NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

JAMES W. MCBARRON II
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is September 28th, 2012. We're at the NASA Johnson Space Center in Houston, Texas to talk with Jim McBarron, one of the world's foremost space suit experts. He's spent more than 40 years in his field. I am Rebecca Wright with the Johnson Space Center History Office. Again, thank you for being part of this discussion. Most importantly, we thank Mr. McBarron, Jim, for coming today to share his knowledge and his experiences, as well as reflections over these past four decades. We'd like for you to start, Jim, by sharing with us how you became interested in the aerospace field and especially in the field of space suits.

MCBARRON: Well, actually I became interested while a college student at the University of Dayton [Ohio]. I saw an article on a bulletin board in the science building at University of Dayton wanting students to work on what was called a psychology project at the time. The psychology project objective was to provide test subjects to the aeromedical laboratory at Wright-Patterson Air Force Base [Ohio] for conducting human experiments related to survival in hostile environments. So I signed up because the pay was rather good at the time, and I needed the money to stay in school. It was a part-time job at the time. In the summers it worked out to be a full-time job for me and a couple other students. I wasn't the only one.

What we did was initially we participated in tests such as human endurance. My first test was on a vibration shock table where they tried to determine the amount of vibration a person

could stand while being vibrated. Similar to what you probably would see during launch on a rocket.

Then I was exposed in a low pressure vacuum chamber where they put a suit on us—it was a partial pressure suit at the time, MA-3 suit—and took us to an equivalent of 100,000 feet at vacuum. I was exposed to a cold environment in a cold chamber. I was in a hot oven up to 350 degrees. I was in a centrifuge they had there. It got up to 10 Gs [gravity] in a Mercury couch type affair. I sat in front of a tube where they had a plume of air equivalent to 600 miles an hour which simulated the ejection of a crew member out of a fighter aircraft, testing the helmet tiedown system on a suit.

I flew on an Air Force zero-G aircraft that they had at the time, which was a propeller-driven zero-G aircraft. I participated in water immersion studies to see how long a person could stand being isolated in a water immersion facility. I participated in a dark quiet room isolation test to see how long a person can stand isolation.

Of course for all these tests we were instrumented with EKG [electrocardiogram] and thermocouples that monitored our health and performance. So I got a full range of experience of the environments that a person would be subjected to during aircraft flight in high performance aircraft as well as manned spacecraft.

During this time, I got involved with helping test different pilots that the Air Force had to familiarize them with the suits they would wear, such as for the X-15; for the U-2, although at the time we didn't know what they were for; for Captain [Joseph] Kittinger's high altitude balloon flight; and for various other aircraft uses that the Air Force had.

One of the last jobs I worked on there was to participate in an evaluation of the candidate suits for Project Mercury submitted by B. F. Goodrich, David Clark and ILC Industries. I was

originally set up to be a test subject for the suits, but I didn't fit into one of the suits at the time. So I became a data recorder for each of the tests. That was very interesting. At the end I helped prepare and assemble the final report that the Air Force prepared to give to NASA on the results of that testing.

During that time the Air Force had a project called Project Dyna-Soar. Ed [Edwin G.] Vail was the man in charge of that, and he was interested in hiring me to work on that project in support, provide the suits for Dyna-Soar. On a Friday on May 28th—I remember that date because it was my mom and dad's wedding anniversary—he offered me the job, my first career job as a GS-7 [General Schedule for pay], working for the Air Force at Wright-Pat.

Well, I was so excited, I went home that night to help celebrate my parents' wedding anniversary. While we were sitting having dinner, I got a phone call from my roommate at University of Dayton saying that I had a telegram from NASA, offering me a job with NASA, and I ought to go to the telegraph office to get it, because he had forwarded it there. My dad and I went down there and got the telegram, and they offered me a job as a GS-9, the same day, which was quite a coincidence. So I talked to my dad there at the telegraph office.

He says, "Jim, you ought to take that job. I know you're going to be away from home, but you ought to do it." Before we left the telegraph office, we provided the response back to NASA that I'd be there in two weeks. I started on June 4th, 1961.

WRIGHT: You went down to [NASA] Langley [Research Center, Hampton, Virginia].

MCBARRON: I worked in Virginia at the Space Task Group. I'm probably the 500th and some person hired by NASA at that point in time. So that's how I got my start in suits and in my

interest in environmental protection for crew members. I did it firsthand, knowing the environment. I had some episodes where my life was in danger at the time. For example, one of the tests in a low pressure chamber I was wearing a partial pressure MA-3 suit, and the faceplate blew off while I was at equivalent altitude of 100,000 feet or vacuum. Of course immediately I became unconscious. I learned the value of the protection equipment, even though it failed at that point. So I learned the value of a good pretest checkout, which was not done. That was the cause of the problem. Fortunately the guys running the chamber were able to recompress it rapidly, and the chamber was small, so it didn't take very long.

I can remember one time I was in a B-58 capsule that was used for an equivalent of an ejection seat for the pilot and copilot on a B-58. They had a capsule and they wanted to test the ventilation system upon landing, how long the ventilation system would work on a battery system that they had to remove the CO_2. What they did, the capsule leaked, and it was a clamshell capsule. It leaked quite a bit, so they gray-taped all the different segments, like there were five segments shut. Then I was inside for the test.

It didn't last very long before the battery started to fail. The CO_2 went up to the point where I became almost unconscious. They decided well, we better terminate this test. They had to peel off all this gray tape, which took quite a while. I ended up going to the local hospital there after that, but here I am. This taught me a lot about how not to run a test and how to run a test and the value of test, which I used all throughout my career.

