating his suit some.

FRANKLIN: Yes. It's a tough thing that, you know, that you think it's going to work and it doesn't.

RUSNAK: You mentioned how relevant some of these things were to Apollo. Could you maybe explain a little bit of what some of these other lessons were from Gemini that were directly applicable to Apollo, and maybe what were some new areas that you had to think about for the lunar program that didn't really have any comparison with Gemini, or maybe some things that you learned that you didn't want to do in the second program that you had done earlier?

FRANKLIN: Well, common and mundane things that Gemini told us, that you want cameras, you want film, and that was resisted on Apollo, and it was put on Apollo. Shuttle, of course, didn't have a real problem with putting cameras aboard, so we had that.

Stowage is a problem on every one of those flights. You try to put the equipment onboard. You have to go through very carefully with the mission and understand the stowage of items, where they're located. We started out on the Geminis to develop what we call a stowage drawing, which depicted everything in that cabin and where it was, and that was kept in and that was put into the flight plan and into the book that they flew up there. So if they wanted to know where something was, they can in there.

How do you tell the crew where that box is? So we got into stowage diagrams, and we also got into numbering systems. We got into numbering systems on the Shuttle, because here you have a whole bunch of stowage boxes where on Gemini, we can say, you know, pilot right-hand side box or under the seat or, you know, wherever else it may be, because it was simple.

Apollo, it became a little more spread out, so we had to come up with where it was located. So we had numbering systems and we had other descriptive phrases that we'd use to locate that stuff. You know, very simple, but they were there.

When we got to Shuttle, the left-hand, right-hand, second-drawer kind of thing didn't work. So we used a scheme of numerics and alphabetical numbers to denote row and column, if you will. You didn't have to know exactly, but what we did, we set up and we just squared everything in the cabin and put it on one-foot centers, just that simple, and everything in that cabin was marked, at least, that way. So now if a box was there, then that showed up as a number. If nothing was there, of course, there wasn't a number there. So that way the crew can look at it right away, and they know approximately where it is, and then they can pinpoint it. So you go from "I know about" to "where," was the scheme that we used on the Shuttle, if that makes any sense to you.

We knew that things were always going to be added the last minute, so we had to have a way to go into that. So we got clever in our stowage to do that, called it last-minute stuff. We always knew the crew was going to carry something, and we got permission from the program office to call that a PPK, or personal pilot kit. We didn't care what was in the kit; we gave them so much room. They had to clear what was in the kit with the program manager, nobody else, or Deke Slayton, one of the two, and then we would pack it. They'd show up and we'd stick it in. The envelopes got in that way, you know.

The program office put the flags on. They kept building those up bigger and bigger, because they wanted more and more flags to give away.

Let's see, what else did we learn from one or the other? I touched on waste management. Where do you put your trash? And the trash is always bigger than. So as we pushed hard, Apollo always had big trash containers capability, and the Shuttle had big trash containers capability. We just had empty areas that you can put trash in. But we looked at compactors, and compactors were heavy and didn't work very well, and we knew other ways to do it.

So that was all done in the stowage document, where you put the wrappers, how you wrap them up. We tried to reduce the amount of wrapping on things, but there was spacecraft requirements put out, or I should say that program requirements put on anything in the spacecraft had to be fireproof. So when we got into Shuttle, that worked out pretty good, because the box was fireproof.

In the Gemini, the container, we didn't have that much fireproof in Gemini, fortunately. Unfortunately. But we didn't get hurt there.

But in Apollo, when we went to there, everything was wrapped up. It had beta cloth on it or something on it. The velcro kind of disappeared. It was minimum.

We did the velcro map, which out of Gemini, we had too much velcro, and after the fire, we were allowed to put some on, but we had to map it and size it and let the program office know where every piece of velcro in that vehicle. But we knew the crew used that.

More personal devices were going to be needed the more you move around. We saw that on Apollo. That was hand holes we started to go to, toe holes in the Shuttle. I had them put in a finger hold. I got a thing at home that's a plaque that says "Franklin's finger-restraint system." But all it is, is just a little knob that goes along the back panel on the upper deck that, you know, you can grab a hold of. You don't want a rounded corner; you want something you can hold on to, but you don't want to be bumped into it.

Since the Shuttle's been flying, they put other restraints in, because they find out where they really need them. I avoided any foot restraints on the orbiter when we were

developing it, primarily because we didn't know what the mission model was. We didn't know how the guys were going to move around. So we gave them some portable restraints that stick them where you want when you get up there. Well, some of those have become permanent now, as I understand, but others are still portable.

Sleeping, we found out they can sleep anywhere. You know, give them a sack and let them hang. We found that out in Skylab. So in the Shuttle, when we wanted sleeping quarters, we had some racks over there, they could sleep back-to-back. You know, there's plenty room. Or they can go stick them on a wall if they don't want to do that. But we gave them that option. The more mobility you have in, the more you give them the options to do things.

When I went to Europe to work with the European [Space]lab to do some of the interfaces there, they wanted a lot of foot restraints and so on, and we talked about that, about how to do it, where to put them, but we again told them, "Work your bets the best way, but put some portable ones in there so if there's an individual crewman that has something that he wants, he can get there." And a lot of that was put in. But restraints are always tough on zero-G. And in 1-G, you can't really tell what to do.

