NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY 2 TRANSCRIPT

HAROLD JOSEPH MCMANN, JR.
INTERVIEWED BY KEVIN M. RUSNAK
HOUSTON, TX – 15 FEBRUARY 2002

RUSNAK: Today is February 15th, 2002. This interview with Joe McMann is being conducted in the offices of the Signal Corporation in Houston, Texas, for the Johnson Space Center Oral History Project. The interviewer is Kevin Rusnak, assisted by Carol Butler and Sandra Johnson.

Once again, it's a pleasure to have you here this afternoon.

MCMANN: It's good to be here.

RUSNAK: I'm glad you liked it enough last time to come back for us.

MCMANN: Well, I didn't know, maybe I talked you to your knees last time and you wouldn't have me again.

RUSNAK: No, it was truly our pleasure.

This time I was kind of going over some of the questions we'd done last time, and I wanted to ask you a little bit about, just to start out, the end of the Apollo Program and going into Skylab. Did you have any interaction for the last several Apollo flights where they had the command module pilot do EVAs [extravehicular activities] outside the spacecraft on the way back? I didn't know if you had anything to do with the equipment for that.

MCMANN: Just barely. They used an umbilical cord for that, and we were working on the Skylab umbilical, so we used a version of that, sort of a simplified version. The Skylab umbilical

had oxygen supply and water cooling lines, supply and return lines, and electrical and a tether. I think they just used the tether and the oxygen line. So that was really the only involvement with those EVAs that I had.

RUSNAK: The Skylab system you're talking about, is that the astronaut life support assembly [ALSA]?

MCMANN: Yes. Yes, I was pretty heavily involved in that.

RUSNAK: Maybe you could run us through some of the development of that, coming up with the requirements and all that.

MCMANN: Oh, sure. This was the first time I ran across the fallacy of—it goes by several names. The most recent might be "Build it and they will come," the idea that if I build the perfect system, people will buy it.

We had been working on a self-contained backpack called the P-E-C-S, the PECS, Portable Environmental Control System. We had been doing this at the same time we were doing some of the Gemini work, and it was meant to be a system that could operate like the Apollo backpack. It was packaged better, smaller, get a four-hour system, and we were using sodium chlorate chemical generation systems for the oxygen, called a chlorate candle. This thing was ignited.

We had four candles, one in each corner of the backpack, and as they essentially, quote, burned down—they weren't really burning, but it was decomposing—you got oxygen from that. Of course, these things had indefinite storage. You could leave one of these candles before you ignited it for years and it would still be good. However, once you did start to ignite it, it was

gone. You were faced with that. Also it put off at a fixed rate, so you had to size it for the highest rate.

Even with all that, it traded off competitively with high-pressure gaseous storage, which is what we characteristically used, so we were developing the system. It had a number of other things. It used the water-cooling principle that we developed for Apollo, the liquid-cooling garment.

Here comes Skylab along, and we said, "This is great. We'll supply this system to Skylab." You can use it with an umbilical. You can use it without an umbilical. You've got these four candles, so you don't have to burn them all. You burn them one at a time. So, of course, it's going to cost several million dollars to bring it into flight-type status.

So we went to the powers-that-be over in the Skylab Program and said, "We got this great system coming along. We've got it practically developed," which is what engineers will always tell you.

They said, "Well, this is great, but do we really need it?"

We said, "Well, but it's got all this capability. It will do your job and so much more."

"But we don't need it to do more." So he said, "Well, look. We've got this huge spacecraft environmental control system. All we've got to do is go out to this Apollo Telescope Mount and take these film canisters off and do that. That's all we have to do. We know what the track is. Why couldn't we use the capabilities of this spacecraft system and maybe just have, oh, some sort of umbilical system? That would be fairly cheap."

We said, "Well, you could do that, but, boy, this is so much more technically elegant and all that." So that was my first lesson in the fact that the program is only going to pay for what they need. They're not going to pay for all this other stuff.

TFX was another example, the first joint Air Force-Navy fighter, the swing wing. Well, it was going to do one thing for this guy and another thing for this other guy. The trouble is, you have to carry extra weight, you have to pay extra for these other capabilities that, while they

benefit the other guy, they don't benefit you. So then your question is I'm limited in budget, I'm limited in time, why should I pay for something I don't really need?

So that was the question that we faced, and I finally started to learn, aha, these programs are so short-sighted, all they want to do is satisfy their own needs. They don't care about my beautiful technical masterpiece here. So that system died an ignominious death.

We had some fun with it before it died, though. We wanted to demonstrate this chlorate candle generation of oxygen. Now, it had some problems. First of all, you've got to start this reaction going. To start the reaction going, you need to have heat, to have heat, you need an igniter. If you imagine a kitchen match, when you got this thing that you strike it and you've got this head that starts burning, it gets this other red part burning, and that finally starts the wood on fire. Well, you can see if you've ever smelled a kitchen match when you light it, all this stuff that comes off, it doesn't smell good like the old wood-burning. So you have all this other stuff.

Well, the same thing is true with this chlorate candle. When you light it, you have this igniter, and in order to get this thing ignited, you have these chemicals, which give off noxious gasses. Then you may have to add some things to the candle to keep it going, to keep the reaction going. Usually the thing they added was little iron pieces in there. Well, you have iron in there, and you get some incomplete combustion and all, you're going to wind up with some CO [carbon monoxide], you're going to wind up with the other chemicals they added, you end up with chlorine, so you have to purify all this stuff coming off.

Well, it turned out we found that in zero-G and within the pretty well insulated container that we had, we didn't need to add a lot of stuff to this to get it to go, to keep the reaction to be self-sustaining. It's an exothermic reaction anyway. It means it gives off heat, and this thing was so well insulated, we kept most of the heat, so we could take most of those things out, those reaction enhancers, if you will. But to demonstrate it in 1-G in the open room, you'd lose a lot of heat.

So anyway, we set up this big demonstration. Here's Mr. Manager, astronauts, all you people, we're going to show you this tremendous way of generating oxygen. We made the cardinal mistake of not having a dry run first to do this. Anyway, we fired this thing up, and I mean the room emptied within about is fifteen seconds. The smoke was so thick you could hardly breathe, and the thought was, "This is your breathing oxygen?" So if we hadn't killed the system with it being overweight and overcost and too complicated for the Skylab job, that one demo would have killed it for us. So that's, again, some of my dumb tests that I've run in my career.

RUSNAK: How similar is that system to what they used on the Mir, if you're familiar with that, where they had the oxygen candles?

MCMANN: Let's see. We used potassium chlorate. I think those are chlorate candles. They've come a long way. They use these in aircraft. Some aircraft emergency oxygen systems are a chlorate candle also. Well, this demo candle that we made was really dumb. Hindsight, we should have put it inside a canister and had some sort of a filtration bed in it, but we wanted to show people. Because when you get through with one of these things after it burns, you have an 800-degree piece of salt. You have sodium chloride left. So that system died.

So we went with a real simple system we called a PCU, a Pressure Control Unit, that mounted on the astronaut's belly and was fed by an umbilical from the Skylab system. We had cooling water that came in and out and oxygen supply and electrical power. Then we had a thirty-minute emergency pack on his leg. That was the system they used real successfully not only during the normal missions during Skylab, but also during Skylab emergency to do the EVAs which essentially resuscitated the station, the Skylab Space Station.

Did I talk about the Skylab Source Board activities out at Ellington at our last time?

RUSNAK: No. Not for Skylab.

MCMANN: I talked about the file cabinet that I couldn't open.

RUSNAK: You talked about the file cabinet.

MCMANN: Yes, that was it.

RUSNAK: You talked about the trains.

MCMANN: Yes, the train chart, okay. I just wanted to make sure I covered that.

RUSNAK: Was that for Skylab or for Space Shuttle?

MCMANN: That was early first Shuttle. That's right. That was Shuttle stuff. I'm getting them confused. Yes, it was the early Shuttle days.

Skylab, I worked with a guy named Travis Brown. Have you had Travis in here?

RUSNAK: No.

MCMANN: Oh, you've got to get [James] Travis Brown. He works for Wyle Labs. His number is 281-212-1274.

Now, Travis was a guy—he was assigned to me in the Gemini Program right as things just really started to get hot. Travis came from the world of advanced studies, sort of a relaxed blue sky. He was working on Mars environmental control systems. He was yanked from that nice, secure, laid-back world and thrown into my world at the time, which was just cranking up.

He was sent to [McDonnell Aircraft Corp.] St. Louis [Missouri]. We were doing checkouts of our Gemini chestpack that we used after Ed [Edward H.] White's pack and sent to do checkout of that. I mean, you talk about culture shock, climate shock, everything. We sent him there.

Travis, when he got nervous, he started eating. We both liked this type of candy bar, Butternut candy bars, and Travis, they used to be able to find Travis, watch it, just follow the trail of candy wrappers to wherever he was. But he was married at the time, had small children. I was single, and I couldn't understand why all these married guys were so loathe to go out on travel, because—I found out later why, after I got married and had kids: disasters wait to happen until you go on travel.

One time I went, it was on a Sunday, I called home to see how things were going. The hot water heater had broken. My wife didn't know how to shut it off. I said, "The valve on top, shut off the valve." She said, "What's a valve?"

So another time a dog bit my youngest daughter. I mean, so now later on, I understood why these guys hated to go off on travel. For one thing, their wives were left with the kids. Their wives considered this is vacation. "You're getting a vacation. I'm stuck here with the kids."

So, yes, we had a number of guys. A guy name Marshall [W.] Horton, if you haven't talked to Marshall Horton, he works for Boeing. He's another one, another one to get. He's right over across from my building, right over on the Boeing Building on the lake over there.

RUSNAK: What did he do?

MCMANN: Well, Marshall came to me right in the early part of the Gemini Program. I think he came from MOD [Mission Operations Directorate]. He was from a little town in Texas, Mineola, Texas. Marshall was really quiet when he first came to work for me. We couldn't figure out much about him. He was very competent, very quiet. Didn't realize he had a sense a

humor until one morning we were sitting there talking, it was in winter in Houston, which was kind of unusual, and this little girl from down the hall came down, was talking to the secretary whose desk was right near Marshall's. He was there with his head down, working. So the girl says, "Boy, it seemed cold this morning."

Louise, my secretary, said, "Yes, I think it was pretty cold."

This girl said, "Well, my mama said it was thirty-four degrees on her front porch."

Then all at once Marshall perks up and says, "Yes, but her front porch is in Duluth, Minnesota." Just came out with stuff like that. Then we realized Marshall was one of the guys. He is another one that got sent to St. Louis to work also.

Then there was Norm [R. Norman] Prince. Norm, he left us and he went to Breckenridge [Colorado]. Now, Norm—these people all had their individual characteristics. Norm—I don't know how to even describe him. There was never a person like him. Norm was one of these people that if you put a wall in front of you or me, we would study, now, what is the best way to get around that wall? I'll try and go around it, maybe I can tunnel under it, maybe climb over it. Norm, without hesitation, would go through it.

I told about Norm's car, didn't I, about the time—he had a '52 Olds. He used to stomp the beer cans through the floor. That was Norm.