WRIGHT: That's good. Well, hopefully as we walk through some of this you can share some of those other episodes that you were able to parlay some of that information that you gained during those early days. Mercury was under way as you mentioned. You were at Langley for a couple

years and then came to Houston, and Gemini was going. Can you tell us when you came here to Houston where the Gemini suits were and how you were involved with those as it was leading up to Gemini 4 and the first EVA [extravehicular activity]?

MCBARRON: In Mercury, I took care of the Mercury suit. When I came here to Houston, it was to become the section head for the Gemini suit development. What a lot of people don't realize is that NASA had established an advanced technology suit program towards the end of Project Mercury. We had three contracts with different contractors to develop an advanced technology, what was called a partial wear quick don suit. These were with B. F. Goodrich, Arrowhead, Incorporated, and a company called Protection, Incorporated. At about the end of Project Mercury, there was an issue about whether or not they should fly an additional MA-10 Mercury flight. We determined that the Goodrich suit was the best suit at the time, although it had been extremely modified from what was used in Mercury.

That became the G1-C suit. That was a candidate for use in Project Gemini. So that's how originally the Gemini suit was going to be a B. F. Goodrich suit that had been allocated and developed for Mercury MA-10. Well, at that point in time, there was a lot of discussion by the crew as to what type of suit they wanted to fly in Gemini. It was determined that we should go to McDonnell Douglas where they had a full-scale mockup of the Gemini two-man capsule with an ejection seat complement and displays, to do another evaluation of the suits that were available at the time.

Of course we were advocating the G1-C which was the B. F. Goodrich suit. David Clark heard about it, and they said, "Can we bring in one of our suits for evaluation?" Which we did. So there was an informal evaluation in that mockup by Gus [Virgil I.] Grissom, who was at that

time assigned to follow the suits. He determined that the David Clark suit was the most comfortable suit that met the requirements compared to the proposed MA-10 suit, which we had brought.

Based on his recommendation to the management of the Gemini Program, lo and behold, the Gemini suit became the David Clark suit. That became through evolution the G3-C, which flew on the first Gemini flight by John [W.] Young and Gus Grissom. That's how we got to be a Gemini suit for Gemini, through an evaluation of the suits again.

WRIGHT: At what point did you learn that Gemini IV had been chosen as the first mission to actually do an EVA with the suit?

MCBARRON: Well, of course I had followed the Russian program for some time at that point. I was called into a meeting by Jim [James V.] Correale, who was our branch chief—Dick [Richard S.] Johnston was in attendance, our division chief—where they announced that Larry [E.] Bell would be in charge of a special hush-hush project for NASA to develop an EVA system to fly on Gemini as soon as could be done.

Joe [H. Joseph] McMann was put in charge of what was called a chamber vent unit, which was a devious name for life support system. I was put in charge of modifications to the Gemini suit required for EVA. We had Art [Arthur H.] Hinners and his people in our test branch who was brought in to make the chamber facilities available for the testing that would be necessary.

The whole project was done not under a formal security classification, confidential, secret or what have you, but under a NASA internal need to know policy, which was done for the first

part of that project. On the Gemini suit we had to incorporate a thermal micrometeoroid garment and eye protection by adding additional visors to protect crew members' eyes from the Sun. That's how we ended up with the GT-4 system that was used by Ed [Edward H.] White.

WRIGHT: Can you share with us your personal involvement? Did you recommend some modifications for that suit?

MCBARRON: Well, an interesting story. I got married February 27th of that year. As soon as I got back from the wedding—we didn't have a honeymoon unfortunately—my boss told me that he was going to send me to David Clark to expedite the equipment for Ed White's suit and what have you. So he sent me up there for six weeks to TDY [temporary duty assignment] with my new wife—we had a honeymoon there I guess—where I was responsible to oversee the implementation of mods [modifications] to Ed White's equipment that resulted from his crew training activities and the results of testing that was being done in crew systems of the whole integrated system.

In particular I expedited the delivery of the EVA gloves that he found needed to be modified. At the time in David Clark we had a quality inspector who wouldn't let us ship the gloves out of David Clark because they didn't have released engineering, which was a requirement for flight hardware at the time. So I talked to him, and we reached a compromise. David Clark had a policy in their production that they could ship prototype hardware as long as it had an X part number in the designation of what it was called. He agreed that we could ship the gloves for evaluation at the Cape [Canaveral, Florida] by Ed White, provided the serial number carried an X part number. Well, David Clark immediately put an X part number on it and we

shipped them and that's what he flew on Gemini. So a little interesting story about how an individual can get in the middle of something and make things happen that was required.

WRIGHT: Well, soon after Gemini IV you began working more closely with the development of the Apollo suit.

MCBARRON: After Gemini IV I was put in charge of the Apollo Block I suit. While Gemini was going on, the Gemini Program, there was a contract in place for NASA to develop the Apollo suit that was implemented with Hamilton Standard and ILC Dover. That program wasn't going very well. There were a lot of technical issues identified, and schedules weren't being met. The Apollo Program Office determined that there needed to be an interim activity to provide a suit for the initial flights that weren't going to go to the Moon, and that was called Apollo Block I. Similar activity with Rockwell on the Command Module, because they were having problems too I understand. I'm not sure exactly what they were.

