ORAL HISTORY TRANSCRIPT

ANDREW HOBOKAN
INTERVIEWED BY CAROL BUTLER
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BUTLER: Today is September 12, 2000. This oral history with Andrew Hobokan is being conducted for the Johnson Space Center Oral History Project at the offices of the Signal Corporation. Carol Butler is the interviewer and is assisted by Kevin Rusnak.

HOBOKAN: …John [F.] Yardley was McDonnell's [Aircraft Corporation] kingpin at Cape Canaveral [Florida]. That's Cape Canaveral Air Force Station, not KSC [Kennedy Space Center]. There's a difference between the two. Anyway, Yardley was down. The launch group had some pretty aggressive people on the staff. G. Merritt Preston, for instance, you've probably heard of him. He was pushing a good launch staff, okay, but he was also wanting to take over other people's functions, and he had a good test team. He had a couple of men there like Ted [George T.] Sasseen, who was very good at test. I enjoyed working with him in his career at KSC.

But we never had a full spacecraft in [McDonnell at] St. Louis [Missouri] because the KSC guys like Preston would get on Yardley and say, "Hey, look. We've got to have the instrumentation to see if we can [unclear] the blockhouse." So without the instrumentation at St. Louis, you could never really check out the vehicle. So we tested as well as we could, and then the vehicle was shipped to KSC, where they put the instrumentation package and they did the altitude chambers test with the crew. They did the complete check-out and put it on the launch vehicle and launched it.

So basically a large part of this task of finishing the spacecraft was done by KSC. When it was launched, people at St. Louis were aghast at some of the temperatures and pressures they were reading, because where they designed the instrumentation in—gosh, KSC, with John Yardley, moved it where they thought it ought to be. So you thought you had a temperature sensor around the heat shield, it might wind up around a parachute box, okay, the parachute container. So you never knew when you launched it whether you were going to see what you expected to see, and that was very frustrating to the design people in St. Louis. This information never flowed back into St. Louis before the launch.

So there was a big flap in St. Louis about how do we fix this problem? The big hue and cry was, "We'll get John Yardley out of there," but they weren't ready for that yet. They weren't ready for that major move yet. They really needed him down there because he was well in with the launch people and was a pretty good manager down there and was taking care of things very well.

But then after we launched—I guess it was after we launched Gus [Virgil I.] Grissom, McDonnell pushed for the Gemini Program to do a bigger job. Now, here was a case where President [John F.] Kennedy had said, "Let's land a man on the Moon and return him safely to Earth." Well, that started Apollo.

Just before that—well, let me back up just a little bit. During the course of the Mercury Program, the Space Task Group opened an office down here on OST. It was a realtor's building that was taken over, and it had maybe eight or ten little offices. So some of the Langley people came to OST, and I came down there a couple of times, and it was a little small operation. Then toward the time of Mercury, where we were launching people after [John H.] Glenn, they moved to I-45, out to this little oil derrick place on I-45. That was a lot space for a lot more

people so it was expanding. If I remember correctly, that's when Apollo started and Mercury was phasing out.

But when Apollo started, the job was formidable. McDonnell came in with a proposal, had come in with a proposal as a follow-on to Mercury going to the Gemini Program, two men in space. It became the pathfinder, really a pathfinder for Apollo. As Apollo was being formulated, things like docking came up. So Gemini was given the assignment, you know, do a docking. Things like firing a rocket in orbit came up, so we had the Gemini Centaur, I think it was, Gemini—

BUTLER: The Agena?

HOBOKAN: Agena. Yes, the Gemini Agena came up, so we would demonstrate that you could fire a rocket in space and you could rendezvous with it, latch onto it, and that kind of thing. So Gemini was doing the pathfinder work. For instance, the heat shield for the CSM [Command and Service Module] came out of the Gemini heat shield. We made samples of the Gemini heat shield, oh, two and half inches or three inches thick, and delivered them to [North American] Rockwell. Then you see the honeycomb appeared on the outside of the command module. But that was the way the heat shield was made on Gemini.

After the fire, we delivered all the latching mechanisms for the hatch to Rockwell, and they made a hatch similar, a quick-opening hatch. But then we found out on Gemini we didn't have a quick-opening hatch anyway. The hatch lever had to be cranked, and you had a pole. You had to move a pole to, say, latch it closed, and you had to move it to neutral in flight, and then when you want to open it, you had to move to "open" and rachet it open. So we didn't

have a handle where you could hit it and the hatch opened. But we did have the ejection seat concept, and we didn't use the escape tower.

So Gemini did many of the things that contributed to Apollo. It really was pretty good pathfinder. When the Gemini Program was ending, we proposed to go out and get a big rocket and do a large Earth orbit, and that proposal got shot down, but the fact that there weren't any lunar modules, the Apollo did it. It [Apollo 8] went around the Moon on that Christmas Eve. But we were planning do that, we really were.

The time that we were building the Geminis, we really got well into the quality and the reliability and the safety aspects of the space program. Things were going on down here at JSC [Johnson Space Center, Houston, Texas], and they were forming the SR&QA [Safety, Reliability, and Quality Assurance] department down here, and they were adopting a lot of the things we were doing and embellishing the things we were doing. So we developed a whole SR&QA operation via the Gemini Program, and then it was applied to everything else.

The Gemini Program was really an interesting program. We did, like on GT-IV [Gemini-Titan IV], Ed [Edward H.] White's first EVA. It was interesting that nobody had opened the spacecraft up at high altitude in an altitude chamber. I was saying we ought to go and test this concept. We starting writing a procedure for opening the hatch and checking the EVA capability of the suit and so forth. But he wasn't going to get out. It was a case of just opening the hatch in that environment and have him go on an umbilical and wave his little propulsion system around. But word got out and we got a call from Dr. [Robert R.] Gilruth to "Come down to Houston and explain what you're doing." [Laughter]

So I got the job of coming down here to make a pitch to Dr. Gilruth and the team at what was now Manned Spacecraft Center [Houston, TX, later JSC]. Dr. [Charles A.] Berry was

there, and Dr. Berry was objecting to us doing this in the altitude chamber. So I said, "If you're afraid to do it in the altitude chamber where I have complete control of everything, what makes you think you want to do this out in space where you don't have any control?"

Well, Dr. Gilruth said, "Let's take a little break here," and he says, "Dr. Berry, I'd like to see you in my office."

Five minutes later when they came out, he said, "Dr. Berry's got something to say."

Dr. Berry said, "I don't think we ought to do this out in space unless we first do it under good controlled conditions."

So I got to go home and we got to set up the altitude chamber for that. Then we put all of the crews through that. We never had a problem. There were three things that really were worrisome. Number one, if you aborted somebody during this operation and you blew the altitude chamber all the way down to the ground, you broke his ear drums, you know. If you really did that to crew members, it's a bad thing. So in development our procedure we had a—the spacecraft was at 5 psi [pounds per square inch]. That was equivalent to about 30,000 feet of altitude. So we put an addendum to the chamber. At 30,000 feet it was at 5 psi. So now we put a rescue crew in there—a medic, a doctor, and the rescue crew, and these guys were there all the time. When Ed White was going up, they were in this 30,000-foot altitude chamber.

We had an abort mode that we could blow it to 5 psi, and these guys could get in there and then take them out, and then they could lower them down in that little altitude chamber while they were taking care of them. The abort mode that blew them all the way to the ground, we never planned to use it, but it was a last resort.

We didn't have a problem until Dick [Richard F.] Gordon's flight. I think it was Gemini X. We got Dick Gordon up there at high altitude, and we opened the hatch. I think the test

conductor guy's name was Parker. He was a McDonnell employee. Dr. Hawkins and I were listening on the earpiece. Dr. Hawkins was listening to heart beats, heart rates, whatever the doctors did at that time, and I was listening to some of the technical stuff. Suddenly I hear somebody say, "Suit pressure, 4.8. Suit pressure, 4.6. Suit pressure, 4.4."

And I got up and I went over to the test conductor and I said, "You're hearing this?"

He said, "Yes."

I said, "What abort mode are you going to pull?"

He said, "30,000. You do it to 30,000 feet where we got the crew."

And I said, "No less than 3.4 psi in that suit." That's equivalent to something less than 62,000 feet. If you get to 3.2, I believe it is, your blood boils. You'd kill him anyway.

So, anyway, the suit pressure was coming down, and the engineers were trying to figure out what was going on. Finally it got low enough, he looked at me and I looked at him, and he aborted.

So we got Dick Gordon out there, and his arms are wide like this because of the suit pressure, and somebody said, "Hey, there's a wire missing out of the umbilical." The wire that's supposed to carry the suit pressure wasn't in the JSC-supplied umbilical. It was a Manned Spacecraft Center-supplied umbilical. So when he switched it, all we had was the energy drooping down from the spacecraft plug-in, all right. He was there at 30,000 feet and everything was all right, and I said, "Dick, do you want to go back up?"

He said, "No." He said, "You guys do the rest of it unmanned." So that was the only problem we ever had in the altitude chamber, and it was benign, but it scared the heck out of a lot of us.

We put twenty-four crews through there, I believe, yes, twenty-four crews through that altitude chamber testing it, St. Louis, but we delivered spacecraft that were really finished, not like Mercury. They were really finished and they flew well, and we had a great rapport between the contractor and the resident office. Now, we had a good staff, good staff, and the president, Walter F. Burke, and I became great friends. We argued a lot about design and we argued a lot about his facilities. I'd get questions from him that said, "Whose facility is this, anyway?"

On Gemini we had a problem when they brought up rendezvous, and that's the first time I heard of "launch window." I said, "What do you mean, launch window?"

"Well, we have to launch in a short period of time to be able to rendezvous with the target without burning a lot of fuel."

I said, "Gee, you know, we're sitting down here with all of our equipment. Somebody's turning a knob. Somebody's reading it. Somebody's writing it down. How are we ever going to launch in a ten-minute window? It takes us ten minutes just to make one measurement."

So I started looking at automatic test equipment for that period of time. Anyway, we did a lot of phone calling, and the Air Force had a plant out in Titaboro [phonetic], New Jersey, that was making a tape machine for automatic checkout of a rocket. I think it was Minuteman or something. I said, "Gee, it would be nice if we'd get one of those machines and see if we could do it on the Gemini Program." We had a priority that was higher than the Air Force when I've checked into it. We had a DX-A2 or something, and the Air Force program was a lesser priority.

So I got with Art Atkinson, and I said, "Art, place an order for one of those and use our priority." Well, they pulled the ones off the production line and shipped it to us in St. Louis.

We had a compatibility test unit which was like a Gemini that we could test the interfaces and all of the stuff.

Anyway, about three weeks after we got it, one of the secretaries come out and said, "Dr. Gilruth's on the phone. He wants to talk to you."

Well, the Air Force found out that we had pulled that unit out of their production line, and they had filed a big complaint with Dr. Gilruth, and Dr. Gilruth read me off up there, and he said, "Don't you ever do that again."

But shortly thereafter, I got a call. I was made part of a team to look into automatic checkout. So based on that, they had gotten some KSC guys and some people from MSC and myself and a couple of Air Force people, and they said, "Go look at this thing of automatic checkout."

Well, the team flew to, I think it was Boeing was doing some work, Lockheed [Aircraft Corporation] was doing some work, General Dynamics [Corporation]was doing some work. So we got to fly around the country and see what people were doing in the way of automatic checkout. And we still piddling with this tape machine there in St. Louis.

The team decided if we're going to do this, we ought to do it with computers, not tape machines. So the team decided they were going to buy two computers, or four computers, from CDC, Computer Data Corporation. They bought the computers from CDC. They went to MSC, and the people started playing with them, looking to see how they could do automatic checkout.

Well, Chuck [Charles W.] Mathews was the manager of the Gemini Program. The computers cost a lot. The people, the employees cost a lot. I think the bill hit 14 million dollars, and he said, "I can't afford it anymore," which was a pretty astute move, because it was eating

up project money. KSC people made a pitch to take the equipment the way it was, all of it, and they would continue to go for automatic checkout because they also had the problem on this launch. You know, it wasn't only the contractor who had to supply the equipment; they had to do it.

There was a guy named Jake Mosher [phonetic], worked for G. Merritt Preston, and they hired General Electric, and they went with these computers, and, by janes, they worked on it and worked on it and worked on it. When Apollo came, they had an automatic checkout system that GE could supply for Apollo. So the system turned out to be automatic checkout for Downey [California, site of North American Rockwell] and Grumman [Corporation] on the lunar module [LM], so that it all wasn't for naught. Chuck Mathews put in 14 million to get it started, but the KSC guys really came through and for the Apollo Program we did have automatic checkout.

But it was in octal. I go down there and look at these lights. You had to read octal, and the guys who did it every day could read octal, okay. An octal is when you have four lights in banks of four. Each one gives you a number when you look at the bank of lights, whichever ones are on or off that gives you the number for that batch. Well, the people who use the machine were very comfortable with it. They could read that stuff. They named it the ACE, Automatic Checkout Equipment. So it was called the ACE.

Then KSC used some of those concepts on the launch site, and we, in turn, up in the latter days of Gemini had some of the concepts put to use there. So we were all leaning toward this thing that is now called the LPS, the Launch Processing System at KSC. So that was a real big development that came around. LPS got a big push, because the people at which is now JSC were developing a system called the UTE, called U-T-E, Unified Test Equipment. It was

supposed to be helping the factories, but like when you fill a tank, you see the tank fill up, they had visual displays as well as accurate measurements of everything. It showed you when the fuel flowing through the lines as valves were opened. It was real interesting setup, but whether how practical it was, you know, and it was another colored horse.

But we spent a lot of money. I was spending money with them to develop this system, and finally KSC said, "Hey, that's our job, really." So the UTE concept was given to KSC, too, and the LPS came out of that thing. The LPS, Launch Processing Systems that's now in use, was also helped from the development of the UTE here at JSC.

So that got everybody on the automatic checkout world. On Apollo, everything was automatic down to two minutes, and then you have an automatic sequence from their autosequence. It has enough checks and balances so that if it sees something wrong, it can stop it. The space shuttle uses the same concept.