A bunch of us decided to be test subjects, and to keep in shape, we'd go out and run every day and we'd do a few exercises. We did a few sit-ups and all that, but Norm, he had sets. He'd do sets of exercises. Before we'd go out on the floor, he'd get down on that tile floor in the suiting room there—there was a restroom with some showers and then some lockers and just a tile floor, really small tiles, kind of really rough. Norm would get down there and do his sit-ups, about three sets of fifty sit-ups before we'd go out and run. Well, I guess the floor must have gotten a little slick when they were wet, because one day we came in and they had put down patches of—the only thing I could say it was like sandpaper, but really, really rough so you wouldn't slip. Well, they happened to lay one of those patches right down in the spot where

Norm did his sit-ups. Well, you or I would move to a different spot. But that was Norm's spot, so he'd lay down there and do his sit-ups, and his back was right on the sandpaper. When he got up, his back was bloody from doing it, but that was just Norm. You didn't mess with him.

We were in there suiting-up one day. He stripped down, and I noticed his hip and all down his leg was black. I said, "Norm, what the hell happened?"

He said, "Oh." Well, he was a water-skier. Norm was a skier. His daughter was out pulling him in the boat. He was trying a new ski, new set of skis, and something went wrong, and one leg got pulled out, almost out of the socket. So he was out on the water.

I said, "What happened?"

He said, "Well, I threw my leg out."

I said, "Well, what did you do?"

He said, "Well, I got back. My daughter pulled me in again."

I said, "Boy, what did the doctor say?"

He said, "Well, I didn't go to the doctor."

I said, "Well, what did you do?"

He said, "Well, after it stopped hurting, I went skiing again."

I told you about the liquid nitrogen phone booth that we had the problem?

RUSNAK: Yes.

MCMANN: Norm was the subject in that. Norm was the guy in the chamber when that happened.

RUSNAK: Did he take that same sort of approach to his work?

MCMANN: Oh, yes, everything. Norm would build up a head of steam. We'd have to get something done, so Norm, if it took a memorandum and a purchase request and all that, Norm would—usually what you'd do, what you or I would do is we had to take this to the boss. We'd kind of maybe put a rough draft together of the memo I wanted to say, because in those days the secretaries did all the typing. You did not want to go back to a secretary with her final after she had made all the file copies and everything, got it just perfect and say, "Well, he didn't like this. We'll have to scratch this out," especially if you scratched on the original. So the prudent thing to do was to always take the stuff in in rough draft form and get your boss to say, "Yes, I don't like this. Change this word. Do that." Then you go back, and you get a typed final, and when he sees it, he signs it.

Not Norm. Norm would go for the final right off. He'd have the purchase request done, all the copies, the memo, all his copies, any attachments, and bring it in to you. Then if you tried to make a change, he'd try and argue you out of it. I mean, he just could not let it go, could not let it go. But that's just the kind of guy Norm was.

I learned secretaries would have to be treated with the utmost care. In those days they determined how well the office ran. It wasn't how good the engineers' work was or how brilliant the leadership. It was were you going to be able to get that memo out or not.

Louise [Y. Perdue], my secretary back in those Gemini days, one day I must have done something, I don't know what it was, but I did something wrong, because Louise came to my office door and then laid a document on my desk from about eight feet. Whap! I said, "Louise? What's wrong?"

Of course, she gave the classic female response, "Not a thing." It took about three days to finally pry it out of her what I'd done. But I mean, that's how you learn.

So that's how the office ran in the old days. We didn't have computers to make your charts. Your work could sit there a week. If you had managed to antagonize her, your work always found its way to the bottom of the stack somehow. There was always something more

important. So you learned you cultivate the secretaries. In fact, your boss' boss' secretary was a good idea to cultivate if you ever wanted to see him.

But actions and all that were very, very crucial. We had the dreaded blue sheet. We had a letter that needed an action done, it came on a blue sheet, and had it a date on it, a suspense date. So these blue sheets were logged. If that suspense date came due and it wasn't down there, then the call went out from the division office.

So one day one of my old bosses had gotten a blue sheet, and it came due. He realized it was due and he hadn't done anything on it yet. So he took it, and he went down the row of offices, and he found this guy's office, Bob [Robert L.] Spann. Bob was a great guy. Maybe you've even had him talk. He's been around forever also. But he had a habit of really never going through his in-basket. It was always about eighteen to twenty-four inches tall. So Harley [L. Stutesman], my boss, went in, lifted up about eight inches of that stack, and stuck that blue sheet in there and then put it down, went back to his office, and then the division came down and said, "Harley, we have to have that blue sheet. It's No. 14. It was due yesterday."

He said, "By God, you're right. Let's find it." So he said, "Come on." He got his staff together. "We're going to find that blue sheet," went from office to office looking for it, came to Bob Spann's office. Bob was in there at this time. He said, "Bob, have you seen blue sheet No. 14?"

Bob said, "No, I haven't seen it."

"You don't mind if we look for it?"

He said, "No. I'm sure I haven't gotten it."

So guess what? Harley found it. Harley said, "It's in his basket." [Laughs]

You had to be devious.

RUSNAK: Yes, we certainly don't pick up on those subtleties just reading the documents.

MCMANN: Oh, yes. That's right. There was always ways. Well, let's see, what else were we—see, you have to watch these tangents you get off on. We were talking a little bit of Skylab…

RUSNAK: Speaking of representing the division, your department, do you have any of these similar sorts of memories about meeting with any of the people from Headquarters, anything like that?

MCMANN: Yes, we used to meet with some. Well, let's see. I remember going up to the Manned Space Flight Experiments Board, MSFEB. That's when we were trying to get the maneuvering unit experiment done. I think we talked about the M-508 last time and some guy's daughter finally got it on, trying to get those experiments on. I remember going up and making presentations on my system, on the Gemini chestpack.

I went up there, and [George E. Mueller], I think, was Associate Administrator for something. I was up there. We'd had to change the configuration of the chestpack and added a heater to it. We talked about that before, when the guy tried to open his face plate at that altitude. Well, that ended up having us put a heater on that piece to keep ice from building up in it.

So I had to go up and explain that. I'm a chemical engineer and not really much of those, even, but electrical stuff, I have about half an inch deep on, but I figure, dumb as I am, I'm the smartest guy in the room as far as electrical stuff goes. So I go up there, and I'll amaze them a little bit with this detail schematic. So I got my board charts that tell about this problem that we had, and we're going to add this heater to the ejector, and I could have just quit there, and it would have been fine. But, no, I had to show off a little bit. Here's the schematic, and I threw this thing up, and even with this chestpack, which wasn't really a complicated device, anything at all with electronics or electromechanical devices in it, gives you a hell of a complicated schematic. So I threw it up there, and I pointed out the area where we added.

All at once, [Mueller], he was a double-E [electrical engineer]—I didn't realize that—man, it was like I gave him a drink or something. Oh, man, he perked up. "Oh, yeah. Where's the ground go over there?" He starts asking me these questions. Well, luckily I was able to fake my way through it, but, oh, man, he was amazed. I thought, never again. Never again. Never put all you know on the chart, because then you aren't even one question deep.

Other times, I remember the elevators in the Headquarters buildings were always slow, always slow, so you ended up taking the stairs. So I remember being up there with a guy from Orbiter Project, Gary [A.] Coultas. Gary Coltas was about six-two, and about five-two of that was legs. He had the longest legs anybody ever saw. A lot of people go up the stairs two at a time. I do it. Maybe you do it. You come down one at a time, of course. Gary goes up the stairs three at a time and down two at a time. Now, if you want to do something sporty, try coming down the stairs, briefcase in your arm and all that, maybe a coat in the other arm, not holding on, two steps at a time. That's adventure.

Oh, making presentations at Headquarters, that was always fun. In those days you had the room where you were going to give it. You didn't project from the front; you projected from the back. So the guy was running the slides was in the back, so you had to give him a slide map. Here's the slide order and all that. We were going up there one time. We'd had the fire on our system. Let's see, was it after the fire? It was either after the fire or STS-5 when we had two units that didn't work.

Anyway, we had to make this presentation on the system and how we had fixed things, so we had all these slides. The guy in the back can hear the speaker if the com is working well. He can't hear usually anybody else. The NASA Administrator then was [James M.] Beggs, who was never known for being a glad-hander and a jolly soul anyway. He was late for the meeting, so we were in there talking. I think it was after the fire that we had in 1980.

So we have all these slides, and I'm not giving the pitch; I'm sitting there. I'm technical support. So the guy that's giving the pitch is going along, and he's talking, and then all at once

somebody says, "Well, wait a minute. Your slide two or three before that talked about such-and-such. Get that slide." Anyway, he ended up, the poor guy in the back room was getting confused about which slide, so the wrong slides were coming up, and room was getting antsy, and then Beggs showed up right in the middle of this. He's mad anyway for some reason. He's coming from something else. He'd rather not be here. Then he realizes what it is, and he gets madder than ever, because here we are the people that had this system that burned. And he starts going after us.

I go back there and try and straighten the guy out with the slides. We never get the slides straightened out. My division chief at the time tries to stand up, and he started getting questioned about essentially how could he let that happen, so he tried to blame it on a guy that came before him, "Didn't happen on my watch," not realizing that the sons inherit the sins of the fathers. It's yours, baby. So it was a brutal time. It was a massacre. That's why you have drinks on the plane when you leave. It was terrible.

Well, there's a saying about Building One [at the Johnson Space Center], I mean, dealing with management is never fun. "Nothing good happens above the sixth floor and damn little there," what they say about Building One here.

RUSNAK: Well, at least in front of Headquarters you didn't have another "great exposure," right?

MCMANN: Not a great exposure. No, I didn't manage to do that.

Those were usually brutal budget-type battles. I did have a couple of successes up there. We sold in the Shuttle Program essentially one of the greatest pitches I ever made in my life. We wanted 15.4 million bucks, I remember, and we got it. Who was it? I can't remember who the astronaut was that was heading up. He was Associate Administrator. I'll think of it in a minute. I had a sharpshooter in the back of the room and managed to silence him, too, and got all the money.

We got out of there, went to the airport. Planes were being canceled. I think we were at Washington National. The last plane was going to be out at ten o'clock, and we finally called up the travel agents and had them get us first-class tickets. We had to get back. So we managed to get first-class tickets. So I remember the lines of people. I mean, the airport was crowded with people. There was people dying in the aisles. I mean, there were kids running this way and that. People slaughtering and roasting goats. I mean, it was just total chaos, people trying to get out of there before the storms hit and trouble in other parts of the country.

So they had the lines, and they had you stand back to leave an aisle in front of all the ticket counters. Then we had this one place that was the first class. Of course, this was all coach and business was all just lines a quarter-mile long. First class were no lines. So Sid and I, the guy I was with, we're coming towards the counter, heading right for that first class. The woman behind the counter sees us coming, "This is first class. Coach is over here. Behind the line."

We keep coming towards her, keep coming towards her. "First class. This is first class only."

We kept coming. I went up there and said, "First-class reservations for Schmidt [phonetic] and McMann." It was great. Got on the plane, I had two drinks before we left the ground. We were the last plane out that night. So that was it. That was absolutely the peak of my Headquarters experience.

RUSNAK: Do you even remember what the $15.4 million was for?

MCMANN: Yes. It was buying extra suits, buying extra space suits. What we were doing was making a case for reality, which is something that's hard to do. We had this case where supposedly we were only going to fit a limited number of crewman, twenty crewmen, the so-called cadre. We were going to have an EVA cadre of crewmen, twenty people.

