NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

THOMAS V. SANZONE
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is July 26, 2011. This oral history is being conducted with Tom Sanzone in Houston, Texas, for the Johnson Space Center [JSC] Oral History Project. Interviewer is Rebecca Wright, assisted by Sandra Johnson. Thanks again for coming in this afternoon. I know your schedule is a bit hectic these days. We'd like for you to start by sharing with us how you first got involved with the space industry.

SANZONE: Well, I have to almost apologize for the way I got involved, because I know most people who work at NASA and JSC have dreamed about working there their whole lives. For me that really wasn't the case.

NASA was really starting to "go and blow" with the Mercury program when I was in high school, and I don't remember following NASA particularly closely. When I was in college at Villanova [University, Villanova, Pennsylvania], I was so focused on trying to get out of college that I didn't do much extracurricular stuff, including following the space program. As I was about to graduate, I interviewed with Hamilton Standard. I was from Connecticut, and they were a Connecticut company.

I interviewed and was actually offered a job to work on the Boeing 747 [aircraft] which was being developed at the time. Hamilton Standard provided many of the subsystems, particularly the environmental control systems, on the 747. I was offered a position in the Field Service department, and the plan was for me to go to Seattle [Washington] and be stationed out

there for a couple years. The day I reported to work I was met by a man, Howard Goldberg, who had taken me to lunch when I had interviewed several months before. He informed me that he had recently been promoted to be the supervisor of the Service Department that supported Hamilton Standard Space Systems. He told me, "You're not going to go to Seattle, you're going to go to Houston, and you're not going to work for that other guy who interviewed you, you're going to work for me."

The joke that's existed in our company for more than four decades is he also told me [I would be in Houston] for one year, maybe a year and a half. That was 43 years ago. And that was one of the best things that ever happened in my life.

I wasn't particularly interested in coming to Houston, probably heard things about how hot it was. I had never been south of Delaware, so I'd never been south of the Mason-Dixon Line [division between northern and southern U.S. states]. I showed up with my dad in July [1968]. We drove down in a Triumph TR250 sports car that I had just purchased as a graduation gift to myself. No air conditioning. I didn't even know what air conditioning was for a car. This was in the late '60s, 1968. We drove to Houston. There was an air show at Ellington [Air Force Base, Houston] that weekend, they were selling water. This was long before water was sold like it is today.

There were very few places to live around JSC. Of course then it was still called the Manned Spacecraft Center. Very few apartments. I ended up living in Pasadena [suburb of Houston] for the first two years or so, maybe two and a half years. I remember quite distinctly being shown this apartment and going in. The air conditioner was blowing and going. I said, "Okay, I'll take it." So for about two and a half years I made the drive from Pasadena to the space center every day, and arrived dripping [wet], with no air conditioner in my car.

Obviously after I was here probably less than a month, maybe even less than that, I was really hooked on what was going on here.

WRIGHT: Where were you located? Were you on site?

SANZONE: I was actually on site in Building 7. It was called Crew Systems Division then. Later the name was changed to Crew and Thermal Systems. That division was responsible for many of the items that the crew utilized, most significantly the space suit and the portable life support system that they used when they walked on the Moon. But they were also responsible for the environmental control and life support systems in both the Command Module and the Lunar Module. That was done out of there, and life rafts and clothing, and everything like that. It was an exciting place to work.

WRIGHT: Lots to see, lots to do.

SANZONE: There really was. I always say that everybody was young, so it wasn't as intimidating as it might otherwise be. Today I can imagine a 22-year-old, like I was, showing up to work at Johnson Space Center and seeing decades and decades of experience from these other guys that are working there. But back in 1968 there was nobody that had more than ten years' experience, and most of them had two or three years' experience in space. So we kind of grew up together, if you will, from an experience standpoint.

There were obviously some folks who were a lot more knowledgeable than I was and had a few years on me, some maybe more than a few years, but very few more than ten. It was a

tremendous team to be a part of. I haven't worked in Building 7 for 25 years, but I always appreciated Crew Systems Division, or now Crew and Thermal Systems Division, because they got to deal with real hardware on a daily basis, hardware that was going to fly.

There were other people that dealt with hardware, but most of the Command Module went from California to Florida, the Lunar Module went from New York to Florida. The space suits came from Delaware, and the portable life support systems came from Connecticut where Hamilton Standard was headquartered. We dealt on a daily basis with the hardware that was actually going to fly.

We liked to refer to the extravehicular mobility unit, which is the space suit and life support system combination, not as a large garment but rather a small spacecraft. One of the things dealing with EVA, extravehicular activity, over the years and decades was we really had our own spacecraft. Everybody that dealt in the EVA world knew pretty much everybody else. They knew the trainers, they knew the flight controllers, they knew the technicians, the doctors who were involved in the tests. We really knew everybody. We knew the guys at the Cape [Cape Canaveral, Florida] that did training, we had an office at the Cape. I'm not sure I recognized it at the time, but over the years looking back, I really recognize how special that was.

It takes thousands and thousands of people to make a successful space program. Many of those people are working on a particular subsystem, almost a component, and it all comes together when we launch and go to space, but we had the added pleasure and experience of dealing with our whole system, our whole spacecraft. I used to tell people we can literally get our arms around our spacecraft. That made it very special. So although I was not a space

aficionado before I came to the Manned Spacecraft Center, it didn't take me long to get there. And obviously I never left.

WRIGHT: That's true. Talk about some of the first duties that you had, because you were sent down, as you mentioned, to be a field representative.

SANZONE: Yes.

WRIGHT: Did you do you what you thought you were going to be doing, and how did that change?

SANZONE: I don't think I had a clue what I was going to be doing, to be honest with you. My degree was in electrical engineering. When I first came down, they were really looking for somebody to help out in that area. While I had a degree in electrical engineering, I had very minimal experience, virtually none. I did a little work for the first couple of months on the communications system that was part of the life support system. It was called the Space Suit Communications System, we called it SSC—basically testing it, making sure it worked properly prior to going into a vacuum chamber training run with an astronaut, and eventually flying.

Then I also was involved some with the power distribution system in the life support system. I mentioned earlier that the extravehicular mobility unit is really a small spacecraft, so virtually everything that a spacecraft had, other than propulsion, we had. We had our own power distribution system, so it had some of its challenges. It had terminal boards and solder issues and things like that that I got to deal with.

But my boss asked me one day if I would help out on a test to evaluate how long and how efficiently we could recharge the primary oxygen system bottle in the life support system. I ran that test, and I enjoyed doing that test, and I think he gave me another mechanical, not electrical, test to do. I enjoyed doing that as well.

So he came to me one day and he said, "You seem to enjoy doing these mechanical tests more than the electrical tests." That was probably the best assessment that anybody could make, and he gave me more and more. We had another engineer that had come down that had done some of that stuff, so I got involved more and more with the hydropneumatic and mechanical aspects of the life support system, and really for the most part backed out of the electrical stuff.

I do remember one time, however, briefing Bruce McCandless [II], who was the capcom [capsule communicator] on Apollo 11. It may have been one of my first experiences with an astronaut. He came over to our office, and I was supposed to explain the schematic and how the communications system worked in particular. One of the things that struck me was after me explaining it to him for ten minutes he knew it ten times better than I did. I looked up his resume later, and he had a master's degree in electrical engineering. Plus, he had all the practical knowledge. I think one of the last electrical things that I actually did was to brief him before Apollo 11 since he was going to be the capcom.

I got to do more and more of these mechanical tests, and that led pretty quickly to system-level testing of the portable life support system, running it through its paces on a great big test stand that we had in the high bay area of Building 7. Just checking out all the subsystems—the oxygen system, whether the regulator worked properly, the sensors and the warning systems and all the systems in the life support system.

We did things a little differently then, than we've done more recently at JSC, in that a particular engineer, myself for example, would run the unmanned tests to make sure that the hardware worked properly. Then we would take that unit, and we would put it in a vacuum chamber unmanned. In Building 7 it was the eight-foot chamber—that is what we referred to it as. I think today they call it the "canned man." We could simulate CO2 [carbon dioxide] removal capability, things like that, before we would ever put an astronaut in a space suit with that life support system.

I started getting involved with some of those more system level tests, and one day my boss came to me, matter-of-factly in hindsight, and said, "I want you to sit on the console when we do this chamber run with this astronaut crew." I was still pretty inexperienced. When I think back on it, I was *very* inexperienced. I was like, "okay." Everybody did whatever they were asked to do, it was a tremendous team effort. I hadn't thought about it too much—his name was Fred [Fredrick] Keune [Jr.] by the way. He was a great leader in my life, he passed away a number of years ago.

This first crew that I got to train was the Apollo 11 crew. In hindsight it seemed like that should have been done by somebody a lot more senior than I was, almost as a reward. But I got the task, and did the hardware preparation and sat on the console when they made the training runs. It was not necessarily in this order, but the prime crew was obviously Neil [A.] Armstrong and Buzz Aldrin, and then the backup crew was later the Apollo 13 crew, Jim [James A.] Lovell and Fred [W.] Haise [Jr.]. We did all the training runs with four guys. We'd do them four days in a row if we could, if we didn't have any issues or anything like that. That was pretty interesting, as a virtual first task. That was about March or so of 1969.

WRIGHT: When you said you prepped [prepared] the hardware, what did that entail and how long did all of that take to get ready for those tests?

SANZONE: We would do a lot of unmanned testing in our lab leading up to a vacuum chamber run. As I said, we actually, as part of our test stand, had a small vacuum chamber. We would take this portable life support system, which we affectionately called the PLSS, and we would put it in there. We would hook up the oxygen umbilicals and the water umbilicals and with the very large test stand we would run the life support system through its paces.

We had to circulate chilled water through the life support system and through the liquid cooling garment that the astronaut would wear. It was four pounds a minute, I think, of flow, so we would have to verify that the pump was actually putting out the flow rate that was expected. If we found that it wasn't we would have to troubleshoot why, what had happened. Usually change something, put a new pump in, and at the same time, in parallel, understand what happened to that pump that had failed and—similar to what we do today—how do we assure ourselves that that failure was not going to occur on the Moon for example. We didn't just change out parts, there was also a lot of analysis.

We had a fan that circulated at approximately 19,000 revolutions per minute. It would put out about six cubic feet a minute of flow through the suit. It would come up over the back of the helmet and flow down in front of the astronaut's face to remove carbon dioxide. We would have to verify that that system was providing the proper amount of flow.

We had about a dozen or so channels of telemetry, we would need to make sure that all the telemetry was working properly. Each subsystem had some type of warning device—not each, but several of them had warning devices. We'd have to verify for example that the low suit

pressure warning switch would actually trigger the alarm at the appropriate pressure, so that if the astronaut was in the vacuum chamber or on the Moon and he started to get reduced suit pressure even before he was aware of it, he would get an alarm. All those sensors were checked out as well.

There are four primary subsystems in the life support system. One is the feedwater system, where the water is fed up to a heat exchanger that we called a sublimator, because the process of sublimation is going from solid to gas without going through the liquid state. With the vacuum of space or the vacuum chambers that we used we could verify that that system worked properly. We had a feedwater system that around Apollo 11 time I think had about eight pounds of water. It would feed this sublimator, which was a very simple system and very complex system at the same time. It had no moving parts, it was an amazing system. We still use the same technology today 40 years later.

We had a transport water system. The pump would push four pounds a minute of chilled water through the system up to the sublimator to be chilled. The astronaut had a temperature regulator; he could regulate the temperature. Then it would go through the liquid cooling garment, absorb the heat from his body, and then be returned to the portable life support system to be rechilled through the sublimator again.