I was put in charge of the Apollo Block I suit program, which was to use a modified Gemini suit with David Clark that would be compatible with the Command Module made by Rockwell, which was a three-man mission. That was in progress, and the suit was being developed when NASA made the decision that they were going to stop the effort with Ham Standard being the supplier of the Apollo suit, and there would be a competition between existing suit contractors. At that time the competition was to consist of a modified Block I suit that I worked on for the Block I program and a suit supplied by Ham Standard—because they still wanted to stay in the suit business, even though they weren't going to use ILC, in fact they used B. F. Goodrich and some in-house activities to build the Ham Standard suit—and with a

suit provided by ILC, who at the time wasn't under contract with NASA anymore, but they wanted to submit a suit for the evaluation. So again there was another competition for who was going to be supplying suits for the Apollo Program.

There was a formal competition here at Johnson Space Center. The contractor suit that had the highest number of evaluation points after a whole series of different tests was the ILC suit. That suit at the time was not under contract with NASA, so I then was asked by my branch chief who at the time was Matt [Matthew I.] Radnofsky, if you recall Matt, if I would be interested in going to ILC and being the local rep [representative] while they developed the Apollo Block II suit, which it became known as.

I went home that weekend, talked to my wife about, "Can we move from Houston to Delaware and spend a couple years there?" She was very hesitant about that, but agreed finally.

The following Monday I went into work with agreement with my wife and myself that we would go do that, and lo and behold I was called into Dick Johnston's office, our division chief, and he said, "Jim, how would you like to run the Apollo suit program here at Johnson?"

I told him, "Well, Matt had wanted me to go to ILC as local rep."

He says, "No, I don't want you to do that, I want you to stay here and run the program based on your experience with Gemini, and Matt is off the program." So I accepted. That's when I became responsible for the development of the Block II Apollo suit.

At that point in time the suit program was in trouble schedulewise in terms of being ready to support a lunar mission. We immediately built 15 more suits like the evaluation suit with ILC with some modifications that we could make, and that became the A5L suit. While we were doing that, we were in process of developing what we thought would be the flight suit, the A6L ILC suit. In fact we were in chamber testing in Building 32 of that suit with Joe [Joseph P.]

Kerwin when the Apollo 1 fire occurred. That had a major impact on NASA and on us in the suit world as a small part of that. We were directed to eliminate all flammable materials that existed in the suit system that we could. Those that we couldn't we would have to justify continued use and get a formal waiver through the Apollo change board for its use.

Of course we had fabric joints made of molded rubber convolutes and nylon restraint and a helmet that was made from polycarbonate that didn't meet the nonflammable requirements that were imposed on the program. So we had to get waivers for use of these things, which required a lot of work. In fact we had to change the vent pad inside the helmet that had a urethane foam protection bump pad inside the helmet. We had to actually initially cover it with aluminum foil and then eventually made it out of aluminum. It didn't make sense, because outside of it was polycarbonate, which was flammable, but that was the rule. You eliminated every flammable material that you could.

For example the boot soles originally were made of neoprene rubber. Then Matt Radnofsky, who at that point in time was in charge of Materials Test Branch, came up with a material called carboxy-nitroso rubber that we made boot soles out of, and they didn't work very well. Then he came up with a substitute called Fluorel, and that's the material we used in the boot soles for example.

We changed the thermal micrometeoroid garment from a separate jacket and pants to an integrated coverall with nonflammable exterior layers that met the flame impingement criteria that were set up. That's where we proceeded, and that became the A7L suit that flew on Apollo 7.

WRIGHT: There were very few pieces of equipment that actually flew the entire missions during the Apollo Program, especially the lunar landing missions. Can you talk about the complexity of the system and the fact that it had so many interfaces? You have the systems that you were working on, but so many of those systems connected with the suit. You had to interface with other entities within the Apollo Program so that the suit would function the way that you had planned to. As a manager, how were you able to work all these systems together to ensure the safety and reliability that the system would work like on a mission?

MCBARRON: First we had to identify all the interfaces and the contractor or organization that was responsible for them. For example pre-launch we had to interface with a portable cooling device that the astronauts used for cooling from the time they left the suit lab, drove in the bus to the launch pad and was installed in the spacecraft. Then we had the installation in the spacecraft interfaces up at the top of the launch pad, including the couch and all the interfaces with the Command Module that was necessary, not only physical but also functional in terms of communications, ventilation, pressure drop with the ECS [environmental control system], and the ability for the crew member to operate all the displays and controls inside the Command Module.

Then there was a requirement that we had to interface with a navigation optics system that was provided by Draper Labs. They imposed an eye relief requirement on the helmet that we had to meet so that the crew member while wearing the helmet pressurized could actually look through the optics and do navigation to determine where the crew member was during transit to and from the Moon and if necessary what the correct time would be to fire the rocket motors necessary for reentry back to Earth.

Once we got through that we had to interface with the Command Module tunnel, which was a mechanism for transfer of the crew members from inside the Command Module into the Lunar Module [LM]. In the Lunar Module, we had to interface again with the life support system, but we didn't have seats in the LM. We had to stand during operation in the LM through landing, and then during the surface operation, and then during ascent off the Moon. We interfaced with a special restraint system that required special brackets on the suit, so the crew member would be restrained properly during landing and ascent off the lunar surface.

In addition we had to interface with the storage compartments in both the Command Module and the LM. For example during all this activity the extravehicular visors and extravehicular gloves and related EVA equipment were stored in separate locations. We had to identify all those different interfaces and provide storage bags if necessary for storage of things like the helmet EV [extravehicular] visor assembly, which was critical so we didn't scratch it or abrade the coatings on it.

