NASA MSFC Oral History Interview
Steve Johnson Interviews – Apollo/Saturn Program

Jack Stokes
Interviewed by Steve Johnson
Huntsville, Alabama – Unknown, Circa 2012

Steve Johnson: I am talking to Jack Stokes, a human factors engineer at Marshall Space Flight Center from 1967 to 2005. Jack, talk a little bit about your education and how that prepared you for your work.

Jack Stokes: I knew I wanted to be involved in the space program from the sixth grade. It evolved into looking to try to get involved with the astronauts and work with the astronauts by the time I got to college. I went to North Carolina State University. They did not have a human factors degree, so I got a degree in psychology with a minor in aeronautical engineering and did some masters. I was short one course when NASA [National Aeronautics and Space Administration] called and asked if I would like to come to work. I said yes. I took off and came to Huntsville [Alabama], and I never quite finished the masters.

Johnson: Were you attracted to the space program, or was coming to Huntsville and NASA just getting a job?

Stokes: I was attracted to the space program because I was heavily interested in aircraft and rockets, space travel, as a child. That is really all I had an interest in doing all my childhood, being involved in either airplanes or space. I have always worn very thick glasses, so I knew I would not be a pilot. I thought I could possibly be involved as an engineer.

Johnson: Talk about the work you did at Marshall starting in the early days. When you joined would have been during the Saturn V years. Talk about what you did as a human factors engineer.

Stokes: I must say I fell into probably one of the best jobs that a person could ever ask for who had an interest as I have. If you will recall the time, the astronauts had moved from Langley [Research Center] to Houston [Texas] to Mr. [Lyndon Baines] Johnson's place down there, which became the Johnson Space Center. They were forming up. Dr. [Wernher] von Braun was at Marshall. He had an interest in human spaceflight, of course, and he had pushed to have a human factors group at Marshall. He had established that with Hayden Grubbs. That was in 1965, 1966. That group was in place when I got a call asking me to come down and interview. I came from Raleigh, North Carolina to the Marshall Space Flight Center. I had one short interview with the man

who was in charge of the human factors group at that time, Stanley Johns, and signed up right then. It was exactly what I was looking for and I could not believe it.

The good thing about being at Marshall versus down at Houston was Marshall had a single group that was interested in human factors. Johnson Space Center had a whole center that was interested in human factors and flight ops [Operations]. As a result, theirs was very differentiated and compartmentalized. At Marshall, you got to do the whole thing. Marshall, at the same time, was developing the desire to do systems engineering. You may have heard this term before, systems engineering, systems integration. Human factors at Marshall fell underneath that umbrella. It was a discipline that was a manned systems discipline. It was an engineering discipline that fell in engineering, not in ops. That was significant. I did not really appreciate that until later.

Johnson: During the Saturn years, what were you specifically doing?

Stokes: I came down with the purpose of being a couple of things. One was become one of NASA's test subjects, which was a role of trying to work the human and equipment interfaces prior to the crew having to do it. It was too expensive to ask the crew to do a lot of conceptual stuff. They were very busy at that time with Apollo and were not looking too much further away. They wanted some grunts to be equivalent to the crew

as far as physiological parameters. Several of us in that organization were tasked to do that. I walked into a world where I got a chance to go on a zero g [Gravity] airplane. I had a chance to learn scuba and be involved in that for simulation purposes under water.

The challenges I had at that time were trying to understand a world I did not know anything about, which was NASA, learning a whole new technological thinking process, and a whole set of language. Once I got a feel for that, things became a little easier. The task they gave me was to start writing crew procedures for Skylab, which at the time was called Apollo Applications Program. The Apollo Applications Program was a von Braun idea to use a continuation of the Saturn vehicle in another way. That was his vision of the first space station that the U.S. [United States] would have. By taking an existing third stage of a Saturn V rocket and using some equipment that came from Gemini, the hatch and some of the other stuff to create an airlock, and then creating some additional equipment, he was able to create a space station that could be launched in one launch, which is pretty remarkable.