RUSNAK: This is Shuttle Program?

MCMANN: Yes. We can change two of them a year. Well, that was limiting the number of crewman. So they bought off on it. The trouble is, the twenty floated. It was twenty, but it was a different twenty. So that meant the number of suits we had weren't necessarily able to fit all these different sizes. You had to buy a bunch of sized components.

So finally we got them to admit, let's go with a probabilistic thing. You've got this many people that are large and this many that are extra large and this many are medium and this many are small, let's figure out a probability of these guys being stacked on missions back to back that we'd have to have so many of this certain size. So we came up a probabilistic determination and said we need this many more things, and, I mean, they actually bought it. So that was great. It was one of the high points of my career.

RUSNAK: It's good that that one was successful.

MCMANN: Yes, because there's been a lot of others that weren't.

RUSNAK: Can you recall any of these that were, as you described them, brutal budget battles that you ended up losing?

MCMANN: Well, let's see. In '91 I was looking at what the Space Station assembly sequence was going to look like. It was old Space Station Freedom. You remember Space Station Freedom. This was before I knew how to use a computer chart, so I decided, okay, I made what I called the Dead Sea scrolls. I had this long thing. Along the bottom I had time, and I had the missions spiked out along here, how long the missions would last, and then how long it would take to ready a system, a ship set of a couple of units to go up, stay up there, come back, get

processed, and be able to use it again. So you had a certain turnaround time. So you'd figure out how many sets of hardware do I have to have in flow to satisfy this mission model.

It turned out we needed about six more than we had. By the time this mission model would get busy, we needed about six more units. So I tried to sell that to Headquarters, and they said, "Well, we'll give you two, and maybe we'll take options on the other four." Well, okay. So we got two and then they never did come through with the options. This was back in '91. Then Freedom went down the tubes. Turns out they've now bought those other units, so I was proved right, probably for the wrong reason. But that was totally unsuccessful, and of course we've done a lot of suffering because we've been short of hardware ever since. I tried to find those Dead Sea scrolls a while back, but when I left NASA, some of that stuff got pitched out.

RUSNAK: In thinking about the Station program and the hardware, were you at all involved in the suit selection for the Space Station where they're considering, well, do we use like an 8 psi suit?

MCMANN: Oh, yes, definitely. There's a lot of that. When the Station first started to be formulated, see, you always have two schools of thought. One says, "Let's use what we have and upgrade it if we have to," and the other school says, "No, no, no. This is limited. Let's build a new one. Let's get a new one that's better." That carried a lot of momentum for a while because we had a lot of requirements that came out of the woodwork. I don't know whether we talked about this some before or not.

The system for Station was going to need to be nonventing. You couldn't have water vapor coming out of it like we have with our sublimator, because you're going to contaminate all these sensitive instruments that all these scientists are going to be putting up there. You needed to have your hands free, so you needed to have automatic control, voice-actuated controls. You

couldn't be just adjusting controls all the time; you needed to have your hands free. You needed to have all these other things that said our current system just wasn't going to hack it.

So then they started to look at the bill for a new one, and I think we talked some more the last time about our current system and, yes, it would do certain things and it would do more, only we hadn't proved it. So then we said, "Well, let's go prove it." So at several times during the program, in fact, when I was going to buy these other six units, other contractors were interested in getting and said, "Hey, let us bid on these."

I said, "But we're not building new units; we're building more of the same. You can't build more of the same because you didn't build the first ones."

They said, "Well, you guys are just going to keep using that suit forever." As long as it's good enough, you do keep trying to use it. At some point you need to come up with a new one, and we keep extending the life of this one, and people not wanting to foot the front-end costs of a new development, because—I think we talked about this last time—if you're going to put something in play midstream like this, you've got to keep your current one going. You bring up your other one. At some point you start phasing the other one out, but at some point you don't know what that point is, so in this interim time you're paying to keep your current system going, you're paying to put the new system in. So can you afford all that for what you get out of that? What do you stand to gain?

So with the Station Program, they get very critical about that. "What's in it for me? If I can use this system to build the Station and maintain it, why do I need another one, unless you're going to show me some phenomenal decrease in operating costs that would pay off the development costs and risk and all the double billing that I'm going to have to do until I get it in place," and if the Station is only going to last ten years or so, you'd be hard pressed to pay all that off, especially to pay a lot of up-front money. You pay real money to save what I call viewgraph money. So it becomes a very hard sell unless you just can't do it with the current system.

RUSNAK: What were some of the tradeoffs to stick with the current system?

MCMANN: Well, it turned out when we started trying to chase down some of these guys with their requirements, they couldn't be found. Turns out we don't have a lot of sensitive instruments that can't take water vapor. This was all somebody's dreams of, yes, maybe someday we'll put these things up there and people took that—we coined a term in Skylab, it was called "desirement." Wasn't quite a requirement. Stronger than desire, weaker than a requirement, so it was a desirement. If you could get it without paying a lot, you'd get it. If it started to cost you something, you wouldn't take it.

Well, these things went from desires to desirements to requirements without any justification. So when it came time for a guy to put up or shut up, it was gone. It wasn't even a desire anymore. But that's what happens in the world of real hard-nosed project office work. Only the things that you really have to have survive.

That's why you have to be smart. Like I said before, if you know or you're pretty certain that they're probably going to use my system outside its specified envelope, then I've got to sneak in this margin where they can't find it or they'll take it out.

RUSNAK: Certainly a good example of the importance of margin like you were describing last time.

Do you think there would have been any distinct advantages or that there were actually distinct advantages to using one of the hard suits, either from JSC or from Ames [Research Center, Moffet Field, California]?

MCMANN: I think for this mission, for the Shuttle mission, for the Space Station mission, no. The weight, they're a lot heavier. I'm not sure that the development risk and the development

cost traded against what we already had. What we had would do the job. They also found out some things about the hard suits. You have pressure-point problems. You have more pressure-point problems than you do with these so-called soft suits, even though they get pretty hard when they're pressurized. Still, if you've done hard suits, it's different.

The hard suits, with the bearings and all, none of your motions in a suit are natural anyway. These are a little farther removed from being natural. You have to kind of program your movements a little bit. I think it's just matter of training, but it is different. The more and more experience you get, particularly use experience with a type of suit, with a pressure level and all that, the more risk you take in trying to change it.

We went through an exercise back in '96 in looking at going to a higher pressure for the current suit and just doing some testing to see if our safety margins could be increased and seeing how much mobility would be decreased and what changes we'd have to make to keep it safe and then make it functional. We did the tradeoff, and the camp out and the current protocols we're using on station, they've worked the time lines in pretty well on those, and it turned out that there wasn't a cost saving. You couldn't really justify from a cost saving.

Plus the thing that really worried me was what am I giving up by going to a higher pressure that I don't know I'm giving up. I've got all these years and years and years of experience at this pressure level with this hardware. I want this hardware to last a long time. Now I'm going to be cutting into that margin. If I test and prove it, still I'm definitely cutting into the margin that I have. Am I cutting it somewhere too far that I'm not smart enough to see now and I'm only going to find out later I should have been smarter? So we managed to stop that. Beside, it would have taken hardware out of service while you're modifying it. We were already short on hardware. It was just a lot of reasons that didn't really seem to make sense for us.

We had some hardware developed, like some of the gloves we're using now were developed for use at 8 psi, the Phase Six glove we're using, and it stands to reason if they're

good at 8 psi, they ought to be great at 4, which turned out to be true, although we rushed into that program a little bit fast, also.

RUSNAK: But it always seems that the gloves are one of the critical factors in terms of flexibility, maneuverability.

MCMANN: Oh, yes. Well, why do you put a person out there? You put them out there for his or her eyes, their brain, and their hands. I mean, that's really all you put a person out there for. They have the ability to do what the eyes see and the brain tells them. So it turns out to be a very critical thing.

One of the errors I think we've made in gloves, made it several times—and I think we may have talked about this before—was having a problem and when we fix that problem, we make a couple other changes that end up causing us other problems. You're dealing with things that you have very little tolerance for error on. If you've got it right, then any changes you make stand more of a chance of being wrong than they do of being right.

People's hands vary tremendously, and the thing that doesn't vary, though, as the hand shrinks in size, you shrink the glove in size, but things like seams don't shrink in size. So from a percentage standpoint, the smaller your finger is, the larger and larger percentage of the available easement or clearance you have for seams and things like that is taken up. So you get somebody with a very, very small hand, the little finger, for example, is almost useless. Then you almost get into an argument for some sort of a mitten-type thing.

There have been several looks or explorations at things like mittens. Maybe you have three fingers, these two. Even for the suits, why do you need legs? Why not just have a tube? Then it turns out, though, the legs are pretty useful. On [STS] 61-B, one of shorter crew persons had trouble reaching, so he developed a technique for taking one of his feet out of the foot restraints and kicking up, being able to go over and reach. So being able to do that was really a

help. Turned out he put a whole new certification requirement on our boot. We had never certified our boot to take loads in that direction.

What you really want, you want your hardware to always stay ahead of the person. You want the person to tire out or quit before your hardware does. We found out when James [D. A.] van Hoften grabbed at the satellite and stopped it from spinning or slowed it down, he felt the pull all the way through down to his foot restraints, and we thought, "Uh-oh. Are we overtaxing the restraint?"

Turns out a person could hold on—we did some tests with bars being pulled away and letting a person hold on as long as they could—some of these persons could hold on and essentially not necessarily break our restraints, but exceed our safety factors. So we had to strengthen up the restraints.

Now, we decided we wouldn't try and stop satellites again, but it gave us a whole new insight into what are the performance envelope limits that you ought to be looking at? People can do a lot more than you really think, and you want your hardware to last longer than they do.

RUSNAK: Yes, I've heard some interesting stories about astronauts either during testing or during operations really putting suits through their paces in a way that weren't really anticipated. I think John [W.] Young was famous for this in the Apollo Program.

MCMANN: Oh, yes. Well, I remember getting ready for Shuttle, John Young getting ready for Shuttle. One of the exercises he had to go through—at that time at one point we would do prebreathe on a mask and then you'd essentially hold your breath and go through the suit and get into it and put the helmet on and purge it and then start breathing again once you had oxygen in there. But to get yourself to that point of denitrogenation, you'd stay in this mask for a while. Well, this mask was oro-nasal, and you or I would get it snug to where you had a nice seal. This was a four-hour prebreathe, or I guess it was a two-hour. He was supposed to spend two hours.

They took him over to the medical ops to do a test, see how fast he'd denitrogenate. He put that mask on and honked it down to where it almost cut into the bridge of his nose, and somebody told him, "John, you don't have to have it that tight. That must hurt."

You could hear him say, "That's what they pay me for." But, I mean, of course his nitrogen went fast. He had no leakage at all. But he was always, "Hey, that's what they pay me for. It's not supposed to be easy." The last of the breed.

RUSNAK: That makes me think about those first few Shuttle missions where even though they had two crew members, they were still training for EVA in case they had to close the payload bay doors.

MCMANN: Close the payload bay doors, yes.

RUSNAK: What can you tell you tell me about that period?