So that was the interfaces. Notwithstanding was the interface with the astronaut himself in terms of fit to enable him to function properly and do the jobs he would be required to do. The suit was designed and certified to enable a crew member, an astronaut, both LM astronauts, to leave the lunar surface pressurized into the LM unpressurized—it couldn't be pressurized—back to the Command Module that couldn't be pressurized, all the way back to Earth pressurized for a total of 115 hours' transit time from the lunar surface back to a safe atmosphere within the Command Module prior to landing in the ocean. So that was quite an achievement. We had to interface with food systems, water systems, waste management systems, communications. Quite a chore. People don't understand all the different facets that the Apollo suit had to meet and was met successfully.

WRIGHT: Because you had how many problems with the suit on the Moon?

MCBARRON: We had no problems with the suit on the Moon. We held our breath a few times when the crew members jumped up and down or fell down. We were concerned about breaking the restraint cables that were in the suit. That, we learned during testing, was a marginal activity with human-induced loads. In fact we had to put in a secondary restraint joint design in the lower torso of the Apollo suits for the later Apollo missions because of that concern.

WRIGHT: Can you share with us where you were on the night of Apollo 11 and the thoughts of your team as you watched that first EVA?

MCBARRON: Well, the PLSS [Portable Life Support System] suit team and our leader Harley [L.] Stutesman were in an office complex. It's part of the Mission Evaluation Room that was in Mission Control [Center]. We had set up a display board of gauges for of EVA time, for run time on the battery, CO_2 levels, and even had heart rate on a video monitor from a medical place, that we monitored the suits, both Buzz [Aldrin] and Neil's [A. Armstrong]. My job was monitoring Neil's suit and life support system at the time. It was Joe McMann's job to monitor Buzz Aldrin's. Fortunately we didn't have any problems at that point. So it was very successful.

WRIGHT: After they returned, how did your team deal with lunar dust? How did it affect the suit?

MCBARRON: We suspected dust would be a problem, and that's why we designed the lunar boots the way we did with traction capability. But we didn't understand or appreciate the effect of low gravity on the Moon and by kicking up dust, how it would rise up high enough to get all over the suit.

So on later flights we actually covered all the suit connectors and made a special cover over the pressure sealing slide zipper that was on the suit for entry, and around the collar of the helmet LEVA [Lunar Extravehicular Visor Assembly], so that we'd try to mitigate the amount of dust that could get into the suit.

This coupled with the fact that the suit had to meet a longer mission endurance from the original landings, Apollo 7 to 14, because on Apollo 15 to 17, we had to extend the operational life, actual use on the lunar surface by double to 24 hours. So that was a concern.

At the end of the last mission, Apollo 17, the crew members did notice that the connectors were becoming sluggish in terms of being able to operate properly. But we were able to overcome it. They had a special lunar dust brush. They did take precautions when they reentered the Lunar Module to try and mitigate the effects of dust, not only on the suit, but on all the equipment inside and what they actually breathe in.

WRIGHT: You had mentioned earlier that the Gemini IV suit development and the whole mission was somewhat hush-hush because it was the first EVA. But of course this one, people knew that this was going to be happening as part of Apollo 11. What were the security issues that you had to deal with because the United States was in a race to the Moon as part of the Cold War effort between us and the Soviet Union? Can you share with us if the work that you were doing was

highly classified? If there was any extra measures that you had to put in place to make sure that this information was not shared outside your team?

MCBARRON: Well, my first involvement with security is I needed to have a secret clearance to fly on the Air Force zero-G aircraft. It was secret that they in fact had a capability like that, and you needed a secret clearance for that. When I started working for NASA, the suits and equipment to be used on Apollo were classified confidential, the actual hardware and all the documentation and all the drawings, which made transfer of information, transfer of the hardware, very difficult between Johnson and the Cape and the contractors. We had to have all the special paperwork. Finally they eliminated that formal security classification on Apollo.

Now for GT-4 and Gemini we didn't have a formal security classification. Although the work done within crew systems and the Center to support that activity was internal restricted information I guess is the best way to put it. There's no formal classification control. It's just need to know.

WRIGHT: Well, Apollo 17 was the last lunar landing. As that ended, NASA and the nation was moving toward its first space station with Skylab. So share with us what your team did to prepare the necessary equipment for the first space station, and also how the importance of EVAs now were going to become even more emphasized with the suit.

MCBARRON: Well, in Skylab, the method for a crew member to get from Earth to the space station was using the Apollo Command Module. So it was very natural to pick the use of the existing Apollo suit configuration, which was interfaced and certified for use with the Command

Module, to be the Skylab space suit. Now there were changes that were necessary to the suit. The first thing we did, we implemented a contract change with ILC for an integration study to define the changes necessary to interface the suit with the Skylab systems.

One of the more significant interfaces was the change in the EVA life support system, which instead of a lunar backpack that we had in Apollo was a chest pack manufactured by AiResearch, called the ALSA, Astronaut Life Support Assembly. We had to interface with that and provide proper attachments and functional interfaces as far as ventilation, oxygen supply, relief valves and so on and so forth.

In addition we had to interface with the Skylab workshop. The cooling system in that workshop used a coolant fluid that was not compatible with the liquid-cooling garment. At the time the tubing in the garment was made of Tygon. So we had to redesign the liquid-cooling garment to use a different tubing material and certify it for a very long mission—I think a 90-day mission exposure—with no degradation to provide cooling for an EVA crew member all the way through the capability of the Skylab mission. So basically it was an Apollo suit modified to meet the unique interfaces of the Skylab. The EVAs were conducted to retrieve film canisters on the exterior of the vehicle that were necessary and to set up some experiments in some cases on the workshop.