I'll tell you another thing we learned, that we had to fight all the time, is you got to design a spacecraft even if it's in orbit and it's in zero-G environment, like a lab, as if it's in 1-G. The reason for that is because the designer doesn't think zero-G. He can't. He's never experienced it. And the other thing is, you're going to test it in 1-G. Now, there's nothing wrong with putting things on the ceiling as long as the things that are on that ceiling are designed for 1-G if the ceiling was turned to a wall or turned to a floor.

So that's how the labs can be developed with stuff all the way around, because the same thought process, if it's on a wall design or on a floor design in 1-G, you can design it for the roof. So we kind of kept that concept all the way around. In Spacelab, we knew that

1-G, the thing was going to be in a vertical mode, so we had everything put in a vertical mode in the crew cabin. So when it launched, we already knew what we were doing.

So those are some of the things you learned to do throughout the space program that, yes, you get freedom of movement, but you got to test it, you got to train it, and you got to understand it. And very few designers can understand zero-G.

RUSNAK: That's an interesting concept, because you're not having engineers who were astronauts or anything like that in these early stages. So it's a foreign environment to think about.

FRANKLIN: Well, in the Gemini program, you know, you talk about that, I guess they're planning on doing that on VIII, they did it on IX, and I think they did the X. I'm not sure of the numbers here, but anyway, we're supposed to go up, dock with the Agena, and the guy get out and go over there and do something, and come back. The first one that went over and did it couldn't do it. He got overheated, came on in. Second one went over there had overheated, came back in.

First one to do that was Buzz [Edwin E.] Aldrin [Jr.]. He's thinking again. What is a crewman doing out there? He's trying to muscle it. He's got a spacesuit that's limited in the BTUs [British Thermal Units] it can take out, so he overpowers the spacesuit systems to take out his BTUs, because, "Here I'm a strong guy. I can go out there and muscle this thing. I can beat this thing. I can get my legs around it." So what does Buzz do? He goes to the water tank, he does his job, never using his feet, using his hands only in going through it. So what does he do when he get to orbit? Smooth as silk.

And that's the best lesson that all the EVA learned was from Buzz on his mission. No doubt about it that, "Don't muscle it, just move it." And from then on, you watch all the astronauts when they work. And there's where the water tank really comes in, because there,

if you start to muscle it, you torque yourself out, because you kick your feet in the water and you turn wrong, where in space, you wouldn't do that. So they learned to move very slowly and very methodically in the water tank. So when they get to space and do it very smoothly, very methodically, they can do that.

RUSNAK: Did you personally have any involvement with the water training at that early stage?

FRANKLIN: Yes, from the standpoint that the group that ran that water tank, Hammersley, was in my group, and we went down there to look at crew interfaces during the testing. He tried to qualify me for scuba, but I kept plugging my ears up. I'm a excellent swimmer, but my ears would keep plugging up after about ten, fifteen feet. I just said, "Forget it." So I couldn't clear my nose. But, yes, we'd go down there to do the evaluations and see how things were working when we needed to on EVA.

I had a little bit when the manipulator facility under water was a fun thing. I had Bill [William K.] Creasy's design group, when I was in the Design Division, devise me a water tank manipulator to be operated just be water instead of hydraulics so it wouldn't have any waste and things. So they built that in-house and built it down at Kinzler's shop, put it all together, and went down there. I've got a picture at home where it shows the water going every which way and they say, "Franklin's Folly." [Laughter] I mean they couldn't keep the seals in there. But they use it now to just move it around manually. But it was going to be operated and controlled. They couldn't get the seals on the motors and everything to work properly. So it becomes a dumb simulator.

Yes, the design of the equipment for the facility I got involved with at one time or another. Yes, all the facilities, I guess I got involved. When I was division chief, I got very

strongly involved with the mockup facilities, the manipulator facility, the water facility. One other facility I had. Yes, we had a big computer facility, too, that we kept building up.

When I set up the Engineering Operations Systems Division, we still had our crew station, we still had our mockups, and we still had the other stuff, but we picked up experiments in the payloads, which were the big camera that this one fellow kept working on and working on and working on, and we finally flew it and got pictures of it. It was huge, looked like a big bathysphere. Huge thing. And they did most all the work right down in our shop downstairs. Then we had a lot of other experiments that we put onboard.

I had a lot of time at that time. I'd inherited from Dean [F.] Grimm when he moved up to program office, and he told me, he says, "You know, there's a lot of money up at Washington that you can come in and you can do experiments with." So we'd go up, a couple of us would go up to Washington and go make our calls to the various groups up there, and we'd find out somebody's pet project that they just really wanted. And so we'd go off in the other room, we'd make up some charts and come back and sell him on a project, and we'd get some money.

Well, one year I had $50 million worth of budgets that didn't include civil service budgets or contractor support budgets, that was just money to work with, experiments and designs and flight hardware and those kind of things. And it was a lot of fun, because you had a lot of things going on all the time, everything from cameras—I had a camera group with the Hasselblads and the movie cameras and this other big camera we had. The IMAX camera people came in, and they'd come in and made a pitch to Headquarters that they ought to fly an IMAX on the Shuttle. So they told us, "Bring it down to the camera people," which was us.

Well, they brought it in and we looked at this camera. The original camera they had is a homemade laboratory setup to run 70 format film sideways, and if you look at it, it's got, you know, two big rolls sitting like this, with the camera in the middle, and it's held together

with bailing wire, literally. But it worked for them. And so they said, "Here's a camera. Can you put in onboard?"