We had a carbon dioxide removal system. Because the astronaut is in the suit, he's producing carbon dioxide. It's not being dumped overboard. Some people are not aware of the fact that the life support systems are not scuba type systems where you breathe it in and you dump everything over. They're actually a rebreathing system. When the astronaut exhales, he exhales some carbon dioxide and some unconsumed oxygen. We don't want to waste that oxygen so it goes back through the loop. The carbon dioxide went through a CO2 removal bed,

a chemical called lithium hydroxide. It's one of the few chemical equations that I can remember, lithium hydroxide plus carbon dioxide yields lithium carbonate and water. My chemistry teacher would be proud of me, but that's the only one I remember. We absorb the carbon dioxide, and with that system it would enable an astronaut (through Apollo 14) to be out for approximately four hours.

WRIGHT: You were talking about how you prepped the hardware for the crews to come in for training. But did you have the use of test subjects?

SANZONE: That's a very good question. Yes, we routinely used other test subjects. There weren't many of them. One that I know the best is a guy by the name of Jack [Jackie D.] Mays. I don't know if you've ever interviewed him, but you might consider it. First of all I should say that in the Apollo program every astronaut had his own space suit. Matter of fact, most of them had three. The flight astronauts had a flight suit, they had a backup flight suit, and they had a training suit.

The life support systems were separable, so we didn't have life support systems assigned by name but ultimately only one life support system went with an astronaut to the Moon because they didn't come back. Jack Mays was the only person that I know who had his own space suit, only person who wasn't an astronaut who had his own space suit with his name on it. He did that many vacuum chamber training runs. There was another fellow that did some work over in the Space Environment Simulation Laboratory, guy by the name of [Kenneth] Ken Dessert, who I still know today. He hasn't worked at NASA for decades, but I do run into him at church

occasionally. But Jack Mays was the guy that did most of the "guinea pig" type runs to make sure that this stuff was going to work okay.

Things were so compressed timewise that most of the proving of the design was done before we got into the real flight stages of things. We did certification runs in Building 32, the Space Environment Simulation Laboratory. We put a test subject out there or maybe an astronaut who wasn't planning to fly, and we would not only pull a vacuum on the system, which would allow our heat exchanger to work and fully test the suit and life support system, but we would also have the ability to put thermal loads on the suit and the life support system. Both hot and cold, very extreme temperatures, similar to what you would see in space, couple hundred degrees Fahrenheit plus or minus.

That was to really wring out the suit and to prove that it would actually meet all of its design requirements, including these thermal design requirements. As you know the suit is like a thermos bottle with like a dozen layers of insulation, a fabric thermos bottle if you will. We wanted to be sure, we needed to be sure, that the life support system in the space suit would provide the environment to keep the astronaut both alive and comfortable, as comfortable as we could.

Because the human body is like a heater, we didn't have heaters. We didn't heat up anything. Even when they were in the cold environment, we didn't have a heater in the life support system to heat them up. Their own bodies heated themselves up. I always said it was like being in a fraternity party with a whole bunch of people—the room gets pretty warm, because bodies are giving off a lot of heat.

Well, the astronaut or the test subject would give off heat to keep himself warm. With the level of insulation that we had, we didn't have to put any heat in, but we did have to take heat

out, even in the cold case, but particularly in the hot case, where it was a couple hundred degrees Fahrenheit. It was insulated, but in that kind of environment, you do have what's called, thermal leakage. That's where we would prove out the design of the system.

Once we got into the training aspects with the astronauts—of course the Apollo flights were so relatively close together, that it was one on top of the other on top of the other. We were just cranking them out. We weren't concerned any longer about the design, the design had been proven. Now we were pretty much into asking, does this life support system work the way it's supposed to, do the sensors work, the pumps, the fans, the regulators?

The fourth system, that I left out a minute ago, was the oxygen system. We had a high pressure oxygen bottle—I'm speaking Apollo 11, because the pressure was raised for the last three Apollo flights—but it was about 900 pounds per square inch. We would drop that pressure through a pressure regulator to about 3.85 pounds per square inch. That's what the space suit was pressurized to. We would have to make sure that that regulator was regulating at the proper pressure, and that the sensors that provided us warning if it wasn't working properly, if we somehow got high oxygen flow, if we had a hole in the suit or something, suddenly oxygen started going out faster than we had planned for it to go out, we had a warning device that would give off a tone and provide the astronaut a little symbol that he could see.

We also had a backup system called an Oxygen Purge System, and it sat on the top of the portable life support system. It was totally separable though; we could take it off. It had two oxygen bottles that were charged to 6,000 pounds per square inch, which is really high pressure. More than six times the pressure in the primary tank. The reason for that kind of pressure was to be able to contain as much oxygen as we possibly could, because as the name indicates, it was an oxygen purge system. If we had a failure of the primary life support system—for example a

power failure, where suddenly we had no fan circulating, removing carbon dioxide, we had no pump circulating chilled water—we had the ability through what was called a purge valve that plugged into one of the ports in the suit to actually open the purge valve, turn on the oxygen purge system. Not in that order—you wanted to turn the oxygen purge system on first, then open the purge valve. It would flush oxygen across the astronaut's face. As it took the CO2 away from the astronaut's face, it would go to the purge valve and be dumped overboard. It was clearly an emergency system. It was good for about 30 minutes, and it was time to get back in and get on the spacecraft life support system in the Lunar Module.

I'm happy to say that we never had to use the oxygen purge system in an emergency mode. We did use it. On the last three Apollo flights we actually did a spacewalk on the way back from the Moon. There was a film canister outside the Command Module, and the Command Module pilot would be hooked up to the Command Module environmental control system, would open the hatch, stick his head out, get this film package, and come back in. This oxygen purge system was actually mounted behind his helmet in case it was needed, in case there was a failure in the umbilical system or the suit or something like that. Again we never had to use it.

But we also didn't want to land with a 6,000 psi [pounds per square inch] charged oxygen system. We didn't want to land in the ocean with that, so after this spacewalk was done by the Command Module pilot, periodically they would dump some of the oxygen from the oxygen purge system into the cabin. It would literally pressurize the cabin. It had so much oxygen that they would do it in several steps over a couple days. They'd actually allow the Command Module pressure to drop a little bit, and then just take this thing and turn it on, and it would

pressurize the Command Module. When they actually landed, those bottles would be virtually empty.

One of the ironies as I'm telling you this is we were always a little jealous of the suit guys. Back then the suit was made by ILC [Dover, LP], and Hamilton Standard made the portable life support system and the oxygen purge system. NASA was really the integrator of those two systems. We all worked together obviously and we integrated those systems.

But, they [ILC] got their suits back. Every time the astronauts went to the Moon, they got their suits back. We never got anything back, because all the life support systems were left on the Moon. After the last moonwalk on a particular mission, the astronauts would come back into the Lunar Module, the hatch would be left open, they would hook up to the Lunar Module environmental control and life support system. They would put the portable life support systems on the porch of the LM [Lunar Module], disconnect from their suit, and kick them off. So there are 12 life support systems, two each at the base of six lunar modules, on the Moon.

WRIGHT: Your litter.

SANZONE: Yes, our litter. If we get to go back there someday, we'll retrieve them. I said we were a little bit jealous that the suit guys always got their hardware back, covered with Moon dust by the way. It wasn't until Apollo 15, that was the first time we ever got any hardware back, because that was the first mission where they actually did the spacewalk from the Command Module on the way back from the Moon. We actually got the oxygen purge systems back for the last three Apollo missions, which was fun to see something that had actually been on the Moon. It was there.

It was also there as a backup system when they did this Command Module EVA. Then they used it to pressurize the Command Module. I suppose our greatest joy was it didn't have to be used in an emergency. That was one system we never wanted to have to use, and we didn't, except on the ground obviously. We would simulate failures, that was part of the crew training. We would simulate a failure, allow an astronaut to just shut off his oxygen regulator, and his suit pressure would start to degrade. He would go through the experience of hearing the warning system go off, looking at his pressure gauge, knowing what it felt like in the suit. It wouldn't drop very much though. Then he would know to activate his oxygen purge system, which would immediately repressurize his suit up to the normal level.

If you had an oxygen regulator failure, you could actually use the oxygen purge system without going into the purge mode, just as a redundant supply of oxygen. But again we never had to do that either. I sit here four decades later thanking my lucky stars that we never had to do any of that.

WRIGHT: Since you're talking about simulation, let's go back to those first days when you were testing the equipment with the Apollo 11 crew and its backup. You said that was your first crew to work with. How long did you test them? Was everything working the way you wanted, or did you have to make adjustments before the crew took it?

SANZONE: For the Apollo 11 crew I remember that there was a problem with the vacuum chamber, because the facility was very complex as well, the facility that was used to test the equipment and the astronauts. So I'm almost positive that we actually didn't get the first run off with Neil Armstrong. I mentioned to you earlier that this was, as I recall, in the March

timeframe, and it was only a few months later he was walking on the Moon, so he was a very busy person. Although I don't remember him really "venting" or anything, I don't think he was really happy that he was going to have to come back another day.

He could count the days he had between then and the time he was actually going to the Moon, and the astronauts needed to spend most of their time in flight simulations. Back then you'll recall that unlike [Space] Shuttle where we have a commander and a pilot who fly the vehicle, and then we have usually five mission specialists who do most of the other stuff, back then our pilots were our mission specialists. Everybody was a pilot, until Apollo 17 with Jack [Harrison H.] Schmitt. He was the first and last of the 12 astronauts who walked on the Moon and was actually a scientist.

I remember vaguely not feeling all that guilty personally, because it wasn't my system. I learned over the years that if you're part of a team, it's your system even if it's not your system. But at that point I don't remember it being a big emotional "oh no we let him down," kind of a thing. The chamber run that I was managing, at least from the life support side, was generally just several hours. That's about the only time that they would actually spend utilizing the flight hardware.

I wasn't on console for this so I don't remember exactly, but I think for the early Apollo lunar flights we would also take them over to Building 32 and put them through the thermal environment. I don't know if we did that all the way through the program or not. We may have. We may have done it all the way through the program, because I do remember doing some other thermal vacuum tests over there.

Generally what would happen is two or three days before the simulation, we would take part of one day and would do a briefing of the crew, like "portable life support system 101." It's

got four subsystems, really basic stuff—the controls, how they operated, where they were located; the warning system, what they could expect, when they could expect it, what actions they would need to take when a particular alarm went off—like the classroom session of a course. Then either that day or the following day we would do a dry run. This was the norm.

We would do a dry run where we would go through the whole scenario with the astronaut, get him in the suit, the whole thing, but we wouldn't take the vacuum chamber to vacuum. Then the next day we would do what we called the wet run, which was get in the suit, and we're going to suck all the air out of the chamber and take you—people used to actually refer to it as taking you to altitude. We would take all the air out of the chamber, then the heat exchanger would work, and then you could use all the systems.

Back to Apollo 11, we probably took two days. Obviously the classroom training was done with all four astronauts, the prime crew and the backup crew. One thing I should mention, I keep talking about two astronauts. The two astronauts that I'm talking about are the commander of the mission and the Lunar Module pilot. We did not train or interface with the Command Module pilots ever until Apollo 15, 16, and 17 when they used our oxygen purge system as the backup system for that return from the Moon EVA to retrieve the film cartridge.

Usually a briefing would be the prime commander and Lunar Module pilot and the backup commander and Lunar Module pilot. Those four guys would hear what was going on, and then they would each make a vacuum chamber run. Those wet runs would occur over four days, usually four days in a row. Then for their flight hardware training, sometimes we would take them over to Space Environment Simulation Laboratory and take them through a thermal run as well. That was it for their vacuum chamber runs, they didn't make multiple vacuum chamber runs.