The interesting thing in the beginning was learning to think in terms of microgravity, zero g. In those days from my world, I had not learned to think in terms of zero g. It was a learning experience. Everybody thought they knew the answer and all we had to

do was go out and do things. Then we found out by flying in the zero g plane and working under water in the Neutral Buoyancy Tank that things were not that easy and you had to really plan for motions you were doing, what you were doing with a piece of equipment, and how you and a piece of equipment were going to interface and who would win. Often, if you put a ratchet wrench on a bolt on a piece of equipment in zero g and turn the ratchet wrench, you turned and the piece of equipment stayed still. That was interesting. Also, you could in fact work backwards. You could lean all the way over and work back behind you. That could be part of the work station, which was an interesting approach.

Johnson: Did you come up with any new tools or materials? It sounds like you came up with more new processes and new ways of thinking about things. Would that be a more accurate question?

Stokes: That is true, but we did develop tools, especially in EVA, extravehicular activity, going outside into space. With the EVA world, that community had to not only deal with the microgravity environment, but also had to deal with the fat suit, a suit that was very difficult to work in, a suit that was in fact a balloon, including the gloves, which ballooned to some degree and were very thick. Your dexterity and your manual interfaces were compromised. On top of that, vision was compromised because of the

helmet design in the type of suit that we had in those days. If a suit did not fit well, you would end up working very hard and not get much done because of trying to bend the arms or bend the legs. We had to learn to design our work sites for the spacecraft with what was known as the null body position, which is a semi guerilla-type posture where the eyes are pointed slightly down and the back arches and the legs are slightly bent. The arms slightly bend somewhat as well. It is an ape-type position. Our work sites had to be designed to accommodate that. We found sitting would not work in that world.

We found on Skylab, for example, when we were working at the Apollo Telescope Mount work station, a control display work station, we started out with a chair that sat on a piece of grid that sat in front of a panel. The astronaut would come in, strap down on this chair, and sit and operate the panel. They used the seat one time and then put it away. From then on, they just stood to operate it because it was much more comfortable, less cramping. The body cramps. If you bend forward in space, which is quite easy for us to do on the ground, and try to stay in that position for very long, your stomach muscles cramp. You have to let the body find its natural position for a microgravity environment. That is how you design your work station.

Johnson: It strikes me as a human factors engineer, you are pushing the envelope a little bit of what you do, that human factors engineers before you were not trying to figure

out the best posture to work in space. Did you know you were doing cutting-edge work?

Stokes: Yes [Laughs], and that was by design. I was very fortunate to work for a gentleman by the name of [James Robert] J.R. Thompson. He had an approach to life that was very interesting. He wanted to get the job done and he very much had an engineering approach. As a result when ran into these design challenges, we were sent off in the zero g plane, sent under water, or built mockups at work to try to figure out what the limits of a human were. As a result, we created requirements and constraints that we laid on the program. There was a human factors requirement set that I was quite involved in. I can talk more about it later. By going on the air plane and trying these things out in the microgravity part of the parabola, we learned that a human can input a great amount of weight in the structure. The structure has to be designed to take, for example, 185 pounds of load striking it. That meant heavier paneling on the closeout panels of pieces of equipment or structure within the space craft. You did not want to be denting these things, you did not want to hurt the wall, so we had to worry about things of that nature.

We had to worry about lighting. In microgravity, in space, you lose your sense of up and down, so you have to create that artificially. We learned that from flying. That was

reflected in the space stations where we had lighting above and air flow above coming down and the return ducts were at the bottom at the feet level. The panels all looked the same, but it would create an artificial up and down appearance. Those types of requirements we had to deal with and come up with numbers that were limiting numbers. You could not do this. You could work up to a certain point, stop, and then your design, if you continued in your design and let the person beyond that, then you were now putting the program at risk, at least that piece of it. It was all about safety, risk control, and performance. We wanted the human to be very efficient in performance because it was so expensive to put a human in space.