And so we went to the program office and says, "That thing will never fly. It's got to be completely reworked. It's not good at all."

Program office says, "Fix it. We'll give you the money."

So the program paid for us to completely rebuild that camera, and we did that in-house with our camera people and with the Canadians down here helping us. We built a brand-new camera, tested it and everything, and then we built the can that it went into in the payload bay for its first flight, and it was in a can with a lid on it. After the payload bay doors opened, the guys inside could open the can and take the pictures, and then he'd close the can, and it'd come home. And it worked, and they've improved it since then. But I remember that is one of the jobs that we were given to go fix.

Vacuum cleaner. There's no vacuum cleaner onboard, but we knew that everything ended up on the filters. But there ought to be a vacuum cleaner. So I gave one of my guys that was working, that was a tinkerer, I says, "You go down and buy three of those portable vacuum cleaners that are about yea long," and I said, "I don't want you to touch the motor or the impeller or anything else, but I want you to space-size it, put the right switches in it, and the right wiring, and the right cover on it, and we'll fly it as a vacuum cleaner."

"Okay."

Well, he tinkered and he tinkered, and I says, "What are you doing?"

"Well, I want to improve this."

I said, "Don't improve the motor, don't improve anything else. That's already been done. Just fix it." So he fixed it. And we finally got it all done, and it looked like a cocoon wrapped up in aluminum tape or something. But anyway, we certified it for flight. And everybody said, "That thing's not gonna work up there." And we took it up and it worked.

So as soon as it worked, we were told to go give it to another division and they're going to make better flight units, which they remade motors and they made everything else on it. So price went up. But that's typical of what we tried to do. There was a need for something, we went off and did it, and then we went up and tried to sell it to the program. But I had a great bunch of guys that worked for me at that time that would come up with things, then others that just wanted to tinker.

RUSNAK: Maybe you can tell me a little bit about working with some of the different contractors from program to program, starting out with McDonnell on Gemini, then Grumman, and Rockwell for the Shuttle. What kind of responses would you get from them when you're trying to make changes or whatnot? If you can maybe compare across the programs for me.

FRANKLIN: Well, let's go back to the beginning. I think Gemini was pretty straightforward. If we made a case to our counterpart up there about something that had to be fixed on the cabin, it went to [John F.] Yardley, and Yardley examined it, and it didn't take long for it to happen. He didn't even have to come back to Houston to ask if they can make a change. If it was of dubious value, then we'd have to go to Change Board and then it'd be directed from NASA to do it. But Yardley was always receptive to fixing things and fixing them correctly, and we worked with them very well. They let us interface with them very well.

Matter of fact, we were down there, it was on Gemini VIII altitude chamber test that we were sitting up there and doing, and the ejection seat had something wrong with it. I've forgotten just what it was, but there was something under the ejection seat that had to be fixed or they'd have to cancel the test. And the test director said, "Well, we're going to have to pull out the whole thing, take it out of the chamber, gonna have to take the ejection seat out, and we're going to have to go in there and fix that."

And this Ray Malone I had with me, he says, "Let me fix it." So we had to talk with the altitude-chamber people up there, and we talked to the manager about it. Says, "Here's what we can do," and Malone explained what he was going to do.

So he said, "Okay," because it was going to save a week if he was successful. So Malone understood that spacecraft enough, he worked underneath the seat blind, and here's the inspector sitting out here wanting to know what the heck he's doing, working it, and he's telling the inspector what he's doing and how he's doing it. I forgot just what it was. But anyway, the upshot of it was that he fixed it, and the test went off as usual. So they were good people to work with.

I always thought there was too many NASA people up there that didn't have to be up there, but, you know, they went up there anyway. I remember this one guy used to get on the plane with me on Monday morning and kiss his wife goodbye, and when he got up there, he got off the plane, he'd kiss somebody up there, and they drove off in the car, and I didn't see him until Friday when she brought him back to the plane and drove him home, and his wife met him and drove him home. You know, I said, "What's this deal?" You know, why was he going up there? Well, obviously it wasn't to see the spacecraft. But anyway, that's a side issue. I'm sure that happened a lot of times.

But overall, at McDonnell Douglas it was very straightforward, and I think it was those two managers that worked close together on how things operated, and their subordinates worked very good with other subordinates.

Apollo. I got in down at Rockwell, I went out there, some of their early mockup reviews—very poor mockups, very poor response. It was a constant battle to get things done in there. Finally, another fellow in my group took over, and he was my counterpart for the command module, and he was on the same staff with me from Warren North, and we used to compare notes, and he used to shake his head.

Grumman was very good. From my standpoint, the two people I worked with up there were smooth. And whenever something came up that we had to go to the management, we went to the management, and we each pleaded the same case, which was good. If we had a big difference of opinion, I mean a huge difference of opinion, usually we worked out what the differences were, and then we'd let somebody else referee it. But it was never adversarial. But I think it's that location.

Some of the other subsystems, though, had a lot of difficulties in Grumman, and I think it was the groups that didn't understand, I think, I'm going to call it the "New York attitude." If you don't understand that New York attitude and you try to go against it, you're against a stone wall. And I think that was some stonewalling done up there until some of the managers kind of fixed things and it started to come together.

Grumman was eager, eager to please, eager to get it done. They didn't like all the ideas we had. They were very pleasant to us when we were up there, but they thought the astronauts had too much say-so in design, and they probably did.