They spent their very valuable time, like I said, flying simulators, and doing a lot of what we called one g [gravity] training, which was putting an astronaut in a space suit that was flight-like. It was designed to the same specs [specifications] as the flight suits, but not using a functioning life support system. The backpack, if you will, was really more of a box that could either have a little cryogenic supply of air—and I think that's what we used most of the time—or you could use an umbilical type system. It was virtually an empty box because our life support system would only operate totally in a vacuum. The heat exchanger could not work outside of a vacuum environment. The astronauts would spend a lot more of their time doing this one g [gravity] training than the vacuum chamber training. The vacuum chamber training was really to get them familiar with and confident with the portable life support system.

The other training that they did was much more extensive and that was for learning where you put the experiments, how you deploy them, how you pick them up. From that standpoint, we were there as a tool that the astronaut would use, but they would spend hours and days doing that kind of training as well. For the most part I wasn't heavily involved with the one g training, I was more with the flight hardware and the vacuum chamber training.

WRIGHT: Did the results of the two types of training, the one g and the flight simulation, have impacts on each other? As they were training in the one g did they want to change things that affected your flight hardware or vice versa?

SANZONE: You're making me laugh because I had a small group of a couple of guys. One of those guys was assigned to support the Apollo 11 crew in these one g training exercises. I would rarely if ever go to them, so he would come back and just report on what happened. We were

very close to Apollo 11, seemed like weeks away, and he came from one of these training sessions and said to me, "Neil wants a camera bracket mounted on the front of his remote control unit." The remote control unit was the control box that they wore in front of the suit.

My first reaction was, "there's no way, we can't do it." It wasn't that we couldn't build it; my thinking at the moment was that we couldn't get it certified. We couldn't go through all the thermal environment tests that we would need to do to verify that this big piece of metal on the front of this remote control unit wasn't going to provide heat into the inside of the control unit, maybe damage the electronics. There just wasn't time to do it. Well, I say this with a big smile on my face, because if you look at pictures on the Moon, Neil Armstrong had a camera bracket, and it wasn't just the -1 [first model], it was the -2 [second model]. In that very limited amount of time we not only designed a bracket, we modified it and ultimately flew the second version of the bracket.

That's when I think I started to realize the power that astronauts had. I hadn't thought about that in a long time, but you made me smile. That's probably the best example of how something coming out of the training might affect what we do with the flight hardware. Usually it didn't, but in that case it certainly did. Many people at NASA are not aware, but Armstrong was the only one with a Hasselblad camera on the Moon, so all the photos taken on the Moon by the Hasselblad camera are of Buzz Aldrin taken by Neil Armstrong. If you want to see Neil Armstrong in a Hasselblad photograph you have to look in the gold visor worn by Aldrin to see the reflection of this little tiny person taking the picture.

That was probably the biggest example of a change, I can't remember another one. There may have been some. I wasn't working on the suits myself then, so there may have been some visor requests or some things like that that may have made some changes, but for the most part

they didn't. It was more just using the suit to go through the exercises that they would go through.

WRIGHT: I would think the whole ensemble had to be in balance with each other. If someone wanted you to have a change, could it affect your portable life support system? What type of safeguards were included?

SANZONE: One thing I should tell you, and I often don't think about it, is the portable life support systems in both Apollo and Shuttle—it's called the primary life support system, an integral part of the space suit—are called fail safe systems. Most of the systems in the spacecraft, both Apollo and Shuttle, are called fail operational systems. The difference between those two systems is in the fail operational system when you have a failure of a component, you go on to the backup system or what I would call the first backup system, and you just keep on operating. It's only when you would have a second failure of that system that you would have to abort the mission or whatever part of the mission that you were doing. So hardware failures in the spacecraft are often not seen clearly by the public, by those outside of NASA, because we just keep on going.

But the primary life support system and the portable life support system in Apollo were what were called fail safe, because we really couldn't afford the weight and size that it would take to have extra backups for every system. Consequently if we had a failure in our system, everybody knew about it, because we had to stop what we were doing, go on the backup system, and get back to the spacecraft.

I mentioned earlier the oxygen purge system was a 30-minute system. If your pump failed for example, you would get on the oxygen purge system and you would get back in. There was no, "just keep going for a while." That wasn't possible. It was just accepted. Our systems were designed to keep the astronaut alive with a backup system, not to keep pressing on with the operational aspects of that particular spacewalk.

One of the things that I remember that ties to experience with spacecraft, or any element of the spacecraft, is as you gain more confidence in the hardware [you have to determine] the risk that you're willing to take. It's not that you're taking more risk; it's that because you have more confidence in the hardware you feel that the risk is less, therefore you might accept something without the same level of backup system. For example, we had three means of monitoring the pressure in the space suit. The astronaut had on the forearm of the suit a pressure gauge where he could look at it himself and see what the pressure in the suit was. We also had telemetry that was being sent down from the Moon so we could monitor to see what the suit pressure was. Then we also had a low suit pressure warning alarm. If the telemetry were to fail and the suit pressure were to drop, an alarm would go off to alert the astronaut that you better get on the backup system and you better get back in. We had three different means of verifying that we had safe suit pressure.

On Apollo 11 the mission rules were that all three had to be functional. On Apollo 17 only one of the three had to be functional, because by the time we got to Apollo 17 we had a lot more confidence in the hardware. We felt we could keep going as long as we could see one of those three things. For example, if we lost telemetry and the warning system didn't work for some reason and the astronaut could still see his pressure gauge, we were okay to go.

The biggest backup system that we had was this oxygen purge system, because it would not only provide more oxygen if needed, it effectively would provide body cooling and CO2 removal. Just the gas flowing away from your body would provide some level of cooling, not the same that a liquid cooling garment would provide, but enough to keep you safe in order to get back in. It was definitely a fail safe operation. I know that I learned a lot working on life support systems early in my career that served me well later in my career. It was because when you worked on life support systems, to borrow a quote from Gene [Eugene F.] Kranz, failure is not an option on a life support system. It's right there in the name—you are supporting someone's life.

So you never took a shortcut. That mentality tended to serve me well later in my career, while working on systems where you maybe could have taken a shortcut and gotten away with it without hurting somebody. It was in our DNA [deoxyribonucleic acid]. We didn't do things that way. So we had some other systems that we treated like life support systems, even though you weren't going to lose your life if they didn't work properly.

I wanted to share a story about Fred [W.] Haise [Jr.]; it is something I've always smiled at. One of the things that we tried to do in the training—and I learned this more as missions went by—is we not only were trying to give the astronauts training in the nuts and bolts of how the hardware worked, but we were also at the same time giving them confidence in the hardware, that it worked just as advertised, that we understood how it worked. It was very predictable. Therefore, you could depend on it and not think about it.

I remember my boss, Fred Keune, saying one time—because we couldn't wait to be on stage with our hardware, and everybody liked to hear an astronaut say, "Oh, I love this hardware," and mention the company name or maybe some engineer's name or something like

that. On one of the missions—it might have been Apollo 11, I don't remember—there was no mention of the life support system. We were like, "Oh, he didn't say anything, he didn't pat us on the back." My boss said, "That is the highest compliment we could ever receive. This astronaut is using our equipment as a tool to do other work on the Moon and he's not even thinking about it." I've joked with people over the years. You drive your car downtown and you don't say, "Hey, my car worked all the way downtown." That's really a compliment to the car, that you have that kind of satisfaction and confidence in the hardware.

Fred Haise took that—I don't want to say to the limit but certainly to a higher level. We had him in Chamber B of Building 32, the Space Environment Simulation Laboratory, SESL it was called. There was a step in the procedure that was always confusing to the astronaut, and a little to the test team. It occurred right near the end of the run, when we had done all the operational things that we were to do. He was still in a hard vacuum. In SESL we had a trolley system that was utilized to hold most of the weight off of his shoulders, so the astronaut didn't have to carry this very heavy life support system around on his back. Of course we had a backup safety system, which was a cable, so that if the astronaut for example lost consciousness he wouldn't drop to the floor, he would drop down several feet, and then this cable would catch him and hold him up.

So the test director read the step. I was on the console as the life support guy. The test director said, "Crewman rest until ready to proceed." I don't know why we never changed that. It said, "Crewman rest until ready to proceed." On virtually every test the astronaut thought he was waiting for us. He was going to rest while waiting for us to tell him we were ready to proceed, but it was really intended for the astronaut to rest because he had to walk a distance out of this chamber. Inevitably, the astronaut would eventually say, "Are you guys ready?" or we

would say, "Are you ready?" and he'd say, "Oh, I was waiting for you." So Fred Haise, this was probably when he was part of the Apollo 13 crew, he was out there and we told him to rest. He said, "Hey, will this thing hold my weight?"

The test director called on me, and I said, "Yeah, absolutely." So he lowered this cable until it took up his weight, like on a swing almost. It was always very quiet during this period of resting, because we were waiting for him and he was waiting for us. Nobody said anything on the net[work]. About three minutes went by with nobody saying anything. The test director called him. He said, "Crewman." There was no response. He called him a second time. I think on the third time he actually raised his voice a little bit. He woke up Fred Haise who was in the suit, in a hard vacuum, sound asleep. I think we were successful in demonstrating to him that he could have a lot of confidence in the hardware. So yeah, that is one of those. Everybody was like, "Can you believe that? He went to sleep out there."

WRIGHT: I noticed you called him crewman too. Did you not refer to the astronauts as individuals when they were in your suits?

SANZONE: Rarely. The test discipline was such that we would usually refer to them as crewman. The test procedures were all written somewhat generically. When we would see them at the post-test debriefing and things like that, we would call them by name, but everybody had a code name, much like Mission Control. You have a capcom and a FIDO [flight dynamics officer] and a GUIDO [guidance officer] and an EECOM [Electrical, Environmental, and Communications]. It was similar to that. Actually my position had a word tied to it because it was PLSS engineer.

Then there was TD for test director and MO I think for medical officer and things like that. But almost always, we referred to them as crewman. They were all men back then.

WRIGHT: Speaking of those that were involved, you sound like you had a variety of people around for testings. For instance did you always have a medical officer present?

SANZONE: Absolutely, yes, we always had a medical officer, because again this is testing a life support system. It wasn't just loss of life that was a concern. The astronaut, because of the environment that he was in, had the risk of getting the bends, much like a scuba diver going from higher pressure when he's down say at 90 feet or four atmospheres up to sea level, one atmosphere. When we would do a spacewalk say in Shuttle we would go from one atmosphere just like we are here in the room to slightly more than a quarter of an atmosphere. That could enable astronauts to get the bends.

Now I should say in Apollo that risk was significantly less if not nonexistent. I'm not a physiologist, but Apollo was 100 percent oxygen environment, not just the space suit, which it is in Shuttle, but also in the spacecraft. The astronauts were breathing 100 percent oxygen all the time, whereas in the Shuttle cabin they're in an air environment, breathing nitrogen as well. So we would go through a prebreathe protocol. We do it both on the ground and in flight for Shuttle and [International Space] Station.

In Apollo the astronaut was coming from an air environment as he arrived on the morning of the test. He would go up into the second floor of Building 7 and we had what was called a prebreathe room. He would get in his suit, which was separable from the life support

system. The life support system would be hanging in the chamber. He would get in his suit. There were a couple of big easy chairs.

Put him in the suit. Button him up. Hook him up to 100 percent oxygen. Lean him back in the suit. Put a towel over the helmet. Tell him to go to sleep for a couple of hours. They would breathe pure oxygen for I believe three hours, then they would come down the stairs to the chamber on a portable oxygen ventilator that would continue to provide 100 percent oxygen. They didn't have any exposure to the air, nitrogen, which could result in him potentially getting the bends.