Johnson: Am I correct that one of the hard jobs you had was coming up with the right questions to ask? What is the best way to stand? What is the best way to hold a tool? You guys were basically starting at the bottom on every one of these things.

Stokes: Right. You will not find it in the records, but Marshall Space Flight Center was very much involved in the early days of defining those. The questions arose any time the astronaut crew was invited to come and look at our one g mockups, which we had at Marshall, and play with them. They would ask questions that would lead to other, more detailed questions. That is why human factors engineering is an type of systems integration. It requires all the disciplines to work together. We would tell the

mechanical engineer we want this. We would tell the electrical engineer we would like the guy to be able to do this with your power. They would come back and say you cannot do that, so we would look for a middle ground, compromise designs where the crew could still perform but it would not be so costly that the mission would go away.

Johnson: Would I be correct in saying many of the things astronauts do now when they are working on the International Space Station, or in any future work, will be an outgrowth of the work you initially did at Marshall?

Stokes: Yes. That is a good question because Marshall was the first of the centers to have a human factors requirements document. It was MSFC-STD-267A [Marshall Standard 267A] and it was in existence when I came to NASA. It was basically a copy of some work that the Air Force had done and the Navy had done, and was also a spinoff of something the military, the TRI-services was suing. It was MIL-STD-1472 [Military Standard 1472]. Marshall had gathered requirements together and put them together in a package. That is what we went into Skylab with. The Skylab design was done against that document. Coming out of Skylab, after it was over with, one of the products was now we had three missions of twenty-eight days, fifty-six days, and eighty-four days of experience.

Outside and inside, we rewrote those requirements and we put out MSFC-STD-512. I was fortunate enough to be heavily involved in that. Then we did a second version of that, an update to it, MSFC-STD-512A. These documents defined what the human could do, what the restrictions on the human were, what the restrictions on the design was so the human could operate something. For example, we defined colors. We defined connector layouts such that a person in a gloved hand could make a connection. If it was too tight, he could not get his fingers in the break and make a connection. Likewise with doors, labels, we had to think about how the labels help you define the up and down. We did not want them haphazard. We wanted them to be in a position so when you looked at it, you thought the label is such that my feet should be down on the ground for me to read it. This must be up. We had to think along those lines.

The loads that we found in trying to twist a handle, for example, in space were different from on the ground. We had restrictions on those that were greater than what you might find in somebody on the ground. We ended up with a set of requirements that Marshall put out on the table as a product from the end of Skylab that was then used when we went through the world of looking at large space structures. We actually used that as a resource, not as a baseline document, as we went into the Space Station Program. MSFC-STD-512 is the base document for what became NASA's human factors requirements document, which was NASA-STD-3000. I was fortunate enough to be

involved in that as one of the co-leads. That document has recently been superseded by NASA-STD-3001, but that was after I left NASA.

Johnson: Talk about the pace of work. When you were working on all of this, how fast did things have to be accomplished?

Stokes: It is better when you are first starting out and you are doing conceptual work. Once the engineering world gets involved and you start making decisions about when things have to be delivered, then things get very hectic. It turns out that most basic engineers in the space program, the classical people, such as mechanical engineering and electrical engineering, dynamics, propulsion, they got there first. Human factors came in later and human factors was, many times, not taken very seriously. That was the one that if you had to save money, let us trim what the guys can do from this Cadillac version you are asking for, Mr. Human Factors Engineer. When the time comes and something breaks, we will try to fix it real-time. That was a battle we had.

To answer your question, it started out easy, a nice pace where we could really think things through. We could really sit around and talk about the possibility of doing things. As the design became more firm, that luxury went away and we were stuck with staying with the design if we could. The risk factors started coming with cost and

schedule impacts, so things were always hectic in the very end. That was culminated with Skylab at its launch.