One of the things that was my other job, and that's what Deke told me, he says, "You take the astronauts' opinions and you formulate them into reality and try to get one focus." And he finally got it in to where astronaut was assigned to my counterpart, like Pete Conrad. If it was EVA, it was Buzz Aldrin. If it was something else, it was somebody else. So he started to focus the astronauts into some cohesion. They had a propulsion guy, they had an RCS [reaction control system] guy, they had a environmental control guy, they had a [space] suit guy. So they finally that worked around where it wasn't too much.

But when they had the original seven in the next group that came in, when they had a mockup review, there was not an opinion about what should be done; there was individual opinions about what should be done. But I think Grumman did very well with it, in my personal opinion. They kept to its schedules. I think the working relationships with them and Owen Morris and the rest of them were very good.

Kenny Kleinknecht had a little harder problem out at Rockwell all the way through, and all the guys said Rockwell was trouble. Rockwell always wanted more money, always more money, always more money. Grumman was not necessarily that way. They would look at it and say, "We could fix it," or they would say, "It does cause a schedule." But that was my opinion there.

Shuttle was the same story at Rockwell. It was tough, very tough to work with. We learned how to work with them, but it was very tough to make it happen.

RUSNAK: How many of these differences do you think might be ascribed to changes in NASA itself or the way it ran the programs from the government side?

FRANKLIN: Well, I guess you have to go back to Mercury and Gemini, is small program office and manager-to-manager. Yardley was essentially given, you know, "Fix it. You're building it. If you have a problem, we'll help you." So they didn't have as many engineers, systems engineers, and others here at NASA helping them. They just didn't have that many people. Gemini, they had a little bit more. They had people to overlook them.

When it got to Apollo, NASA wanted to do the design. They were frustrated. They wanted to do the design, but they were not supposed to. They were supposed to give the requirements and see that the design is done and the testing is done properly. Some of the subsystem people understood that, others did not. And so I think as you get bigger and bigger in a program, again just more and more people, you have more and more interfaces that you have more and more dissent, and it costs you more.

Then when you got into Shuttle, it was nothing but a paper mill. All the money was spent for paper to making proposals, nothing for hardware for a long time, because nobody can make a decision. So you want to have it as small [a group] as you can to make the decisions.

RUSNAK: Well, if we can talk about a couple of smaller points, I guess, related to the lunar module. I understand that NASA had wanted some degree of similarity between the cabin layout of the command module and of the lunar module. Can you tell me about what some of these areas were and how difficult it was to coordinate with your counterparts who were working on the command module, and then what areas that just weren't really compatible between the two?

FRANKLIN: Control and displays had to be compatible, eight balls and eight balls. Again, the lunar module, Grumman didn't want to put in an eight ball. "I don't need an eight ball." We were going to have an eight ball. And they said, "Well, we'll put one in right here."

"No, you're going to put two in, one on each side, because you don't know who's going to fly this machine."

Control and display layout had to be the same. That's, again, where my group came in to make that happen. Switches had to operate the right way, nomenclature's the same, the right guarding of them, how you put the guards on the things, those all had to be the same.

We got into the ECS [environmental control system]. We wanted it to be the same, but the command module has already done their thing with the round one [lithium hydroxide cannister], and the LM had done their thing with the square one, and neither one of them were going to change, they're going to cost big bucks to change, either one of them, and so they left them alone.

The stowage between the two we kept constant, the same kind of accoutrements in one as the other. They operated the same. I guess we made sure that all the things that were noted, they all had to be the same. The controls and displays all had to be labeled the same. You know, an RCS is an RCS. You know, an ECS is an ECS. It's not something else. So we had that little nitpicking nomenclature to fight.

And locations of switches, we tried to get reasonable compatibility but not completely, because the two missions are completely different.

Computer keyboards had to be the same. Hand controllers, exactly the same. What else have we got in there? Well, those are the equipment that they contractors provided.

All the latches that the crew had to operate were the same. We didn't have doorknobs and one kind of latch and a different kind of latch somewhere else. We made them all the same just so the crew knew how to open something. It's that simple. I mean, there's always a designer out there say, "Well, this just ought to be a hook," you know.

"No, it's going to be a latch, and it's going to operate this way."

When we got into switches, which was an interesting thing, we had two vendors, or more than two vendors, doing switches, both at California and up at Bethpage, and they weren't the same. They didn't operate the same, they didn't have the same feel, they didn't look the same, and we kept trying to make them, at least the knobs that the crew interfaced, the same. Well, when they finally got into the testing of switches, they found out that there were some problems with one of the vendors, that the balls of solder kept falling out into the switch and causing some problems. And they wanted to keep testing them and testing them. So finally what they did, the program says, "Same switches from both vendors." I've forgotten which was which now, but that's what made them the same.

Colors were the same. Make the guy feel like he's not in a strange area. When he comes in, he's in familiar territory, was kind of the name of the game, I guess.

RUSNAK: This makes sense from a perspective of, if something's going wrong or whatever, where they have to know instinctively where some of these important switches and controls or whatever are, regardless of which vehicle they're in.

FRANKLIN: Yes, and we tried to place those, you know, in need. You know, one of them, I guess we had in the wrong place, was—well, we don't think we had it in the wrong place, but on [Thomas P.] Stafford's mission when they say he leaned out the window and disabled the autopilot or whatever he disabled, I've forgotten what it is now, and where, fortunately, they recovered and came out, he had moved a switch inadvertently is what he did, but we guarded it from then on. He said it wasn't guarded and he bumped it. Well, that wasn't true. It was a guarded switch to begin with. But he would never admit that. I remember getting him off in a corner one day and he said, "No, no, never."