Well, anyway, after Gemini was over, we were building the airlock tunnel in the instrument room for Skylab, and these things were being built in St. Louis. We had all kinds of problems. I've got all kinds of samples of when you stow equipment—I don't think we had velcro at that time—when you stow equipment for launch, the astronaut has to be able to get it out of there. So we had all kinds of long-handled wrenches and things that we were practicing with to try to find a way that you could have the equipment secured for launch, but then easy for the crew to get out afterwards. It was fun developing all of this. We'd go down in a tool room and have people make tools for us, and we'd try them out and junk them by the sixes. You know, you very seldom hit on a good idea right off the bat. You try some things and slowly you evolved the one you really want to use.

But it was this time that I got a call to—well, the fire happened. The Apollo problem happened, okay. My boss, Wilbur H. Gray, got transferred to Downey to be the resident manager at Downey. In those days, we called the office the RASPO. We had the ASPO here at JSC, Apollo Spacecraft Program Office, but the resident offices were Resident Apollo Spacecraft Program Office. So Bill Gray got assigned to Downey. Bob Ridenour [phonetic] shot himself or something, but I guess you got that in your record somewhere. Okay. Well, Bill was assigned to take over that job. That was before the fire. That was before the fire.

Anyway, Bill was trying to find a house, so he called me one day and said, "I don't want to leave the office empty for a week or so while I'm looking for a house. Could you come out here and sit in for me?" So I did that. I jumped on an airplane and I went out there and I sat in his office for a few days while he was out house-hunting. He had in his office a TV set. The TV set was always on. It was hard-lined, and it was always on. I heard somebody say, "Ed White was here," and I looked up at the TV, and, hell, here is a group of people out there with your cameras and—probably that's why I'm shy of some of the cameras—they were saying this guy was laying, you know, like this in the seat and this guy was over here.

I got up, and suddenly the guy said, "We're coming to you from the mockup room at Rockwell International in Downey, California." I got up out of my seat and I ran to the mockup room, and there they were, photographing all of this stuff, and I thought that was pretty raw. This was only like a day or so after the fire, and these guys are putting this out on TV. So I said, "I want this operation shut down."

Well, the Rockwell said, "Who the heck are you?"

I said, "Right now, I'm the resident manager."

So they said, "Well, we have permission from the company to do this. This is our building."

I said, "It's not your building. This is my building." NASA owned that building, so I said, "This is our building. It's not your building."

The guy said, "We got the permission from the President to do this."

I was standing next to a fire ax on the wall. I reached out and I picked up the fire ax, and I raised it up. I said, "You either shut down, or I'm going to give you your cables in one-foot lengths." Those cables are about that big around [Hobokan gestures], and I know they're costly, because at Patuxent [Naval Air Station, Maryland] I had what they called a peanut system from Dumont [phonetic], and I knew how expensive those cables were. Finally the guy shut it down. But I was going to cut those cables.

I got back to my office, and I wasn't there five minutes when the phone rang, and, of course, it was Dr. Gilruth again. He said, "Why am I always giving you hell?"

So I said, "I shut it down," and I explained to him what was going on.

He said, "Well, it's good you shut it down. Keep it shut down. Don't let them do that." So I got over that hurdle, and it never came back on the air again.

Then Bill got his house and I went back to St. Louis. I hadn't been back very long and I got this phone call from Marilyn Bockting down here. Marilyn Bockting happened to be George [M.] Low's secretary. She said, "Mr. Low wants to see you this afternoon. Can you get on an airplane and get down here?" Well, I didn't work for him. I worked for whomever was doing the Skylab, and I think that at that time it was Bob [Robert F.] Thompson. So I was working for Bob Thompson. What the heck does George Low want?

So I got out my TR [travel requisition?], book of TRs, and I went on an airplane, and I came down here. I got down here about four o'clock in the afternoon. I knew something was up, or I should have known something was up. Marilyn Bockting handed me a cup of black coffee, closed the door on her way out, and I go, "For crying out loud, here I am in trouble again." I wondered what was going on, because I didn't have anything to do with Apollo other than supply those items that I told you about, the heat shield and so forth. Now what was this all about?

So stop here a minute. There was a guy named General Carroll [H. "Rip"] Bolender. He worked for George Low. He had called me once before and he asked me to go take a look at a manufacturing company out in California that people at JSC said were doing a lousy job. He said, "I want a second opinion. You go out there for me and look that over."

Well, they were doing a great job. Just the fact that JSC wasn't helping them, JSC wanted to change contractors so they weren't helping, and they were allowing them to do welds which were called unauthorized welds. Now, they weren't unauthorized welds at all. The weld procedure was agreed to by Grumman, who was the procurer of those tanks, okay. JSC never approved of the weld procedure, so they called them unauthorized welds and gave the company a bad name, okay. The company's name was Air-Right [phonetic], I believe. Gave them a very bad name.

Anyway, I thought the company doing a bang-up job, so I told Bolender. But the tank, they continued to make the tanks and when they did some testing on the tanks, the tank burst, not because of the welds, but because of the water that they used. It caused hydrogen embrittlement of the titanium tank, and the tank burst. We didn't have very good fraction mechanics approach at that time. I have to come back to this tank later.

Anyway, after I did that for him, he called me one day and he said, "I want you to take a check on the Grumman operation. You got a task there with the Skylab stuff, but can you spare some people to go to Grumman and do a check on how the Grumman operation is going?"

So I sent five people out to Grumman under Bill Nesbitt [phonetic]. Bill Nesbitt was one of the original people on the STG. They were there about a week, and I got this phone call that said, "I want to come home. We can't do anything here. We're not learning anything."

I said, "What do you mean?"

He said, "Well, we can't get schedules. We can't get drawings. We can't look at work orders."

And I said, "But you guys have all the authority you need to go do this stuff."

He said, "Well, the company won't cooperate."

I said, "Stay there. I'll get on an airplane and I'll come out and see what we can do."

So I flew to Grumman on a Thursday, I guess it was, and I got with my guys around the table. They were all telling what they can and can't do, and so I said, "Well, let's go en masse. We'll just go out there and talk to the people."

So we got out there and we tried to talk to the people. We tried to find drawings. They didn't have them. That's why they couldn't cooperate. They didn't have everything that they needed to do to build these lunar modules. So I stayed.

General Bolender came up that night, and I called him and told him that things were really, really bad, that I don't know how they knew what they were doing. So Bolender came up, and we went out to dinner Friday evening, and we were just talking about things, and I said, "Well, I'll go home in the morning and then I'll write you a report."

He said, "Oh, no. I don't want you to write a report." He said, "I made arrangements. Seven o'clock tonight you're going to talk to the president and the board of directors and all the vice presidents at Grumman." It was like an hour from now. He said, "I don't want it written down. I want you to tell them."

So I said, "Okay." I went in that conference room, and their big senior vice president was a fellow named George [F.] Titterton. George Titterton, and I'll come back to him later, but George Titterton was, I believe, the senior vice president at the time. I told them what I thought, they didn't know what the hell they were doing; they didn't have schedules; they didn't have procedures for anything; they didn't have work orders; They didn't have a quality program. You know, I went through the whole smash of why they were so far behind. They were years behind in the development of the lunar module. I thought George Titterton was going to have heart attack right there. I could see his eyes going and going and I got worried about—but I laid it on the line.

Lew [J.] Evans, the president—[E. Clinton] Clint Towl the chairman of the board, when I got through, Lew Evans come up there and says, "I know exactly and I understand exactly what you're telling us." He said, "I wish I could fix it."

Clint Towl said, "Yeah, we've got a bunch of people here that are really great, but we don't have the quality system or anything else that can make it even greater." He said, "But we get along. We build our airplanes."

Well, I was sailor in World War II, and Grumman was supplying the airplanes for the war, and my home town had the biggest General Motors manufacturing plant in the country. It was the Linden [phonetic] Division of Chevrolet, Pontiac, and whatever the other one was. When you bought a car, if you had it made there, you could pay the workmen a couple of fifty-

dollar bills, and you're get four coats of paint instead of one. You know, it was one of those operations. It was so big that you could get anything done in there that you wanted as long as you paid for it.

Well, Grumman couldn't produce the airplanes for the war, and they took over the General Motors plant and converted it to Eastern Aircraft. All right. Now, there's some connections here. George Titterton was assigned as the contact to Eastern Aircraft, and Eastern Aircraft was to build the TBM [Avenger, a torpedo bomber], the F-6F [Hellcat], the F-4F [Wildcat], and whatever else the Navy needed, okay. I had just graduated from high school and entered the Navy. I was too young to go by myself, so my father had to sign a waiver to let me get into the Navy. But the friends from home—I saw them once and a while or wrote to them once in a while.

Then I met Mr. Walter Burke, who was senior vice president at McDonnell when I first got there. All right. Then when I got know Walter Burke a little better, I found out he was the chief engineer at this Eastern Aircraft Corporation. Okay, so he knew George Titterton, who was the interface. Then I got the whole story. Between my schoolmates at home and the story from Walter Burke, Grumman couldn't produce the airplanes fast enough because you couldn't stamp out parts. You couldn't mass produce parts. Each one was hand-made.

So Eastern Aircraft tried to mass-produce the parts like they do in an automobile. They had to loft the airplanes and design them from scratch so that they knew the size of all the parts. The drawings from Grumman—no dimensions on most of them. The guy cut the part to fit, you know, drill the holes. Okay.

Anyway, so Walter went through that at Eastern Aircraft, and they built—oh, in order to loft it, they had to have dozens of people to measure the parts and fit, and all the children, all my

graduate mates were hired by this Eastern Aircraft to do that job. So every time I got a letter from some of my friends, they would tell me about all this work they were doing to loft the airplanes. Well, the kids—I call them kids, we were kids in those days—they did the job and Eastern Aircraft pounded out 33,000 airplanes in three years. That was a hell of a lot of airplanes.

If you remember, the four airplanes, or three airplanes, that went in formation under the George Washington Bridge, they came from that factory. The pilots came over and flew them off to Mitchell Field in New York, where they were processed to go onto the carriers and so forth. These guys decided to fly in formation under the George Washington Bridge. I think all of them got court-martialed in some way or other, but they went under the bridge in formation and came out the other side and delivered the airplanes. But that's the story of the status of Grumman.

Now, all this time while Eastern Aircraft made 33,000 airplanes, Grumman made less than 3,000. So you see the difference between a good production operation and a cut-to-fit-and-paint-to-match operation. Anyway, that is the background I had when he asked me to go to talk to these high wheels from Grumman. So I knew the company better than most people, knew because my classmates were the people who took that stuff and made it work.

Anyway, after that, I went on home, went back to doing the job on the Skylab. Well, one Friday—I'm going back to Marilyn Bockting now—I got this call from Marilyn Bockting. I went around in a big circle. Anyway, I got this call from Marilyn Bockting, and I got down there at 4:30. I didn't know what he wanted to talk about. I thought maybe he wanted me to tell him what I had told the people at Grumman, but not what he wanted at all. I sat there and he told me. He told me that he was losing control of the command and service module out at

Downey because Eberhard Rees and his hundred merry men were out there. They had gone into Downey to fix the problem, okay. Bill Gray was out there with his JSC team, but now Eberhard Rees, who was the director of Marshall, took his engineers and went out there to oversee the program, because now they were through with the Saturn V launch vehicle. They had a lot of men leftover and not too much for them to do, right? So they decided they were going to go out to Downey. So they were making changes. He said he couldn't keep up with the changes they were making. They were spending money like mad and couldn't account for the dollars, and Bill Gray was frustrated and couldn't do anything either.

So he said, "I'm losing control of the CSM program, and if we're not careful, we'll all be working for Marshall." Then he got on the lunar module. He said, "I heard what you said about the lunar module." He said, "We can't let Marshall get a foothold in the lunar module, because then they'll have the Saturn V, they'll have the CSM, they'll have the lunar module. What's there left for JSC to do?" Anyway, it had him really worried. Then he said, "Right about now your wife is getting a telegram transferring you to Grumman eight o'clock Monday morning."

I said, "Ye gods, I ought to be there, you know. Why am I down here and you sent a telegram up there?" I said, "She reads that thing, she's going to have a conniption."

Anyway, he said, "What are you going to do?"

I said, "Well, if you want me at Bethpage [New York, site of Grumman plant] eight o'clock Monday morning, that's where I'll be."

Then he said, "But we have a manager up there. What do you want me to do with him?"

I said, "If you can transfer me between now and eight o'clock Monday morning, you sure as hell ought to be able to transfer him. So I don't want him there when I get there. You

can't have two managers in a job at the same time." So they transferred the manager out to the West Coast with Eberhard Rees on a special assignment.

So, Monday morning I appeared at Grumman. Well, I was there, I think. Introduced myself around to everybody. Since I had made that talk, I knew all the big wheels at Grumman anyway. So I took over the office. I think I was there three or four days. NASA had just had a big acceptance review of lunar module number two. After I was there about three or four days, the secretary said, "There's a whole bunch of NASAs here that want to talk to you."

Well, the first thing that came to my mind was [they would be asking], how do I get out of this chicken outfit? I sat there for a few minutes, and I said, "Well, my answer's going to be, you don't. Not until I'm ready for you to go."

But when I had them come in and sit down, that's not what they were there to tell me. They were there to tell me that LM 2 was not flight-worthy. And I took off. I said, "You're responsible for this LM. You're the guys that are here, supposed to make sure that everything goes right. Now you're sitting here and telling me it's not flight-worthy?"

They said, "That's right. We won't consider it flight-worthy."

I said, "But NASA's already accepted it. It's sitting over there waiting to be shipped."

"We want you to call George Low and tell him it's not flight-worthy."

So I reached out and picked up—after a good bit of argument, I finally reach out and picked up the telephone. If all of these guys are saying this, you know, there must be something to it, and I wasn't there long enough to know. So I called him, and I explained to him about everybody in my office here, they're telling me this vehicle is not flight-worthy. I said, "I don't know what to do except to tell you."