Johnson: How about work hours and shifts? Did you work any odd hours or extra-long shifts?

Stokes: Sure, six and seven days a week throughout that time period. We travelled a lot. We were down at Houston a lot, down at the Cape [Canaveral, Florida], out at Martin Marietta in Denver [Colorado] and out at Huntington Beach [California] at McDonnell Douglas, and even up in St. Louis [Missouri] at Grumman, Washington, D.C. [District of Columbia]. Yes, we travelled a great deal. Your travel time was off hours, and the tests you were involved in would often last a long time into the evening. That was to be expected. It was a very intense time from Critical Design Review on.

Johnson: How about the work environment? In your group or your area, was it a great environment, cannot wait to go to work? Was it tough? How would you describe it?

Stokes: I enjoyed going to work every day. I was fortunate in being placed into a group that had good management skills, had a mission, had good relationships with our counterparts at various centers, at Houston and out at Ames [Research Center], at

Langley. It was a heck of a lot of fun to work with really smart people who also had a mission, were working a mission, had a focused mission. There were times when it would get intense and personalities would clash, but that would pass. It was a lot of fun. It was a great place to be.

I mentioned J.R. Thompson, and he was a man who was trained in propulsion. He had gone away to Auburn [University] for a Ph.D. [Doctor of Philosophy] degree. He came back and they did not know what to do with him. They had to do something with him because he was at a first level management position, so they made him the human factors branch chief, which is about as far away as you could ever ask of a propulsion person. That was education for him to work with people who were worried about their flight crew and education for us to work with somebody who did not care about the flight crew. We came to a melding of understandings and appreciations through the years. J.R. was the only guy in the world I knew as a branch chief that could pick up his phone and call the head of the Johnson Space Center at his leisure. He was the only person I have ever heard of who went from being a branch chief to a program manager in one step.

Johnson: How were you able to control costs? Was that a factor in what you did?

Stokes: Costs were always there.

Johnson: How were you able to control them?

Stokes: The way we addressed that was risk was a problem. Risk would create costs, but risk also could create hazards. In the engineering world, we were the proponents for the human piece of the story. We would always start out with a Cadillac approach. We needed a particular design to have all these features and backup features that the astronauts were going to need to do the job. Then the world of costs would arrive about late PDR or CDR, Preliminary Design Review and Critical Design Review. The managers would start pushing back and we would start giving away a little bit at a time. We had already decided what the minimum was that we could not turn away. We would hopefully not reach that point, but if we did , then there was usually a battle royal with some other discipline. We always had the ace in the hole because we could call the crew in if we needed to. We did not like to do that. We liked to try to do it from a systems engineering design approach. The flight crew was always a big club that you could use, but it was not one that you wanted to use.

Johnson: My assumption is during your work dead ends happened a lot where you thought something might work, and when you did it, that was not quite the right

approach. How did you recover from any dead ends you may have gone down in your work to figure out what exactly astronauts could do?

Stokes: When we reached a dead end, what we effectively did was establish a limit. That limit would then be converted to a requirement. Now we had a constraint that we could put into our requirement set. We found out you could not do that, but you can do it up to a certain point. We drew the line at that certain point and wrote the requirement. Good always came from it, we were always able. If the question had come up, for example, as I was a test subject for the Lunar Rover early on, we found the way the contract had laid out the controls that the driver of the Lunar Rover needed to see, which were these little tachometers for the electric motors, they had placed them in a place where, when you put a pressure suit glove on and operated the control, you totally covered up the tachs [Tachometers]. We were forever bringing up the little electric motors on the wheels. That was a lesson learned. We learned that we had to reposition those types of gauges such that the hand could not get in the way. You are now working with a much heavier volume when your hand is covered up with a mitt that has an outside cover on it for a space suit. That is an example, but a requirement with a constraint would come out of that.

Johnson: Name a surprise, something you thought might work one way and it would just not work that way?