MCMANN: Well, that was the OFT, the Orbital Flight Test portion, and, of course, well, things were very iffy. I remember shipping the space suits for the first mission. I mean, here we'd been doing all this processing. We had the suits down. We'd done the checkout. We'd done altitude chamber tests with the crew. All we had to do is pack them up and ship. I still remember the Quality Assurance Office, the day we were supposed to ship, all the discrepancy records and test preparation sheets that hadn't been closed out, I remember at one point just standing back from it. The room was maybe one and a half times the size of this one, filled with screaming humanity, waving paper, arguing. There were almost fights breaking out trying to get stuff closed out, because we had a deadline. We had to ship this stuff. This was the first time we had ever shipped. I remember just standing back from it saying, "We'll never make it. We can't do it." But we did. So those were hectic days.

I had a number of other systems, ESVS, Escape Suit Ventilation System. That was a system consisting of a couple of fans that pumped cabin air through the suits, through the launch escape suits that the guys wore in case they had to eject, and they needed ventilation. So they stayed suited, not in the space suits, but in other suits, and my office provided those things. In fact, there were some old Skylab fans that we used. We had ACOS, ALT Carry-on Oxygen System. That was for the very first flights, the Approach and Landing Test [ALT], when they were essentially unpowered drops. We had a carry-on oxygen system, and we used some Skylab hardware for that, too, oxygen bottles.

RUSNAK: There were some other Shuttle things that you were involved with; for instance, the rescue system.

MCMANN: Oh, the PRS [Personal Rescue System]. Yes, that was a beautifully well-thought-out project. The idea was, hey, what if we have an Orbiter up there with seven people on it and it's disabled? How are we going to go up and get these people out? So we raced off and came up with this concept, and there were various ones. One of them looked like a sarcophagus with arms, if you could imagine that. The little head, you could see the person's head, and he had his arms, and the rest of it was like a tube. We had various shapes.

Then we came up with a ball. First it was thirty-nine inches, and then I think we shrunk it to thirty-six-inch ball. We were going to use this portable oxygen system in it. Everybody had a portable oxygen system onboard. They'd get in there and it would keep them going for forty-five minutes. That was enough time to have the two people in suits string them together like a string of beads and carry them over to this other Orbiter that was going to magically appear and going to take them in.

So we went cranking away on the PRE, Personal Rescue Enclosure. We got it built. Had a zipper in it, a little window. We got Bob [Robert F.] Thompson over. He was early head of

the Shuttle, early Shuttle. So he was a good-sized guy, but it turned out it was kind of amazing. Thirty-six-inch sphere, you get it in, I mean, I got in it. Your back's against the wall, so it doesn't look like it's that small, because all the walls are curving away from you. I thought, "Gee, if I had a light and a book in here, it would be all right."

So we put Bob Thompson in there. So as they put him in, he got in there, and all at once he wanted out right now. He said his foot was cramped. Maybe. He was claustrophobic. Anyway, they got him out, and as they raced to get him out, his head was balder than mine, and they took a hunk of hide off the top of his head with that zipper when it came over the top.

So anyway, we had the PRE with the portable oxygen system and all. Altogether the thing was called PRS, Personal Rescue System. Then they started looking at, okay, let's see, we need a rescue kit for this Orbiter. We have to haul these guys in. So keep this down at the Cape. Let's see. We'll need a crew that knows how to do this, so we'll have to have some crewman trained to do this rescue mission. Now we've got an Orbiter down there we're going to have to launch up to save this other Orbiter.

So how long would it take? So they looked at, well, what's the worst case? Worst case is we've got this Orbiter in the VAB [Vehicle Assembly Building] and we just put a Spacelab in it. How long would it take to take the Spacelab out, get the Orbiter, put the kit in, get it over, and launch it? Want to guess how long it was? Just a tad over a year. So that's why we don't have a PRS. [Laughs]

RUSNAK: Yes, that would make it a little difficult to rescue somebody a year later. Although I heard a story that one of these surviving rescue spheres is used over in the Astronaut Office for the AsCans [Astronaut Candidates] to test their claustrophobia.

MCMANN: Claustrophobic. Yes. It worked on Bob Thompson. [Laughs] Yes. That doesn't shock me at all.

RUSNAK: We had Bob Thompson in here, but he didn't mention this experience.

MCMANN: Well, I'm going to give him the benefit of the doubt and say his foot did cramp up.

RUSNAK: Well, if we see him again, I'll ask him about it.

MCMANN: Yes. How did he like his time in the personal rescue sphere?

RUSNAK: As you're developing this for Shuttle, there's other things going on with the EMU [extravehicular mobility unit] that there's a lot of problems before you get to the first flight, some of which you've alluded to. I was wondering if you could maybe illuminate some of your experience there trying to get this space suit ready for these first few flights, I mean, what some of the critical issues were. I think it was even subjected to a review by the Inspector General and these sorts of things because of ballooning costs and all that.

MCMANN: Yes. We had, early in the program, I think ten major replans. A replan, simply stated, means, gee, we don't have the money we thought we were going to have. We're going have to stretch it out a little bit. Anytime you have that, you lose momentum. It ends up costing more. Things that take longer, cost more, first rule. I mean, there's just no other way to avoid it.

Why? Well, people think of things to do and all that. The problems we had, the technical problems we had, they started pretty early. The hard upper torso [HUT], putting in the pivots in that because [F.] Story Musgrave couldn't get through it. He was our key astronaut. He couldn't don the doggone thing because his elbows couldn't get close enough together. He couldn't do what I'm doing. He couldn't get that close. So we ended up putting gimbals and

bellows on that suit to allow you to get in and then be able to operate. So that was a significant technical challenge to get that done, which we did.

But those things remained a key worry point because you had these pivots buried in that fiberglass, and we had cases of the pivots loosening up after a while. If they ever blew out, you'd blow the bellows, and you'd be dead. So we got some early warnings of that potentially happening in our WETF, in the old Weightless Environment Test Facility, in the water, because water accelerates the process. So we ended up getting back to that earlier-type configuration with things just oriented a little bit different, the opening just a little bit different shape, and the orientation. Even Story Musgrave could get back in it.

So the lesson was that we jumped too soon at a complex design early on. But looking back, the schedule pressure was on. We felt we needed to do something dramatic, and this was certainly a dramatic change, yet if we'd have waited, later on we could have done it, made much less change and not operated with that potential problem for so long. Now we've gotten rid of all those.

Some of the other things, we couldn't buy a test. I remember we couldn't buy a test success. We'd get over into one of the chambers and the lithium hydroxide cartridge would break through. We'd be getting high CO_2. The sublimator would clog up. The water-pressure regulator would start cycling. The battery would crap out early. I mean, we couldn't hardly buy a test success.

Part of it was doing to the real lack of development that we did. We went in early to the program, and we tried to say, "Hey, we need this development unit."

Program said, "Well, we're not getting one for the Orbiter. Why the heck do you need one?"

We said, "Well, we need one so when we go to our certification tests, we'll be sure and pass it."

They said, "No, we'll take that gamble."

What we really should have said was, "We need a development unit to learn how to build the damn thing. Then we'll worry about testing it." So I learned a valuable lesson. The lesson is you will have a development unit. You may call it a flight unit. You may call it a cert unit. It will end up being your development unit. So you're going to have one, just how early in the program you're going to have it is what you have to figure out.

RUSNAK: So that decision came down from the program office to run it that way?

MCMANN: Came down from Headquarters, yes. And it was partially our fault. We didn't do a good job of justifying why we needed it. We knew in our hearts why we needed it. We didn't do a good job of selling it.

So it ended up with we went right for our certification unit, and I remember the valve module, a real complex casting that we had. I remember at last count there was, the last time I remember, there was twenty-five repairs on it, and we flooded the system several times. Each time we flooded the system, we ran water. Water would go through the lithium hydroxide canister, wash that caustic chemical into the aluminum tubes, and they would eat up the tubes. We'd have to rebuild the tubes again. So I don't know how many times we flooded the system, but it just got to be a joke. If we'd have done a development program—and all that costs a lot of money, because we had a controlled configuration. So anytime we'd change it, we had to go through all the paper hurdles and all that, where as if we'd been doing it in development, it would have been a lot cheaper to do it. We'd have found out before we actually committed to our production design. So I'd say they were short-sighted, but we didn't do a good job of justifying it. So we really can't lay all the blame on them.

RUSNAK: What was your role in this?

MCMANN: I was head of the life support system part. We had really two pieces, the life support system and the suit. Jim [James W.] McBarron [II] was the suit guy.

I remember going to the critical design review. This is when you're going to establish your configuration for production and going into certification testing. We have something called a RID. Anybody you've talked to, just mention a RID to them. That's a Review Item Discrepancy. Everybody comes, they want to write RIDs. Some guys get their value in life, their reason for existence is based on how many RIDs they can write. Of course, the trouble with a RID is you've got to be able to close it someday, and I remember we had over 400 RIDs just on my system, just on the life support part of it. Just the logging, processing, tracking, arranging, collating that much paper—forget what's on it—just handling the paper takes almost all your energy. Then if you've also got to figure out what is it saying, can we even do it, what's my answer to it, do I want to do it or not, all that, I mean it was an enormous thing.

RUSNAK: Did you and Mr. McBarron have to coordinate a lot in terms of getting this together? I mean, how did that interface work between you two since obviously the systems are a lot more integrated than they were in the previous suits?

MCMANN: Yes, one of biggest problems we had was that there was always a tendency—and it was probably not a bad tendency—to make try and make everything look alike in terms of the way you handled it, in terms of the way you maybe depicted the configuration or the way you defined certification requirements or testing or whatever. But in point of fact, a life support system and a suit are very, very different. A life support system has a lot of metallic components. It's governed by drawings and very rigid specifications, and you can measure performance specs, and you can get tolerances down to ten-thousandths of an inch or so.

On a suit, the soft goods in particular, the tolerance are much more liberal. They have to be. You get tremendous variance, sometimes, from lot to lot of material. You don't have

drawings; you have patterns. So you have a different way you even describe what you're going to make. The fiberglass of the HUT, of the hard upper torso, that was different. That had to be laid up in layers, and trying to get that repeatable turned out to be a problem. So there's just a load of difference between the way these two things operate. Yet, like you say, they are eventually married together, and in management's simplified view, it would be nice if I could say, "Well, a cycle on the life support system is the same as a cycle on the suit," but it isn't. So you have to define your certification requirements differently.

The suit typically has components or materials in it which have a lot shorter life. The material ages, and pretty soon, maybe in three years or six years or eight years, you've got to replace it, whereas on the life support system, maybe you think it's good for fifteen years, you find out later you can go to twenty years on it as maybe more handbook data gets gathered. So the logistics of suits, their size, you sized elements. You don't have size elements on a backpack. So you've got a whole different logistical problem. So they're enormously different, yet they have to work together.

RUSNAK: Your mention of working together makes me think back when you have ILC [formerly International Latex Corp.] and Hamilton Standard initially working together on the Apollo suit, things didn't work out very smoothly for them, and NASA had to step in as the integrator.

MCMANN: Yes.

RUSNAK: Yet here on the Shuttle you've got them working together again. How do they compare in this area versus that area?