So the doctor was there. The doctor started very early in the day actually when the astronaut first arrived. He would do a quick physical [on the astronaut] for example, to make sure that his ears were clear. If he had a cold or something, the odds were very high we would just cancel the test, because like flying in an airplane, you get your ears plugged. When you're going all the way to vacuum or only four pounds per square inch above vacuum, and then back down, you could literally burst an eardrum. Those were the kinds of things the doctors would look at.

Obviously they would monitor the astronauts. We had CO2 carbon dioxide level telemetry. They would monitor that along with us, so if the CO2 level started to climb he might say, "Okay, that's it, we've got to shut it down." This is somewhat obvious, but he was really there protecting the health of the astronaut, because you had all these engineers that are trying to collect data. They're not as focused on the astronaut—it wasn't that we didn't care, but we were focused on other things. The doctor was focused strictly on the safety and health of the astronaut.

There was always a doctor. There was always a test director. There was usually an assistant test director. Then there were various operators of the facility, the vacuum chambers, and the power systems and those kinds of things. Particularly when we went to SESL in Building 32, that was like a mini mission. It was really like a mini Mission Control. It had a lot more console positions than the chambers in Building 7. It was structured more like Mission Control; you really almost felt like you were in Mission Control. That's the way I always felt.

There was a lot of discipline. There were probably—I'm going to guess 15 to 20 people sitting at consoles. Maybe I should say ten to 20 people, each sitting at a console, most of the time monitoring whatever their particular system was—the vacuum in the chamber, or the temperature in the chamber, or things like that and informing the test director if they saw a potential issue cropping up.

Most of the on-network discussion during the chamber runs were either the test director talking to the crewman about setting up certain conditions, and then the PLSS engineer, the portable life support system engineer, would be delegated the authority from the test director to communicate directly with the astronaut during the training portion. When I was the engineer, it would be me and the astronaut. We would communicate back and forth almost directly, as long as everything else was okay.

WRIGHT: Quite a first year, wasn't it?

SANZONE: Yeah it was. My mother, God bless her soul, kept telling me to smell the roses. Not in those words, but my mother was born before the Wright brothers [Wilbur and Orville] flew

their airplane [first flight] and here her son was helping train the first man to walk on the Moon. She kept reminding me to recognize where I was and what was going on.

But I have to say we were all so focused on the task at hand. People at NASA are very task-oriented, that's an understatement. We are so focused on the task at hand that it was difficult to do that. We didn't generally ask astronauts for autographs as we thought that was a little unprofessional, but I do remember thinking this guy is going to be the first guy to walk on the Moon, I don't care if it's unprofessional or not. I went and I cut this ridiculous photo of Neil Armstrong in a Gemini space suit. I cut it out of the [local] newspaper, remember the Exchange newspaper? I had him sign it with a red pen, which was all I could find. I still have that someplace. He signed some other stuff for me over the years.

It was an amazing environment to be in. Of course as I said earlier, we had one mission after the other after the other. Once we got the Apollo 11 crew trained, we were training the Apollo 12 crew. Then the 13 crew was behind them. There was always stuff going on.

We did work a lot of hours. I was single at the time, and it really wasn't like work. I think I shared with you a Hartford Courant [newspaper] article where the guy that wrote the article interviewed me. His last line quoted me; it's true. I said, "We would have done it for nothing." I'm not sure with [their] kids in college, people could have done that, but nobody had kids in college. Everybody was 22, 23, 25.

It was very intense, but there was so much passion around what we did. The fact that we had this incredibly powerful vision of landing a man on the Moon in this decade and returning him safely to the Earth—there was never any need to motivate anybody, to remind people what we were there for. It was part of the DNA of everybody.

There was also this incredible attitude of never quitting, never even thinking about quitting. I can remember we were getting ready for a chamber run. It was around midnight and we were running a pump test. Today you'd never be running hardware eight hours before a chamber test with the astronaut; you just wouldn't be doing it, but everything was so compressed and that's what happened. This pump failed. There wasn't the slightest consideration of, "Well, let's just scrub the run tomorrow." It was just like okay, let's do what we have to do.

I remember that in particular because I was obviously a contractor and we had NASA civil servants who had leadership responsibilities. For each mission, Crew Systems Division had someone they assigned to be what was called the mission manager, or their mission manager. He was responsible for making sure all the hardware that the astronauts needed worked properly, got to be where it needed to be at the right time whether it was at the Cape or chamber run or whatever. It included clothing and food and cameras and things like that. Obviously it included space suits and life support systems. In order to work on these life support systems or run tests on them, we had what were called test preparation sheets that identified everything we were going to do. Everything was documented. Attached were procedures and things like that. They were signed by several people approving and concurring on what was going to be done.

If we had an issue in the middle of the night like happened here—I was the lead engineer and I had to call the mission manager and get his permission to change this pump out, and let him know we just had a pump failure, because we don't want to scrub this training run. We knew we'd have to figure out what happened with the pump later. But what we wanted to do was put a new pump in, test it, make sure it's going to work okay, and then deliver this life support system to the chamber. All this would take five, six, seven hours to do.

So I called him and I woke him up; I'll say midnight but it may have been closer to 2 a.m. Woke him up, told him what we wanted to do. We all had white clothes on, working in the clean room, so he gave me the okay. We started to work. About ten minutes later, maybe five minutes later the phone rang. It was the mission manager and he said to me, "What did I just agree to?" Because I woke him up out of a dead sleep, he called. So I told him. We got the pump in. We got it tested.

From the astronaut who was being trained, from his aspect, if he was coming for a chamber run, he had a chamber run. I'm interested in car racing. When you're working on a car, when the clock is running, it's called thrashing. That's what we would do, it was like thrashing. Then we would deliver the hardware. We'd have the chamber run.

Interesting times for sure.

WRIGHT: It was. Where were you on Apollo 11?

SANZONE: Apollo 11. For the landing I was in my apartment in Pasadena, totally by myself. We were all going to work the moonwalk or the EVA, so we got instructed, appropriately so, to all go home and go to bed, to get some rest and be sharp for the EVA. But there was no way I was going to sleep when they were landing on the Moon, and I don't think anybody else did either. The original plan—at least as I remember it—was to land on the Moon and then they were going to rest.

None of us were overly surprised when the crew decided, "We need to go out and do this." I don't remember exactly if the plan was changed before the mission or real-time. I think it was real-time, but I don't think anybody was really too surprised, so I watched the landing at

home all by myself on my little TV. I think shortly after that I got a phone call that said, "They're not going to rest before they go out, you need to come in right now." So I don't think I'd gotten any extra sleep. No less than they had.

We all came in. I say all; I don't know how many of us were covering the mission. There were probably about eight Hamilton Standard people. There were some ILC people. Then there were some NASA people, all having to do with the extravehicular mobility unit. At that point there wasn't a whole lot more that you could do with the suit. The life support system had all the stuff. The suit could have problems, but the life support system had a whole lot more stuff that could go wrong just by its nature, so there were more of us monitoring the life support system. There were some NASA people—Harley [L.] Stutesman comes to mind and Don [Donald L.] Boydston who was a tremendous mentor to me in that first six months, just a tremendous mentor. He was like the expert, so he was there.

We were together in Building 45 on the third floor. Back then it was the Mission Evaluation Room [MER]. Something that we still have today, but it was a lot more Dark Ages compared to the MER today. We were literally in what are still today used as offices.

So there was a front room, a fairly large room, with lots of people with headsets on and all that. Then our group was in a room that was relatively small; we were all together. We would monitor the telemetry that was coming down from the Moon, and there were 10 or 12 channels of telemetry. We had two engineers monitoring each life support system, each looking closely at their half dozen elements of data.

I had Armstrong's data. There was another engineer with me that was looking at the other half of Armstrong's data. Then we had two other engineers monitoring Aldrin's data. We had some more senior folks that were looking over our shoulders. One of the more humorous

things in hindsight is we got the data telemetered down, and it was displayed on CRTs [cathode ray tubes] like TV screens in a digital format. But we also wanted to be able to monitor things like oxygen consumption, how much is the oxygen going down.

We had—I never say this without laughing—we had big sheets of graph paper that we hand-plotted the data on like every two minutes. Primary oxygen system pressure, for example, might start at 900 PSI [pounds per square inch], and then we would plot it as it came down. Suit pressure we would hope to hold at approximately 3.85 pounds per square inch. We would know that if it goes to 3.8 that's not a huge problem; if it goes to 3.9 it's not a huge problem. If it gets out of that band, we better take a closer look at it.

We would literally take Magic Markers [permanent ink markers]—this was before highlighters existed—yellow Magic Markers, and we'd go across the graph paper, where we expected the data to appear. Similar to what computers do today, but this was all by hand. I have one of those actual sheets of paper from the night of Apollo 11. I have copies of all the data. Somebody actually had the foresight to take a couple of photos, wasn't me, but somebody took a couple of photos of maybe four, five of us—took photos of us sitting there.

It was so antiquated compared to today. We had these display boards with stopwatches on them, because we wanted to know how long the astronaut had been on his primary oxygen system. That was one of the important jobs that existed during the mission. We had some other folks in there, some other NASA folks and some other contractors helping do calculations for consumables or expendables. The system was designed for approximately four hours.

I had said earlier we had a certain amount of water in the tank that would be used to sublimate, to remove heat. We had a certain amount of oxygen. We had a certain amount of lithium hydroxide chemical. We had a certain amount of amp-hours in our battery. We would

watch that stuff very carefully so that we could accurately and safely predict how much time they had. We didn't want them running out of gas on the last lap of the race.

Well, there was no worry on that for Apollo 11, because the EVA ended up being about two and a half hours I think. Everybody was interested in, "Let them get back in, get them back in, and close the hatch."

In later missions, we would push the limits more. Obviously we wanted to get them as much time on the Moon, and later in Shuttle as much time during an EVA, as we could provide them, so that they wouldn't have to be rushed. We would keep a very close eye on that and a lot of it was engineering calculations—understanding what the heat load was, the Sun angle, leakage rate in the suit, then predicting how long this was going to go.

I have to say tongue in cheek that there were the engineers who worked on the life support systems that worked very closely with them and just almost became one with them. Then there were thermal analytical engineers that would calculate stuff—with their slide rules by the way—would calculate the stuff. We always had a little friendly rivalry on who could predict it more closely. I don't remember the numbers, but a fair number of times, we winged it a little more closely than they could do it with their slide rules. It was always pretty close. We never were in any particular risk.

So, [going to] the Moon was really similar to what it is today [Shuttle], where often the contractor experts are the people that really know the "blood and guts" of the hardware. Flight controllers knew the hardware very very well, and they knew how to react to certain failures very well, but sometimes you could have a failure that would just stump people. We'd have people that would know if you rip this thing apart, this red wire is the one that goes over here. It would be something you would never expect a flight controller to have, not that level of detail.

NASA had a front room flight control, the Mission Operations Control Room. For Apollo 11, [James A.] Jim Joki was working. He had as I recall three prime people in the first back room. I'm not sure exactly what it was called; it's had different names over the years but it is what I call the first back room. You didn't see them on TV. One person was monitoring one life support system—one was monitoring Armstrong's, one was monitoring Aldrin's.

The third was responsible for the consumables and the expendables and how much time do we have left, because that was the question you got more than anything. How much time do we have? How much time do we have left? We were constantly updating that. Once you got beyond their level of expertise or experience—and they had a lot of experience—then it would quickly get bounced back to the MER, and they would ask for assistance. Or [ask], "What's going on here, what should we be doing? We're using more expendables faster than we thought." So we might say, "We're looking at this, we're looking at that." It was very much a team, separated by walls and in our case by one building because 45 was right next to Building 30. But we knew each other. We worked closely together. That always worked pretty well. So Building 45 was the MER back in the Apollo days.