Stokes: I think the thing that was most interesting to me was the fact that the body turns, if you are not restrained by your feet, if you are just holding on with a hand and you try to twist a fastener, that you will spin your body versus the fastener. The fastener has more hold down torque than you can overcome. The other thing that I found to be interesting was how much load a human can put into a structure when they fall against it. We found out that in a pressure suit, you had to design to 285 pounds of linear impact force at one foot, we ended up with one foot, to protect the equipment behind that.

Something that was interesting in Skylab, we never had a serious injury that we knew about, until later, except for the air drying out. We had moisture in the air, but there was some drying out because of lack of humidity. Otherwise, the only thing I think we ever had on there was [Charles C.] Pete Conrad managed to dislocate a finger when he was doing his gyrations up in the upper dome of the Skylab and managed to catch his finger between two of the storage compartments. At the time he had been running around the ring, he was going to do a forward loop, threw his hands down, and caught one of his fingers. [Joseph] Joe Kerwin had to put it back in the socket. As far as I know,

injuries did not happen because when you fell into a panel, the energy transfer was in reactive force. There was very little transfer of energy across the panel, into the panel, even though we had a design for that. The body would immediately go back in reactive motion, so the body did not get bruised like we thought it would. That was interesting.

Other surprises. This is a tough question. (Laughs)

Johnson: You have given a good example. I have to believe that these things popped up all the time working in an environment that nobody had ever worked in before.

Stokes: I stop and think about the bathroom. Everybody likes to talk about the bathroom. That was the first successful toilet we ever had and probably was the most successful toilet that has ever been built for space in the Skylab. But, it was possible to blow yourself right off the seat, so we did have a seatbelt. That was a learning experience that we needed that. There were some interesting stories about that, which I probably do not need to go into here. (Both Laugh)

Sleep compartments, we had sleep bags on Skylab, each person had their own private sleep compartment. We found out through flying on the KC-135 and also on some closed environment tests that the air had to flow down across the body from the top.

Otherwise, it would blow up a person's nose and that would tend to keep them awake. Another thing we found on some of the crew when we were doing the bunk design was we had certain crew members who, as they were drifting off to sleep, had a feeling in space that they were falling. We had found this from Apollo. They would jerk, it is a reactive force, involuntary reaction. They would jerk and wake themselves back up. Sleep became tough for those people. The Skylab sleep compartment had a lightweight netting that was available for those crew members who wanted to use it to put across their forehead. It forced their head back against the little pillow that was there. That was just enough pressure to make the person be able to sleep. We learned that, but we had to do it through testing.

Johnson: You have already alluded to this when you said you worked with other centers. Were there differences between Marshall and the other centers? Were there any rivalries?

Stokes: Of course there were rivalries. NASA is known for its rivalries (Laughs), especially in that world. Think about it, Johnson Space Center, who basically owned the astronauts, really did not want anybody else in that game. They really wanted to be the ones that oversaw what was going on. In the meantime, Dr. von Braun believed he could put together a vehicle that would handle anything the humans needed and he

wanted to make sure you could do that. He pulled together a very crack group of human factor designers, physiologists, and other specialists in this group that looked at that human factors design. The rivalries really were not too bad during Apollo because we were doing engines and booster. When we got to Skylab, that began. There was some rivalry there, but we all worked together, I feel, quite well. We worked together on the Lunar Rover quite well. Some of my very closest and dearest friends, we worked together on Skylab.

Coming out of Skylab when we started looking for more work and the Apollo Program was going away, each center had its own interest. There was interest after Dr. von Braun left Marshall to maintain a human design presence because we felt like we needed to understand that piece of it in order to design the vehicles we were planning on designing. Of interest when we got to Space Station, back in 1984, it was a Marshall person who had the responsibility of design activity that was called skunk works. It was held at Johnson Space Center, but a Marshall man was in charge. A bunch of us were sent down there and I was one of them. I worked with my counterpart at JSC [Johnson Space Center]. We got through that part, through the skunk works design, and came out with a design that worked pretty well. It was going to require a lot more scrubbing, but it would have worked.