He said, "I don't know what to do either." He said, "Why don't you go and conduct your own inspection? Then you call me back and tell me."

So I took two days and I took all of these guys down there and said, "Now, show me what you're talking about." Sure enough, it was a mess, you know, wires going over sharp edges that won't last a launch, and the workmanship was terrible. Every place we went, it showed me fluid lines not tied down right, wire harnesses not tied down right. Finally after two days—oh, then we got into the checkout. They started telling me about the test history. Well, Grumman was manufacturing when they had parts. If they didn't have parts, then they did testing. Then when they got some more parts, they did some manufacturing. When they didn't have parts, they did some testing. So you never tested a whole system. In fact, they tested some systems and then found out they got parts that had to go behind and, instead of taking those systems apart, put those parts in. It was really a slipshod opportunity.

I finally called George Low back, and I said, "I agree with them." I said, "Why don't you just tell me to scrap it. I'll have the QC [quality control] guys write a MRR [material review report] and we'll designate it as scrap."

He said, "No, no, no, we can't. We'll make a big problem here and we'll get more Marshalls." He said, "I'll tell you—let me think about it."

He called me back a couple of days later, and he said, "I think I've got the solution." He said, "What we'll do is we'll ship it to JSC. I always wanted to do a drop test." This had honeycomb for shock absorbers and stuff, those big boots down at the bottom, and so forth. He said, "We'll ship it to Houston. I always wanted to do a drop test." He said, "We'll drop it and we'll test the landing gear strength and all of this kind of stuff, see what else goes wrong. Then we'll clean it up a little bit and we'll ship it to Japan for the World's Fair. They want a display

from Apollo on the World's Fair in Tokyo." He said, "We'll ship it to Tokyo and that'll get it out of the system."

I said, "You're right. That'll get it out of the system," and I said, "I'll be happy with that." So that's what we did with LM 2. So the team there was satisfied that nobody was going to get hurt flying that thing.

I guess I was there another week or so, and Lew [Lewis R.] Fisher—I guess you've talked to Lew Fisher already.

BUTLER: No, we haven't yet.

HOBOKAN: Lew Fisher was my deputy for engineering up there. Tony [Anthony L.] Liccardi was the deputy for test operations for me. Two great guys. So I was there about a week or ten days when Lew Fisher came in, and he said, "A big problem."

I said, "What now?" Grumman had mounted the docking tunnel on the roof skin of LM 3, but they had it indexed 180 degrees from where it was supposed to be. So I said, "Come down. I want to find out how this happened." Well, the workmen couldn't interpret the drawing. I said, "Well, where's the work order that tells you how to index this thing?" No work order. I said, "Well, where's the inspector?"

And the inspector says, "Hey, if they can't interpret it, I can't interpret it."

So I got Lew back in the office and we said, "What's going on here?"

He said, "Well, the Navy is the cognizant plant."

I said, "Oh, déjà vu all over again, just like the Leo Durocher [phonetic] said."

He said, "The Navy's got cognizance of this plant." And that was that. I had the contracting officer right there, right next to my office, so I walked out the door and into his office and I said, "I want everybody on that NASA payroll whose salaries are being paid for by NASA transferred to my office for the day-to-day operations right now." Well, he was delighted to do that. He didn't like the Navy guys anyway. The Navy guy, I tried to talk to him, and strangely enough—when I talked to him the last time, he said, "Look, I'm retiring in a month or so, and I got a good job lined up with Grumman. I don't want anybody making waves while I'm on my last month here. I got it knocked, and don't screw it up for me."

So when I got to Frank Battersby [phonetic]—he's dead now, but he was my contracting officer, and Frank didn't like the Navy guys anyway, so when I said, "Transfer all of those people to me," he did it. He jumped right on it, and the next morning I had all these Navy guys now that were NASA guys. I had a QA [quality assurance] manager named Harry Briggs. Harry Briggs, I think, passed away two or three years ago, maybe a little more. But I sat down with Harry and I said, "Look. Now you got this whole staff. You didn't have this responsibility before, but now you got this whole responsibility. You got all these inspectors. You assign them their jobs. You got complete control of it and I want a quality job."

He said, "How about the Grumman QC?"

Well, the Grumman QC guy's name was Joe Kingfield. So I said, "Get Joe and you and him come into my office."

Well, when I talked to Joe Kingfield, Joe Kingfield said he reported to the project manager, which was Joe [Joseph G.] Gavin [Jr.], Vice President Joe Gavin, and he [Kingfield] said, "If I raise a ruckus, he'll fire me."

I said, "You're not going to report to Joe Gavin. You come with me."

So Harry and Kingfield and I went over and we walked into Lew Evans' office and I said, "Lew, tell this guy he works for you and that Joe Gavin can't fire him, that you're the only person that could fire him, and you're not going to fire him without my permission." I said, "You tell him that right now."

So we all sat down and had a cup of coffee with Lew Evans, and Lew Evans said, "That's the way it is, Joe. Now you work with the resident office, the RASPO. You work with the QA people and you do the bang-up job that they want done."

So, anyway, I felt pretty good, and I went home and had a couple of good cocktails. Next morning I came to work, the phones were ringing everywhere, and the secretary was jumping up and down. She said, "I'm glad you're here. George Low's been calling and calling and calling for hours." He must have started calling at five o'clock.

I picked up the phone, and he said, "What did you do?" Here it comes again.

"What did I do?"

He said, "Yes, why did you shut the plant down?"

I said, "I didn't shut the plant down."

He said, "Well, the whole plant's shutting down. Everybody's calling down here and saying you've got the whole plant shut down."

So I said, "I'll find out and I'll call you back."

So I went out and I got Harry Briggs. I said, "Harry, what's going on?"

He said, "Those new inspectors have everything shut down."

I said, "What do you mean by that?"

He said, "They must have had a bushel basket full of stop work orders, and the stop work orders says," you know it's a federal offense if you work on this job while this tag is hung.

They must have had a bushel basket full of those tags and they had on every job that they didn't agree with, which was, you know, ninety percent of the work.

I said, "Get Joe Kingfield and then we're going down. We're going to talk to the inspectors."

So he got Joe Kingfield, and the three of us went down. The first tag I saw there, I stopped and asked the inspector why the tag was there. Well, no drawings, no work order. Well, that's a good reason. Go to the next one. No drawings, no work order. Go to someplace else, he's got a red-line drawing all marked up. After I got through with all of this, I said, "These guys are right. You know, they should be handing those tags."

So I got up there and I called George Low back, and I said, "George, these guys are doing their job. They're right, and it's just a shame that, you know, it all happened at once because the whole plant is shut down."

He said, "Well, see what you can do about fixing it as fast as possible." The LM was already years behind schedule at this point, and I know he's tearing his hair out.

So I went to the planning office. The guy, head of production planning and scheduling was a guy named Bill Going [phonetic], an ex-basketball player. I said, "Look, your corporate policy says you take a drawing. It's a released drawing. It goes through production planning. You guys write the route cards, the work orders. QC then takes those things and stamps them that they're ready to go to work. They get the parts and all this kind of stuff. Then you do the work and you stamp it off. That's the way your policy is, and that's what you're going to do."

And he said, "Okay."

But three days later, nothing happens. So I go to see him again, and he said, “Andy, we can’t do it. We just don’t know how. We’ve never had to do it before and we don’t know how.”

I said, “Go hire a company and get it in here, and then while they’re doing it, you can get your people OJT and then you can get the company back out of here.”

Well, about three days later I’m still hearing from George Low every day and I keep telling him, “Give me some time. Give me some time. I’ll fix it. I’ll fix it.”

And suddenly they’re in my office. One Friday afternoon walks in Lew Evans, the president of the company, and he sat down and he said, “If you want these people trained to do the job the way it should be done, then you’re going to have to train them yourself.”

I drank that in and I said, “Oh, my, you know, I can’t train all these people. Just beyond the scope of what I’m going to do.”

So we talked for a while and he said, “I tried to find a company to do this. I talked to other companies to see if they could spare some people. I haven’t been able to do anything. But my back is against the wall, and I've got to get this production going.”

So I thought about it for a while, and then I walked out to my secretary and I said, “Get me Walter Burke on the telephone from McDonnell." It was now McDonnell Astronautics in St. Louis. I said, “Get him on the phone. Tell him it’s important that I talk to him.”

So she came back in. I had a speaker phone and I wanted Lew to hear the conversation, but I told him, "Don’t say anything. Just listen." And I punched the button up.

After pleasantries and so forth, I said, “Walter, I’m in trouble.”

He said, “What are you in trouble about?” So I told him about the situation.” He said, “What do you expect me to do?”

I said, “I would like for you to train the Grummans in your position planning operation so that we could use that here.”

He never cusses. He’s a Lutheran minister. He never cusses, but you sure know when he’s cussing you out with some nice words. He says, “They’re our biggest competitor. We’re not going to do it,” and a whole bunch of other stuff.

I said, “Walter, I know you can’t do it on your own. What I want you to do is go up there and tell Mr. Mac [James S. McDonnell, Jr.] I’m in trouble. I’m trying to head off a problem in orbit or on the surface of the Moon or on the way back to the Earth. Tell him I’m in trouble. I need his help.”

He said, “I don’t like it, but I’ll do it for you.”

Well, Lew Evans and I sat there for another half hour or two or more, and the secretary walked in and said, “Walter Burke’s on the phone.”

So I punched the speaker phone button, and I said, “Hello, Walter."

And he says, “You got to be the luckiest guy on in this whole world.”

I said, “What do you mean by that?”

He said, “Mr. Mac told me that that program is so important to this country that if you’ve got a problem, I’ve got to fix it.”

So I said, “Thank you."

And he said, “When do you want to do this?” Now, this is Friday afternoon, remember, about three o’clock. He said, “What do you want done?”

I said, “I want you to train these Grummans in your position planning scheme so that they can do it here on this lunar module program.”

He said, “That’s a big order."

And I said, “Sure.”

He said, “When do you want to start this?”

I said, “Eight o’clock Monday morning."

And he said, “You’re not giving me much time.”

I said, “Walter, I don’t have much time."

And he said, “Okay, eight o’clock Monday morning. How many people do I plan for?”

Right off the top of my head, I said, “Fifty."

And he said, “All right, I’m going to expect fifty people eight o’clock Monday morning in St. Louis. You make sure you get clearances for all those people here, and we’ll be ready for you at eight o’clock Monday morning.”

Now, Lew’s sitting over here and he’s dazed, and I said, “Lew, Lew, Lew, can you get this done?"

And he said, “I think I can. I’ll get on it right now.”

And they packed up fifty people, got them to St. Louis, and I put my TRs in my pocket, I figured my passport’s there [in St. Louis] and if I have to leave the country, at least I can go get my passport.

So, anyway, I went over there and I came into the planning room for McDonnell. It’s like a big auditorium. I’d say it’s twenty times, thirty, forty times this space. Had a hundred desks in it. Bill [William] Dubusker, their manufacturing manager, always maintained no papers on the desks when you leave. He kept the greatest planning department you every saw. No paper on any desk ever when they’re not working. Anyway, all these desks empty, and standing at each desk were two chairs, and a McDonnell guy was at each of the desks. When the Grummans started coming in, they asked about QC, whether you’re production planner,

you're a production scheduler, you're an estimator, whatever, and they paired them off. Every McDonnell vice president was there, and it was tremendous thing.

I took one look at that and I said, "I can't do any good here," so I went over and said, "So long" to Walter. I said, "I'm going back to New York. How long are you going to keep these guys?"

He said, "I have it planned for two weeks."

I said, "Okay, I'll be back in two weeks."

So I went back to New York, and the plant is quiet. Nothing is going on on the lunar module program. All these damned—every time you walked down there, all you see is these damned tags hanging on everything, see the NASA inspector standing around, nothing being done.

When the two weeks was over, on a Thursday night I flew back to St. Louis and I called Walter, and he said, "Everything went great. I think they really are having second thoughts about the way they're working and they look like they're going to work the way we're training them to work."

So I got my wife and I said, "Look, throw a party tomorrow night. We've got to throw a big party for the Grummans and the McDonnells and finish this thing properly." So she threw a big party that night. We had a room half as big as the planning room. So we had a big party there. She'd cooked four or five turkeys and hams and stuff. The neighbors were cooking for her.

Anyway, we threw a big party, and everybody headed back toward Bethpage on that Saturday and Sunday. There were so many of them, you couldn't get all out on Saturday. You had to split—some of them flew Sunday and Saturday.

Anyway, when we got back to Bethpage, it took about three days and then you see a sea of change. Man, every place that work was being done was called a workstation. They had planning books. This is electrical. This is fluid lines. This is structure. This is whatever else, you know, and installations and so forth. Every place you looked, they had these books. Wasn't anything in them, but they had the books there and they had the workstations defined, and they were defining the work teams.

The next day, you see two or three pieces of paper coming down, going into these books. They weren't labeled like they used to be, "LM 3." They were for "LM 3 and sub [subsequent]," meaning it applied to all of them, so that now instead of working one vehicle, you could work four or five vehicles at the same time because you issued the same work order for all of them and then you put the extra copies for the ones you're going to start later on. You're already doing those books.

Well, it took them forty-odd months to build a LM 2, and it took thirty-two months to build LM 3, and it took twenty-six months to build the rest of them because of that good planning. You know, everybody knew what work was going to be done. The people knew when the parts were going to be there. We had the best schedules in the world. You just wouldn't believe what happened.

Unfortunately, Mr. Burke's biggest worry came true: the Grummans applied the system to the F-14 program. When they applied it to the F-14 program, Republic Aircraft was a subcontractor. They forced them to use the same system, so there went McDonnell's advantage on being able to properly estimate the cost and time and everything to make it work. But it went that way.

The big problem then was when we shifted to testing. Grumman didn't have a test team. So we insisted that we have a test team. They put a guy, I think his name was Standefer [phonetic], in charge of the testing. He was a good manager. He picked the best people he could find to do the test work. So we started writing the test procedures. All this came under Tony Liccardi. Now, he was the honcho on all of this for me.