WRIGHT: Were you able to actually watch Armstrong on the Moon?

SANZONE: No, I was asked that same question by the person who wrote the article for the Hartford Courant on the 40th anniversary of Apollo 11, and I don't remember watching it. I don't remember even having a TV monitor in our room, in the room that we were in. There may have been one, but by virtue of the fact that I can't even remember it, tells me that if it was there I didn't watch it. Again, it was that we were so focused on the task at hand. We were in the

critical path. By the time he got down to step onto the Moon, our system had already been operating roughly for more than 30 minutes. We're staring at data, looking for any sign that something might not be right so that we could take quick action. Although I don't remember a single issue on Apollo 11, we still were incredibly focused on what we were doing.

WRIGHT: It seemed like a long three-and-a-half-hour time period. Or did it go by quickly?

SANZONE: In hindsight I think it went by pretty quick. We had a lot of personal confidence. I keep saying we're looking at things to not go right, but I probably had more confidence than I should have had because I really expected things to go well. I had a lot of confidence in the hardware. It was quite a while later, maybe years later, when I became a manager, and just older and more experienced, and started having a better understanding of what could go wrong, that it doesn't always go the way it's supposed to go. I remember one of the early Shuttle EVAs. Joe [Harold J.] McMann was a NASA EVA guy, really sharp guy.

He and I had been through the wars together in past years. This was a Shuttle EVA. We're over in the new MER. We had these young engineers—older than I was on Apollo 11, but they were young. They were—I don't know what the right word would be. I'd say jovial or certainly not the slightest bit worried. They weren't lackadaisical, but they were joking around. I remember Joe saying, "Get them [astronauts] back in. Get them back in." They were in no rush to get them back in. I remember talking to Joe, and we were thinking, "You guys don't know what can happen." So I guess we were in a total risk avoidance mode, and they were in the "Let's be on stage" mode.

WRIGHT: You sound like you have posttraumatic anxiety attacks; you didn't have them when you should have.

SANZONE: There is. Many years after I became the general manager in Houston I often used to go over to the viewing room in Building 30 in Mission Control to just sit there in a comfortable seat and watch the EVA, knowing that if something happened I could run downstairs and be there in a minute. This was long past the time where I was sitting on consoles and monitoring data. As much as anything, if I saw something that might be tricky, I might alert our Hamilton public affairs folks because I knew they would get questions and explain what was going on technically, because they didn't understand the nuts and bolts. So many times I got to sit there. It was not boring; [it was] like being a fireman—a lot of boredom separated by moments of sheer terror. That's how EVAs are.

It was fairly common for astronaut wives to be in there [viewing room]; this became the norm. I knew some of the wives and I would go in there. If I knew the wife, I'd often sit with her and even tell her what I thought was going on or whatever. One time we had an engineering manager for our department in Connecticut here during an EVA. His name was [Chris Poythress]. He came down and I took him over to the viewing room with me. Jerry [L.] Ross was doing the EVA. I'd known Jerry for a long time, and his wife Karen was in the viewing room.

I said, "[Chris], come here, I want you to meet Karen Ross." We went over, I introduced them, and they exchanged pleasantries and all that. We sat there for a while. EVA was successful, no problem. I don't think [Chris] said anything to me right away, at least I don't remember him saying that to me right away. But when he went back to Connecticut—he was

running our whole department from an engineering standpoint—he got with his engineering staff and he said, "We all know we work on life support systems, and we all know how critical it is that we do a good job. Let me tell you something. When you are sitting next to the spouse of the person that your life support system is keeping alive, it gives you a different perspective."

I never really thought about it because I knew some of the astronaut wives. To him it was a new experience, because he was 1,800 miles away. I always remember him saying that. At JSC what I have found is even for people who don't know the astronauts personally or know their spouses or [families], they get that. There's an understanding of *that*, which is why it's such —when we had the *Challenger* and the *Columbia* accidents—why it's such a family loss. It really is a family loss.

I think for some people who don't work at JSC or NASA, it is very, very hard for them to comprehend that. It's something that is part of us. It's very hard to explain. I've tried somewhat unsuccessfully to explain it to people sometimes. They'll nod their heads, but I know they don't really know what I'm saying. I personally think it's because people outside of the JSC area view astronauts the same way they view NFL football stars, movie stars,—people that they only see on the big screen. They live very, very private lives, where astronauts don't live private lives, at least in this area. You go to church with them, you see them in the grocery store, you see them at Little League games. They are your coworkers, and they are your friends. They just happen to be astronauts, too. It is very, very hard to get somebody to understand that who doesn't work here.

WRIGHT: You were talking earlier about working so focused. Your days were full, especially that first year, second year. A bond was created with all of the teams, and the teams within the

teams. Can you share a little bit about how you also found time to have camaraderie outside of the building as well?

SANZONE: You're probably talking about Friday afternoons at the Flintlock. It was very common for us to work seven days a week. It was very common for us to work double shifts. It's not that we worked double shifts seven days a week, but it was not uncommon. I don't know who started it, but—there was no liquor by the drink sold in Texas; it was only sold in private clubs, so there was a place on NASA 1 called the Flintlock. On Friday afternoons, and I don't know who initiated this, but on Friday afternoons it was like the malt shop for NASA, except with scotch and bourbon. They had a band that played, started I think around 4:00 or 5:00. They actually had a great buffet. I was a bachelor, and it was tremendous food, but people didn't go there for the food. I think you could join the Flintlock for $1 or something. Every Friday afternoon the place would be absolutely packed.

We would actually send somebody over from work to hold a table for us till the rest of us got over there. Everybody was young and so there was a lot more drinking done then than there is now. People would just let their hair down. They would park cars up and down NASA Road 1 on medians. The place later had signs in there, "No parking in the medians." There would be cars parked all up and down the road. That was the one afternoon everybody would blow off steam, then Saturday everybody'd come back and work again.

One of the things about JSC that I know you know is it's a campus environment. It looks like a campus. I say it's a campus without a football stadium. It really looks like a campus. The vast majority of people who work there are college-educated. This is just my own assessment. They bring with them a fraternity, sorority, love your school background. JSC becomes like

their new school. They have their college banners up [in their work areas]. Everybody has pride in their own banners, but you've gone off to this new school, a graduate school if you will. I just really can't describe it. I don't think it's as much the environment of the physical facility as it was the mentality of the people and this common bond and this common goal. If you go to a school that's playing in the Final Four for the national championship, there's not a single alum who doesn't want them to win. Our Final Four, Super Bowl, whatever you want to call it, were the missions. Certainly Apollo 11 was the ultimate Super Bowl because that was [President John F.] Kennedy's vision. It was met, but the missions after that there was tremendous passion as well.

I think it was the thought that we were doing something really special, but because we all knew it was really special we never talked about it being special, because we were all doing it together. It was an amazing place to work.

WRIGHT: Must have not had much time to celebrate Apollo 11, because like you said, the missions were so condensed. You were working on [Apollo] 12?

SANZONE: We didn't celebrate for weeks, but I can tell you we celebrated for a day or two for sure. One of the places—as I said there were no liquor by the drink places—well, Ellington [Air Force Base] was still going and blowing. It had an officers' club, so we would often go to the officers' club. I know on the night of Apollo 11 we went there.

The Nassau Bay Resort Motor Inn—a hotel on NASA Road 1—actually had an NBC news studio on the very top floor, so they could shoot across [the street] to show the Manned Spacecraft Center. I remember that the grand piano at the Nassau Bay Resort Motor Inn ended

up in the swimming pool on the night of Apollo 11. So people, yeah, there were a lot of celebrations.

And the splashdown parties were renowned. They weren't totally crazy, but Apollo 11 was just a total celebration, because it was the implementation and the finalization of Kennedy's goal, this vision that had driven people for a decade.

The other splashdown parties, after each of the Apollo missions, they were all a lot of fun too, but not quite as intense as Apollo 11. It was a culmination of another championship, that kind of a thing, but people enjoyed getting together to celebrate. Almost everybody did. There were very few people that didn't go out. Yeah, fun times. They were fun times.

WRIGHT: [Charles] Pete Conrad and [Alan L.] Al Bean [Jr.] were a different team of astronauts compared to Armstrong and Aldrin. Do you remember working with them much as they prepared for their mission?

SANZONE: Ironically the Apollo 12 crew was the only crew that I didn't work with closely. I think it may have been that things were so compressed that I had the Apollo 11 crew and another engineer who worked for us had the lead for the Apollo 12 crew. Then I jumped to [Apollo] 13, but then I think I did the others after that. I think it was just that we had it down now more, and it was a little bit more of a routine that could be done by one person versus the whole intensity of Apollo 11. I wasn't thinking about anything other than Apollo 11. I wasn't thinking about Apollo 12, so somebody else took care of the Apollo 12 crew.

By the time I got there—I had sometimes used the phrase that I felt a little bit guilty in that there were guys at Hamilton at NASA that had been working toward Apollo 11 for eight or

nine years. Here I was, this 22-year-old kid that comes in and gets to play in the championship game, "Here's your uniform." Some of these other guys were on the bench. Not really on the bench, but they deserved a lot more credit than I did. I got to play in this incredible universal championship game. So I felt a little bit strange about that.

I think I must have supported the Apollo 12 chamber run maybe a little bit, because I do remember Pete. What I remember most about Alan Bean is not the professional side of NASA but being a renowned space artist. And he's such a perfectionist in his art. He called me one day and he was doing some artwork for on the Moon [scene]. He wanted to know exactly where these certain snaps were on a flap on the portable life support system. I pulled the drawings or sent him the drawings or a sketch or something like that.

He was always a nice guy. I didn't deal with him that much but he was always a very nice guy. Then Pete was a little bit more of a sailor—the "right stuff" astronauts. Not that they all didn't have the right stuff, but some were a little bit more spirited. I think Pete was a little bit more spirited. I got interested in car racing in the early '70s —I'm sure today they [NASA management] would just have a coronary, but Pete Conrad was racing Porsches up at Texas World Speedway [College Station, Texas].

Then the [Apollo] 13 crew. They had been the backup crew for the Apollo 11 crew. I do remember it being pretty straightforward, because they got to train for 13 not too long after they trained for 11, so that was pretty easy. I remember Fred Haise being one of the nicer guys, just a real nice guy. It's not to comment on anybody else, but he just seemed to be particularly nice. I remember we had some issue with his life support system. We had some problem in the chamber run. I don't remember what it was, but I remember calling him at the Cape. I was like 23 [years old].

I called him at the Cape because we needed his input on something, "Did this happen or did that happen?" We're troubleshooting something, and he couldn't have been more cordial. He said, "Call me anytime, if I can help." That kind of thing. I'm thinking my God, this guy is getting ready to go to the Moon. Telling this kid, "Anytime, just call me."

[T. K.] Mattingly [II] was supposed to be the Command Module pilot on Apollo 13, but he got bumped because of his exposure to a contagious illness. We had done some work with Mattingly, not so much me but some of the other guys. Mattingly was involved with the portable life support system development. He had worked with a lot of our guys during the development stage.

So [Apollo] 14 was [Alan B.] Shepard [Jr.] and [Edgar D.] Mitchell. Mitchell was a little quieter. Shepard, I had never dealt with him before. He was the first American in space and probably the sharpest astronaut that I dealt with in training. Again, not that they're all not sharp, but you tell him one time, and that was it. I remember it distinctly. He was just really sharp.

Then when we got to Apollo 15. We haven't really talked about this, but the life support system up through Apollo 14 was a four-hour life support system. Approximately four-hour life support system. When we got to Apollo 15, 16 and 17, it was called the J Mission series. There were quite a few design changes, including substantial changes to the extravehicular mobility unit, the life support system.