But we had to watch those kind of things, try to place things where they really needed them, and that's where the—and I call it "human factors" for lack of a better name, or crew interface, trying to develop the right places for things.

I had some real good guys working for me that knew how to do that and knew how to do it well. We argued a lot, we fought a lot with the avionics group about placements of displays and controls, and labeling and the way this switch worked and everything else, but we did it.

We also forced systems to operate the same. Let's say a propulsion system, the guys would go off and design their propulsion system from the rocket through the tanks, the valving, and through the switches, and they would show up on the instrument panel at Rockwell. And RCS would do the same thing. They'd show up on the instrument panel.

So the first time we went out there, here was all these different-colored switches, different shapes, different-colored panels, different-colored instruments, different dials, because the systems said, "Here's the way it ought to be." And so we had to go in and make that a common thing, which the systems people disliked immensely that we were designing their interface.

We also then would go in and find out what the functions were of those switches, and if the functions weren't the same, then they were labeled differently. And they didn't like that.

So we had to do a lot of systems integration, if you will, with those things, and we got into all the systems. That's where I think I was fortunate and be able to understand an awful lot of systems in that vehicle because of bringing it together at the panel and how to operate it. "What does this switch do?" That's the first one the crewman's going to ask.

"Well, that operates this safety valve."

"And what does that do?"

"Well, that doesn't do anything." You know, something of that nature. So you had to sort through that stuff and try to bring some sense to it.

RUSNAK: Well, that hits right on the question I'd been planning on asking you, but if we can stop for a moment to change out our tape again, and then we'll get back to it.

FRANKLIN: Sure.

RUSNAK: Well, if we can get back to what we were talking about before we stopped. You were describing interfacing with the various subsystems, engineers and such, and I was taking a step back and looking at your position there where you're kind of in the middle of a group of contractors, you've got your NASA engineers who are managing, in some cases having a hand in designing systems, and the astronauts who are actually using these. Can you describe, from all these different perspectives, how you were doing this sort of systems integration you were describing?

FRANKLIN: Well, you go to a hell of a lot of meetings, and you listen and you make inputs, and then you try to convince the people that you make inputs to that you're right, and you kind of hope that they make those things. And if they don't make them, then you go to the change board, and you make a presentation to the change board that RCS people ought to change their system this way to do this, and convince the board that that's the right thing to do, and the reasons why. So I had that opportunity to do that.

Propulsion systems the same way, environmental control systems, I made pitches there to make changes to it that the guys didn't want to make changes voluntarily. So I said, "Well, we're going to the change board and we'll go fix it."

We had a working relationship, you know, adversarial, if you will, but still understanding what the differences were and clearly understand it, and make that presentation, and then make your case from an engineering standpoint of what should be done, and then you let Mr. Low make that decision. I would say that I probably won more than I lost, primarily because I had the crew and I had my systems engineers that work in the same group I did, give me the data and the background necessary to go do that job, and I understood enough of it to talk about it. I couldn't design it, but I can do enough to talk about it. So that's the way you do that. You coordinate with each other, you help each other.

I remember going to one guy one time, I've forgotten the system, but I went to him and I said, "You know, we got to get this changed and here's why."

And he says, "I know, but I haven't got any money and I haven't got any time, and I need two designers to go get it fixed."

And I said, "Well, you want me to call your boss and ask him to give you some help?"

And he'd say, "No, don't bother. I could take care of it."

Or my other ploy was, "Oh, you need some more help? I'll send over two engineers to help you finish that out." You know, the drawings.

"Don't bother. I'll fix it."

You can overcome an awful lot of inertia by offering to "help" in some fashion. I remember going to purchasing one time and I needed something to go through purchasing right away, because I needed a part or the contractor, whatever it was, and I put it in and I'd wait, and I'd call up, "Where is it?"

"Well, it's on Joe Blow's desk."

I said, "Where's it gonna go next?"

"Going..." so and so.

"You want me to come over and move it around?"

"No. You just have to wait."

And I said, "Well, is there something I can do?"

"No."

So I'd send somebody over there, and they'd go over to the paper and they'd pick it up, and they'd say, "You have to see this." And they'd look at it and just sign it, and they'd walk it to the next one. And we'd walk it around.

So we would help that way. And I don't think people really resented it, but they did come around. And there were some hard-nut cases, but you get over that. But I guess you cajole, you convince, you help. Those were the only weapons I had. I had no command weapons. As a subsystem manager, you have no command weapons. You don't have any people working for you. You got to get that time early. You got to go to the branches that had the resources to do the work. I had to go the mockup people, and I'd go to Lou Richard and I'd say, "Can you fix me up with this?"

"Yeah, we can do that."

So when he was getting ready for budget, I'd help him with his budget. See? I'd say, "Hey, put a lot of this in there." And I'd go to the other and do the same thing.

So budget-wise, I would help coordinate the budgets to make sure that what I needed later was there somewhere. So that's the way you kind of do that.

But you got to help each other. I think a lot of that went on there. There were some people got their backs up, but not often. Like the TV people, they wanted to put things on the vehicle, but they were afraid to go tell people about it. So they'd come to me and make me go up there and put the TV on.

RUSNAK: Well, they probably said something about your skill with getting these things done.