MCMANN: Well, I think it's better, but they're still, ILC and Hamilton, are different. The profiles of company are different. Their product lines are different. Now that Hamilton is

Hamilton Sundstrand, you have the Sundstrand influence. There is a lot of difference. The type of people you have working at ILC are typically different than you have at Hamilton. Soft-goods people are just different than hard-goods people, and there is some difficulty in the translation a lot of times.

But I think overall you have people on both sides that want to make it work, so, yes, you have problems and all that, but I think in the end I think it's working much better than it did in those days. You still have disagreements and all that, but there doesn't seem to be the wild swings that you used to see in the old days. Part of that may just be due to some of the personalities we had, because that influences a lot, I think, on how well people get along, is their personalities, just the way they relate or don't relate to one another.

You have other subtier vendors also that enter into it. Air Lock [Corp.] provides a lot of the hardware for the suit and provides some valves for Hamilton. Carlton Controls in New York, they provide the pressure regulators, oxygen pressure regulators. They've been doing it since Mercury, so those guys are the experts in oxygen pressure regulators.

But the characters of those companies change over the years also. Carlton's changed a lot. I think who you're dealing with, whether or not you're dealing with somebody that's a prime, like if this hardware, if the suit hardware was coming as a part of overall—what was the Rockwell package, let's say it would have been part of Rockwell package, or let's say that the suit on Station was coming as a part of the Boeing contract, you'd see a difference there also. When it's a direct NASA contracting, that also makes a difference.

RUSNAK: What difference is that?

MCMANN: It means that you have now another interface between the vehicle and the things on the vehicle, whereas most of the vehicle systems, a lot of vehicle systems, anyway, are sub-subcontracted. The APUs [auxiliary power units] and all that are subcontracted, whereas the suit

comes in and it's now another government contract interfacing with the overall government contract that has the rest of the vehicle. So it just makes for a different relationship. It gives the suit probably a little more clout than it would otherwise have. You're not submerged beneath the prime.

RUSNAK: Have you found that the personalities working for these different contractors ends up being more important than which companies themselves, I mean, either due to expertise or the interpersonal relationships, these kinds of things?

MCMANN: Well, they're sort of interrelated. I think at different points in time companies have different competency portfolios, if you will. I remember back in the old days in the Gemini Program I remember, and later working in early Shuttle, I had a lot of experience with Allied Signal's AiResearch Division in those days, in my Gemini days, and, in fact, in the Mercury and even the Apollo command and service module environmental control systems were all built by AiResearch, and then the lunar module and the Apollo EMU and then the Shuttle EMU were all build by Hamilton.

What I found was, boy, at least in the old days, AiResearch, in my view their long suit was being able to crank out hardware at a reasonable cost and pretty good rate, but I didn't think their design engineering was all that great. Hamilton, on the other hand, from what I could see, their designs were great. They had a lot of trouble manufacturing stuff. I got to thinking, boy, if I could just mash these two guys together, I'd have the perfect contractor.

One of my favorite contractors to deal with, even though it gave me hell during the Gemini Program, was McDonnell. McDonnell was tough. Their view was essentially if you were going to buy a system from a subcontractor, you went ahead and designed that system and you didn't give him a system-level statement, you gave him component-level statements, and he had to meet those, plus he had to meet the overall system requirements. So you controlled him at

the component level, and that's the way they did AiResearch during the Gemini vehicle ECS [environmental control system] contract, and they hated it.

North American [Aviation, Inc.] at the time was building Apollo command and service module [CSM], they did the opposite thing with AiResearch. They told them, "We want you to give us a system," so they essentially wrote a system-level spec and didn't really control AiResearch at the component level. I don't know, I guess both sides have their strong points and weak points. I think Apollo ran into a lot of problems, but their problem statement was a lot more severe than the Gemini one. Anyway, so I don't know. There's just pros and cons to both ways of doing things.

RUSNAK: You've given us a lot of insight into the personalities on the NASA side. Do you recall some stories or anecdotes, whatnot, about some of the contractor people you've had a chance to work with over the years?

MCMANN: Well, let's see. We talked some about Jim [James A.] Chamberlin. He was NASA for a while, and then he went to work for McDonnell. We talked about him some. Some of the guys at AiResearch, some of those guys I really, really liked to work with. A guy name Tom Iles, out at AiResearch during the Gemini Program and then during Skylab, just one of these guys that's got a lot of integrity and probably tells you more than he should. Sometimes you wish he hadn't said what he said because he gave you too much insight, then you had to go take action on it, but just really a great, a great, great guy to work with. He was vulnerable. He left himself vulnerable, all in the service of doing what he thought was a good job. Put the good job ahead of company loyalty or anything else, which you really had to respect.

There was a guy at Rockwell in the early days, O. T. Stoll. O. T. Stoll, he was one of the top ECS guys, and this was right after I had started with NASA. I was really green and young

and was working with a guy that came over to the ASPO, Apollo Spacecraft Project Office, named Jerry [W.] Craig. You may have –

RUSNAK: I haven't talked to him, but I'm familiar with the name.

MCMANN: Jerry Craig was one of sharpest guys. I'll get back to O. T. in a minute, but I've got to tell you about Jerry Craig. I had been kind of running the Apollo command service module ECS at that time—this was like '62, '63, sometime in there—for the program office, and all at once here comes this hotshot Jerry Craig in that they hired to do this. I was kind of miffed. I wasn't in the project office, I was over in Engineering Directorate, and it was only right and fitting that the project office staff up to have a specialist in those areas, because things were growing fast.

So Jerry came over, and I was going to brief him. So we got out the schematic. This was the flow schematic for the Apollo command and service module ECS. It showed where that fans were and the pumps and the valves, and I was showing him where the flow goes. In this one area were all the cold plates where you had coolant flowing through these flat plates to which electronics were mounted, and they would dissipate their heat, these cold plates. So you had a very complicated pass. As I remember, it was like a maze where all this coolant went.

So they had this shown on the schematic, and I thought I knew it pretty well. I thought I had studied pretty well, so I was explaining to Jerry how all this worked. All at once he said, "That's not right."

I said, "Excuse me? You've been on the job one day, I've been here a year, and you're telling me it isn't right?" I mean, I didn't say that, but that's what I was thinking.

He said, "No, over here you're violating Kirchoff's Law, which says what comes into a junction has to equal what's leaving it." He said, "You're creating coolant here," and he showed

me. I say, quote, showed me, and I nodded like I understood. I didn't understand. I was sure he was wrong, but I couldn't prove him wrong.

So we got on the phone with North American, got their guy. Sure enough, he was right. So in five seconds this guy has seen something I'd been looking at for a year and never saw, and then I realized this is a guy to be reckoned with. [Laughs]

But anyway, O. T. was our contact out there. We'd go out there, go out to Rockwell and O. T., we'd go out to eat. O.T. was kind of a quiet guy, kind of a small guy, balding a little bit, which I have sympathy for now, and took us out to eat in his Volkswagen. I mean, driving on the California freeways is an adventure that I really wouldn't wish on anyone, and in a Volkswagen, I mean, you were at the mercy. Well, you'd thought he was driving an eighteen-wheeler. I mean, I didn't think we were going to make it. It was hell-bent for leather all the way, cutting in and out of traffic, and all that. Knott's Berry Farm, my first experience with Knott's Berry Farm.

And O. T. would tell us stuff that we probably shouldn't have known, but he was being open with us. One time we are on a telecom with them, and Jerry and I got mad about something that they were trying to sell us, and then we came out with some knowledge that we could have only gotten from O. T., essentially burned him good. So we went to talk to him later on the next week, and first he wasn't in. When we finally got him, he said, "I'm not allowed to talk to you anymore. I cannot speak to you. Don't call me." We had burned him good. We had violated a trust. We didn't really mean to, didn't realize what the hell we were doing. So those are the things you learn when you're young.

RUSNAK: Well, you seemed to learn from a lot of your experiences.

MCMANN: Oh, yeah. I learned a lot from the fire that we had. I don't remember whether we talked much about it or not.

RUSNAK: Just in terms of materials afterwards.

MCMANN: The incident where Bob was burned, Bob [Robert] Mayfield, then the government was sued, and I was being interviewed by these lawyers. I finally asked them, "Are you looking to sue me?"

They said, "Well, yes, we're looking for stuff for a possible civil suit for negligence." So that really bothered me, but I went for days. Another thing I learned about lawyers, lawyers don't know what this is, a watch. They have no concept of time. We went for days and days and days, and it didn't look like there was any end in sight. Their interviewing technique was something. They'd talk to me just like I'm talking to you. "How are you doing? Where are you from?"

I told them where I from where.

"Where did you go to high school? What kind of sports did you play?"

I was talking about all this stuff.

"Where did you go to college? Oh, well, what did you study? Oh. Boy, I bet that's pretty tough. How many hours did it take to get a degree?" Just all on this. "Well, as a chemical engineer, you knew that aluminum burns in oxygen didn't you?" start slipping in the zingers like that.

So this went on for days and days and days, and I started realizing, hmm, sure is nice to say that you're a subsystem manager or a chief engineer or something like that. People, "Oh, boy, you work on the space suits? Oh, you're a chief engineer? That's nice."

There's a flip side of that, that you have accountability. So it turned out we ended up settling, but that lesson was not lost on me.

I remember a guy worked for me, Ben [Benjamin F.] McGhee. He's dead now. Ben used to be a test director over for the Space Environmental Simulation Lab [SESL]. When he

was working for me, at the time he was working for me, we were over in the project office, and of course those days were long gone. He used to reminisce a lot about those. He loved those days, because he was powerful. I mean, a test director, you rule. It's like the captain of a ship. You rule. What you say, they have to do. He was talking about a division chief one time that he'd ordered out of the room. Boy, that was great.

I said, "Ben, did you ever realize that you're liable for what you're doing?"

He said, "What do you mean?" He said, "I work for the government."

I said, "Oh, yeah. But people can file civil suit against you." It's like O. J. [Simpson]. He was found innocent of the criminal charges. Doesn't leave him free from a civil suit, and standards are very much less.

So along with all this wonderful exposure you get and this feeling of power, there's also this feeling you are accountable for how well you do your job, and when something happens, you could very well be hauled up. So that's something I try and reinforce to people. These are great jobs and all that and working with the astronauts and working with the space suits and all that stuff. You make inputs, you make decisions and all that, you are accountable for it.

I had a boss that talked about documents, signing documents. What does your signature on a document mean? This boss I had one time, he called me down to his office, and he had this document. There was about eight or ten signatures on it. I don't know whether we talked about this or not, but he said, "Did you read this?"

I said, "Yes."

He said, "I see your signature. Did you read it?"

I said, "Yes. Well, yes, I read it pretty—well, I kind of skimmed it. Well, I didn't read it read it, I mean I just read it."

He said, "Well, how about this?" And he turned to it. "There's a bunch of problems with it."

So we went down. It turned out probably the only guy that really read it was the guy that wrote it, and he said, "Well, from here on out, if you just read a document and just skim it over, then just sign it. If you read it, understand it, agree with it, would go to bat for it, underline your signature. I'm not saying you have to agree to every document like that, but I want to know when I get something what these signatures mean."

I thought that was a damn good input. So later on I was working in the project office. We'd get these changes to our failure modes and effects analysis [FMEAs] and critical items lists, be that damn thick, just changes to it. They came with a change request, so it had to come through me and on to my boss. So I did what I was going to do, and I signed it, took it to my boss. I started to walk out, and he said, "Just a minute, Mr. McMann. I see you signed this."