From the spacecraft side it was the first time we ever flew the lunar roving vehicle, the rover. We wanted to give them longer time on the Moon. One of the things that we did was we changed the design, improved the design of the portable life support system to take it to a seven-hour system. Almost doubled the duration.

I think we had one EVA on the Moon that was seven and a half hours if I'm not mistaken, so virtually twice the capability, in virtually the same package. That was the technical challenge. The size of the life support system didn't change with one exception and that was we added a water tank on the side. We haven't figured out how to compress water yet, so we put an extra water tank on the side that was maybe a four-inch-diameter tank. If you look at photos of EVAs during Apollo 15, 16, 17, you'll see this little bulbous object. It's about two feet high and maybe three inches, four inches in diameter. That held an additional three or four pounds of water I think, the water that's used in the heat exchanger.

We enlarged the battery but it still stayed inside the enclosure. We packed more lithium hydroxide into the canister that absorbed carbon dioxide. We used new materials and technology in the oxygen tank. We took the oxygen tank up by about 50 percent in pressure. With that they were able to do seven-hour moonwalks.

So leading up to that, I had said earlier that I didn't have too much to do with the design, virtually nothing to do with the design. I was working the operational stuff when I got down here, but I did get involved with this design change. Ironically the only trip in my 43 years that I ever made to NASA Headquarters was part of the design certification review for the J mission series or Apollo 15. I helped put together the presentation that was made to the board up there [Washington, D.C.]. I went up with Harley Stutesman, who was the NASA life support expert, and [Charles C.] Charlie Lutz, who was the NASA space suit expert, and whose son [Glenn Lutz] currently runs EVA for NASA, which is another story. So Harley made the presentation on the life support system and Charlie made the presentation on the suit.

Because I had pulled it all together, I got to go with them. I didn't actually make the presentation, but one of the things that stuck in my mind—and I can't remember everybody who

was on that board—but it's the most impressive board that I've ever been in front of. It was like Rocco [A.] Petrone. It was [Robert R.] Bob Gilruth. Wernher von Braun. In hindsight 40 years later, it's like, "Holy mackerel," all of these guys in one room. I also learned on that particular presentation—I'm trying to think of the right word—I'll say, the relativity of rank.

[James A.] Jim McDivitt was the Apollo Spacecraft Program manager. He was a former astronaut. He flew on Apollo 9, so when we would present at JSC, he was the highest level person that we would present to. It was one of the first times I was ever in the big conference room on the ninth floor, and everybody has their own microphone, and somebody else is putting the slides up [for view]. I was pretty impressed.

But when we got to Headquarters and all these presentations were being made, he [McDivitt] had a substantial presentation that he had to make as the Apollo Spacecraft Program Office manager. When he was finished, one of those guys, Petrone or von Braun or somebody said, "Okay, sit down. Next." I thought, "Oh my gosh." It was just to us he was like the highest guy we ever saw, and up there it was, "Okay next. Who's next?"

The J mission series, Apollo 15, 16, 17 had the rover. Obviously, the astronauts got much farther out from the Lunar Module. We actually designed something called a buddy secondary life support system, which was a long fancy series of words for what was an umbilical with a splitter connector. I talked about the oxygen purge system would only give us 30 minutes to get back in. It gave us the ability, we actually redesigned it so you could get less flow out of it and it would last longer.

You ran a little risk that the CO2 level might build up if you started working really hard. So we designed this thing that would enable one astronaut with a working, say a cooling system or a pump working, to unplug his water connector from his suit, plug in this big adapter with an

umbilical coming off of it, and then plug his connector back in. It basically split the water cooling to two guys. They wouldn't want to work that way, but they could ride back in and be more than 30 minutes a way riding from the Lunar Module. That was another system we never had to use. I love the fact that I can sit here and say we had this backup system and that backup system, but we never had to use them.

WRIGHT: And everything you designed had to work with space gloves.

SANZONE: Yeah, it still amazes me what the guys do, particularly in Shuttle. I say particularly in Shuttle, because in Apollo we didn't have anybody taking little tiny screws and trying to put circuit boards in and work like that. They make it look so easy. It's not.

In Building 7, we have something called a glove box. We have the ability to take somebody in shirtsleeves, ideally an astronaut who wants to try on a pair of gloves without getting in a space suit, and by sucking some of the air out of the glove box, the differential pressure across the glove is about 4.3 pounds per square inch, which is what the pressure in the suit is normally. So you can just go in shirtsleeve, put your hand through these arms and gloves [glovebox], and manipulate them.

I've taken our company presidents and visiting dignitaries to the glove box, and I warn them how hard it is to operate the gloves when they're pressurized, how challenging it is. We have little tools in there that they can play with. As much as I try to warn them, I have never taken anyone, not a single time—I have never had anyone put their hands in the gloves and not heard, "Oh my gosh, this really is challenging." You just can't really comprehend it.

As I'm telling you that story, I'm remembering that I was doing this astronaut training in the vacuum chambers. In Apollo we had three controls that were not on the remote control unit. They were in the back of the portable life support system. The astronaut had to put his hand back there to operate them. One was to turn the oxygen on. One was to regulate the temperature. The other was to turn the "feedwater" on, the water that would go to our heat exchanger. You didn't want that water on if you weren't in a vacuum, because it would just dump overboard. For multiple chamber runs I'm telling these astronauts, "Oh, just reach back." They're having a hard time getting back there. "Just reach back. Swing your shoulder back. Drop your arm down. Do this. Do that," I'd tell them. They would struggle with it.

Then one day I got in a space suit for the first time. I learned, this is so hard to get to these controls, because you've got this pressurized glove on. I was trying to teach somebody to do something I had never tried to do myself. Then when I finally did it was–if I were them and I heard from me, "Just swing your shoulder back and drop your arm down," I know how I would feel. When we got to Shuttle, all the controls were put up front. They're all in the box.

I never actually made a vacuum chamber run, but I did do at least some of the one g pressurized suit exercises.

One of the things that we had to demonstrate obviously was that we could still get out of the Lunar Module hatch. Now dimensionally we knew we could, but could somebody in a pressurized space suit do this? We had to prove it, so I was the subject. It was supposed to be really a quick exercise. Just go in. But this is one g—compared to one sixth g on the Moon when you are lying on the floor of the Lunar Module trying to back yourself out onto the porch. It was supposed to be a quick test, and we don't normally provide cooling in one g other than through an umbilical. We couldn't use an umbilical because that would destroy the test; the

mockup was in Building 5. I remember being facedown on this Lunar Module trying to back out, sweating so much that my perspiration was sloshing in the helmet in front of my face. Anyway we showed, we proved that you could get out.

I always liked doing those kinds of things, because it just, I don't know. It made you closer to the hardware. I regret that I never made a chamber run. They didn't throw those opportunities around. My boss swung it where he did one one time, but it's not going to happen in this lifetime.

WRIGHT: You talked about the buddy secondary system being one of the changes for those last three missions. Were there more that you can think of?

SANZONE: As I said, the whole life support system expendables size changed–making the battery bigger, more lithium hydroxide in the canister, the extra water tank, the redesigned oxygen tank. Those were pretty substantial changes to make in the middle of a program, now that I think about it, but they worked. They worked fine. The technology in the battery was there. They just put more cells in. Now I say, "just." There's not much *just* in the space business. Everything is more challenging. Any time you change anything you run risk, particularly if you try to make it better.

I think it was Charlie Lutz that said, "Better is the enemy of good." So it's not that you don't want to improve, but engineers will always want to improve. They'll never be satisfied with what you have. So it's important to get something that works, and then prove that it works, and then stick with it without constantly tweaking it, tweaking it, tweaking it.

WRIGHT: In your case it was heavier?

SANZONE: It was a little heavier. Well, certainly the water tank was heavier, because we put another four pounds of water in there. It wasn't substantially heavier. We did pack in some more lithium hydroxide, and we did have a little bit more oxygen in the tank, probably making it a little bit heavier, just because of its strength. Like a pound maybe, but not substantially different.

The one sixth g environment was something where nobody ever commented that this is too heavy. Because we're talking about–I'm trying to remember the weights, but the Shuttle EMU is around 275 pounds. Apollo was somewhat similar to that, maybe 250. When you start thinking about how much is the weight that they're carrying around on their back, it's 35 or 40 pounds. That's the whole system, that's the suit and the life support system. I don't ever remember any issues.

WRIGHT: Was there a concern it was adding weight to the spacecraft?

SANZONE: No. There's probably concern, but what we did we couldn't have done it and made it any lighter. It wasn't a substantial increase, because the life support systems in the space suits were already a couple hundred pounds. If we added ten pounds, it's probably not that big of a deal. I don't know. I don't think they had to do anything with the Lunar Module or anything like that. They weren't changing engines or anything like that. It was more that the Lunar Module was going to fly the lunar roving vehicle. The lunar roving vehicle itself had to go through design reviews and show that it would work. Then the suits and life support systems

were good for almost twice as long. Those were the major changes that I remember. There were probably others.

WRIGHT: Did the astronauts have an extra training aspect for getting in and out of the rover with the life support system?

SANZONE: That's a good question. As I said earlier, I didn't work on the suits until Shuttle came along and Hamilton Sundstrand was the prime contractor. I still didn't do much with the suits personally. In Apollo ILC was the suit contractor and Hamilton Standard was the life support vendor. As I remember, the first time the astronauts ever sat in a rover in a suit, their bodies dropped in the suit so their noses were—, well, they were looking out with the top of their eyes. That was one of those uh-oh moments. I remember flying over to Huntsville [Alabama]. I can't remember if this was after it was fixed or maybe the first time we saw it. I think it was probably after they had fixed it; I don't even know what changes they made to the suit, but I do remember that uh-oh moment.

The rover was developed in Huntsville [Marshall Space Flight Center]. NASA had a charter plane. There was so much travel between here and Huntsville that this charter was going back and forth all the time. I remember going over there. We did some sort of an exercise. They had a lunar rover simulator over there, too, and a trainer that was really cool. It was like the size of a wall of a lunar simulator, and then this little tiny rover with these four sensors. The astronaut would sit in a chair or something with a hand controller. In front of him would be a screen; it was really a cool toy.

This is only on the subject of going to Huntsville. John [W.] Young and [Charles M.] Charlie Duke were over there when I was there; they were the Apollo 16 lunar crew. They each had flown T-38s. They landed at the Redstone Arsenal [Alabama]. Because we were using the NASA charter, the charter was there too. While we were all getting ready to get on the charter to come back, they went down the runway in their T-38s, and right in front of us and flipped their planes over–it was like show time. I thought it was great. They were headed back to Houston. They were probably back in Houston before we were on the plane.

WRIGHT: Sounds like that made a lasting impression. You mentioned to me earlier some other iconic astronaut images including the parking lot at JSC. Share with us that illustration because it's such a good one, for those of us who didn't get to see what the parking lot looked like during this timeframe.

SANZONE: I'd give a lot of money for a photograph of it. In Apollo the whole environment was different. The times were different. Astronauts were able to inexpensively buy or lease Corvettes from a Chevy dealer in Florida by the name of Jim Rathmann who won the Indy 500 in the early '60s. Consequently, the vast majority of astronauts drove Corvettes.

My office was in Building 7. The Astronaut Office was Building 4, and the cafeteria was Building 3. In between Building 3 and Building 4 was an astronaut parking lot. We would go to lunch almost every day to the cafeteria in Building 3. We would cut through Building 4, and when we came out the door there was the parking lot. The parking lot was full of Corvettes. Looked like a Chevy dealer almost. Not everyone had one. I don't know what the distinction

was, but there were a lot of Corvettes in that parking lot. We just got so used to it. We didn't think anything about it, which is why I never took a picture of it. I wish I had.