Now unplanned was the fact that when the Skylab workshop space station was launched, it lost its thermal shields. We had to do an emergency system to provide a capability for crew members to enter into the orbital workshop at the time. We developed special hardware to do that. When I say we, the suit people supported activity for a thermal shield. Either a sail was one approach that was proposed by [NASA] Marshall [Space Flight Center, Huntsville,

Alabama] to cover the outside of the workshop. Or an umbrella called a parasol, which was actually used to provide thermal protection on the outside of the orbital workshop.

The suit people got heavily involved in that. For example Marshall needed the capability to assemble their sail with Mylar-coated nylon material. They didn't have any sewing capability, so we sent an ILC team to Marshall in a NASA Gulfstream [aircraft] with ILC sewing machines to do the sewing in support of Marshall, who were building a sail.

Likewise here at Johnson, Jim [James H.] O'Kane, who was in my section, led the fabrication of the parasol shade in the building where the centrifuge was at one time. He laid out tables all over to build this great big parasol.

The suit people were indirectly involved with the recovery of the Skylab after the thermal emergency, including modifying the suit to make it as lightweight as possible so they could take all this extra material up to the workstation to do the repairs. Then during the repairs to the workshop we actually performed EVAs to deploy a stuck solar panel that was on the outside, using a hammer and pry bar and come-along and human strength with all that equipment to deploy that solar panel, which was necessary at the time. So that was what the suit contribution was to the Skylab. It was a very hectic time. I think during that period of time I worked over 100 hours in one week. My boss Charlie [Charles C.] Lutz actually never went home. They set up cots in one of the rooms in Building 7 where people could spend the night and sleep. It was really quite an involved activity.

WRIGHT: But it rescued the program.

MCBARRON: It saved Skylab, you bet.

WRIGHT: During the ’70s, although Skylab was up in operation, the beginnings of Shuttle had started with the development and the design. Tell us the first that you heard about the Space Shuttle and how you became involved in the suit design for Shuttle.

MCBARRON: There was a gap between the last ASTP [Apollo Soyuz Test Project] flight using the Apollo type suit and the beginning of Shuttle of about two years. I think from ’75 to 1977. During that time I participated in the preparation of an RFP [Request for Proposal] that would be used to procure the new system for Shuttle. However, there was a lot of questions whether or not we needed a new system. There was an advocate of people that were pushing to use the Apollo suit modified for Shuttle. Then there were people who were advocating use of a new suit for Shuttle. I was caught in between that because I think I put together 13 different cost estimates for different ways of keeping the cost minimized for a new program.

These included such things as using the Apollo backpack with a new suit, the Apollo suit with the old backpack, reuse of helmets and new designed helmet, reuse of bearings and suit hardware versus new hardware. There was all kinds of perturbations of different ways of doing that. Finally it was resolved that we would develop a new Shuttle EMU [Extravehicular Mobility Unit] with reuse of some Apollo hardware such as the helmet design and neckring and gas connectors, and wrist disconnects. We actually stripped all that hardware off the Apollo suits, except those that flew that went to the Smithsonian, and provided them as GFE [Government Furnished Equipment] to what would be the new contractor that made the Shuttle EMU. So my involvement was doing all that.

During the proposal evaluation I was in charge of evaluating the contracts, different contractors' proposals, as lead on the management evaluation team, where we evaluated the different proposals. My job was the management structure that they proposed for that job.

WRIGHT: At first there was consideration to not include EVA capability from the Shuttle. How did you and the EVA community talk with the decision makers to move this direction into the direction that it turned into?

MCBARRON: Very definitely at the onset of the Shuttle Program there was no EVA capability in the Shuttle system. Harley Stutesman was our advocate. He was my boss at the time. We got approval to award contractors study proposals to show the benefits of EVA to a system like the Shuttle. We couldn't say it was for Shuttle, but like the Shuttle.

These contractor studies went out to all the satellite manufacturers and asked them how could EVA benefit the in-flight maintenance and servicing of satellites. That was just one thing. Then looking backwards at the success of programs like Gemini and Apollo with the use of EVA combined with the satellite repair and servicing, we were able to convince Aaron Cohen at the time, he was the program manager for Shuttle, that we should have an EVA capability in the Shuttle vehicle.

At first it was a very minimal capability. Finally they agreed to put an airlock in fortunately, with the understanding that we would be self-sustaining, except for servicing things like oxygen resupply and water cooling while we were in the airlock from the vehicle. But other than that we would be self-sustained and could be removed and left out if necessary if they

wanted to have a full length payload bay without an airlock. That was the way it was finally worked out and implemented.

Fortunately we developed an EVA capability for Shuttle because it proved very valuable in many missions. It contributed to accomplishment of mission success.

WRIGHT: It certainly has. We know that there were a lot of differences between Apollo and the Shuttle Program, especially as you mentioned with the suits. But what principles and lessons learned were you able to apply in the development for the suits for this new program, ones that you had learned from Mercury and Gemini and Apollo that you were able to apply? Especially because this program had new requirements for reusability and for generic sizing. How did that all work in your design?