I called George Low and I said, "I need to rewrite all of the test documentation. That's going to be a lot of money."

He said, "Well, don't do it."

I said, "But we've got to do it, and we've got to rewrite the whole smash. It's going to take us four months or something to get it done. I'm going to run your bill up getting this done."

He said, "Well, I don't think you ought to do it."

I said, "Look, you got a guy down here named Don [Donald D.] Arabian." Don Arabian was the head of POO. We were old friends, and I think it was appropriate that he was the head of POO. Anyway, I said, "Send him up here, and I'll walk him through it." That was the Program Operations Office, and they were responsible for the MER [Mission Evaluation Room] and so forth. His people knew something about testing, and Don knew a lot about testing. I said, "Send him up here. If I can't convince him that we've got to do this, then I'll tell you."

So Don came up and spent three days with me, going over all of this stuff and how bad it was and so forth. He finally said, "I agree with you. If you don't rewrite these procedures, we're never going to be able to have confidence in a lunar module."

So he went home, and I got a phone call a day or two later from George Low. He said, "Go ahead and do it." So we rewrote everything. Tony Liccardi was tearing his hair out because there were so many documents to take care of, and we had other problems cropping up.

Anyway, the test procedures were rewritten. We had a team and we developed a process where manufacturing owned the vehicle, and when it was manufactured up to the configuration that the test people wanted it, then the test people owned the vehicle and manufacturing was out of the loop. Now, the test people could call in manufacturing people to do what they needed to do, but manufacturing wasn't able to go in there and screw up the tests. The test guys took care of all that themselves. And it worked beautifully.

We didn't have a very good program manager. Joe Gavin was at that time considered to be the program manager. Tom [Thomas J.] Kelly was considered to be the program manager, and there was a guy named [Robert S.] Mullaney or something that, who was the real program manager. When I got there, I couldn't find Mullaney, and I had been beating Lew Evans on the head to get a program manager in there that would meet with the new concept of what we were doing, the new planning and scheduling, the new testing, and so forth. He said, "Well, OAO," the Orbiting Astronomical [Observatory] thing, "the OAO office is closing down. There are some good people over there, and I'll go shop around."

Well, he found "Doc" Tripp, Ralph [H.] Tripp. Ralph Tripp was a quiet guy. He had a degree in physics, I believe, and he was instrumentation oriented, so testing was something he understood. When Lew Evans offered him the job, he wasn't going to touch it with a ten-foot pole. He knew that there was trouble there.

Anyway, finally, after I talked to him, Lew talked to him four or five times, the chairman of the board took him out to dinner once or twice, and finally they convinced him to

take the job. So he became the new manager. He helped us with the testing, get the testing organized.

Since we had, now working on a bunch of vehicles, we had to get more ACEs, more ACE equipment, so he was instrumental in getting us another set of ACE equipment, and we had the cables going down the steps. We couldn't even install it properly, but he got all that stuff going for us, and we were now checking out the vehicles properly and so forth.

Suddenly one day a window broke. I got this call from Harry Briggs that said, "A window just broke on LM 4."

I said, "Who hit it?"

"Nobody hit it. We were doing a pressure test on a crew cabin and the window broke."

When I checked, the window broke at 4.8 psi, and the cabin pressure's 5.0 psi. How did that window break?

So we called Corning Glass. This is a special chem-core [phonetic] process. I don't know if you ever heard of it, but you take the glass and you get it good and hot. Then you clench it, and the outer pieces shrink, but the inner one is still solidifying, but outer ones are shrinking faster than the inner ones, and you can bend that glass. These windows are big. The way you test them is you bend them over a one-inch roller, one of the tests that you do on a window. Anyway, the window broke, and it broke at a low pressure. It was scary.

So Corning couldn't find out why the window broke. Doggone, a month later, another window goes on LM 5, 4.5 psi. These windows are made out of the same stuff like your car. They're made to shatter into little pieces that don't have shards that could cut an astronaut's suit, okay. It goes like sugar. If you break the window, you got a pile of sugar that's not sharp-edged, okay.

Anyway, the second window broke, and we never could figure out why. So I called the quality people together and I said, "I'm issuing orders to you now. I want every window to have an inspection before every operation and an inspection after every operation, and I want you to look at the slightest difference, and anything you see, I want to know immediately."

Well, I think four months or so went by, and one day the secretary walked in and says, "There's an inspector on the line and wants to talk to you."

He said to me, "I'm down here at the thermal chamber, and we just took a window out of the thermal chamber and I see something in here now that I didn't see on this window before we put it in."

I said, "I'll be right down. You put your stop-work tag on it. Don't let anybody touch it."

So I came down there, and he said, "It's right here in the glass." Well, I couldn't see anything. He said, "Here, take my loupe," and I go down there with that little loupe, and I couldn't see anything. He said, "Look right here." He had a flashlight. [I saw what looked] just like a diamond in the glass.

So now we had something to go on at least. We called Corning in, and I had that impounded. You know what bonding is; nobody can touch it. It's just considered government equipment and nobody can touch it without your inspector's permission. So, anyway, they came in and they looked at it, and they said, "Sure enough, looks like a stress riser in there." So they got another window. They put it through the same thermal test, and they examined that piece, and, sure enough, there was what looked like a stress riser in there. So they took the second window and they pressurized it and it broke at 4.5 or 4.6 psid.

Anyway, now we thought we had the real cause, but when they analyzed this thing, it was the anti-fogging ribbon on the window. You know the anti-fogging ribbon, you put it on the window, heats the window so the window doesn't fog, and where it comes out, it gets connected to the wires from the electrical system. Well, when they glued the wires to the window, right where they put the electrical connect wires coming out, they used a thing called Hysol [phonetic] as the adhesive. The Hysol was selected because it was strong and it was good. Fact of the matter, it was too damn strong. The window had a coefficient of expansion, you know. When it gets hot and cold, the coefficient of expansion of this Hysol was zero, but the bonding to the window was so great that when the window moved there, it just tore the glass.

So this one inspector—I wish I knew his name—he should have gotten a [Silver] Snoopy [Award] for his work, and I didn't do it and I'm sorry to this day, but how he found that little diamond in there, he must have been examining that thing with a fine-toothed comb, because it was so small I couldn't even find it until he pointed it out with his flashlight. But it solved the window problem and we didn't have any more window problems.

BUTLER: Before we go any further, actually, if we could just pause to change our tape out real quick. [Tape change.]

HOBOKAN: ...we got to building several at a time, and he was putting on—we had called what we called spacecraft managers. Al Geweed [phonetic], you probably heard of his name in the past, worked for me, and he was the spacecraft manager for LM 5, Eagle, okay. We had a

manager for LM 4 and LM 6 and 7. We rotated these guys. As one vehicle left, we put them on another vehicle.

George Titterton put a man named Harrington on LM 6, but I'm jumping ahead of myself. Just a minute. We had solved the window problem and the test problem, and we got down to where Apollo 8 was going around the Moon. Apollo 8 went around the Moon because there wasn't any lunar module, okay. Now, right after that, we were going to deliver LM 3, in the first part of 1969. We had to do this thing before 1970, if you remember.

So we came up to Christmas on 19[6]8, and I was ready to deliver LM 3 to KSC. There were about five things that were undone on the LM 3, late changes because we had no parts. We couldn't do them, so I said, "We'll ship it to the Cape. I'll send the people. We'll get the parts. We'll go down there and do it after it gets to the Cape."

A couple of people at JSC said, "No, we want those changes made, and we want them made as fast as possible."

Well, Grumman had planned to work over the Christmas holidays, between Christmas and New Year's to finish up, package the vehicle, and ship it to the Cape. I called George Low and said that was their plan. From General Bolender comes this comment that we need all those changes made. I said, "General, I just got the word that if you want those changes made, Grumman is going to take the whole time off until the parts arrive, and nothing's going to get done."

So they insisted that they include the changes. Sure enough, within two hours, there was a letter telling everybody to go home from noon on Christmas Eve till the second of January. So I went to the contracting office, and I said, "Look, this is not a scheduled holiday. Sue the company for the money. We won't pay for these holidays."

So we sued Grumman. Lew Evans came over and said, "That's two and a half million dollars of our profits you're going to take."

I said, "I didn't tell you to put those people off. You did it, not me. The lawsuit stays."

Frank Batterby [phonetic] was working with the federal government in getting this done. Then something else came up, and we got some more money involved, and I said, "Sue them again. They're either going to stick to their money plan and what kind of holidays they have, or they'd better tell us about it in advance. We just can't afford this money going for no production."

Anyway, we sued them again. Now things are getting strained between me and Lew Evans there because of this.

Right after the first of the year, we had delivered LM 3. In January we got the parts and delivered LM 3. Suddenly my secretary came in one morning and said, "Wernher von Braun is here to see you."

I said, "Send him in."

Wernher came in and he says, "Where can I find George Low?"

I said, "George Low? I didn't even know George Low was coming up here today."

He said, "Yes, he called me on Friday and we were to meet here."

So I said, "If he told you he was going to meet you here, he'll be here. Why don't you sit down."

He said, "I'll take my man and we'll tour the plant." He had a representative on my staff, a guy named Franklin, and so he got out and got Franklin, and they were going to take a tour of the plant.

It wasn't long later that George Low came in, and George Low said, "I want to take a tour of the plant." So I took him on a tour of the plant, and he said, "I don't want you listening to what I'm talking to these guys about. I don't want them to be concerned about you doing anything to them if what they tell me that you don't like, okay."

So I said, "That's fine. I'll stay out of earshot."

So I took him to wherever he wanted to go. He wanted to talk to some propulsion people. He wanted to talk to structures peoples. So I just walked off and let him talk to them. I got the word from him later that he was asking them what was their personal opinion of the lunar modules. They built them. Did they believe in them or didn't they believe in them? What was their concerns? After doing this for about two hours, he talked to quite a few people, and he said, "Okay, I'm ready to go back to your office."

We go back to my office. He said, "Let me see your schedules."

Well, as I said before, we had a whole new scheduling system. We had the best schedules in the world, and I had them all laid out for every LM that we were ever going to build. He wanted to see the schedules. He said, "How much confidence to you have in them?"

I said, "Right now, I can tell you within three days every one of those deliveries is going to take place within three days of that date."

He said, "How long is the Cape going to take to process the LM?"

I said, "Well, they keep saying three months, but they've never seen one."

He said, "That's right. If they have a lump, we'd better say four months processing at the Cape."

Then Wernher von Braun came in, and we all sat there going over the schedules, this, that, and the other thing, LM 3, LM 4, LM 5, LM 6, LM 7, and so we started out with the

January 1st, 1970 and started working back. And there was LM 6 sitting there for, I think it was September or October of '69. We discussed LM 6, and Wernher was saying, "That's too late. That's too late. That's too late." When you put the four months of scheduling at KSC in there, you were going to launch that one after 1970, after January 1st. So we all agreed that LM 6 was too tight and too close and we'd never make it.

So then we went to LM 5. LM 5 was delivered four months earlier, back four months up. We looked at LM 5, and that had plenty of slack. If you took the four months for the Cape and then a bumper here or there with rockets, you know, you had a little time, a little lead time.

Then we went to LM 4. Well, LM 3 was already off, so LM 4 was in March or April, and it had lots of time. Wernher von Braun wanted to go with LM 4. So he was arguing LM 4 was going to be the first lunar landing, and George Low didn't want that. He wanted LM 5 to be the first lunar landing, and he had reasons of his own, like the damned LM 4 was a little heavier than it should have been.

Anyway, Wernher was getting upset and he said, "Do JSC's—" Oh, George Low mentioned a few things about backup. He wanted to have LM 4 as a backup to LM 3. This vehicle had never been manned in orbit at this point. Now, it's after January 1st, 1969. Not one of these vehicles had ever flown man, and we had to do it by January 1st of 1970. So that's your back against the wall and you're between a rock and a hard place besides.

So he said, "I want LM 4 to be able to go into Earth orbit if Jim [James A.] McDivitt's flight had a problem."

Wernher came unglued. He said, "You JSCs want backup on backup on backup. Sometime you have to make your mind and go."

Well, that was pretty strong language, but George Low wasn't giving in that easy. Finally he said, "I'll tell you what, Wernher. We'll go with LM 5 internally, and we'll tell the world we're going with LM 6. Between the three of us in this office, we're planning to go with LM 5, but we're going to go and tell everybody else we're going with LM 6. Andy, call Lew Evans. We're going over to see him."

So we went over to Lew Evans' office, and George Low broke the news that we're going to make the first lunar landing with LM 6. So Lew called George Titterton. George Titterton then assigned Harrington to that vehicle. Harrington was a friend of his. So he assigned Harrington to LM 6. But LM 5 we were working on internally to make that first landing.

Anyway, when you looked at the open items on the LM, there were thousands of open items. You know, failures here, failures there, failures in that subcontractor, all kind of failures all over the place, and all of these have to be closed out by the FRR. So here's Grumman working to close them out for LM 6. Well, I had to work to close them out for LM 5 without telling the Grummans that's what I'm going.

So we got with Carroll Bolender, General Bolender, and said, "We'll put some incentives on closing these out." So we had a quarter of a million bucks, I think, that we could put as an incentive there for Grumman to close them out by LM 5, so that they're closed by LM 6.

But then JSC was the big problem. JSC never had much to do with the lunar module. I didn't know anybody from JSC who ever worked on a lunar module other than General Bolender. We had so many items, that when it came to sending them to JSC to close them out, the JSC guys wouldn't close them out because they didn't know enough about the LM to be

able to say, “Yes, I can agree with this,” okay. So it got to be pretty touch-and-go there for a week or so.

Finally I called George Low and I said, “We've got to do something about this. I'm JSC. Why don’t you give responsibility to me. If your damned engineer won’t sign it off, then I’ll review it and if I agree with it, I’ll sign it off.”

So he said, “Okay."