But of all the Corvettes that were there, there were two crews that I remember, and these were the only two that I remember, that had matched sets. The Apollo 12 crew, Conrad, Bean and [Richard F.] Gordon. The cars were gold and black and specially painted. Three Corvettes. Behind where the driver sits, outside, one had the letters CDR for commander, one had LMP for Lunar Module pilot, one had CMP for Command Module pilot. It was fairly common to have the crew members who were flying together also park next to each other, so you'd have these three gold and black identical-looking cars except for the insignias on the side. Gold and black Corvettes. Alan Bean's Corvette occasionally shows up at Space Center Houston; I think it's now owned by somebody in Dallas, but I've seen it at Space Center Houston a couple times. There were three like that.

The other crew that had a matched set that I remember was the Apollo 15 crew. That was [David R.] Scott, [James B.] Irwin and [Alfred M.] Worden. The three of them had Corvettes, but they were matched differently than the Apollo 12 crew. The Apollo 12 crew had identical black and gold Corvettes. Apollo 15 crew chose to have one with a red Corvette, one with a white Corvette, and one with a blue Corvette. Then each of the three had the corresponding alternating stripes that would go across the hood, across the roof, and down the back. It was very colorful to see these three cars parked next to each other. One red, one white, one blue, with these stripes on it. I wish I had a photo of that.

WRIGHT: One of the things that we haven't talked about is how your role changed. Were you given more responsibilities and starting to move toward management?

SANZONE: I didn't really have a particular desire to be a manager. Through my whole career things just were handed to me, and then I just did them. I never plotted out my career.

Even when I mentor folks, I tell them do the best job you possibly can at the job you are doing, and people will find you; you won't be left behind. I've seen some folks try to focus on their career and take some emphasis off their daily job, and it hurts them a lot more than it helps them. So through Apollo I pretty much did the same thing. I had this small group of two or three people.

The other thing in retrospect, when you're that young you never think about anything ending. I never really thought about Apollo 17 being only two years away and what's going to happen? I'd always been so blessed in my life and still am. It was like, "It'll be all right." I didn't really think it through, "What's going to happen after Apollo?" I just didn't seem to worry that much about it. I was single. I was still in this, "Okay, I can get a job somewhere else." I think more of me just thought that I was just going to be here and won't be affected by all these layoffs. Ironically I wasn't, but that was almost miraculous in itself. Part of it was trying to do a good job in the job you're doing.

From Apollo 11 and through 12, 13, 14, I picked up a little more responsibility. I was running a group in Houston, a small group that was responsible for what we called systems engineering. I'm not even sure that's the right title, but we took care of the crew training, the vacuum chamber runs, the mission support during the missions, getting ready for the missions, making sure all the data packages were complete—anything at the system level versus the component level. When Apollo was over, we did ASTP, Apollo-Soyuz Test Project, but we

didn't fly our life support system on that mission. I helped with oxygen masks and stuff like that that weren't even manufactured by Hamilton.

Then when Skylab came around, the life support system for the suit—the extravehicular system—was not a portable system. It had an umbilical, but it was made by a competitor of ours. That point was the most likely that I'd be put out to pasture, because we didn't have a big contract anymore.

But because of the experience that I had had at the Manned Spacecraft Center, the NASA manager over us chose for several of us to stay and support Skylab even though we, Hamilton Standard, didn't make the Skylab system. So in Skylab I was involved with the ground support equipment for the space suits and portable life support systems, because Hamilton had designed and built all the ground support equipment for the Apollo program for the extravehicular activity equipment. It made sense that we could still do that, maintain that equipment, which was pretty elaborate.

Then we had a lot of experience maintaining the training equipment that the astronauts used in Apollo. So this NASA manager made the choice to ask us to take care of the training equipment for Skylab, and we did that. That kept us busy—like runs in the water tank, and all the preparation of that training equipment. Somewhat similar to what we had done before, but with another company's equipment. The other company was obviously responsible for all the flight hardware that was used, so they would test that. Then after Skylab there was more than a lull.

Contrasting it to today, I think the planning for Shuttle—I just saw this the other day. I thought it was the early '70s, but the first working group actually came together in 1969. So about the time we were landing on the Moon they were starting to plan Shuttle. Now 12 years

passed before it actually flew, but I know that [North American] Rockwell, the eventual winner [to build the Shuttle] submitted its proposal in 1972. The winning proposal in 1972.

We knew Shuttle was coming. Ultimately Hamilton Standard built about a dozen systems for the orbiter. None of this stuff I worked on personally. It was designed and manufactured in Connecticut, shipped to California, installed in the orbiters out there. So the big thing for us was the EVA system. The EVA system was put out for bid around 1976.

WRIGHT: Now if you don't mind, before we get too deep into Shuttle, I did want to ask you just a couple quick questions. One is about your effort in the MER. Did your role change through the course of the missions?

SANZONE: That was our place in Apollo, the MER. I did take a picture, and I probably have it someplace. I did take a picture of the main room in the MER in Building 45 after the Apollo 17 splashdown. It was just a room but there were all these tables. They were just gray tables, the gray government tables. It was very unconsolelike compared to today's MER where everybody's sitting at a console. I guess I had the foresight, I knew this was the end. This was the end of Apollo. I took a picture of that room with nobody in it, and just all the tables that had headsets on them. I don't think I was that nostalgic, but I knew this was the end, and in a way the photo says, this is the end.

WRIGHT: Everybody put their headsets down.

SANZONE: Yeah, they put their headsets down, and Elvis has left the auditorium. It was like that. But we knew Skylab was coming. There was always something coming. It really did feel like, this is just a phase.

Now the challenge of this phase that we're in right now is not as clear as it was back then. Shuttle was already on the drawing board. There was a fairly clear plan of what we were going to do. So through Apollo that's pretty much what I did. It didn't change much.

WRIGHT: Did you have participation in Apollo 13?

SANZONE: Yeah. I did. Apollo 13 was interesting. I had mentioned earlier that everybody was young, and there was more drinking being done then than there is now. We had landed on the Moon in Apollo 11, done that, then we'd done Apollo 12, so this was going to be the third one. It was already starting to feel a little bit routine. Those of us that worked with the EMUs, we worked the spacewalks. We didn't really work other parts of the mission. We didn't work the launch or the landing, anything like that.

I remember [the Apollo 13 problem] being on a Monday, because I was in a ski club, a snow ski club in Houston. Space City Ski Club. It was more of a social club than a ski club. They met at Sonny Look's [Restaurant], down on the South Loop. I think they met once a month on Mondays.

They had their meetings on Monday, so several of us would go down there. Everybody had a few scotch and waters. I was driving home from that meeting maybe 11 p.m. or something like that, and I turned the radio on. I didn't know anything had happened. Turned the radio on, and the first impression that I got from the news was there was a problem, they're not going to

land on the Moon, they're going to have to come back. But it didn't convey to me, or I didn't infer from what was being said how serious it was, so I just didn't have a sense that it was as serious as it ended up being.

So I get home. Of course, we have no cell phones or anything. So I got home and I got a call shortly afterwards from somebody from my office, maybe my boss. He said, "Hey. We have this problem with Apollo 13." I was like, "yeah, I know about it kind of," although I didn't know much. He said, "We're going to start working three shifts around the clock." I said, "Well, I just came from the ski club meeting, I've had a couple drinks, why don't you just put me on third shift starting tomorrow?" Or whatever it was. "Because I just don't feel right coming in right now to work." Wasn't that I was drunk or anything but I just didn't feel right. They were splitting up shifts and talking about who's going to work what shift.

I still didn't have a sense of the significance, so I went to bed. I slept. No CNN [Cable News Network], no Internet. I slept as late as I could the next day, because I knew I was going to be working this crazy shift. Maybe it was second shift, I don't know. I drove in, parked the car, still not having a sense of what was going on. I went to the MER, Building 45. I think it was a different room. It was probably a room where the environmental control and life support system guys were. If I hadn't already mentioned this, Hamilton Standard was the manufacturer of the environmental control and life support system for the Lunar Module. I didn't work on that system. Again, it was designed and manufactured in Connecticut, shipped to Grumman in Long Island, the Lunar Module manufacturer. I was far from an expert on the Lunar Module system.

But I got there; this still sticks in my mind. I went to the room. I walked in the room. The first guy I saw was a NASA engineer, guy by the name of Al Behrend. I said something like, "What's up?" His response was, "We're not sure we can get these guys back alive."

Suddenly I got it. I had no idea that it was that serious. Then it became very intense. We were trying to do as much as we could do with our portable life support systems to help the situation. Clearly they weren't going to need the portable life support systems because they weren't going to go to the Moon.

I talked earlier that the portable life support system had a canister that contained lithium hydroxide chemical to absorb carbon dioxide. Well, not so coincidentally, the Hamilton Standard-designed environmental control and life support system in the Lunar Module used the same technology, the same lithium hydroxide cartridge. It had a primary canister that was maybe a foot in diameter, maybe 15 inches. It was pretty big. Then they used what was called a secondary lithium hydroxide canister which was maybe five inches in diameter.

The secondary lithium hydroxide canister was identical to the lithium hydroxide canister that we used in the portable life support systems. One of the first things that was obvious is that—I think we had six of them; no, we were only going to do two EVAs so we probably had four of them that could be used in the Lunar Module system. But we knew that was far from enough.

I talked about we had like eight pounds of water. I think somehow we looked at how can we use this water, how can we use the PLSS as almost like a water bucket to transfer water.

We had batteries in the portable life support systems. Obviously, the Lunar Module was dying for power, so we had a little bit of power that we could use. There was a lot of engineering going on about, how do we do this? How do we take this battery from here and kludge it up so that we can tie it into something else?

I won't go through the whole Apollo 13 story. Most people are aware of that. The Command Module was built by North American and their supplier for their environmental

control and life support system was a competitor of Hamilton Standard, and was an independent design, as was the Lunar Module system. There was no attempt to make them compatible, although I think I mentioned to you that I actually know someone who turned in a chit in the early design phases to make them compatible, Richard Hergert. It was obviously disapproved.

So the command module was designed for three astronauts for about two weeks. The Lunar Module was only designed for two guys for like three days to be on the Moon. Again I won't go through the whole design thing, but the lithium hydroxide canisters in the Command Module were rectangular. Those in the Lunar Module were cylindrical. So the whole Apollo 13 thing was kludging them together with the tape and the plastic and the checklist and all that so that they could get the oxygen in the Lunar Module to recirculate through Command Module canisters.

Obviously that was successful, but I'm not sure most people even today know how close of a call that was. For years in Building 7 they had framed and on the wall in the hallway the expendable chart for oxygen and the CO2 level—what the level of carbon dioxide was inside the vehicle. It's amazing. I don't know. I seem to remember reading that they had a couple hours to spare or something like that. It was close. Those of us from Hamilton were proud of the fact that it was a Hamilton system in the Lunar Module, but because those of us in Houston didn't work on it that much it wasn't like "yeah, yeah, yeah, we did it."

I do remember being in the Control Room over in Building 30. They used to take Polaroid shots [pictures] of data screens so that they could go back and look at the Polaroid and see the data. Well, somebody from the Lunar Module side of the house—I don't know if it was somebody from Grumman or one of the NASA guys, and this was after they're safely back—but like an hour after they're safely back somebody drew this little sketch. It humanized the Lunar

Module with a big smile on its face towing this Command Module with the side of it missing, back to Earth. So it was one of those little "we're all on one team, but then well, there's an offense and a defense too" reminder. Nobody took it in a bad way. It was a fun thing.