MCBARRON: The Shuttle Program required a reuse capability because initially it was going to fly 60 flights a year—that was the initial ground rule—over a 10-year period, 600 flights. To have custom suits like we had in Apollo and prior programs was just not economical. It just seemed ridiculous in fact. So we had to have a reusable suit system, and we wanted a system that was standard size, so you wouldn't need custom suits. So those were the two ground rules. And in writing the RFP for the Shuttle suit EMU, we put in requirements that the suit had to have a minimum of a six-year life, which meant that they couldn't use any neoprene or rubber compounds in the design like we had in Apollo to eliminate all those problems we had. They couldn't use cables and swages, which was a continuing problem in the Apollo suit. It had to have a life I believe of 100 missions for the system, which was quite a bit, and be standard size.

But we prohibited use of cables and swages and any materials that had less than a six-year shelf life. That fortunately built in the life reserve that the Shuttle system had initially that enabled it to be successful for the number of uses in the [International Space] Station Program, the ISS. It worked very well. It also prohibited the use of pressure sealing slide fastener for entry. That was a problem. We replaced those in every flight suit a minimum of three times for every Apollo flight before flight due to leakage issues and nicks in the zipper seals.

WRIGHT: There were a lot of steps in developing a new design. Could you share with us some of the elements that you specifically looked for, especially in the cases of reliability and safety? I know you just mentioned some about the leakage, but are there other facets that you wanted to make sure were in place as you developed the suit? I think too going back to what you said earlier about all the testing that you had done as a test subject when you first were a student at Wright-Pat, how you applied some of that knowledge into these development phases to ensure that your final product would meet the standards that you were looking for.

MCBARRON: I learned the value of testing and more testing to verify the adequacy of the design and the margins that you had in the system that were designed in just inherently by the approach that was taken. Testing I think was the biggest thing I learned, the value of testing, man-testing, by actually having individuals in the suit do the actual use of the suit to evaluate its life characteristics in particular. We called it life cycling. Early in the Apollo Program, ILC had built a mechanical cycle test fixture where they could put four convolutes in a mechanical rig that would flex the joints. We flexed the joints 50,000 times I think with no failure, but we put a

man in the suit, and after five hours of use, we had a failure. It showed the value that mechanical testing was not adequate in all cases for certifying the use of a suit.

WRIGHT: Is there a part of the suit or system that caused you the most difficulty in the process?

MCBARRON: I could say the thing that caused us the most difficulty was that we did not recognize the importance of man-loads in the design of the Apollo suit. As we progressed from Mercury to Gemini to Apollo, the suit was able to provide more mobility and more capability. The crew member could impose loads into the suit that were not very well understood, until we got to Apollo where we first measured the capabilities of a crew member to induce loads into the suit. That is one of the reasons why we had a lot of the cable problems in the Apollo suit, because it was not designed for the man-loads that we experienced. Even in Station we took it to the point of satellite man-loads where a crew member was stationary in a foot restraint, and he tried to grab a satellite and manipulate it. The loads that that would induce into the suit that could break the restraint system. So I think that was probably the most challenging over multiple missions, was the design of the restraint.

For example the initial Shuttle suit did not have a redundant restraint system in the suit. We had I think Bob [Robert L.] Crippen in a water tank in Building 29 at the time, and actually had the boot blow out and do a failure of a restraint connection. It was debated whether a technician failed to make the connection or it actually had failed on its own. It never was clearly in my mind defined well. So we implemented a requirement to incorporate axial restraint in all the joints of the suit at the time, which we did. We took a lesson there from what we did in

Apollo. We actually put in secondary restraint in the legs part of the suits, Apollo 15 and 17, to get by through that.

WRIGHT: Technology has advanced a lot during the years of space suit development and of course your years in your roles. So did the tools and the materials. Talk to us about how these changes helped you but also how they hindered you.

MCBARRON: Well, as we progressed in the evolution of the development of suits and EVA equipment, things got more complicated, more demanding, and more useful to the program. So the programs became more depending that they would work properly. I think the value of testing went up and the role of interface control, configuration control was increased.

WRIGHT: How much value did the people that you worked with impact the success of suit development?

MCBARRON: Well, people are indispensable. We had a dedicated corps of young engineers—way back then I was a lot younger at the time—who were interested in the success of what they were doing and of an EVA. We all knew the danger of EVA, and we wanted to minimize that, mitigate it. I was very fortunate to have some really good people work for me and to work with me, not only within NASA but also the contractors as well. I think the one common denominator amongst everybody that I espoused was respect for each other's work and accomplishments.

WRIGHT: You had a long tenure at NASA and also at ILC. Most of that is in the management sector of it. Tell us what you consider to be the most challenging aspect of that, considering that you had to deal with schedule, you had to deal with cost, you had to deal with quality of product. Do you have anything that you would like to share with us on how you were able to balance those three to get your product done?

MCBARRON: Well, I think communication was extremely important between the people working on the team internally and externally. One of the challenges I had that I didn't like—and I imagine a lot of managers didn't like—was evaluating performance of employees, rating them against each other. Some people would be rated outstanding, and others would be rated successful, and there wasn't much difference between the performance of the people. So to pick some people over other people was really a challenge for me. I think it may be for a lot of managers still today.

I was fortunate enough to have some outstanding people working for me, like Glenn Lutz for example, who went on to where you know he is, and others as well. To constantly give them a rating that was better than other people who worked just as hard, were just as successful with the jobs they were given, was a real challenge for me personally.

WRIGHT: You had a pretty successful career and had gained already notoriety in the late '70s when you decided to enroll in a master's program at UHCL [University of Houston-Clear Lake]. Why did you decide at that point in your career to enter a program for an MBA [Master's in Business Administration]?