I said, "Yes, I did."

"What does your signature mean?"

I said, "Well, I'm glad you asked me. I'll tell you what it means. What it means is I've picked three samples of changes, and I went back and I made sure that they were good, that they'd done what they said they were supposed to do and that, yes, this satisfied all the requirements. On the basis of that I signed it. If I hadn't found those, I wouldn't have signed it. That's not saying I looked at every one."

He said, "Okay. Just so I know." So I think people need to understand what their signatures mean. What are you certifying when you sign something?

I think we talked about the tech before that I signed his timecard and ended up—did we talk about him?

RUSNAK: No. No, you didn't mention that.

MCMANN: Good old boy. Good old boy. This was early in the Gemini days. We were making mockups. We were working nights and weekends, and we don't have an overtime policy. We

didn't have a comp-time policy. So he asked me come Friday morning, he said, "Look, I put in a bunch of hours this week. I've already got way over my time. Can I take off this afternoon?"

I said, "Sure," because the division chief also had a very liberal policy. "Yeah, you can work out any kind of deals you want."

He goes off, has a few beers, decides to go visit an old buddy of his, went up banging on the door. His old buddy didn't live there anymore, but this little old lady did. She called the cops, came out. They grabbed him, did what turned out to be an illegal search of his car, found some downers or some uppers, I guess, that he had gotten from a guy that had access to the survival kit stores, controlled substances. He was also on his one-year probationary period and they had found out doing their background already that he had been arrested one time for fornication, which means caught in the act.

So I get hauled up Monday morning when they brought in the timecard that I had signed him as being at work. Because we had this deal, a little hand-holding deal. Well, I got in trouble. My division chief got in trouble. This guy got terminated, since he was in his year probationary period anyway. He cried when I had to let him go. They told me to go out and tell him to let him go. He cried like a baby. It was tough, but what does your signature mean? People just take those things for granted. I'll just sign it. What are you signing? What does it mean? Legally, all kinds of liabilities attached to your signature, when you're holding a job like that, if you're a supervisor or holding some sort of government job.

RUSNAK: At the time of each of these instances, you've told us a lot about these lessons that you learned. Are those ones that you processed at the time and thought about this, okay, I'll remember this, or are these things that upon reflection years later that you came up with?

MCMANN: I think that it's an unconscious part of you. I think one burned, twice shy. You take these things in and you don't necessarily meditate on them, but it's later that when you see

patterns reemerging maybe, maybe not with yourself, but others you realize "I've been down this road before."

I've got a little course that I teach on the failure recovery planning, and one of the things is that I've learned is you watch for patterns. If you wind up with these tire treads across your chest, you kind of, "Hmm. I ain't going to let that guy get me again," so you start to recognize patterns, and you listen to your gut. You hear a story and you say, "This sounds familiar. I've heard this before." Particularly as a manager, when the engineer is coming in and selling you something, you start coming up with certain questions to ask, and depending on how well he answers the questions, you get a warm feeling or you get a very cold feeling. Like we talked about the management brain, the only temperature it likes is warm.

But you learn to recognize patterns. "This is the same type of thing I've seen before." I think that only happens after you've done it several times or had it done to you several times. What you try and do is pass that knowledge on to the next guy that if it happened to you a dozen times before you realize it, maybe he only has to go through six times before he realizes it.

RUSNAK: One of those lessons you mentioned last time was never to trust an engineer, since you were one, you knew.

MCMANN: Oh, yeah. I are one. Yes, it's never believe the first story. I have bunch of those little aphorisms I've come up with over the years. Somebody's had your problem before, you just have to find them. I found that out in the nature of car repair, working on your car. You've got a problem with your car, come in to work and talk about it with a bunch of guys that work on cars. Somebody will have had your problem. You just need to find him. I think the same things holds true.

I don't think there are any new problems; they just look different. All problems look different when they're coming at you. When they pass you by and you can look at the back of

them like the Wizard of Oz, you can see the guy back there pulling the bells and whistles and all that. There are, I think, only a very few number of real different problems—they look different—because you're dealing with laws of physics and people. So you're dealing a limited set to start with.

Now, there's a lot of variations on those things, but basic problems are the same, they just look a lot different, and again, if you recognize the pattern.

Works in personal life too, limited number of things there, too. People don't like to have you, your spouses or SOs [significant others], they don't like to have you necessarily use work techniques of analysis on domestic problems and all that, especially with kids or whatever. They don't sit too well for that. It's much more fun to get all emotional, whereas at work that usually doesn't work. But some of those same techniques can work at home. It's harder to use them, though. You have to be clever.

RUSNAK: Yes, probably a little more indirect.

MCMANN: Especially with kids, yes.

RUSNAK: Have you told your kids that's what you were doing then?

MCMANN: No. No, and I won't even now. My kids, the youngest is twenty-seven.

RUSNAK: So they're not quite old enough to know the truth there, right?

MCMANN: Yes, we'll spare them a little while longer. The kids learn laws. Their laws are very interesting, too. I've gotten a lot of education from my oldest daughter. She's thirty-three now, but when she was a kid, I learned some very interesting things from her. For example, I got

separated and then divorced, and I'd have the kids for a good part of time, and so she'd say, "What are we going to have to eat tonight?"

I'd say, "I'm going to have roast beef, mashed potatoes and gravy, and corn."

"Yuck. I want real food."

I learned what real food was. I said, "What's real food, Erin?"

"Pizza."

"Okay. I'll stop by Kroger's on the way home, and I'll pick up."

"No. Yuck. I want real pizza."

Real food is pizza. Real pizza comes from Pizza Hut or Domino's, doesn't come from Kroger's. So I've learned quite a lot of things.

I learned about, this is my first wife, had her tell her one day, she was trying to get Erin to clean up her room. She says, "I hate housework. It makes me sick, physically sick."

My wife said, "Well, it makes me sick, too."

"No, it doesn't. You like doing it."

"Jesus. What? What do you mean I like doing it?"

"You're always doing it. Therefore if you always doing it, you must like doing it." Oh, yeah. And the air-conditioner in her room broke down. I said, "Well, I can put a fan in here until I get it fixed."

She said, "I have to have air-conditioning."

"Well, wait a minute, Erin. You don't *have* to have it. I mean, it's nice to have it."

"No, I have to have it."

I said, "Well, look, I don't have to have it."

"Well, that's different for you."

"Well, why is it different?"

"You were brought up without air-conditioning, so you don't have to have it. I've always had it, therefore I have to have it."

"Oh."

So you can learn a lot from your kids. These are laws that I bet you didn't know.

RUSNAK: I did not know those.

MCMANN: That's right.

RUSNAK: So with all your years of working environmental control systems, you couldn't fix the air-conditioner yourself?

MCMANN: Well, I finally got it—no, I couldn't fix it myself. I had to get it fixed. I don't claim to be able to fix—I could prepare you a presentation. Yes, if it could be scared into working by making a presentation on it, I mean, I could do that. Oh, I can write paper till you can't stand it, but actually doing something useful, that's out of my realm.

RUSNAK: I see. Well, we've talked a lot about the things that you've done in the past. I thought maybe we'd kind of bring some things up to date, and maybe you can share some of your experiences having worked on sort of the current iteration of Space Station, both before you left NASA and now that you're working with Hamilton.

MCMANN: Well, let's see. At the time I left NASA—and that was really an experience. I had been there thirty-five years and few months, and go over to check out. I'd been gearing myself up for this mentally for at least a couple of years. So I go over there. The last few months I'd been kind of shunted off into a position where I was essentially out of the way so my boss could work with the people he was going to be living with, and I was sort of in a limbo-esque mode. Anyway, all this is background.

I go over to check out, and they've got a room over in Building 45 with all these tables and you can go to each station and take care of your library and various things. I get around to this one person that has to do with, I guess, for want of a better word, keys. She says, "You've got a key to room such-and-such, 612 in Building 1."

I said, "Six-twelve. Wait a minute. That was our old office. That room doesn't exist anymore. It's gone. They've torn down the walls."

She said, "I'm sorry, you have this key for 612. I need to have it."

I said, "I don't think I ever had the key."

"Well, it was charged out to you."

Well, I said, "Well, yes, I was head of the office. My secretary probably had it. I mean, what difference does it make? I mean, it's gone? There is no 612."

"I'm sorry you have to have this key."

So finally this guy comes over. I think, "This is great. Thirty-five years and I can't get out because I don't have the key to an nonexistent office."

This guy comes over and said, "What's the problem?"

"Well, he's charged out with this key to this office that he says doesn't exist anymore."

He said, "Give it here," and signed it.

So even with that holdup, it's about fifteen minutes, and I'm out the door. The last thing is I get my badge, my retirement badge, that's it. I'm now gone. So I'm now one of them. I'm a retiree.

So I go out, and I knew I was going to have to work some, and I wasn't allowed to go do anything before I left. So now I go out and start pounding the pavements. I go to Hamilton, they're my first choice, Boeing, Allied Signal, Wyle, USA [United Space Alliance] all the places. Well, I get very polite but, "Well, yes, we'll get back to you."

So I put down a figure, figuring I'll put down this figure, but I'll be willing to go for less, for 10,000 less than this figure. I get an offer back from Boeing. They offer me what I asked

for. Well, damn, but I haven't heard from Hamilton yet. Well, Hamilton's having trouble. The president of the company is a lawyer. The basic company, Pratt [& Whitney], had gotten in trouble through the Navy by hiring an ex-government consultant who got them in trouble by giving them some proprietary information, and they got socked with a big fine, and so he wanted to stay away from ex-government employees, but one of the guys went to bat for me. So they were struggling with that.

I got an offer with Lockheed, a little bit less than with Boeing. Finally I get from Hamilton, and theirs was eight dollars a year more than I asked. So they made it to where it rounded off evenly divisible by twenty-four. So I went to Hamilton. Well, let's face it, I had been over with NASA thirty-five years. I hadn't been hunting a job in all that time. I've got to go take a drug test. This little girl younger than my youngest daughter is telling me to go into this room, and the faucets are taped up and everything, and I have to take off my coat, empty my pockets so I'm not carrying a little bottle of urine. I couldn't believe all this. The world has changed since the last time I went looking for a job. So that was one of the first big shocks.

So I went in, and I started work for Hamilton, and I told my boss right off, I said, "Tom, one thing I do not want to do is be a supervisor. I've enjoyed all the wonderful experiences since 1964 of being a supervisor. I've had people crying in my office. I don't want it." So I haven't had that.

The biggest thing I've seen change, I think, is the whole demeanor. It is definitely all about money on both sides. I kind of realized it would be that way when I got with a contractor, but it's really about money. And it's safety. Safety just assumes a gigantic proportion. Aversion to risk, any kind of risk. It's really something. Yet this business is inherently risky. So it's money, it's safety above all, and aversion to really any kind of risk. Any pitfall, any slip you make, it's punitive. The whole attitude is punitive now.

I think it comes down from Congress to everybody. The attitude is you make one misstep, you get flogged for it. Success is expected. Failure is not tolerated. Yet the business

you're in, no one has ever done it before. No one has ever built a real space station the way we're doing it, before. So to me, it's not really surprising at all that we're this much out of bed. If you'd have looked at the Apollo Program, the cost growth of that thing was astronomical, too, because you'd never done it before. You can't really compare the Russian station or Skylab to the thing we're building. It's never been done like that before.