Then the politics really took off between the centers. As a result of that, it cost the problem a heck of a lot of money with posturing and jockeying. In those days, there was not just Marshall and JSC, but it was also Langley, Goddard [Space Center], and Lewis [Research Center; now Glenn Research Center], Lewis at the time. Everybody was trying to get in on that game. That was the big game. The human factors part of that story was really interesting because Marshall had the capability of overseeing and being the umbrella for all the crew activities, inside and outside, EVA and IVA [Intravehicular Activity]. That gave us a slightly different way of looking at it. If you went to JSC, there was no one organization that oversaw all these disciplines that came together that we at Marshall would say was equivalent to human factors engineering.

Down there you had the flight ops world. That is a different world. That is basically where the crew lives. The crew is supported by a group of people on consoles, so they take what the engineers come up with and they use it. You have that faction also at Johnson. You have the faction of the flight ops world and then you have your engineers. There is a competition between them at Johnson Space Center. We were getting pulled to help one or the other from Marshall. Weird. (Both Laugh)

Johnson: Talk about Dr. von Braun's involvement in what you did and what you were doing. Was he involved? Did he visit a lot? Did he ask a lot of questions?

Stokes: Yes, he was a very special person. I did not understand until later what a special person he was. I always thought all center directors must be like him. He was fun to be around. He liked to visit our group because we were doing stuff the astronauts would be involved in. When the astronauts came to Huntsville, they came through our group, basically. We would shuttle them back and forth to the airplanes and help them out when they needed help in meetings. As a result of that, if there was a crew person in town, they were more than likely using a desk in our area. If Dr. von Braun or somebody in that group wanted to chat with the crew guys, they would often come down to our area because the crew guy was likely to be at a desk there.

He was also interested in what J.R. Thompson was doing. As you recall, we had a Skylab 1g mockup that, in appearance, looked like flight hardware, completely detailed out. That piece of hardware, which was a development hardware, eventually went to Houston as the crew trainer. J. R. assembled a second one for us. That is what was used to train the flight ops people from Houston and at Marshall. Dr. von Braun and company would come in, drop in unexpectedly, to see what we were doing. It was great to be able to walk him around and be able to talk about that. We would show him what we were doing. He would try out things. If he wanted to go on the zero g plane, he would find out when we were flying and he would meet us. In those days, we flew out of Wright-Patterson Air Force Base. He would come up and join us. When we began to

fly in Houston, I believe he had moved on to Headquarters by then. If you wanted to go and try something out under water, he was qualified He was a scuba diver, qualified for operating in a pressure suit, and he would try out the design. He gave us some darn interesting feedback, which was good. People listened when he talked, not only because he was a center director, but because he had a great thought process in evaluating a problem. It was the German in him, I guess.

Johnson: Talk about the integration of all the different parts, projects and designs. What you did impacted many things, but did you feel like all the work you did was translated to performance on Skylab?

Stokes: For the majority, yes. I am sure there were times when we were probably wasting the tax payers' money a little bit. Nothing comes to mind right now. Yes, the whole idea was we were mission-oriented, we had a goal we had to reach, and the design part of it was for us to interface with the other disciplines to come up with something the astronauts could use. That was always there. It was never out of mind for us. It may have been out for some of the other disciplines, but it was always there for us, knowing that it had to be safe. Our group really worried about the safety of the crew.

We also worried about safety for the piece of equipment the crew guy was working with. We were always worrying about the crew because it was an environment that we were still learning about at the time and still do not know a lot about. We had to worry about explosions. We had to worry about spacecraft being out of control. There was a period where we worried a little bit about personalities conflicting. That is one of the reasons we went down to Tektite II, which is an undersea habitat in the St. John's U.S. Virgin Islands. It was to try out and use some real missions where we had actual aquanauts performing actual work. We laid over that some of the things we were planning to do for Skylab to see how they would work, to see how these people would react to them.