I said, “I’m going to need some men.” So he sent me a young fellow named Dave Anderson from General Electric, and he sent me about eighteen General Electric engineers. We put in a fax machine and we put in extra telephones for these guys. These guys were to work with the Grummans to close out the paperwork and then ship it to JSC to have it signed. If they didn’t get it signed at JSC, then it came back and me or some of my engineers would review it. If we thought it right to sign it off, we’d sign it off.

Well, we put that into effect, and the guys at JSC suddenly realized that, you know, they’re not seeing anything now. Before they at least saw the failures. Now they’re not seeing anything because when they got the piece of paperwork and they didn’t act on it right now, the piece of paperwork disappeared out of the system because it came back to us, and we worked it with the Grummans up there. Anyway, we started to clean up the backlog, and with the incentives we got the whole job done pretty well. But Dave Anderson was a key person in getting all of that done. Those GEs were at that time working at JSC also, so he had a direct line to his own people down at JSC on how the wind was blowing on this and that, and he could get those guys down there to pave the way for this piece of paper coming down so it’d be signed when it got there. He had his people telling them, “Look, if you don’t sign these off, you’re out of the loop. Somebody else is doing it. You’re not going to know how it really wound up.”

So with that good scheme going, we got the JSCs doing more of it, and I didn't have to review a heck of a lot of them after them. But old Titterton was pushing LM 6 now, not LM 5, and he had a management scheme you won't believe. He carried hundred-dollar bills in his pocket. If he wanted something done on schedule, he used to bet the foreman a hundred dollars that they can't do that job and get it done by this day, okay. Everything else stopped, but the foreman got that hundred dollars. That was his management technique. It didn't move everything forward. It only moved one item, and, in fact, it moved stuff back.

So, anyway, we got the LM 5. George Low said, "Keep the weight out."

I said, "If you can keep the changes down, I can keep the weight out."

He said, "I'll keep the changes out." So it stayed a nice lightweight vehicle that it was planned, except that when we got it to move to ship it to the Cape, on the overhead was a hook to lift it. The hook has a pin to lock the hook closed, okay. Now, the pin is held by a piece of steel cable that's welded to the top of the hook, except none of us ever looked at that weld.

This one day we were going to move LM 5, that pin came out of there. The docking tunnel was right on the top, okay. The ascent engine is right down the center, and under that is the descent engine. Luckily, the engines weren't in there. That pin came out, went right through the hatch down through both engine covers. So now we had to patch the engine covers and do an inspection of the whole damned hoist system there.

We had the doors open for, I guess it was LM 4 for Apollo 10, to move it out to the truck to take it to the airplane for delivery. A damned squirrel ran into the white room. [Laughter] The squirrel was running around all these LMs and so forth, and I didn't know about it until somebody came running to my office that the guard just shot a squirrel in the white room. The guard shot a squirrel in the white room? Where's the bullet? Nobody knew.

Where's the squirrel? They threw it out in the trash, and the trash has gone to the dump. "Get me security."

We had to send a guard to find out where that truck dumped it and find that squirrel and see if that bullet was in the squirrel. This bullet, it was .38-caliber, it'd go right through that damned squirrel. We all knew that, but you had to make sure. Then we found a place where it hit the concrete wall but didn't penetrate the concrete wall. It went somewhere. So now we're out there with all kinds of projecting devices trying to find the trajectory of this bullet. We never did find it. Someplace in a LM or in the white room was the bullet that he shot at that squirrel, but we never did find it. That was an interesting anecdote. But we spent two days trying to sort that one out, and we never did find any trace of that bullet.

We had another where somebody left a crowbar in one of the LMs. We tilted them to clean them, and somebody had a crowbar that they were doing something with and left it on top. When they tilted it, it came crashing to the floor off the LM, and now we had to go down there and do all this trajectory work again to see if it could have hit a tank or whatnot. No, it didn't hit a tank. But all of that stuff scares the hell of you that you might have damage that you don't know about and so forth.

But the interesting thing about the Apollo Program was, it went off without a hitch. When they put LM 4 in the vicinity—Tom [Thomas P.] Stafford and Gene [Eugene A.] Cernan and, I don't who was—

BUTLER: John [W.] Young? Up in the command—

HOBOKAN: Yes, up in the command module. I made the pitch for Apollo 10 reunion down here. I did the talk on Apollo 10. I told them a lot of the things that I'm telling you now. But when that vehicle went down, it was too heavy to land, so it went part way down, and while they were down there, Tom Stafford threw a switch. Now, I don't know if you knew about the AGS in the lunar module. The lags, the lunar module had PINGS and AGS. PINGS was the Primary Inertial Guidance System, and AGS is an Abort Guidance System. There is a switch that will allow you to switch between the two.

When the PINGS is being used, the data is recorded in the AGS, so that the AGS has access to that data. In other words, when you leave the command and service module to go to the surface of the Moon, both systems are plotting the trajectory and knowing where the LM is at any given time. Tom Stafford threw the switch from PINGS to AGS. When you throw the switch from PINGS to AGS, that vehicle's going back to the command and service module. That says, "I'm in serious trouble, and I'm going home," okay.

So here they are down around the surface of the Moon, and he threw that switch and that LM turned around and started back, and he had to throw the switch again and put it back on PINGS, and it stopped that operation, and he made a big cuss word. I thought he said, "Son of a bitch." So they never would say that what he said until the anniversary the other night. He said, "Yes, I said that." [Laughter]

Gene Cernan was saying, "He held me, kept me quiet all these years, but he promised after thirty years, he'd tell me what he said.

And he said, "I said it."

After all these successes of the lunar module, I got another phone call, and it was from some people assigned to the space shuttle. They said, "Andy, we have a bunch of drawings here for tooling, that we don't understand tooling. Would you review them for us?"

So I said, "Okay, I'll review them. Just send them up to me."

So they sent them up to me, and I looked at these drawings. Everyone was for 200-plus man hours. The Orbiter's big, you know, so these are big tools. Well, when I looked at them, every one is designed in a different way. One is using round tubing. One is using square tubing. One is using big tubing. One is using small tubing. The analysis, I spent today and yesterday over here in Building 220 watching the guys align the X-38, okay. Just breathing on the tooling, you can see the tooling move, okay. Now, if you're going to build big tooling, you at least ought to have the same lattice work so you can analyze one piece of lattice work and not go and analyze a different piece of lattice work for every one of your damned tools, where the coefficient of expansion and contraction is different.

So when I saw this stuff, I said, "Look, I'll come down to Houston. Why don't you call those Rockwell guys in and call their tooling manager in and let me talk to them."

So I got to Houston. The guy's name was McCarty [phonetic], and Joe [Joseph W.] Cuzzupoli came. The tooling guy worked for Joe Cuzzupoli. I said, "How come we got all these different lattice works on the tools? Why aren't we using a common lattice work?"

McCarthy said something, "Do you design tooling?"

I said, "No, I don't design tooling, but I know enough about it to know that if I were going to do it, I'd do it with the same damned lattice work on all of them, so an analysis would be easy to do for the whole smash. Besides, these tools are so big. Why aren't they modular?

You know, why don't you make modules that you can analyze and just stack these modules, how many you want, use them for wing, the fuselage, the tail."

Anyway, the tooling manager said something, and Joe Cuzzupoli said, "Meeting's over."

So I got up and I flew back to Bethpage. Well, about a month later, I got this phone call from Houston again that said, "Joe Cuzzupoli wants to have another meeting on tooling. Would you come down?"

Well, I got there and McCarty isn't there. I said, "What happened to McCarty?"

He said, "I fired him. I want you to meet Charlie Ho." Charlie Ho was the new tooling manager. When we sat down, Charlie Ho had a big, big book in his hand. Joe said, "You remember your comments about modular tools?"

I said, "Yes."

He said, "Take a look at Charlie's book." There, over in Charlie's book, he's got a standard module, and then all the end fixtures are standard. Then I go through his book, and a beautiful job of designing modular tools. Then he said, "We'll put them in General Dynamics. We'll put them up there at Grumman for the wing. We'll put them over here at Republic for the tail. We'll put them every place and we'll use them at Downey." So they developed this modular tooling program.

At the end of the Shuttle Program, Joe called me. He says, "You can't get an award for modular tooling, can you?"

I said, "No, it's a part of my job description. I can't get an award for that."

He said, "Well, my people can. Will you and those JSC guys back off and let us say it's our idea?" So they collected $50,000 for the idea of the modular tool, but it was used

throughout the program, sure saved money. One of those things cost 3,800 bucks. One of those modules just cost 3,800 bucks, and here 200,000 man hours at twenty bucks an hour, that's an expensive damned tool. Here they were making them pretty cheap. But it got out of the business of having all this different structure to analyze and so forth.

Then we had John [P.] Healy. Yes, John Healy was vice president of manufacturing at Rockwell. He came in one day and wanted to make a pitch on the windshield for the space shuttle. Now, that's a big windshield. He was proposing to have a riveted and welded-up structure. Now, I remembered the LM problem with the window, and for a long time we thought it was the frame, the window frames, something stuck on a window frame that caused those windows to break, and I remembered that. I listen to his pitch on his buildup of the window-frame, and I said, "No way will NASA ever accept that. You go and propose that, and I'm going to be right there to say no, no, no."

He said, "Well, what do you want to do?"

I said, "You get a billet and you mill this whole thing out of billet."

He said, "You realize the size of the billet?"

I said, "Yes."

"You realize the size of the machine?"

"Yes."

"Well, there's no machine like that around."

I said, "Why haven't you looked?" Well, they found out they had five-axis froreep [phonetic] right there in Segundo [California], and they found a contractor who would make the billets from which to machine those windows. So they finally wrote the program and they made a left-hand one and then inverted it to make the right-hand side, so the software, the NC

program was relatively easy to do because they just had to work one side and then flip the whole thing and made the other side. So they machined that in two pieces and then welded it down the center. It turned fine, but, boy, if we had ever had a window structure that was flexible, I would have worried about it all through my days about that window.

Then we came to the point where we needed a thrust structure where the engines on the Orbiter supplied a thrust into the Orbiter fuselage. Joe came up with the idea of welding the thrust structure, and the thrust structure was going to be titanium. In the Grumman's F-14, the wing carry-through boxes is titanium and it's welded. It took them year to get a process that would be satisfactory. They were going to make lots of them, so they got this big automatic welding machine. It's bigger than this room. It has to done in a complete vacuum, and everything has to be cleaned within hours of the weld and so forth.

It was one tremendous undertaking. We could never, I don't think we ever get a thrust structure made if we were welding it. People would be questioning this, questioning that. So they came up with this idea of a diffusion bonded structure. Well, the airplane industry had been using it for years. That's where you just heat something up so hot and you squeeze it together and two pieces of metal become one. It's a molecular bond as well as the one metal diffuses into the other, and it makes a very good bond. Anyway, nobody had ever tried this on a big structure before.

In the tooling world, you got these pieces that are going to squeeze out. So when you make the structure, you've got to machine all your pieces, and you're going to squeeze them this way, this way, and this way, and pieces are going to squeeze out. So you've got to have in your blocking system, little rivulets that this material can run into to that gets squeezed out, okay. So

it's a very ticklish thing, and nobody at JSC would buy our concept of diffusion bonding the thrust structure.

So it finally got to Chris Kraft. I remember telling him that if you go back to the old Damascus steel, the way they made that was to get it red hot and pound the hell out of it and it finally became one piece of metal, you know, where you could take pieces and pound them till you get red hot. Pound them together, that's the way they did it in the old days. I said, "It's no different."

So finally he said, "Okay, we'll go do it."

Well, the problem that came up was how do you test it? How do you examine it for defects? You know, when you're squeezing these two things together, what happens if you get an air bubble or piece for foreign material in there and so forth?

So Joe and I were sitting talking about it, and I said, "Why don't we make predetermined flaws in the thing. That way engineering can put them where they won't hurt anything. But if you can't find them, then your X-ray operation is no damned good. If you've got a flaw in there that you know the size of it and you can find it, then any similar flaws, as you do it, you should be able to find."

So the engineers hid a couple of flaws. They knew where they were, and they were on the drawing, but nobody knew where. None of the manufacturing people knew where they were. We didn't. Joe and I didn't really know where they were, and we didn't care. We had to find them. The guys had to find them. So that's the way we did the thrust structure. Got through all this malarkey about nobody ever had a diffusion bonded structure before that big. We did that in El Segundo area, and the whole thrust structure in there is diffusion bonded. But

machining that stuff to rid of that overrun, you know, the stuff that's squeezed out, that is a tough machining job.

Oh, the other thing about space shuttle, everybody was yelling about cross-range. Everybody was yelling about cross-range, and I was a newcomer. I got transferred from St. Louis. For the first in my life, I was here at JSC. I'd never been assigned here before. I was a JSC employee all these years, but I was always out there building the hardware and doing the QA and so forth.

Anyway, I got to California, and it was in preliminary design. Now, preliminary design is where you just get concepts, okay. The guy who was the program manager at the time was Buzz [Bastian] Hello. Buzz Hello. "Hello" just like you say, "Hello." He said, "Let's go out to preliminary design and see what's going on on the drawing boards."

So we got out there at the preliminary design, and everything I looked at, man, it was a copy of the B-1 bomber with all the sexy shapes, the Coke-bottle waist, and everything else, you know, curved wings. All these concepts were out there, but they were all difficult to manufacture. So I was talking to Buzz, and I said, "Can I get up on this table and make a speech?"

He said, "Sure."

So I climbed up on the table, and I said, "Everybody listen to me. I see what you're doing down there, but you're not going to be able to manufacture that stuff. Look at the B-1 and you'll see what kind of manufacturing problems they had with all those curves and so forth. I want to see straight lines and I want to see conic sections. If I don't see that the next time I'm up here, I'm going to break all of your French curves." And I stepped down.

Now, these guys I don't think knew from Adam who I was, but they knew who Buzz Hello was. When I stepped down, Buzz Hello stepped up there and he says, "If he doesn't break your French curves, I will."