So that comes with it, but we don't want to hear that. You don't want to tolerate that, so somebody has got to be punished. George [W.S.] Abbey had to be punished for the Station overrun. You have to find one neck, because people's hands can't get around more than one neck, so you've got to find that one neck, and this was George Abbey's time.

So it's a very punitive environment and very structured to try and remove risk. When you remove risk, though, you make things to where it's tough to maintain motivation, because you don't want to try anything new. Why should I go with something new? It's tried and true. We'll just modify it incrementally. Something new is risky, yet something new is where all the fun is, especially for the younger people. So I think we're going to have that to deal with.

Backing off on the Mars thing, maybe we were too ambitious to think we were going to go to Mars by 2012, I don't know, but it seems like we're backing off so far. We had a great effort going up at Hamilton. I call them the lunch bunch. These guys get together at noon on their own time, and they come up with a Martian suit design. We had a mockup of it, kind of a semi-functional mockup with this little robotic cart, FIDOE, Fully Independent Deployment Of Expendables, this little cart that was voice-activated and followed the guy around. It was fairly crude, but it was new. The whole system, the design of the space suit for Mars has got to be entirely different than it is for orbit, because you have an atmosphere on Mars, you have gravity, you have dust, you have a lot of things worse than the moon, a whole bunch of different challenges. You want to climb jagged rocks and all that kind of stuff. You want to bend over and pick up stuff. You want to climb things. You want to haul stuff. You want to drill for water. It was exciting working on that. I mean, I helped somewhat with that.

Now, though, with business going down, what's the first place you start collapsing? You start to collapsing in on all those things that are the maybes. I focus in on next quarter's bottom line. How am I going to satisfy the stockholders next time? So all that stuff goes away, and with it a lot of the motivation.

With the Station, collapsing the Station back to three. You get to the point where you're just able to march in place. That makes things easy to kill. If you're not really doing much with the Station, if all you're doing is keeping the Station operating, then you've got to say, "Why?" You don't just let your car sit there and idle; it needs to go somewhere. If we can't find a way to really show a good crew productivity index, that these guys are really getting something done, then I think we'll lose the station, and we probably should, if we can't. If we can't show a reason for it to be there, we should lose it. But I just wonder what comes in its place. That was our problem, I think, after Apollo. We didn't really have a direction after Apollo.

RUSNAK: Had you seen these characteristics appearing while you were still at NASA?

MCMANN: Yeah. Oh, yeah. The first thing I saw was 1995. The feeling was, the feeling just came about that award fee scores are too high. So without changing anything in terms of criteria or ways of grading, award fee scores dropped about ten points. You just put a different bias. You put a different pair of specs on when you looked at things. So let's start cutting back. I saw it then.

I think the increased emphasis on safety, I think is good. I've seen that really at Hamilton, really, really an increase, and there's a philosophy that I've seen. At first this philosophy was negative, and that is that the relationship with something called a close call to an incident was if you have a close call and you report that and you fix that, the idea is that ultimately I'll be preventing worse things from happening. A close call by its nature is

something that didn't happen, but it almost happened. So if I take steps to prevent it from happening, then something serious won't happen later.

So all at once the emphasis started being on close calls. Well, but close calls were looked at first, hey, that's bad if you have a close call, so I'm not going to report it. Dupont and a number of others have showed there's a certain relationship like, I don't know, so many hundred close calls per incident. So if you have a large body of close calls, legitimate close calls being reported and fixed, then you are decreasing your chances of having a severe incident. That type philosophy is something we never used to have. You would never call out necessarily and broadcast to the world a little piddley thing like water on the floor by this water cooler. Well, no one slipped, but that's a close call. Somebody could slip, so let's fix that water cooler. Cord across the floor, something like that, you now call attention to that.

So you're constantly scrubbing your environment, your work environment, and it carries over at home. We start each meeting with a safety tip. Somebody comes with up a safety tip, you start each meeting over there. When I teach this course on failure recovery planning, I have everybody, and I start with myself, I introduce myself, where I'm coming from, what my expectation is for today's course, and then a safety tip. So maybe there's twenty people in the room. We go around, and we get twenty safety tips. I mean, that type of thing is new. That's something we didn't used to have. You didn't think about.

It carries on to your home. I cannot do a job at home now in my workshop out there without putting on a pair of safety glasses. It bothers me not to do that. I've got my wife doing it. She does a lot of the yard work. Since she's retired now, she does a lot of that. She always wears safety glasses. She didn't used to always wear them, but it's just something that a safety consciousness has really become part of the culture. That's one of the good things that I've seen change.

One of the bad things is essentially just feeling the need to punish when things don't go right, you miss your cost targets or whatever. Going after root cause of things is a change. We

used to fix the symptom of the problem, didn't really go after—it's the old analogy, I've got a boat that's sinking. Your first inclination is bail faster, get more people bailing, and then they always come up with the answer, well, what you really need to do is plug the holes. They usually stop there, but you need to go one step farther. What's making the holes? Stop what's making the holes. That's getting to root cause. That's a change that we didn't used to do.

RUSNAK: Do you find the increased emphasis on safety has an effect on either the willingness or ability to take risks?

MCMANN: Oh, yes, I think there's very much less willingness to take risks, very much less. I don't think it's just that. I think it's what I said before, some of the retaliation if your risk turns out bad. A few years ago there was this feeling of making people—making them feel empowered, letting them fail, because you learn from failure. We pay lip service to that. I don't think we really believe it. We don't tolerate failure well. They say, "Well, all we want to do is find out what caused it. We don't blame the person, we blame the process." Somewhere in there sometimes the person gets blamed. Somebody gets blamed. Somebody as an owner of the process gets blamed. You feel like somebody has to take the fall. That's the part I don't like. I don't think it's really objective. I think you're still feeling "I've got to get somebody" because this happened.

RUSNAK: Where do you think the balance is between safety and risk, at least in terms of finding viable balance for the space program?

MCMANN: Well, there's no really one answer to that. You only know after the fact you've had a problem, that I took too much risk. So you go with the knowledge you have, but you try and develop the processes. I think more important than the processes are the mindset of the people

that you design it in. Putting it in later, putting Band-Aids or things on it later is always the worst way to do things. If you get somehow the culture, the mindset going of when the person originally designs a test or designs a piece of hardware, that they're thinking safely about safety, then I think you have to do much less later. And how much can you afford? Well, I think sometimes you don't even know it's there. If the person has been thinking right, then the margin is built in. It's that same old thing, if you get it in early, it's a lot easier than trying to put it in later.

That's why remodeling, like we said before, remodeling is much worse than building. If you build it right the first time—I've had the guys out—my foundation—probably, I want to say conservatively ten times, the first time to put the piers and then been out to cap them off, rejack up my house, and all that, whereas maybe if I'd have had real good piers or if the guy that built the house would have had real good piers put in the first time instead of just little chintzy builder's piers, I might never have had to do it or maybe had to do it less. But it's much easier to do it right the first time, I think.

That's another concept, it's called mistake-proofing, where you try and take processes and make them to where you can't put the pieces together wrong. We had a case over in our hardware processing facility years ago where a guy hooked up a high-pressure line to a primary life support system water tank, overpressurized it, and I think we talked about it, cracked that structure, and that's like a two-year lead item. It turns out that the high-pressure line and the low pressure line both had the same fittings on them. Now, if I would have made those different, that would essentially be mistake-proofing it. He couldn't hook up the high-pressure fitting to a low-pressure port.

So that type of thing, if you think about that as you're building it, rather than try and later come in and say, "Jeez, I wish I hadn't done that," now I come in with something else and try and fix it later, that's really the thing. So if you're thinking that way, right off, but that takes

time to inculcate that into designers and testers and people that make things happen, people that develop processes.

RUSNAK: That reminds me of a story that Bob [Robert L.] Carlton, one of the flight controllers, was telling us from his Air Force days. He worked in maintenance planning in the design of aircraft and how they would do their hydraulic lines such that the high-pressure lines would be one size and low-pressure another, so that you couldn't switch these things, but they would have instances of people who actually work on the airplanes trying to jury-rig things so that you could.

MCMANN: Oh, yes. That's right. You have that, too.

I used to work for Liquid Carbonic in Chicago, compressed gas, and I remember you have what they call oil-pump nitrogen. It's high-pressure nitrogen gas, and it's pumped to pressure in a compressor that's oil-lubricated, so you have a little bit of oil getting into that cylinder. You also have a nitrogen that's used maybe to pressurize oxygen lines before you put oxygen in. Well, you don't want to put that oil pump nitrogen in there, so you have water-pump nitrogen. The compressor that's used to compress that nitrogen is lubricated with a soapy water solution. If you get a little water vapor in there, that isn't nearly as bad as having oil vapor in it.

So these two cylinders, the oil-pump nitrogen has a male left-handed thread. The water-pumped nitrogen has a female right-handed thread of a different size. So there ought to be no way you can interchange those. I remember I was back in the lab one day, and I found this fitting that a guy had very carefully made to adapt oil-pump nitrogen to water-pump nitrogen. He had brazed it up, made it, brazed up the fitting. That's the kind of stuff that gets disciplinary action when you do something like that. I mean, that is going way outside. A person has mistake-proofed it and you're going intentionally around it.

RUSNAK: Again, learning from these different things, I guess.

You'd mentioned something offhand last time that you had a chance to try on one of the Russian suits.

MCMANN: Yes.

RUSNAK: I was wondering if you could tell me about that.

MCMANN: Yes. Very much easier to don than our suit. You open up the back, you jump in, close it. I'm not crazy about the latching mechanism at all, seems a little clumsy. But getting into that suit, the helmet and all that, is very much easier than ours.

The suit itself to me, when we operated it, I guess we operated it at pressure. It was less mobile, noticeably less mobile. The gloves, of course, didn't have gloves that necessarily fit me, but their glove sizes are very limited. This was a training unit, so I didn't really get the feel of what their life support system really did. But as far as the suit itself, I thought the visibility was good. I thought, to me, the mobility was less, and I don't know what it would have been done if I'd fiddling around with knobs or levers or whatever, but it seemed to be pretty good. I think it bears a lot of resemblance to ours, maybe the Apollo glove, the blue fingertips just like we had on the Apollo gloves.

So I think it's pretty good rugged hardware. I don't think they're nearly as careful putting it together. I know one of the guys in the Mir getting ready for an EVA mentioned he found a screw floating around in it. They have to partially assemble the units in orbit, and I think it was the fan they were trying to install, and they had four bolts. You could get any three to line up, but you couldn't get four of them to line up. So they ended up with that. So I think they're maybe a little less careful, but their stuff is rugged, and I think we could learn a lot from that.

I think we tend to operate, like to operate on kind of the cutting edge. I know our APUs and all operate and our main engines operate just almost at the material limits. We've got, in the

space suit, our fan and pump operate around 19,000 rpm. Well, that means that the pieces are like the pump, for example, is very small, because they're operating at 19,000 rpm. It has to be small, because they're not putting that much water, 240 pounds an hour. What that means, though, is that you have very close tolerances and a very small particle can lock you up. So I think that we operate much less ruggedly. We're much less robust in a lot of our hardware than they are.