That celebration rivaled—not so much the drinking and the partying—but the emotional part of it was very similar to Apollo 11. That's what I remember. It was like "man, did we dodge a bullet on this thing," and it brought home that it ain't easy. This stuff is not easy, despite the fact that NASA still makes it look easy. It's not easy. It's really really hard. I think that probably helped us maybe refocus or realize that it's not a given that this stuff is just going to work.

We did have a little bit of a scare. Not Apollo 13-like but on Apollo 14 which was the only Apollo launch I ever saw, and I am thrilled to say that I did get to see an Apollo launch. We were at the Cape during the early part of the mission, when the Command and Service Module mates with the Lunar Module. Shepard couldn't get it to dock. He tried once, he tried a second time.

This is one of those things that you remember where you were. I was in the parking lot of the Cape Kennedy Hilton. [Walter M.] Wally Schirra, me and two other guys that I didn't know were listening on a car radio. On the third attempt they actually got it to mate. I don't remember if anybody said it out loud, but I know how I felt, and I think the way they felt was after we'd already successfully walked on the Moon twice but then had Apollo 13, now if we can't dock, this could be the end of Apollo. It really could, because we'd already met Kennedy's vision. They docked and the rest is history. He [Shepard] got to hit his golf ball. Shepard got to hit his golf ball on the Moon.

WRIGHT: You mentioned that you went to the launch, but getting to see Apollo 14 launch was a little different for you than it was other people, wasn't it?

SANZONE: Well, yeah it was. I worked for two great guys. One was a NASA manager, Harley Stutesman, and one was my Hamilton manager Fred Keune who I've mentioned before. Harley had a NASA badge which was good for any NASA site, so no problem for him to be at the Cape. My boss [Fred] had a KSC [Kennedy Space Center] contractor badge in addition to a Houston badge, so he could get on site. I, however, did not have a KSC badge. I was down there for a meeting the day before that we had on ground support equipment.

So on the morning of the launch, I think we were probably supposed to go back to Houston. But on the morning of the launch the two of them said to me, "Well, let's go see if we can get in. Let's go see if we can go watch the launch." I said, "I don't have a badge to get in." They were like well, the most that's going to happen is they're just going to turn us around at the gate, doesn't hurt to try. We'll just see.

So we pull up to the main gate, the one closest to Cocoa Beach on the Air Force side. All I had was my KSC one-day badge from the day before. That wasn't going to work. I had a Houston badge, but I had one other badge. It was a Mission Evaluation Room badge for Houston. It had a big 14 stamped on it. Now we do everything electronically with badges, but back then every mission had its own badge.

For Apollo 11, by the way, the MER badge actually had artwork on it. Black-and-white artwork. It said "first manned lunar landing" and all that, but the other missions simply had Mission Evaluation Room and had a big number stamped on it.

So we pull up to the guard. My boss shows his KSC contractor badge. The NASA manager shows his NASA badge. I hold up my Mission Evaluation Room Houston badge with the big 14 on it. The guard looks at it, and I'm sure all he can figure out is that he doesn't know what it is but it sure looks official, and the other guys are legal. So he waved us in. I'm like, "oh my gosh, I can't believe that we're here," and "I'm not supposed to be here." So now I'm thinking I've gotten away with it.

We pull up to a second guard station. Now I'm really starting to get worried, because now I am on KSC illegally. I do not have a badge. He's going to ask, "What is this?" The same thing happens. I'm in the backseat. There are stories. I can't substantiate them, but there are stories about people that got onto KSC flashing packs of Marlboros [cigarettes].

Now we've gone through the second station. I'm like, "Oh my gosh, I can't believe I've dodged this bullet." We drive out toward the VAB [Vehicle Assembly Building]. We get, I don't know, maybe half a mile from the VAB or something. Now there are Marines in uniform carrying weapons. Now I'm thinking I'm not only going to go to jail, I'm going to get shot. Same thing happens. He waves us through. We go over and we park in the parking lot of the VAB and watched from the Launch Control complex parking lot. Watched Apollo 14 launch.

In hindsight, I would have risked going to jail. An Apollo launch was just an amazing thing. I love Shuttle launches, but they're pretty quick. I sometimes describe them like a bottle rocket. By the time you hear the sound, boy, it's starting downrange. Apollo was so slow. The thrust-to-weight ratio was so close to one that it would just like sit there. The old, "I think I can, I think I can," almost like that, to the extent that many people when they see the videos today think that it's slow motion when it's not. They just took that long to launch. Consequently you got to just soak it all in, because the sound got to you when the vehicle was much closer to the

launch pad than with the Shuttle. It was just of course incredible power with the Saturn V. Just incredible. So I'm very happy to say I got to see one Apollo launch. I'd really regret it if I didn't.

WRIGHT: Let's go back to the beginning when you first got here. One of the first things that they asked you to do when you arrived in Houston was go on a business trip to Grumman.

SANZONE: I was actually here probably maybe a month and a half. There was so much work going on in Houston that they had to triage who got assigned to what. Since everything was important but some things were more important than others, there was a lot going on this particular week, chamber runs, astronaut training, etc., etc., and one of the important things but least important of all the things that week was for somebody to go to Grumman with a portable life support system in order to do a communications check in a Lunar Module.

It was Lunar Module number four. It was the Apollo 10 Lunar Module. My boss tells me, "Okay, you need to go to Grumman. Take this life support system up there with you. They'll run this communications check." When I had been in Connecticut for a month and a half before I came down here, they did some training with me. Familiarization stuff. The life support configuration that was going to be used during the first spacewalk on Apollo 9 was a -5 configuration. It had a remote control unit, a control box on the front with all the switches, etc., etc. Because that's what was going to fly, that's what they trained me on. Took me through the schematics and how it worked, and all those kinds of things.

So I take this trip to Grumman, which was interesting unto itself, because there was a story that said nobody gets into Grumman on the first day. I think that happened to me. You

show up and say, "I'm here for this." And you hear, "No, you're not on the list. You have to call back to Houston" and all this stuff.

I got in there. They take this life support system in the shipping container out from bonded storage. Take it out to the side of the Lunar Module on the ascent stage level. It was a big shipping container. They take the cover off of it. Here's this portable life support system sitting in the box, but it was a -4 configuration, not a -5 configuration.

I didn't even know anything about configurations. But the most significant part was the -5 system had all the switches on the front to turn it on, to turn the power on, to get the communications to come on. This system had no remote control unit. It was an earlier version. All the switches were in the back. So I as the contractor's expert from Hamilton Standard, there to support the test, did not know where the on-off switch was on the life support system.

Luckily the NASA guy from Houston—his name was Ted Buras—he was from the communications side of the house. He was way more familiar with this life support system than I was, so I took about three big steps backwards and just let him do whatever he wanted with it. He took it over, and they took it inside the Lunar Module. Ran a bunch of tests. So isn't there some saying like if you can't do it, fake it or something? That was the ultimate "fake it" for me. That was my first ever business trip.

WRIGHT: Learned a lot in that trip, didn't you?

SANZONE: I did. I learned that there's a lot I don't know.

WRIGHT: Explain to me the reference to the -4 and the -5 configurations.

SANZONE: For any hardware at NASA you start with a particular part number, and as improvements are made, there's a dash number that comes after it. I can't remember what I had for breakfast this morning but I can remember the part number. It was SV706100. That was the base part number for the Apollo life support system.

The dash number that we flew on Apollo 9 was -5. The dash number we flew on Apollo 11 was -6. The dash number that we flew on Apollo 15 was -7 when we put those improvements in. The basic design is the same, but there are particular improvements that are made. So like as I said -4, all the switches were in the back. The -5 had the switches up front.

WRIGHT: Big difference.

SANZONE: Yeah. Big difference. Then when we went to the Moon in the J mission series, Apollo 15, 16, 17, it went to a seven-hour system from the four-hour system. To differentiate one system from another, although they had the same basic part number, the dash number changes. That lets you know okay, if it says -7, the -7 has the extended duration time for the Moon. Configuration control, not just in our systems, but in all systems, is really really important, so you know that if you've had a failed part and it's some design flaw and the design is changed, you want to make sure you never fly that particular part again. So they have all these configuration records. The quality assurance people will verify that a particular piece of hardware meets all these configurations so that you don't unintentionally fly something that you don't want to be flying.

WRIGHT: Good thing to know. One of the other memories you were going to share with me has to do with Apollo 9 and steak and eggs.

SANZONE: Oh yeah. Apollo 9 was the first time we ever did a spacewalk in Apollo. We did not do one on 7. We did not do one on 8. Obviously we were getting ready to do the ultimate moonwalk on Apollo 11.

But Apollo 9 was intended to demonstrate a couple things. One was it was the first time a Lunar Module was ever flown. The Lunar Module used in space was very light, not strong enough to be flown in the air around here, so they had a separate training thing that they used. But on Apollo 9 we also did a spacewalk from the Lunar Module to show that the space suit and life support system would work properly during a spacewalk, prior to the time we stepped on the Moon.

[Russell L.] Rusty Schweickart was the astronaut that did that first [Apollo] spacewalk. I don't think any of us knew much about space sickness, but I think he had some space sickness the day the EVA was planned or the day before. I remember some of our guys being a little perturbed with him because this was our day to be in the sunshine on the stage with the spotlight. There was a lot of pride and we would get to show off.

The EVA was relatively short. I don't remember how short, but it was way shorter than we had planned. Anyway we were happy that everything went well. As I remember it was like 6:00 in the morning or something when the EVA ended, so we decided to all go out to breakfast together. I think we went to some hotel or something locally. There may have been ten of us, something like that. I think my boss [Fred Keune] was the guy that may have started it, when the waitress came and said, "What would you like?" He was in a celebratory mood and said, "I'm

going to have steak and eggs." Very few of us eat steak and eggs for breakfast, but he said steak and eggs. Everybody else said, "I'm going to have steak and eggs too." For a long time and I couldn't tell you when it stopped, but for a long time thereafter following the final EVA of a mission we would all go out and have steak and eggs. We did that into Shuttle.

As I said, I don't remember when it actually stopped, but I can remember on at least one occasion at Hamilton Sundstrand in Connecticut at our headquarters where they had a [Silver] Snoopy ceremony in the older days. Not the surprise celebration, and not exactly the way it's done now. What they did was they had a reception like a luncheon in the executive dining room for the Snoopy recipients, their families, and obviously some of the company executives, and the astronaut who would be giving out the pins. That luncheon would be steak and eggs, so it's a great tradition. I don't really remember when it stopped. I'm not even sure there's anybody around other than me who even remembers the steak and eggs. But that was the tradition of steak and eggs.

WRIGHT: That's so nice, I'm glad you shared that. You were telling me too you almost had it the other morning.

SANZONE: Well, my wife and I went in to be with our friends to watch the [Space Shuttle] Atlantis landing, for the last landing. I just heard today that there were between 2,000 and 3,000 people that went in [Johnson Space Center] at 4:00 in the morning to watch the landing which occurred about 4:57. There were a lot of people, so afterwards I didn't feel like going home or whatever, so I said to my wife, "Let's go out to breakfast someplace." So we ended up picking Jimmy's [Egg] on Bay Area and Space Center [Boulevard]. When we got there there were a lot

of other NASA people that had had the same idea. We were able to get a table. I didn't know what I wanted. I ended up ordering something and I was just flipping through the menu while we were waiting. I came across that they had steak and eggs. I regret that I didn't order it. I definitely would have ordered it had I seen it before, because it would have been the ultimate, the last flight of Shuttle. But anyway it brought back great memories of steak and eggs.

WRIGHT: Well, I am going to release you for this afternoon. I appreciate all the time you gave us. When we meet again we'll talk about Shuttle. Thank you.

SANZONE: Okay, I look forward to it.

[End of interview]