MCBARRON: Well, actually I started my formal education as part of a JSC management development program that was run by the University of Houston-Downtown that provided 12 hours of credit for four four-hour courses. At the end of that I recognized how much I had learned and the value of that in management systems to my job. My job was not only the technical performance of the hardware but managing the contract, putting together budgets, evaluating cost proposals, negotiations, evaluating schedules, things that you normally wouldn't know anything about except by experience. I recognized my shortcomings, so I went ahead and got my master's degree. My objective was not necessarily to get a master's degree as much as it was to get experience in accounting, economics, managerial systems, systems management. That eventually resulted in a promotion that I got after I completed it.

WRIGHT: Earlier in your life here, even back during the Mercury Program, you had created a system to classify controlled and uncontrolled hardware, even in your early career. Why did you decide to make that system, and how did that system change over the years?

MCBARRON: You're all familiar with the classification of hardware. Class I, II, III and IIIA. I established that classification way back during Project Mercury. The Mercury suits were stowed, maintained and tested for Mercury at the Cape in the astronaut crew quarters. The astronauts did not want quality inspectors in their facility at all, which meant that Quality could not inspect the suits we had.

So there was this initial problem during Mercury where inspection wasn't allowed on the suits, until we got to Gemini. The Gemini inspectors said, "We've got to have inspection." They had a much more formal organization at that time of quality, so we established a

compromise. They wanted everything inspected the same. That didn't make sense. It seemed like a waste of money to have training hardware that would never fly controlled to the level or degree that you would a piece of flight hardware that you were actually going to fly.

So we established a classification difference between Class I flight and class that was uncontrolled for nonflight hardware. During that discussion it was pointed out that there was training hardware that would be subjected to hazardous use but would never fly. That's what established the Class II configuration of hardware. So we had Class I of flight, Class II of flight-like but not flyable, but capable of use in a hazardous environment, like an altitude chamber, and Class III, which would be like used in a water tank or on a rock pile or in a lab. Then later on in Shuttle with the advent of the deep large water tank, it became obvious that that was a hazardous environment, but not to the degree of flight, so we created Class IIIW. The W stood for WETF [Weightless Environment Test Facility] at the time. So that's how we got the classification of hardware that I think was used throughout the manned spaceflight program now. Give me a credit for that. That's one thing that was throughout the program.

WRIGHT: It's a longstanding program still in place. Well, if it's okay with you, I'm going to ask to see if anybody has any questions before we close.

MCBARRON: Sure, go ahead. Anybody?

UNIDENTIFIED: You mentioned that in your early career as a test subject you went through some anomalies and some close calls. What close calls if you could say happened in the NASA development of suits?

MCBARRON: I think there was an incident when Jim [James C.] LeBlanc was in an altitude chamber when a hose connector disconnected from a chamber ECS [Environmental Control System].

Close calls at NASA that I was aware of, I think I wouldn't really call it a close call but Bob Crippen lost suit pressure in a water tank. I can't think of any other. Well, we did have a test subject in our lab was buttoned up in a suit, and he got hypoxia from breathing hard because he was confined in a small place, small volume, and it was an anxious time. We had to actually physically remove him from the suit. I won't mention his name but we all know who he is. It was not an astronaut, it was a test subject. I can't think of any others unless anybody else might know of one.

UNIDENTIFIED: [Was there an incident where] they ripped a suit coming back in or going back to the back on orbit?

MCBARRON: I don't recall that. They might have ripped the outside cover layer, but I wouldn't call that a close call. That was in Gemini I believe.

UNIDENTIFIED: There was the Apollo 1 fire, but that's not really a suit thing.

MCBARRON: Yeah, the suits were part of the fire in Apollo 1 but they didn't cause the fire. They didn't provide protection either. I think those were the close calls that I can remember.

WRIGHT: Other questions?

UNIDENTIFIED: Jim, I wanted to see if you could share some information about the legacy of the CO_2 removal systems in the life support when the suits were developed. Some of the thoughts that were going into why we chose certain things to go into the portable life support system, particularly if you remember anything associated with the CO_2 removal systems.

MCBARRON: CO_2 removal? I think the technology that existed at the time for CO_2 removal was lithium hydroxide [LiOH]. That was pretty prevalent throughout industry. It was used successfully in submarines before they went to an electrolysis system. I think it was just in the early part of the program that was the experienced technology that people were familiar with and had confidence in. I didn't work life support that heavily. I won't call myself an expert in that field in other words, but the use of lithium hydroxide in the Apollo system required the use of a special grade of lithium hydroxide that provided the life capability of the cartridge that we used in the Apollo PLSS. There was a lot of work and involvement to establish the criteria for acceptance of drums of LiOH that came from the contractor that made it before it was used not only in the suit ECS but also in the Command Module and the LM. Pretty much used all the same life support system specifications for lithium hydroxide.

UNIDENTIFIED: Could you comment on the contrast between the US suits and Russian suits? Maybe even Chinese suits?

MCBARRON: I'm not too familiar with the Chinese suits except that I've tried to follow it as best I can. I know they are using the design practices from Russia by Zvezda in their suit system. One of my hobbies was collecting and trying to understand Soviet and then Russian suit and life support equipment that goes back to 1958 when I worked for the Air Force when I collected information from Pravda newspapers, defense intelligence documents that were unclassified at the time. I established quite a file system that became recognized by the intelligence community at NASA Headquarters [Washington, DC]. So we communicated quite a bit on that.