FRANKLIN: Yes. Or I'd go to Kinzler. Kinzler would never go the meeting. Nobody would ever go down there and talk to Kinzler. But if the program wanted something right away, that was the shop I went to, and I'd tell him, "We furnish the drawings, you furnish the design." And so we'd have guy making the drawings just as they make the parts on the machine, you know, so when they stamped them off when they got through. Well, Kinzler was happy, because he built a lot of stuff for us, and it was great stuff, but he didn't have the resources for it and the designer down there, see. We had the designers. With the mockups, we had to budget for the materials. He had the people that could hammer it together.

So it was that kind of give-and-take you kind of give. You know, you go back and forth, you help them out a little bit, they help you out. And if you look at it, it's for a common good; it's to get that program done. And I think there was a lot of that going on at the program. Not just me, but a lot of people just did that, because that was the only way you got it done, is cooperation with each other.

RUSNAK: Earlier you talked a little bit about having to, on Apollo, make sure everything was fireproofed, having to remove velcro from the cabin, that sort of thing, obviously, as a result of the Apollo 1 fire. We're wondering if you can maybe tell me a little bit more the

impact of the accident there, and the other changes that had to be made in the months following that before they could fly again.

FRANKLIN: Well, at that particular time I was full-time on the lunar module. I didn't have any more contact with command module. My counterpart was doing that.

Of course, when it happened, it was devastating. You know, those people were very close friends. Ed White and I used to swim all the time together. You know, it just, you know, hurts you that way.

But then you start to look at the program. I remember I had quit smoking for ten years, I guess, and we started having these late meetings. I remember Bill Lee would sit there, and you kind of wonder how big his bladder was, because he'd stay there for so long and never move, where the rest of us would be in and out of the room. So I took up smoking again up there, because everybody was smoking.

But trying to work out what we had to get done to fix the LM and try to still meet the same schedule, we knew we weren't going to meet the same schedule. We knew what was going on in the command module, that the wiring was going to be fixed inside, everything was going to be fireproofed out, you know, in the cabin. We knew that was going to happen. So we were looking at the lunar module and knowing that we had to go through that.

So all the subsystem people were going through their subsystems, looking very carefully to make sure that what they had was meeting the new fire code and what materials we could use or substitute, what changes we had to make to the vehicle. Grumman was well involved with that as we went through it.

With Bill Lee, we kind of had a head start. We had to get to work before they told us what we had to do. You know, we just knew that there was fire—fireproof the thing. That was one of the things. Fireproof it and then look for source. We still didn't know what the

source was yet. We knew that [the module] blew up, but we didn't know it was bad wiring or chafing of wiring or whatever it was in there.

So that was all reviewed and continually reviewed and continually worked, again trying to press schedule and stop manufacturing, because manufacturing was going on and trying to meet some of those schedules. So was pretty trying, I would say, to get back to where we were, keeping, you know, the disaster in mind down there. Yes, I think most of us focused on that kind of thing.

That was one of the other things you noticed at NASA. When there was a crisis, I'll tell you, everybody pulled in. There wasn't a soul that if they knew anything about the vehicle and knew any way to help with the situation, were working it, and were working it day and night.

The umbrella for [Sky] Lab, I remember the group I was with, we were coming up with a new umbrella device, trying to work it out, while Kinzler was doing his own. We had it spread out all over the centrifuge building trying to work that out. We worked for seventy-two hours, and there must have been about thirty of us, in all kinds of ways trying to get something designed, built, and how do you fold it and how do you put it together, and how do you hammer it. Kinzler came up with it first, because his machinists down there were more adept than we working. I mean we were just designers. He was capable of putting things together. So he made the deadline.

But Marshall was doing the same thing. They were trying to figure out how to do it. The whole center was doing it. But I was remember staggering home after seventy-two hours, you know, and just passed out, and we came back and Kinzler had his idea, we tried it out in the mockup, it worked. We went to program office, built it, put it onboard.

Apollo 13. Around the clock, people were there. I guess I was there for, that time, about forty-eight hours until we finally got what we knew that they can contribute and what my group can contribute. But we didn't lay down. And other people were working

constantly, too. When that happens, you don't see any rivalry or anything else. I mean you see total cooperation and problem-solving, and we don't care who comes up with the idea. Matter of fact, whoever came up with some of those ideas, you got to say, "It was a group. Here's a group of fellows that one of them had an idea, another one had an idea, another one had an idea."

And when I read in a book that Joe Blow went to Kranz and says, "This is a fix," and he gets credit for the fix, he had nothing to do with it. It was his people down there, the [Robert L.] Spanns and the Malones, and the other kinds of people that got together, and composite put something together, but they had to go through him to go up there, see. So some of that, in the history of this thing, it gets distorted a little bit.

But all the way through the program, the space program, it's all the little people working together that really get the problem solved and come up with the big ideas to go fix something. That's the way I see it. Now, there's about 80 percent of the people don't contribute at all, but you still get down there. And that's about true.

I got a story I got to tell you. I guess in the middle of the Shuttle program, that far along, there's this fellow from project office, they're the intermediate, he came down to me one day, and he said, "George, have you got a job down there in the division that you can put me into?"

And I said, "What's wrong?"

He says, "You know, I've been up there all these years." He says, "I haven't done a thing." He says, "I got a problem, though, I want to tell you about." He says, "I fall asleep. I just drop off to sleep right in the middle of things."