We also took data every six minutes for a year for ten missions. We had a contract with the University of Texas to take data of where everybody was and what they were doing every six minutes. That was a lot of data, punch card data. We really found we did not have the problems from personality conflicts. We saw a little bit, there were some irritations. These people were doing real work, it was not busy work, and as a result, they did not take time to let personalities get in the way. We figured that was probably going to be the case with Skylab. As it turns out, that was. People had a mission to do. Everybody had a mission to do.

Johnson: How about the contractor experience in your area? Was it a good one?

Stokes: Yes. By then, I was kind of the old dude. There were not many of us still working then in human factors.

Johnson: What era are we talking about here?

Stokes: When I was working as a contractor, we had completed the design and the building of Nodes 2 and 3, which were two of the nodes on the International Space Station that were built by the Italians.

Johnson: This was moving along in years. You actually became a contractor.

Stokes: Oh. Ask me the question again.

Johnson: When you were working from Marshall, in general, the contractor experience on both ends, as you have experienced, has it been a good thing?

Stokes: Yes. We had a family in the Skylab days that was a family of civil servants and contractors. Nobody really paid much attention to the badge. Once you believed the

person on the other side of that table as trying his or her best to do the job and you saw he could produce without endangering him or you, then he was brought into the fold. In our group, there was no gaming, that posturing of the civil service versus the contractor. In fact, we even created a fictitious organization that still lives today in some minds called the Bioastronautics Research Foundation, or BARF. It turns out if you had experience in the zero g airplane and underwater training, you could become a BARF Bonafide Authoritative Game-saver, or BARFBAG. That, in some circles, was a lot more important than being a contractor or anything else. If you attain team BARFBAG status, then you were highly recognized in the industry, even Jules Bergman was a BARFBAG. [Both Laugh] We almost got one of our decals on one of the Apollo flights, but it got kicked off at the last minute.

Johnson: Talk about NASA Headquarters for a moment. Did it help or interfere in the development process, especially for Skylab?

Stokes: [William C.] Bill Schneider was a really good manager, so yes, it helped. That organization helped us a great deal, especially when we had the launch of Skylab and the micrometeoroid debris shielding panels were blown off and we thought we were losing the mission. Schneider came down, rolled up his sleeves, and gave us all the resources we needed. I say us, but I am talking about NASA because everybody

assembled at Marshall. For a week and a half, it was incredible the design work that went on there. He, at that particular time, was outstanding. He had been outstanding all along because he had really supported the program and he believed in the Skylab Program. He fought Congress and had gotten the money and kept the program going. He was incredible during that timeframe of recovery. As a result of that, I understand we got 109 percent of the mission that we planned to even after we had to do the repairs to keep it alive.

As far as the other part of that question of Headquarters, I actually pulled a stint up there. [Laughs] It was a different world. I realized that their job is to look toward Congress and they did not pay much attention to the guys back in the centers. They tended at times to forget the centers even existed. They saw a different NASA. They saw a NASA that was more of a research capability who happened to build rockets. Their counterparts were over on the Hill. That was an interesting world. That was very enlightening to me. I am really glad I had that experience because I needed it when I came back. It helped me when we were involved in working on the International Space Station on the Nodes Project where we worked with the Italian Space Agency and their contract with Alenia [Thales Alenia Space Italy], which was effectively their version of Boeing.

Johnson: When Skylab first flew, how did you feel?

Stokes: I was fortunate enough not to be working on the console that day, so I was down at the Cape and watched it go. That was the second Saturn I had seen fly, we saw Apollo 15 fly. Watching an Apollo vehicle take off was incredible. You always thought it was going to fall over because it moved so slow to begin with. Then all hell broke loose and we immediately had to come back to Huntsville. It was "Katie, bar the door" for that time period. Then it was catchup, especially with that first mission. That group of crew members, we had really great crew members. They did a lot of work. We loaded up the spacecraft to send it up for recovery, found out all the food that had launched on the vehicle was gone because it had been living in 130 degree temperatures for days and days and days and had effectively cooked all that stuff. We had to carry new food up. The water we had, it survived.