The next time I got out there, there's that boxy shape. Everything's straight. When Joe Cuz looked at the manufacturing problems on that thing, he said, "You missed one thing. We got one sworfed [phonetic] weld right under the windows." The weld has two turns in it, and that was the only place we had a problem with a non-straight line or a non-natural curve. So the boxy shape came out of that one conversation where I said, "I'm going to break all your damned French curves," and cross-range just came, you know. Cross-range wasn't fashioned by all this fancy work; manufacturing problems were. So it got to be the boxy shape.

PPD has been a problem here at JSC. I say it's a problem. It's a problem from my point of view, not from their point of view. PPD always wants a backup. As I told you with the Air-Right [phonetic] tanks, they start out with somebody. After they make a sufficient number of mistakes, then they say, "Well, now I know how to do it, so let's start out with somebody else." Okay. Usually this is the one that finishes. So the Air-Right tanks were not flown. Somebody else made the tanks in the end.

We had a problem with thrusters on the CSM and lunar module. On Gemini, we had Rocketdyne making the engines and they wanted to go to somebody else when Rocketdyne's price got—originally it was 30 million. It got to be 130 million, and that's no time to change horses, after you put in that much money.

But on the space shuttle, they had selected Marquardt for the thrusters on the nose, okay, and these were very delicately made engines. They were welded, and they had insulation in the nozzles. They weren't ablative. They were reusable, okay, but the injector, the guys decided to

have Marquardt build injectors—the PPD told them how to build them—and these injectors have fuel anoxidize and they have to impinge in groups, like your gas stove, okay.

When they designed the tools under JSC's direction, they designed to make perfect circles, okay, but they never designed that every hole would be lined up perfectly. So if you got this circle and that circle that weren't correct, or if they were crooked. It was a big, big problem. Anybody would know that if you want to do that right, you'd drill a hole this way and you'd drill a hole that way at the same time so that you have them all lined up all the way around this circle.

So Rocketdyne demonstrated that way of tooling it. So now they wanted to quit Marquardt and have Rocketdyne build these engines after all this development work by Marquardt. So we in management just said, "No. Make the thing work at Marquardt." So they used a set of optics to put a pin in that hole and then line it up so that the drill would be correct in the other hole. But PPD has done that to us a lot, a lot of times.

Al Geweed was my man on mockups, trainers and mockups on space shuttle. We built this great, big trainer of the crew compartment out in Downey, and then we were going to ship it to JSC for the crew to use it here in Building 9. Anyway, this was a big thing, and I was, being at Marquardt, I was heading for Marquardt when Al Geweed got in touch with me and said, "Hey, that thing is so big, we've got to cut it up, and then when it gets to JSC, we've got to reassemble it. It's going to take eight weeks and a lot of money."

I said, "Al, you don't have eight weeks to get that trainer ready for these guys. It's late and they need the trainer. Find out some way to ship it whole. You know, take it to a ship out there in Long Beach and ship it from there." Well, that turned out to be a dud.

But I just happened to be driving past Van Nuys Airport, and I looked out on the airport, and there's the Aerospace Seattle's Guppy, the big Guppy, and doesn't have any engines on it because NASA owns the engines. We've always owned the engines for that Guppy.

So I got to Marquardt and I placed a call to Al. I said, "Al, you know, maybe there's some way that Rockwell can get us to put the engines on a Guppy, get it close to Downey as we can and load that thing on a Guppy and then fly it to Ellington [Field, Houston, Texas] on the Guppy."

Well, he called me back and he said, "Hey, they want four hundred and some-odd thousand dollars for that."

I said, "Four hundred and some-odd thousand dollars? From one trip?"

He said, "Yes."

And I got to thinking about it for a minute, and I said, "Al, why don't you just go and buy the goddamned thing? Go down to contracts. Tell them to buy it. We'll own it. We'll put the engines on it, and we'll use it."

I got a call back the next morning. He said, "Yes, we bought it. It cost us 6 million."

So they bought the airplane, delivered the thing to Ellington. Then we delivered the airplane to Joe [Joseph S.] Algranti over there in the Aviation Division [at JSC]. My phone rang for days. He didn't like that airplane for nothing. Finally the wings were giving way on it. Marshall used it when we had the *Challenger* problem. Marshall used it quite a bit for delivering big chunks of the engines back and forth.

So the wings kind of wore out, and Joe parked it out in Biggs Air Force Station out in San Antonio. A lot of my friends in the Air Force there—I'm a member of the Officers Association here in Texas—and a lot of my friends out there say, "You don't own it anymore.

It's our Super Guppy." So they own the Guppy out there, and they're proud of it in San Antonio.

But that's how we got the Guppy. Al just kept pushing it and convinced the contracts guys that in order to meet the schedule and keep the cost down, it was better to invest in the airplane and get that trainer here. It's a shame Al passed away, you know. He was head of our Rotary here for a while.

Oh, another thing that came up was on the ALT [Shuttle Approach and Landing Tests]. I think Bob Thompson told you the reason for ALT was the program was so light that we had to have something to attract national interest. So that's why we did the ALT. It was a useful thing to do as well, but *Enterprise* got so heavy—I'm not going to mention one name, but I'm going to tell you a story, part of why it got heavy. You make lightning changes every time you can, okay. But when the crew compartment for the first OV-101, the first Orbiter, was put together, the skins are machined with integral stringers, okay. In other words, it's flat plate but then there's a T-stringer sitting up to strengthen it, okay. Then you roll them. We had these made someplace and LTV [Aerospace Corporation] rolled them in the right conical shape, and then we took out to Downey and we welded them together.

Well, the first one they put together, instead of indexing the thing properly so that the stringers were like this, they indexed the stringers and went like that [Hobokan gestures]. I just happened to be at Downey when Bill [William B.] Wilson, the Space Shuttle resident manager, told me about it. He said, "It's terrible. The indexing of the tool was done wrong."

So I called down here to the boss, and I said, "I'm going to give them till overnight to come up with a solution, but in the morning I'm going to tell them to cut it off and reweld it."

Well, some manager here called out there and directed Bill Wilson to go down and sign off the MRR before I got a chance to look at it again. So they left it like that. Well, Bill Wilson was so angry that he kept records on the result of that decision. When that decision was made to leave it, these stringers had a design that tied them together. Now they're this way [Hobokan gestures]. That design was no longer feasible. Now you have to have "Y"s, okay, and you have to have Ys all the way around here to pick up those loads. That was a big design change, costly to machine all that stuff.

After that piece was done, you had to apply secondary structure to those stringers to hold equipment. Now they aren't where they're supposed to be. Now you've got to do all that redesign. So Bill Wilson, when it was all over, said, "That must have four months and 25 million dollars, just that one decision not to cut it off and do it right." And he had all kinds of records he showed me about the things that had to go on. So you can get some bad decisions out of management at times.

I don't guess Bob Thompson told you about the ejection seats, did he? Did anybody talk to you about ejection seats on the Orbiter?

BUTLER: We've talked to a couple people yet, but we haven't that part of history with Bob Thompson yet.

HOBOKAN: Okay, well, you be sure you ask him about that.

BUTLER: Okay, we will.

HOBOKAN: Because there was a problem when we did the sled test. This fix was relatively simple, but we had a real problem on the sled test.

BUTLER: We'll be sure to ask him about that.

HOBOKAN: Well, I don't know anything else of interest that I've missed.

BUTLER: Okay.

HOBOKAN: Let me tell you about suing Grumman a couple of times. Well, there was a change made on Apollo, or proposed change on Apollo. Lew Fisher, to whom I referred before, the engineering manager for me, deputy for engineering, came into the office one day, and said, "That change we've been discussing, Grumman's going to go ahead and do it."

I said, "No."

He said, "Well, if you're going to stop it, you'd better come down now."

So I said, "Take me to the meeting."

We got in the meeting and Doc Tripp had his engineering team there to go ahead and make this change. Grumman didn't want to do it. It was a dumb change. They had a much better idea, but nobody down at JSC would listen. So when I came in with Lew Fisher, I said, "Doc, I understand you're going to make this change."

He said, "Yes, we have no alternative."

I said, "Yes, you do. You know, you don't have to agree everything that you get up here as direction."

He said, “Well, we’re going to make it.”

I said, “Doc, that’s criminal. You know that you’re doing something you know is wrong. To me, that’s a criminal act.”

He said, “Well, what would you have me do?”

I said, “I’d have you pick up the telephone and call George Low and tell him you don’t want to do it, that you've got a better idea.”

He said, “Well, you think he’ll listen to me?”

I said, “Of course, he’ll listen to you. Pick up the phone and call him.”

Now, he’s got all these people around there, and I’m arguing with him over here at his desk, and it’s kind of an embarrassing situation, but I knew he didn’t want to do it and I knew nobody in that room wanted to do it. So I said, “Pick up the phone and call him.”

So he picked up the phone and he called George Low. When George Low answered, he said, “This is Doc, and I’m calling about this change. I don’t think we ought to do.”

George Low said, “I don’t think you ought to do it either. You know, I kept that in my desk for five days, and the only reason I sent it to you is because I’m getting beat bloody down here by the people who want to make that change. Do you have a better idea?”

Doc said, “Yes.”

He said, “When can you brief me?”

He said, “Tomorrow morning. I’ll have a team down there at your office at eight o’clock and brief you on it.”

George Low said, “I’ll send you some paperwork to cancel that direction."

So Lew Fisher got that accomplished. We had to stop it, and the only ways to do it was to tell them, "That’s criminal."

BUTLER: George Low was the kind of guy that would listen.

HOBOKAN: Yes. And you know about the [Charles A.] Bassett [II] and [Elliott M.] See [Jr.] disaster?

BUTLER: Not very much.

HOBOKAN: Did Tom Stafford brief you guys on that?

BUTLER: We've only been able to talk with him briefly, and that was a little more focused, I think, on his Apollo-Soyuz work.

HOBOKAN: Yes, this happened in the morning. They were coming to St. Louis for an altitude chamber test. The weather, it was Bassett and See in one airplane and Stafford and Cernan, I believe it was or, and another. Yes, it was Cernan. When they came into St. Louis, they came into a landing system, but they were too fast. Stafford decided to out and come into, I think it was 24, runway 24, and Bassett decided to keep the airport in sight and just come around and land on 24.

I was in my office, and I heard this engine roar. My phone rang, and somebody told me there was an accident out there. When I got out there, the airplane was foamed and the nurse was already there, and I asked her about the crew. She said, "No survivors." So I asked the firemen to slosh off the tail so I could get the tail number. I called Dr. Gilruth, got Kenny

[Kenneth S.] Kleinknecht and told him that it happened. Then, of course, Tom and Cernan landed, found out about it, too. So they were part of the team to do the failure analysis.

Joe [Joseph F.] Shea was the manager of Apollo when the accident occurred. About two days after the—no, I had come back from Downey, so it must have been a little bit longer than that—but my secretary come in there and said, "Joe Shea's in your outer office and he wants to talk to you."

So I had him come in and he said, "I need to use your office and I need to use your secretary for a while."

I said, "Okay." He was kind of shaken.

The secretary came running after me in a little bit and said, "He wants me to call the White House."

I said, "Call the White House. Do what he asks you to do." Her name was Pat [Patricia] Goldstein, by the way. She's still here in the area.

She tried to place the call, but just about this time, I got a call on another line, and it was Mr. Mac. He said, "I hear you got a visitor from Apollo."

I said, "Yes, I have."

He said, "You got everything under control?"

I said, "Yes, I have. I don't foresee any kind of a problem."

He said, "Ask him if he would go to Washington with me." I had told him he was trying the President, and Mr. Mac said, "Ask him if he'll go to Washington with me. I'll get my private plane, and I've got to there anyway. I'll take him to Washington with me."

So I went out to see Joe, and he said, "Yes, I'll go with him."

So we had the security guard come by and pick him up, take him to Mr. Mac's airplane, and they went off to Washington, D.C. I think Mr. Mac helped him get done what he wanted to do up there.

We had been doing those kind of tests with the Gemini's pure-oxygen environment. I knew they were dangerous, but I didn't know how bad they were.

Yes, here's the one about Ridenour. But that's about it, I guess.

BUTLER: Looking back, when we were first beginning to talk today, you mentioned how you were involved in the checkout on John Glenn's spacecraft for Mercury. So jumping way back, what was involved in that process, in that checkout process?

HOBOKAN: Well, it wasn't a very sophisticated vehicle, as you well know. He had a hand controller that gave him some rate commands and position commands. He had a periscope and a few things like that, but it really wasn't much except the radios and, as I said, we didn't have instrumentation. The KSC guys always ran off with that. We had flown the chimps before. Yes, we flew the chimps before Glenn. But there wasn't much involved. It was a three-orbit thing, and it was mainly the rocket shooting you up there and the retro to get you down. So there wasn't much, but somebody had to do it, and I was the only guy there that was willing to do it.

For some of the Mercurys, the later Mercurys, we had pretty extensive testing but I don't where we stopped the guys from pulling the instrumentation from us all the time, but McDonnell was getting tired supplying VCOs. We had voltage-controlled oscillators for

instrumentation in those days, and every week we were shipping three and four of them to the Cape because they wrecked them. McDonnell was getting upset about that.

BUTLER: That's be understandable.

HOBOKAN: But we used to laugh about John Glenn. You know, he ran the beaches down at Cocoa Beach [Florida] a lot, and the big story at McDonnell was he wasn't running to do anything except lose the weight that he had from all those steak and eggs breakfasts on the missions that didn't go. [Laughter]

BUTLER: While the missions were up, Mercury, Gemini, and even into Apollo, because you were at the resident office there at McDonnell and then later at Grumman, what did you do during the missions?

HOBOKAN: I used to go and be in Houston and visit the MER, the Mission Evaluation Room, and just see how things were going there. Sometimes I went over to the viewing room and talked to the—well, one of the guys that I used to talk a lot with was Umberto—who wrote the book, *The Body Clock.*

BUTLER: I know who you're talking about, but I'm not placing the name.