I gave several briefings to the senior staff on the Soviet status before we became partners with them on their systems and capabilities, the original Orlan suit and what have you. Through my participation in international conferences I met a German, Ingemar Skoog. I don't know if you know him, but he introduced me to Guy Severin who was in charge of Zvezda at the time. We had several meetings and we ended up jointly coauthoring a chapter in a book between NASA and the Russians. So I got to know the Russians very well. I actually got an opportunity to go to Moscow as part of an airlock evaluation team and met with the Zvezda people before there was a joint activity to provide the suits for the Station. We had a lot of discussions.

Their practices were very similar to ours. There were some differences. They tried to do things that we tried to do with redundant pressure bladders that were not successful. We had very similar materials that we used, although different supply, they had their own supply and we had our own suppliers. But I have quite a collection of history of Soviet suits.

UNIDENTIFIED: What about the rear entry approach?

MCBARRON: They evaluated the rear entry approach, and they didn't have a good supplier for the pressure sealing zipper or slide fastener that existed at the time, which was from B. F. Goodrich. What they didn't know is that during Mercury when we had problems with the pressure sealing slide fastener that they also had, they bought 50. I know for a fact talking to the B. F. Goodrich people, they bought 50 of them for evaluation during their suit program. They didn't work very well because they had leakage problems. But the zipper closures that we bought from B. F. Goodrich were specially made in special controls. It was a proprietary process they had at the time.

When they sold closures to the Russians it was their commercial version and not their NASA version. They didn't know that at the time. That's why we were successful in using them somewhat. We prohibited their use for Shuttle because of the problems of having the lips nicked and causing leakage problems. So that's what drove them to the configuration they had of rear entry closure, was some way not to have a pressure sealing slide fastener.

I talked with Guy Severin about that several times. They didn't know that we had a special process at that time. Of course by then it didn't make any difference because we were going to a bottom entry with no pressure sealing slide fastener that we have on Shuttle. Any other questions?

UNIDENTIFIED: I heard that when we put Ed White, I guess this is the first EVA, it was actually almost a mini space race. Would Russia or US would get in a suit first. Anyway I think the decision for NASA to go on that mission was a last-minute kind of thing.

MCBARRON: I wasn't involved in any of the politics of that. I knew they were working on it. NASA knew they were working on doing a space walk. I'm sure at the higher levels there was concern about who would be first. But you've got to recognize we were so busy just doing what we were doing to fly the first flight when we did and developing the suit when we did that that wasn't a factor in our work really. Not until we were told, "You've got a new job. We're going to make this and we're going to do it quick and we're going to keep it restricted info," did it become apparent to us that we were in a contest. But the contest was over. They'd already done their space walk with [Alexey] Leonov. So at the working level I don't think it was much of a factor. I'm sure the managers were concerned about it because it didn't look good to the world, I don't think.

UNIDENTIFIED: But the call to do it on that particular flight. Were we positioned either not to do it or to do it and then there was a go?

MCBARRON: I wasn't privy to those conversations. I'm sorry. I was just a working level section head at the time.

WRIGHT: Busy working section head.

MCBARRON: Oh yeah, very busy. I was balancing the contractor's work and our internal work and budgets and schedule and performance management of the people, all that stuff.

WRIGHT: A lot going on those years of Gemini.

MCBARRON: Yeah, and raising a family at the same time.

WRIGHT: Well, if we don't have any other questions—there's one.

UNIDENTIFIED: I understand that you've done numerous presentations and given numerous interviews sharing the information about the suit with the public. You even met with the queen of England during her first visit here at JSC. What kind of impact do you think it would make today, sharing this information with people outside the space industry?

MCBARRON: The impact. Well, the impact today is probably not as big as it was back then, because space was the in thing then. I think now people take it for granted, and have lost interest somewhat in it. I was privileged to give talks to grade schools, high schools, people at JSC. I even participated in a briefing to 25 Chinese specialists that were brought over that wanted to know how we did space suits back when. You asked about the Chinese suit. They had a study group back during early Shuttle.

I was fortunate to be able to brief the queen of England and her husband and the ladies-in-waiting. Over in Building 9 we had a glove box set up. When I was introduced to her, I was one of the few people that she offered her hand, wanted to grab my hand and congratulate me on the job we did. I was surprised, because you don't offer her your hand first. You wait till the queen puts her hand out to meet you.

I offered for her to try her hand in the glove box that we had there to get the feel of space in the glove in a vacuum chamber. She said no, but she told her husband to do it, which he did,

and then the ladies-in-waiting. It was funny at the time. Not funny but interesting that I told them they couldn't wear rings or any jewelry to put their hand in the glove box. So the ladies-in-waiting would come up and take all these fancy expensive jeweled rings and put them in my hand for me to hold them while they put their hand in the glove box, almost half a dozen of them. Then let them come back and pick out, "This one's mine, this one's mine." What kind of trouble I could have gotten into. They were really some kind of rings. So that was an interesting part of that. That was really probably the most significant—although I gave a briefing to the president of Romania at one time that was here visiting us, and to the science adviser to the president of France. I attended a meeting at NASA Headquarters where I met the science adviser to the king of Thailand. He invited me to come to Thailand, and that was interesting. So I've had a lot of interesting briefings to people.

WRIGHT: Including today. So we certainly thank you for giving us a preview of what you'll be saying in the future when you come back and talk to them in more detail.

MCBARRON: A lot of the technical things I tried to shy away from today, because I'm going to give a briefing on each of the programs over the next couple months. I'll get into technical details and schedule details of each suit program. Not life support, but suits.

WRIGHT: I think we'll end on that.

[End of interview]