RUSNAK: What about the approach to redundancy in the suits?

MCMANN: That's interesting. They have some different degrees of redundancy. I think in the bladder, they've got some redundant bladders, or used to have. I'm not sure they still have them. We back up our fan by just going to our emergency pack. If the fan dies, we go our emergency system and come home. I think they've got an ejector that they can use for quite a long time. So there's a little bit of difference.

They have a little more redundancy than we do, but I think we have designed our stuff to operate a long time, so we've certified it. Even though it is complex and maybe susceptible to small particles and all, it's still got a lot of design margin in it. It's just that as an approach and having it to over, I'm not sure I'd do it the same way.

RUSNAK: Do you think there's anything that you learned from Russian technology?

MCMANN: I haven't really studied it that much. I think their whole philosophy of EVA in relation to their Space Station was good. The way I see it, they used EVA as kind of a backup means or if you just couldn't do it any other way you did it EVA, and if you had a problem, you go out EVA and fix it. We, on the other hand, said we're going to assemble this Station largely

by means of EVA, so if somehow there was conceptually something wrong with that, if it was just something that you couldn't do EVA, you really have no backup except more EVA.

I don't think that's been proved wrong, so far. We've been able to do it. We had some troubles on STS-49 with the MPSS, trying to put a large structure into place and get it aligned. When we had to do the three-person EVA to get the satellite, we pointed out some deficiencies from both those incidents in our training methods, which I think we ended up fixing.

But it always kind of bothered me, even though I live EVA, that that's where we put all our eggs in the Station thing, and various studies at various times have showed we needed so much EVA, wondering how we were going to do it. The ability to predict a lot of times is not real good. Also the tendency we've noticed from a lot of the contractors, Station contractors, is if they really don't want to spend the money or do something like put a motor on it, they'll just say, "Well, we'll just do it EVA because that's free. EVA is free," and it's really not. I think maybe we suffered a lot of trying to do a lot of things EVA that maybe could have been done better in an automated way.

But EVA, I think, was kind of if the problem was taxing at all, maybe you could throw it over the fence at the EVA. I think we were hungry. We wanted to keep justifying our existence, too, so we sort of took it on. I'm not sure that was really the best overall way. I'm not sure the best trades were done all the time.

RUSNAK: It was kind of interesting how, as you pointed out, the EVA is so critical to Space Station, yet when it comes do spending money to come up with a new suit or something that might be optimized for all of this work, then it's hard to make that money appear.

MCMANN: Yes. One of the problems is—there's two things, one is up-front money and other is risk. I mean, if I go and I say, "I'm going to commit to a new suit," that means I'm going to have it ready by a certain date. Well, if that date slips, the rest of the program doesn't slip, what

do I do? So if I'm going to replace the current Station suit, that means I've got to spend a lot of money and run the risk that it may not happen, so I've got to keep the old one going.

Well, if the old one is doing the job well enough, why do I need a new one? How does it pay off? In Shuttle, our first look was not at building a new suit. Our first look was at essentially resurrecting the Apollo. I'll take the Apollo suit. I'll build the same exact suit. I'll build that life support system with whatever the new technology is giving me now, but I'll stick basically with the same schematic. Why would I need to do anything different? The reason was, I can't afford to do it the way I did in Apollo. I've got many, many more crew that I'm going to try and fit. I had just a few crewman in Apollo, and I made custom suits. I can't afford to go custom again. So I've got to come up with something different.

Then we had some other things come into play. I don't want those exposed hoses out there. That was always a liability. I want to get rid of those hoses. So there were some things that came in. Again, here's where personality had a strong impact. Jim [James V.] Correale, who was the division chief, very much wanted a hard upper torso. He wanted bins of parts that you'd pick and choose, and he essentially drove that. He essentially drove that existing Shuttle suit design. There was one guy where personality really did play a role. He was a strong personality.

But you have the luxury of doing that if your program is just starting out. Everybody is starting from ground zero, then you can take a clean look. If you're already going and blowing and now I want to come in and change, that's where the real risk comes in and the real cost, because I've got to keep my current one going while I bring the new one up, so I'm paying double costs. Who foots that bill? The guy that's footing the bill's got to see that this is definitely going to pay off for me.

RUSNAK: As you pointed out, in the Shuttle Program you had the luxury of it all being new so you could take advantage of slips elsewhere in the program, and obviously the Shuttle flew a lot later than they originally intended, so you had this extra time.

MCMANN: It's a good thing, because we lost quite a bit of time when we had the fire. It's the old umbrella game. You're out there. Who's going to raise the first umbrella that everybody else jumps under? Back over when I was in Crew and Thermal Systems [Division], I was running the life support system end of it, and we had a lot of testing we were going to be lined up to do. Well, you need people, paper, parts, and equipment to do a test. You need a test procedure. You need something to test. You need people to run it, technicians, engineers, instrumentation people, and you need interfacing equipment. You need the chamber itself and support equipment. So all those things have to come together in order to run a test. So they'd have a kind of test readiness meeting, see how everybody was coming. So I would have a problem. I said, "Well, we were going to test on the 13th. I've had a problem with the PLSS [primary life support system]. Can't do it till the 16th. Anybody else have a problem?"

Nobody else had any problems. "Oh, we're all ready to go on the 13th." Pretty soon then I find out later chamber had had a big problem. He wasn't ready at all, but since I spoke up first, he said he was ready. He got under my umbrella. So pretty soon it even got to be a joke. I could have had just the PLSS, the Primary Life Support System, drop on the floor in pieces, I'd come to that meeting and say, "PLSS is ready." Who else is going to speak up? It got to be a joke. I'd walk in the room, and they'd say, "Don't tell us the PLSS is ready." But you learn. That's another one of my little laws, never be more honest than the people you're dealing with.

RUSNAK: Did your coworkers ever write all your laws down for you as one of those retirement gifts or something?

MCMANN: I've got a bunch of them written down. It's funny, you've heard of Lewis and Clark?

RUSNAK: Yes.

MCMANN: The satellites?

RUSNAK: Yes.

MCMANN: Well, was it Lewis or Clark? One of them got launched, got up in orbit, lasted a little while, and augured in. They did a big study of what happened to it, and it was a real comedy of errors. So I looked over that, and I made a few comments on their program, I mean, after they'd figured out what happened to it. You could see the seeds of doom being sown in that program real early. They changed it around. They changed launch vehicles. They moved it from one group to another. They separated people that should have been working together, just a whole bunch things, took people off of monitoring it during its phases to save money and then when things started happening, the guy wasn't there. I mean, just amazing the number of things.

So I made a few comments to that, and it turned into kind of lessons learned, overall lessons. So I kind of used that as a trigger and then launched into everything I've learned about hardware and people and all that. So I got to put some stuff together. If you're aware of what's going on around you at all, pretty soon you can't help but develop some of these things. So I have a little pitch that I have put together.

RUSNAK: Well, that's about all the questions I had had for this time, but I did want to see if Carol and Sandra had any, if you don't mind.

MCMANN: Sure.

RUSNAK: No? Sandra?

Okay. Well, it looks like we're all about out of them.

MCMANN: Okay. Well, I enjoyed it.

RUSNAK: Good. Were there any other comments you wanted to make before we called it quits?

MCMANN: No. I think it's a great thing you're doing, and I was really, really impressed by the roster of people that you have. I suggested a couple of other names I think you'll get a real kick of out what those guys can tell you. Marshall and Travis are both great storytellers.

I could prime you with a couple of things. If you get Travis Brown, be sure and mention to him right off that it looks like he's put on a couple of pounds. Just mention that to him. I'm doing this for his own good.

For Marshall, just tell him that the guys in the GFAE, Government Furnished Aerospace Equipment, Crib, at McDonnell are still waiting for the chestpack. He used to have fights with those guys.

Marshall was a great guy. He could calm the waters. See, I've got to tell you one more story. Getting ready for Gemini III, which was the first manned Gemini flight, we had these portable oxygen ventilators. Norm Prince was working for me at the time, and an old technician named Charlie [Charles B.] Nies. So I sent Norm and Charlie down to the Cape.

These ventilators, there were two ventilators per crewman you had to have ready. They were liquid oxygen ventilators. So you had a prime and a backup for each crewman, so you had two crewmen, so you had four. So you'd fill these things up on the first floor, and you'd go up to the suiting room on the second floor of the MSOB down at the Cape. Norm—you remember I

told you about Norm, how hard-charging he was. Norm was in his thirties then. Charlie was probably close to sixty. So they'd fill those ventilators up, Norm would grab two, Charlie would grab two, Norm would go up the stairs two at a time, up to the second floor to get to the suiting room. Then Charlie would come struggling after him, and I mean really huffing and puffing by the time he got up there.

One day one of the guys at the Cape, there goes Norm up the stairs again, Charlie starts going, the guy said, "Charlie, why don't you use the elevator?"

Charlie says, "What elevator?"

He said, "There's an elevator right around the corner."

He said, "Norm, did you know there was an elevator?"

Norm said, "Yes. It's too slow." [Laughs] I thought Charlie was going to kill him, but that's just the way Norm was.

So when we got ready to send the chestpack down to the Cape the first time, I knew it was going to be a mess. We were going to need somebody with super human strength and untold endurance, so we sent Norm down there. Well, he got the job done, but he pissed them off at the Cape like they had their knives drawn.

So Norm came back. This was for Gemini VIII. For Gemini IX, they were ready for Norm again. Well, this time I sent Marshall Horton down there. They just started to beat on him, but Marshall is such a nice guy, everybody likes him instantly. I couldn't have done it any better if I'd planned it. I sent down the guy that was the tiger to get things set up, piss everybody off, and then send down the guy that could pour oil on the troubled waters the next time. It just worked out perfect. [Laughs]

RUSNAK: Well, we'll be sure to ask him about that if we can get them in.

MCMANN: Oh, yes.

RUSNAK: Actually, that just reminded me, speaking of Gemini, that reminded me of one question I had had from last time which was involving Gemini X and the environmental control system where the guys complained of their eyes burning, but they couldn't really figure out what the problem was.

MCMANN: I don't remember ever knowing what that was. I tell you, have you have had Larry [E.] Bell?

RUSNAK: Yes.

MCMANN: He would have been the one to know, if anybody knew.

RUSNAK: Well, his thought was that John Young had used his suit hose as a vacuum cleaner to suck up some Tang he had spilled.

MCMANN: I wondered about the Tang. I was going to mention that, but I didn't know whether they'd ever proved that or not.

RUSNAK: Yes, I don't know if they did. I think John Young would deny that story.

MCMANN: Have you had him yet?

RUSNAK: No, we haven't, but we sure try.

MCMANN: Oh, yes. I'd get him. Yes. Yes. It's been a great ride, I'll tell you.

RUSNAK: Yes, it certainly seems like your ride was a lot of fun.

MCMANN: Oh, yeah. I guess you tend to remember those things, and you remember the characters. The characters. I guess maybe there are characters like them now, but I don't see them. I don't see the characters like we had in the early days.

RUSNAK: The wild men.

MCMANN: The wild men, yes. No more wild men. Okay.

RUSNAK: All right. Well, thanks.

MCMANN: Thank you.

[End of interview]