HOBOKAN: He and I used to sit there and talk about the astronauts getting acclimated to the mission. Umberto—he gave me his books signed one time over there in Mission Control. We used to talk to him, okay.

Then during Apollo, Dale [D.] Myers used to come down quite a bit. Now, there's an interesting story there. I was on the LM. Dale Myers was Rockwell at the time. Apollo 10. The guys in the lunar module had to change an LiOH [lithium hydroxide] canister. It didn't fit. Somebody had not fit-checked the canisters, all of them, before the mission took place. There in Mission Control, the decision was made to package that canister and return it back here via the CSM. I was sitting there talking to Dale Myers. In fact, we just talked about this the other night at Gilruth's ceremony over here. He was writing busily. So when splashdown came—a couple of days later we had splashdown—he reached into his pocket and he pulled out a piece of paper and handed it to me. It was a bill, and it said, "LiOH canister, weight 2.2 pounds, packing and handling, $25, shipping rate, $1 per mile times 250,000 miles: $250,000." Added it up and it come out to be $275,000, and it says, "Payment due now." So I took it and we had a nice laugh about it.

But then Apollo 13 occurred. I happened to be in Houston for Apollo 13. I was actually in the MER when I got a phone call. When I answered the phone, it was a guy from Grumman. He said, "Mr. Hobokan, how much water is in the PLSS?" The PLSS is the Portable Life Support System.

I said, "With the problems that we've got, what makes you want to know how much water is in the PLSS?"

He says, "Because you're going to run out of water."

And I said, "Oh?"

He said, “Yes. Our projections show you’re going to run out of water."

And I said, “I’ll find out for you how much water is in the PLSS.”

So I went down to the place where they were plotting the ECLSS [Environmental Control and Life Support System] stuff, and I said, “I just got a call." [Robert W.] Fricke, the young man Fricke? Fricke.

BUTLER: Okay.

HOBOKAN: I said, “You’d better plot the water because I just a call that we’re going to run out of water. I don’t know how true it is, but someone ought to plot the water.” I've forgotten the name of the contractor now that did the ECLSS work for us. But anyway, they plotted the water and, sure enough, we were a day and a half short. So Fricke came back to me and said, “He was right. We’re going to run out of water.”

So I called the guy back and told him how much water was in the PLSS. Then the guys from MER advised Mission Control and they started the process of controlling the water usage and shutting stuff down and so forth.

But when the mission was completed and they abandoned the lunar module, I turned to Lew Evans, who was sitting there with me, and I said, “I want you to prepare a bill for me. I want you to prepare a bill that I can give to Dale Myers here for pushing the command and service module around the Moon and on the way home.”

Well, we were sitting there and there’s a man there, a right-hand man named Butch Voas. I don’t know if you ever heard of Butch Voas, only man who ever commanded the Blue

Angels twice. Lew said to Butch, “Call Bethpage and have them prepare a bill and have them data-fax it down here.” So they prepared the bill. I don’t know if you ever read that bill.

BUTLER: I’ve seen a copy of it.

HOBOKAN: Yes, "Room with a view, jumper cables supplied, no charge." You remember all that stuff? Anyway, when it got to Houston, unbeknownst to me, Lew Evans signed it. The bill was actually signed and given to Dale Myers. We were laughing about it here the other day, but he didn’t know it came from him giving me the bill in the first place. So he had given me the bill for the LiOH canister and that’s how that reminded that it’d be fun to give him one back for the lunar module pushing the command module around the Moon and back.

There was one other aspect of Apollo 13. The lunar module had incentives on landing. You know, there were incentives on the mission. For a successful launch, the Saturn V guys were given an award, won an incentive award. For pushing the LM to the Moon, Rockwell would get an award. For successful descent on a lunar surface, Grumman would get an award. For a successful ascent back to the CSM, Grumman would get an award. Then successful return and reentry, Rockwell would get an award. Well, after the mission was over, Grumman didn’t get any of its awards because it never separated from the command and service module, never descended to the surface of the Moon, never went back up and redocked. So Grumman got zilch out of that flight of all of its incentives. But Rockwell did push the LM to the Moon, and it did reenter the Earth’s atmosphere, and it did do the landing. They got their awards. So that was interesting.

BUTLER: Doesn't seem quite fair.

HOBOKAN: No, it wasn't ever fair.

BUTLER: Had there ever been any planning on your side with Grumman? Had there even been any talks, any testing of the LM ever filling a role like it did on Apollo 13?

HOBOKAN: No, not that I know of. We did a lot of what-ifs, but mostly for other purposes. You know, what if you landed on a rock? What if you landed on a hillside? We did a lot of what-ifs. In fact, I got a call from George Low one day, and he asked me how did I get along with Jim [James A.] Chamberlin, and I said, "Fine. I've known him for a long time, and we get along fine."

He said, "Well, make an office for him up there and make all of his interview arrangements. I'm going to send him up there to do safety review of the lunar module. It's going to be an overview. It's going to be in addition to everything else. But I just want him to take an independent look."

So, yes, we did have a case like that, but I don't think we ever expected to push the CSM the way it happened. But it shows the flexibility of the mission controllers, and it worked.

BUTLER: It shows that the good engineering and the safety that the LM did end up having.

HOBOKAN: Yes, the last thing that Jim [James A.] Lovell did before he left the *Aquarius*, take the dive into the ocean, he said, was to reach back and grab a piece of the netting. I don't know

if you ever heard that, but he reached back and grabbed—we had netting so that if they dropped something, it wouldn't go behind the panels, and he reached back and grabbed a piece of the netting. I have a piece of it on a little piece of cardboard where he glued it down, signed it, and sent it to me.

BUTLER: That's really nice.

HOBOKAN: Yes, and I got a letter from George Low after the Apollo Program and the problems I had with him and everybody else. It just said a simple thing: "We never could have done it without your help. George Low." It's a shame that we lost him.

BUTLER: You've mentioned a couple of time some of the astronauts. How big of a role did they have as you were working on the different spacecraft, Mercury through Apollo? How much input did they have and how much did you work with them to make it a spacecraft?

HOBOKAN: Starting with Gemini, we had designated certain tests that they were to perform themselves. Like the altitude chamber tests, they were going to do that. Nobody was going to sit in for them. So we put the primary crew through that altitude chamber test, and then the next day we put the backup crew through that chamber test. We had to put all new food in there and everything else and dump the urine and all that kind of stuff. We put twenty-four crews through the twelve flights.

On Apollo we had them there for integrated tests all the time. They came up and they went through the integrated test, the ones where you simulate docking, the ones where you

simulate descent, the one where you simulate ascent. Nobody sat in for them. They came up there and participated in those tests. It was difficult for us to get any of the JSC guys. During the tests like that, you need a lot of people.

There were a lot of things going on, and you'd like to have somebody from GN&C [guidance, navigation, and control], if you have a GN&C problem, and the only guy we could ever come up there was a young man named [Newton T.] Buras. He was a very nice young man and he came up. He was in communications, as I recall. We never had a "no" from him. When it came time for a test that involved his equipment and Russ Clickner would call him, why, the guy would come up and participate very well. You have Russ Clickner down there? Russell [E.] Clickner.

Now, there's a guy to ride the river with. I told you Liccardi was my deputy for testing. But the real honcho of the test was Russ Clickner. He's the guy could read octal with his eyes closed. He could feel the heat of the bulbs, I think, and read octal. Anyway, he was the guy that was responsible, and he had a bunch of Boeings working for him.

I think the Boeings wanted a contract to NASA and to me, and they were assigned to his department. One time when Wernher von Braun came up, he wanted to know something about something, and I called Russ to have one of his people come over and brief Wernher von Braun. When the guy walked into the room, it was like a dangerous situation—not a dangerous situation, a strange situation. The guy that Russ sent over was one of Wernher von Braun's friends from Peenemünde. And all Wernher said was, "Can I borrow your office for a few minutes?" And they sat down and they hadn't seen each other since they left. Russ sent the guy over there to do that.

The other thing about Russ Clickner, as I said, he was a real man to ride the river with. When I came down here for Space Shuttle, he was working over at POO, Don Arabian's office, okay. We remembered the problem of the test of the oxygen and hydrogen tanks that sealed the switches on Apollo 13. It bothered us, you know, that it might happen again.

In our conversations—by the way, let me digress just one minute. That team in New York that I had on the lunar module, you know the ladies still meet every month?

BUTLER: Do they?

HOBOKAN: Yes. Every month the ladies here meet. Every two or three months, the guys meet with them. So my team, those of us who are still alive are still meeting since the old Apollo days.

BUTLER: That's great.

HOBOKAN: Yes. Russ came and was worried about testing and other people testing your hardware. Now, that's a big thing, you know. NASA spends a lot of money on what is called sustaining engineering. That is, somebody builds a GN&C box for you. The only guy that we would allow to open that box and do any work in there was the guy who built it. NASA would pay for the duration of the program to have those guys who built that box on call to repair that box. Okay. It was called, quote, "sustaining engineering." They would keep the tooling, the test equipment, and the people there. The people could be doing something else, but they had to be available in case NASA wants them.

So Russ said, "Why are we allowing others to test hardware if that has been our motive all the time?"

So I said, "If Rockwell's making the Orbiter, Rockwell ought to be responsible for the test, regardless of where it's done. Rockwell ought to tell them how to do it." So we talked about that a little bit.

One day he came over and said, "Hey, I have a way we could implement what's going on. Why don't we have the maintenance requirements all defined by Rockwell. Then we'll impose them on KSC, that they'll do these requirements and they'll do these in this way."

I wasn't too computer-oriented then. I said, "How are you going to do all of this stuff."

He said, "Well, we'll put a computer terminal at Rockwell, one at my office, and one at KSC. We'll have Rockwell write the requirements and ship them to us. If we agree with them, we'll ship them to KSC. When they agree with them, it becomes a requirement." Then he said, "We could do that with a SRBs [Solid Rocket Boosters]. We could do that with an ET [External Tank]." So the OMRS system, the Operational Maintenance Requirements documentation. He's the guy that started that because of some concern back there about people ought to be responsible for their own testing, and Russ Clickner was the guy that put the OMRS system together for us. Yes, he'd be an interesting guy to—I think he came out of Wallops Island [Virginia].

BUTLER: And is he still in this area?

HOBOKAN: I think he's around here. He used to own a coin shop over here, and his daughter was here not too long ago because she was a technician for a dentist, Dr. Allen [phonetic] over

here. So you might find him through there. But he'd be an interesting guy to talk to, because after he came down here, he went to POO. He didn't like to sit around. He liked to be in charge and doing things.

BUTLER: Well, if we can just take a few minutes and we just need to change out the tape real quick, and I have a couple of closeout questions for you, if that's okay. [Tape change.]

...came down here to JSC to work on the Shuttle Program. That was the first time you were actually working here, even though you had been employed the whole time. What was that experience like for you, having been sort of part of the industry for such a long time, but yet being a government employee?

HOBOKAN: Very frustrating. [Laughter] Yes, I spent a lot of time in California early on, as I said. The boxy shape, those things I could get out to and do, but the tiles were a big job. I spent a lot of time with Bob [Robert] Dotts, trying to get the tile system straightened out, but I kept my hands in the business. I worked with [Robert G.] Chilton over here in, I think, Building 13 or 16. He was worried about three IMUs [inertial measurement units] functioning together when they're not all on the same axes, so we used to have lunch together and discuss the problem. We finally decided to go buy a big multi-axis table so that he could put it in Building 13 or 16 or whatever it was, and then put the three IMUs on there and find out how they reacted together, how you can tell one what its location is with respect to the others so that they were all giving you the same coordinates and so forth. But I did that.

Then I worked with—the back of the Orbiter was a high-noise area. We had something like 163-decibel level there that would just rattle your cage. We had a young man here, I still

see him on occasion. I can't think of his name right off the bat. But he wanted to put together a scheme that would test this stuff at high-noise level, and he worked on some schemes that you took the noise and you combined it and so forth. We took one of the buildings out here on Second Street, and out of the project I would scrounge the money for him to go ahead with this thing. He built this outfit over there, and when it was all done, it could really put out the noise. But then he came back and he said he could only run it between 2 AM and 4 AM because of the power it consumed and so forth. But he's an interesting guy to talk to if I can think of his name. He was worried about the noise.

BUTLER: If his name comes to you later, you can always give us a call and let us know.

HOBOKAN: I think he was a mechanical engineer with a lot of dynamics experiences, and he just was gung-ho on building that noise machine. But when I was down here, I kept my hand in this all the time. I was always over there working with the guys to make comments and look at their design of the UTE and how they were coming along and out here in PPD kept tabs on what they were doing, testing pieces of our engine stuff. Yes, I didn't sit in my office. That was the main thing.

You had Dan Mangeri [phonetic], I understand. He said he's gotten his stuff back from you. He was the guy that worked with Russ Clickner in my team in New York. Then when Russ came up with the OMRSD, Dan worked with Russ. But I said I wanted to make sure the system was working first, so I retained signature authority for the Orbiter for, oh, four or five months till I was sure it was going good. Then Dan took over and he did the rest of it, but I kept in touch with that.

We had a problem with going for the ALT. How do you check out an Orbiter at Edwards Air Force Base? Rockwell wanted to send a RF signal up to the top of a mountain and back down to Edwards Air Force Base so that we could use the ACE at Palmdale to check out the Orbiter over at Edwards. That's a concept that we had pushed for a long time. We said, "Why do we have to have more than the LPS [large pointing system?]? Why can't that LPS at KSC bounce a signal off a satellite and go to any factory in the world and check out a piece of hardware so that they get first-hand checkout information? Why do we have to buy a piece over here, a piece there," you know, and so forth?

So, anyway, when the Rockwells were going to do this, it was a 3-million-dollar job to put up the antennas. I had Ed Bacca [phonetic] working for me. He was one of my men from—you see, I kept all those guys from the lunar module when I came down here, okay, and Ed [Eduardo] Baca was doing GSE [ground support equipment] for me. Ed, I think, is an electrical engineer, too. I'm an RF engineer, electrical engineer, but RF. Anyway, we were talking about this thing. I said, "Why the hell do they want to do that?" Well, they were worried about airplanes taking off on the runway there at Palmdale [California].