Well, I knew what he had been doing. He had been doing nothing but going from A to B, to C to D, doing nothing, carrying his coffee cup back and forth, because his boss said, "Go here and do that," and this one would say, "Go do that." And he never got a chance to do anything. He's a smart guy. He was from Georgia Tech [Georgia Institute of Technology,

Atlanta, Georgia], very smart. So he came in and I said, "Yeah, I'll give you a job," I said, "if you want to come in."

He said, "Well, I'll take a cut in pay."

I said, "You don't even have to cut a cut in pay. I'll just put you as a project engineer, and then that'll support you."

He says, "Fine."

So I gave him a project that I had. It was going to run about eight or nine months, I guess, and I said, "Now, you're going to be in charge of this project." And I says, "Here's your budget. You got a million and a half dollars to get it done, and here are two other people over here that will help you. And if you need any other help in the division whatsoever, you go ask, and if you can't get it, you come in and ask me." I said, "But I want you to plan it, I want you to test it, I want you to implement it, I want you to give me a final report, I want you to give me the hardware at the end."

He said, "Okay." So off he went.

He came in about four months later, just as happy as can be. And I says, "How's it going?"

He said, "Right on schedule." He said, "You know, George," he said, "this is the happiest I've ever been. It's the first time I've ever accomplished anything in this space program." And he went on, and he was good from then on. He's never went back to sleep or anything else. But he'd been battered up there. He got caught in this—there's a vortex that happens in program offices that there are people running around that think they're working, but they aren't accomplishing anything. They don't have a role, but they don't know it. And it happens. The bigger the organization, the more you see that. That's why these corporations today are saying, "I can lay off 10 percent of my people." You know, they won't miss them. They're called middle managers.

RUSNAK: I'm looking through my questions here, and I think by this point we've covered most of the specific and the general ones I had for you. I wanted to give Jennifer and Sandra an opportunity to ask any questions they might have come up with as they've been listening to what we've been talking about. Jennifer?

ROSS-NAZZAL: Yes, I just had one question. You talked about the use of cameras and the need for television during the Apollo program itself, and you mentioned a few times that they were the TV people. I'm wondering if you could clarify who the TV people were?

FRANKLIN: They were the communications group. I want to try to remember their name. They worked for [Ralph S.] Sawyer. I'm trying to think of the guy's name that did the TV. Man, I've got a picture of him right now. He was a branch chief in Sawyer's group that was responsible for all the televisions. Real nice fellow. Yes, tracking and communications group under Sawyer. Man, I can't think of his name. [Olin L. Graham]

RUSNAK: I can't either, but I think we've had him in here to talk to him.

FRANKLIN: You may have. If he did TV, he's there. You know, when you talk about the mockups and the TV when, well, what's the guy's name that got the award for the TV program of lifting the, the—

RUSNAK: Ed [Edward I.] Fendell.

FRANKLIN: Fendell, yes. I know Fendell has said he when he was going to do that, he came on down to work in the mockups in order to work the timing out, to get that camera, or send the signal to the camera before the liftoff, see, because of the time delay on the

communications, and he'd work down in the mockups with us all the time. That was a lot of fun. It was, you know, how do you set that up and how do you do that? We'd set the mockup up, and we'd just move a ball, you know, at the right time, and see if that camera would track at the right speed. You know, we did all that, and then they did some simulations, too, later on as simulations came in.

You got to remember, in the early days of the program, we didn't have big computers. The biggest computers was in a simulator, and that wasn't very good. We did a lot of things without computer technologies or computer help. We had to come up with mechanical methods of doing things. Some of them worked out pretty good. I always thought the early simulator was neat where they had the scale map of the Moon and the camera flying over it. I've got one of those scale maps at home. I don't know what to do with it. It's in the attic. God, it's huge. I guess it has value somewhere, but I think, you know, just mold those and throw them away.

But the technology has come great. And if you think about it, that's what Kennedy wanted to do, was advance the technology of this country, not go to the Moon. Of course, it was to advance the prestige of the United States, but it was to push the technology in this country. And the way you push the technology is you put a project out there, and you'll push it.

Did I answer your question? I really didn't.

ROSS-NAZZAL: Yes.

FRANKLIN: [Olin L.] Graham. Graham's the guy's name. Graham's the guy's name, at Tracking and Communications.

ROSS-NAZZAL: I'm curious, did you work at all with any of the Public Affairs [Office] people? Did they approach you about the use of television and cameras during the Apollo program?

FRANKLIN: No. No, the only time I worked with them when they would bring around visitors to go visit the mockup, and I'd have to go out there to give them a pitch on the mockup.

I remember one was the president of China, came down, and when he came in, he's a little feller, but his bodyguards are bigger than I am—tall, big, huge guys. Well, he went into the Shuttle mockup, and he was to go into the cabin and then come on out through the back end. So I was back at the tail, because as you come out of the back end, there was a step, and it was not good lighting, and I thought, "Well, I'd better stand out there just in case he comes through here and get him." So anyway, when he got up to the hatch, these two big guys just picked him up and put him in there, see.