So I went out to Palmdale and I looked around for the high end of the structures, you know. Heck, the buildings were tall, you know. We got to Palmdale because the big tail on the Orbiter was sticking up so high we had to get a high building. So I didn't want to go up there, so I had one of the Rockwell guys go up and take a picture looking at Edwards Air Force Base, and we could see Edwards Air Force Base, line of sight. So I talked to Ed again. I said, "No bouncing off the thing. Just go straight across."

Well, Rockwell disagreed with that, so I had them take a helicopter with a radar altimeter and fly it right across the terrain between Palmdale and Edwards Air Force Base, and it

recorded that there's a valley between the two places, which further enhances the ability to go line of sight. So Rockwell was still pushing the high-priced system.

Ed Baca had a friend that worked at Goddard [Space Flight Center, Greenbelt, Maryland], and he called his friend at Goddard. His friend over there said, "Hey, we have relay stations. That's some of our business here."

So Ed Baca said, "Well, I need to talk to you about this." He got the charts and everything laid out and went over to Goddard and, sure enough, Goddard had the equipment.

They said, "We can set it up. We have a tower." We put a tower out at Edwards, and I think Baca got it done for something like $300,000 and the rental per month was zilch. The system worked beautifully. So, yes, the guys from Bethpage, if you turn them loose, they could get a lot of stuff done, but Ed Baca got that done without a problem and very cheap and it worked beautifully.

BUTLER: Fortunate to work with a good group of people over your—

HOBOKAN: Yes, you're right. They were people to ride the river with, and it's a shame it got off to such a bad start, but I'm sure it was just they didn't understand Grumman the way some of us did, and the people that were working and supervising them just weren't good managers.

BUTLER: Certainly is a challenging program all throughout. Looking back over your career with NASA, what would you say, throughout all these programs, that was your biggest challenge, and then also what was your most significant accomplishment, do you think?

HOBOKAN: Well, I think the biggest challenge was the lunar module. It was in such bad shape that just pulling it off—if it weren't, as I said in the speech on the anniversary of Apollo 10, if it weren't for Walter Burke and Mr. Mac, we never would have made it on time. Those guys coming through for me was outstanding. But I knew Mr. Mac well, and when I said I was in trouble, apparently he knew I meant it.

BUTLER: I want to just ask Kevin real quickly if he has any questions, and then that'll be about it.

HOBOKAN: Okay.

RUSNAK: I did one or two. One of the things you talked about several times is testing and the role of testing, the importance of it. For all the programs, you got a certain degree of testing going on at the plant, whether that be St. Louis or if that's in Bethpage or wherever. Then you've got another level of testing going on down at the Cape. I understand that there were issues in terms of how much testing to do where, and even if these sort of different levels of testing were necessary, could you do them all at the plant or whatever.

HOBOKAN: Yes, there is a hierarchy of testing that you have to understand. Number one, if a guy builds a black box for you, he's got to swear by that black box and everything that goes into it and everything that comes out of it. So he does detailed testing on that black box, and you hold him to requirements that are, like, 1 or 2 percent accuracy. You can't be from the mean

more than 1 or 2 percent, okay, So you do a very lot of testing and very detailed testing to very accurate limits there, the guy who makes the box, okay.

Now, you say when I add this box to another box, the two errors may add together or they may subtract from each other, and so the cumulative error from here to there, I've got to have a wider range, okay. In our business we call it the funnel. In other words, you hold a black box manufacturer to 1 or 2 percent. As soon as he mates his box to something else at the system level, the system level, you may say, I have to go plus or minus 5 percent. At KSC I may have to go plus or minus 7 and a half or even 10 percent. So you have this funnel that you build at the start of your program and everything stays within that limit.

Now, you have another big problem, and it was most prevalent, from my point of view, on the Gemini Program. When you have people who are frightened—and I don't mean frightened that they're going to die in their automobile, but I mean they're frightened of making a decision that might cause some problem, okay. Now, in the Gemini Program, very, very few of the people at JSC would accept deviations. Now, when you build a black box, and you say, "This is going to come out plus or minus 2 percent," it has a range over which it has to work, okay. Trying to hold it at plus or minus 2 percent over the whole operational range is not good. In fact, every time you do instrumentation, you put instrumentation in a vehicle that's going to be read by Mission Control, you have to provide a calibration for that specific instrument by serial number and location to those guys. They used to call for a three-point calibration. You take some point 5 percent within the lower limit and 5 percent within the upper limit and in the middle. You give them that data and you just tell them whether it's curved that way, whether it's that way, whether it's an S-curve. You give them some idea of the shape and you give them those three points.

Well, during the Gemini Program, we found out that three points weren't accurate enough. So we started giving Mission Control five points, the middle plus, you know, like a zero, one quarter, half, three quarters, upper limit, and that works out pretty well for Mission Control because now you're not guessing at what that curve might be. They got a pretty good feel for that.

Of course, today instruments are much better. They'll do some calibration on their own before a mission. Anyway, when you're doing a thing like a radar calibration at a factory, you're going to deliver a radar, okay, and you have range rate, angle rate, ranging angle. You can't always read those things on a straight line, you know. They want angle. Down here they say, "I want a readout angle so many volts per degree." All right.

Well, when you make the machine, the machine may not be a perfectly straight line. It may have some bumps in it. And you won't get people, who don't understand that equipment, that will buy that at the factory. If you let that prevail, everything's late, because you know the factory isn't going to be able to fix it. It's going to be that way. Now, you're not going to go and change the spec, so you've got to say, "Okay, I'll buy it on a deviation and install it in a spacecraft and go." All right.

But on Gemini we could hardly get anybody to do that. So as the resident office, our necks were on the block. We had to tell McDonnell we would buy it. We had our own QC people and we reviewed that stuff. Jim [J.P.] Harris [III], by the way, was our QC guy for vendors. So he would come in and say, "Here's the curve and it's holding up delivery."

We'd review the curve and tell him, "Sign it off. It's okay." But he would make us sign it, you know. Then he would go and take care of it and get the stuff delivered. Had a very bad name down here.

Chuck Mathews had a guy, name of Bob Lunt [phonetic]. I don't know if you ever heard of his name. Okay. Bob Lunt got up at the end of the Gemini 25th reunion. All right. Chuck Mathews said, "I want everybody in here to tell me what you did and how it contributed to the program."

Bob Lunt got up and said, "My only job on Gemini was to stay in St. Louis and spy on Andy Hobokan." How about that?

BUTLER: That's interesting.

HOBOKAN: Yes. So we were doing things to move the program. I went to lunch with Chuck Mathews and Walter Burke one day, and we were walking down a passageway, and Walter Burke was asking Chuck Mathews about something that he wanted to do on the—I guess it was the Gemini Program. Chuck Mathews said, "Why are you telling me? Why don't you just talk to Andy and he'll get it done and I'll never hear about it."

And I just turned around and left. I wasn't going to be party to a conversation like that. But, yes, when you're trying to do the job, it's a lot different than sitting someplace and complaining. But when I was here, I got around. I knew everything that was going on, and if I didn't, some of my people did.

Walt [W.] Jaderlund, you probably talked to him. Walter Jaderlund. He was the head of structural testing in my office. He worked the SSMEs [Space Shuttle Main Engines] and he worked the structural tests of the Orbiter out in Lockheed's facility in California. That's where we flew the bird. Hydraulically we never left the ground, but we flew the bird, through all kinds

of takeoffs and landings and everything else. Jaderlund was our integrator for that. He was our interface with the Mississippi Test Facility for the engine work, and he kept good tabs on that.

I went to a special committee to oversee the SSME and I asked the guy how they were going to qualify the engine. He said, "Somebody'll sign a piece of paper."

I said, "That's an incompetent answer."

And the Marshall guy that was head of QC got up and said, "I agree with him." [Laughter] So if you're going to do things, you got your neck stuck way out all the time. I think at that time NASA was different than it is today. You know, you can't find anybody who will even let you stick your neck out. You get your head chopped off before you're allowed to stick your neck out. People just want a 25-million-dollar study before you dot an "i" because you've got to be sure it's an "i" and you got to be sure it's a dot. Yes.

My son-in-law was a CO [commanding officer] of the fighter squadron over here. He was also on the staff, the astronaut staff, here in Building 4. After he was here six months, he said, "Even on obvious things, I can't get an answer." So he quit. Got out. "That's enough." Quit. Went to work for American Airlines. So, yes, he reminds me every once in a while, he used to fly some of the astronauts around, the non-pilot astronauts. You remember the black girl, Mae [C. Jemison]?

BUTLER: Yes. Mae Jemision.

HOBOKAN: He said he was in the T-38 and his job was to take Mae up and put her through a bunch of maneuvers. She had planned to do this, okay, It wasn't something he was doing, but he got assigned to be her pilot that day, and she said, can she operate the radio. He said,

"Offhand, I said, 'Sure, you may.'" So they got out to the end of the runway and Mike [Hobokan] said to her, "You can call the tower and ask for permission to take off." He said Mae got on the radio and said, "Hello, tower. This is Mike and Mae. Can we go now?" [Laughter] He said he was trying to scrunch down in the cockpit so nobody would know it was him in there. But, anyway, she said, "Hello, Tower. This is Mike and Mae. Can we go now?" [Laughter] But he didn't stay long. He just felt the current environment wasn't good for that.

Now, you got some people here that are working hardware and structure that are doing a good job, and that's the X-38 people. I think you got some people there that are willing to maneuver and get out and get things done, and I think that they're working pretty well.

Got any more? Did I answer your question on the funneling?

RUSNAK: Yes. Related to your days at Gemini, one of the original goals for the program was also to prove the ability to land on land instead of in the water. So I was wondering how you as someone who would be interested in how you're going to actually apply this to the capsule, what you thought of the things like the paragliders.

HOBOKAN: Well, at that time, you know, the paraglider was being used a lot by people. We watched a lot of people run around with those things and dive off the damned cliff and soar around in it. It looked pretty good. It was called the Rogallo wing. The Gemini was supposed to land on land, and it landed on skids, not skis, not wheels, okay. The Gemini was supposed to have a parachute, then deploy the Rogallo wing, and then by moving the CG [center of gravity], you could take it down and land on the skids.

The skids were an interesting design. The skids were not straight. The skids were angled, and one of our big problems was to find out what that right angle was. Now, when you're skidding down there, if both skis are tipped at the same angle, the friction here and the friction here is the same [Hobokan gestures]. So it'll go straight. But now if it starts to wallow and this one goes that way, then you get a lot more friction here and it tends to straighten you out. If it overshoots, you get some more here and you kind of—okay.

So one of the big things was to get that skid angle correct, and we did a lot of work letting it come down on a swing and, you know, on a line with pulleys and hit the ground and go off. So, yes, we were very, very enthusiastic about that.

Rockwell caught the job to do the Rogallo wing, and at JSC here, one Scotty [H.] Simpkinson was working with quality and safety with Rockwell. Scotty kept reporting to us that they were having trouble because of the number of sequences that it had to go through. First, you had to deploy the drogue chute. Then you had to get the wing up, wing deployed. Then you had to fill the wing, you know, with gas. Then you had to get rid of the parachute and then you had to do this, then you had to do that. Well, deploy the landing gear.

As I understand it, there were some twenty-one sequences that had to be accomplished to do all of this, and Rockwell had trouble getting past fourteen or fifteen of those sequences. They never could get through this chain of sequences reliably. So the monies that were going into that program were canceled, canceled on the Rockwell side. Then we gave up the skis, the skids, skis, the deployment mechanism for the skis. When you're on a Rogallo wing, we had to have a lanyard come all the way down between the hatches and hook onto the nose so that you were holding two lines aft and one line forward so that you held the vehicle pretty level. Okay.

So when the Rogallo wing effort was terminated, then the skis were terminated and then that's when McDonnell said, "Hey, if we use those attach points, we can tip the vehicle this way and we can enter the water on the point, and you're not getting this bang like we did on Mercury and Apollo. You could land on the point, the corner of the heat shield in the body. Then you get a much nicer entry, and you don't get that sharp jolt."

But we were really keen on doing the paraglider and the skids, and we were a long way along on the Gemini side of the house. It was the Rockwell side trying to get that job done that stopped it.

Now there's a corollary here. Rockwell with the B-1 was trying the develop an ejectable pilot crew capsule, if you remember, early on. Never did get that to work. The B-1 doesn't have that ejectable capsule. They had planned to eject the crew as one piece and have it come down on a parachute, but they were never able to get that going. That was Tom Healy [phonetic]. Tom Healy went to do that job and never got it. So there are two things that Rockwell had tried like that, and neither of them worked. Now, they did make the ejection seats work on the Gemini, but you be sure to ask Bob Thompson. If he doesn't answer your question, call me.

BUTLER: Okay.

HOBOKAN: It was a real, real blow when we saw those sled tests. Yes, but I want him to tell you.

RUSNAK: Okay.

BUTLER: Well, we'll be sure to ask him.

HOBOKAN: Let's see. Anything else?

RUSNAK: No, those are all the question I had. Thank you.

BUTLER: Thank you very much for coming and talking with us and sharing your experiences.

HOBOKAN: Yes, it was interesting.

BUTLER: It was very interesting.

HOBOKAN: The whole business has been interesting.

BUTLER: Would you ever have imagined where your career would lead you?

HOBOKAN: No. When World War II started, I didn't figure I'd ever survive. My brother and I figured we were going to get drafted and that's the end of that. But from all of my family, we all survived. My brother and I and my sisters, two brother-in-laws survived, and it worked out fine.

But, I'll tell you, sub-hunting in convoy isn't fun. We spent the first part of my career sub-hunting and trying to find out where these submarines were getting refueled down around

South America. So we spent months anchored out with our airplanes night and day searching. We got all the way down to Argentina and that's where they were getting refueled.

Okay.

[End of Interview]