So he walked on through there, and I was watching him come on back, and he came in, and I reached out to hold his hand when he was stepping down the stairs, because he's a pretty rickety fella. So he took my hand, and he was holding on and he was coming down the stairs, and suddenly this big guy grabbed a hold of me and tried to pull that arm away, and I mean he was about ready to lift me, and I wasn't going to let go of the president at that time, because he's on the step. So I let him on down, and then I turned loose of him, and he pulled me away, you know, and looked at me, and I said, "You know, I shouldn't have touched him." [Laughter]

But, you know, the public service, we did things with them. When they even wanted to have a show-and-tell down there, we'd set it up and we'd give the pitch, you know, whoever was a dignitary or whatever they wanted down there.

But they didn't come forward and ask for all this stuff. This was generated from inside. And primarily, it was just, you know, the engineers and others just saying, "You know, you got to do that. You got to do that, because it's necessary." Photography people wouldn't do it. They would want to furnish the film, but they wouldn't want to do it.

RUSNAK: I did have one other question here. I was just checking my list. Looking at the Space Shuttle, since this was going to be a vehicle that was going to be reused a lot, it was going to have a lot of different capabilities, do a lot of these different things, what sorts of accommodations were made to maximize its utility, particularly for things like being able to perform EVAs and do a lot of different functions, getting in and out of the payload bay and working around that area?

FRANKLIN: Well, it's got an airlock. It had an internal airlock. They wanted to put it outside, but that encroached on the bay, so we had it inside. We did a lot of work there to make sure the hatches were big enough and that all the accoutrements were inside to hang spacesuits. That was in the launch position for them. It was a drying station. It was the donning station. The hatch end of the payload bay, and the handholds leading from there, we had integration, to make sure the crew can get in and out. A lot of water-tank work went into that, to placement of handholds.

The sizes of hatches, the structures people wanted to make things small, and to accommodate a guy with a backpack, we wanted to make them very large. So we arbitrarily hit on the size of the hatch. You know, we made it large, fortunately, because now the packs are even larger than they were when we first started. All the airlock accommodations of controls and displays in there, because they have switches and they have gas things and they have other kinds of things in there, we had to integrate that. The lighting in there, we had to make sure we had the right lighting in there so they can see.

We had to have some safety features in there to make sure that we can get the hatches closed, because if the guys couldn't come in and close that outer hatch, you certainly can't open the inner hatch. But we investigated, because we depressurized the cabin to bring a guy in if we had to. We went through a systems test of the cabin to make sure that if we did depressurize the cabin, nothing would fail. So all the switches in there and all the instruments and everything else were vacuum-qualified, which was one of the things that people didn't like to do, but we knew how to do it, so we did it.

All the payload bay handholds along the rails we put in so the guys can walk back there. When they designed the payload bay door latches, I was with Spacecraft Design Division then, and that group, mechanical group, worked under me at that time. And so we worked with them and their Human Factors Group to make sure that there was handholds available to go up there and ways to mechanically close those latches if they didn't go electrically, and ways to pry them closed if we had to, because you can't reenter if that thing's open.

So all those interfaces are looked at as crew backups, if you will. When I left, they were starting to put the backpacks in the payload bay, the ones that were going to fly, McCandless and the rest of them. They're just starting to do that on the design. We were working that as to how to get out and get into those things.

How to recover a payload. We were looking at a lot of that in the water tank and telling the payloads what they had to do on their payloads so that can happen. So there was a payload integration that took place, as well as going to the payload people and tell them where to put handholds, where to put the manipulator interface, where we can put it, and we did a lot of tests in the tank of how big an object that you can move around. Well, you can move it as big as you want, as long as you move it slow. You know, that was remarkable. You can move a locomotive with one finger. I think somebody said, "Well, how big can we move?"

And I says, "You know, if you go up and stand on the dock in an ocean liner and push at it with your finger long enough, it'll move." You know, it's a force. So, you know, people understand that.

So we did a lot of that integration of the crew EVA, how you handle your tethers, where you put your tethers, how do you tether your tools, how big the tools are, what do the handles look like, how much motion you can get into them. So a lot of that we did in the group, lot of it.

RUSNAK: Do you remember if this EVA capability was included in the Shuttle from the very beginning?

FRANKLIN: Yes. Yes, the airlock was included in the very beginning to do EVA. That was going to be part of the task of buildings space stations or handling payloads, or doing those other things. Now, a lot of the payloads don't require EVA, but every payload has a presumption that EVA is required in case something fails. So that's all built in.

I guess the first one that required EVA was the telescope. That was to be serviced. The others were not to be serviced. But every payload that went up there can be handled by a man, every one of them, in some fashion.

RUSNAK: This time I am out of questions. But I did want to let you have an opportunity to make any final remarks or any other stories that come to mind before we wrap it up.

FRANKLIN: No. I won't keep you any longer. [Laughter] You can all go home.

RUSNAK: Well, our work day's not over just yet. So we're happy to stick around if there's anything else you'd like to add.

FRANKLIN: I don't have anything in particular. I think it's an interesting program. I'd sure like to see the whole thing some time.

RUSNAK: Well, it's a pretty big project so far. So there's a lot to see. I want to take the time to say thanks for coming in this afternoon and spending these few hours with us.

FRANKLIN: Well, I enjoyed it. I haven't talked about this in ten years.

RUSNAK: Well, we're glad you liked it.

FRANKLIN: You know it's tough when you go back forty years and try to remember stuff, but I'm glad you guys are doing this. There's a lot of people that can really add to this thing. I'm sure you're getting them as time goes on.

RUSNAK: Well, we're always happy to take suggestions for more people if there's anybody else that comes to mind.

FRANKLIN: I'm finding out they're dying fast.

[End of interview]