There was a lot of work that had to be done during that timeframe. It was busy, but again, we were staying focused, everybody working as a team, not just human factors. We were just a little piece of that. We had the crew piece of that, of what the crew had to do. Once we figured out we still had one of the solar arrays available, we had to figure out how to release it, working that real-time so it actually happened. We got power back and were able then to deploy the Apollo Telescope Mount power. By the

time we got to the third mission, we were back doing what the Skylab was originally supposed to do. It was not quite as exciting. The first two missions were pretty darn exciting. I think the issues you periodically read about on the third mission where they threw up their hands and said enough is enough, slow down. The urgency was not there to keep the mission alive by the third mission.

Johnson: While you were doing these missions and one of the first great repair stints there, did you sense you were making history? You were the precursor to the International Space Station. Did you sense you were making history?

Stokes: Yes, we knew that it would be history if it failed and it would be history if it did not fail. We knew that if it failed we were possibly going to lose NASA. If you recall, Skylab was after the first rift, after the first funding cutback, after the decision not to go to the Moon anymore. What were we going to do with NASA? Do we really need it? That was a tough time. Yes, we knew that if we could not pull it off, we probably would be looking for work and there would not be a fun organization like NASA around anymore.

Johnson: We know how much recognition von Braun and the German rocket team got for the accomplishments during the Saturn Program going through Skylab and the

Soyuz rendezvous. Do you feel like the rest of the workforce, including what you did, received the recognition you deserved?

Stokes: I do not know about the term "deserved."

Johnson: Should have gotten, let us put it that way.

Stokes: That is the wrong question for me because the payoff for me was being a part of it and watching it happen and work. The understanding that I was a part of that, decisions that I was involved in came out with a positive result, and I really did not care that much about recognition. I did not even think about that. It was not that important to me and it still is not. The important thing to me was, and you alluded to it a while ago when you asked me about the contractors, we had a team of people that I miss terribly because it was so much fun working with that group. That was not just the people that were working in human factors. That was the engineers, the design guys, the structures guys, the propulsion guys, the electrical guys, each one had their own little world and their own way of looking at things, but we all worked together as a team. We had great meetings where neat things came out of it, things we had not even thought could come out of that and send you off in a new direction to go look at things.

I do not know what recognition means, I really do not. Is that something for now? Is that something they are going to put in a textbook and rewrite it in 100 years whenever they want to change what happened? I do not know. That is an interesting question because I do not think that was a driving force, the recognition part of it. It was fun. I have enjoyed the get-togethers we have had since then. We have had several get-togethers and I was fortunate enough to get to sit as a panel member on one of the von Braun forums. That was enjoyable, that piece of that recognition, and getting back together with these guys after we all got old.

Johnson: You worked on Skylab and later the International Space Station. Would you compare the challenges of doing the two different things? I have to believe the Space Station was kind of an outgrowth of what you had already done for Skylab. How would you compare them?

Stokes: I would say the comparison or contrast, the first one was a technological challenge, the second one was a political challenge. Skylab was totally different. The Apollo was a spacecraft that was a small pickup truck type of thing and it was designed to go on a quick mission. You knew exactly what you were going to do when you launched and you knew when you were coming back and everything in between. The neat thing about Skylab was it was just a workshop. It was a place that, once we got it

going, things happened. We tried different things, the Comet Kohoutek came flying by, nobody had ever heard of it. We were sitting up there and could take photographs of Kohoutek as it went by. That was neat. We had to look at different instruments we had onboard that we could use in a way that we could gather data on that.

We learned a lot about fire in space and how it burns. It burns in a sphere rather than straight up like we are used to on the ground. Different types of materials, a lot that was going on on Skylab. The things you hear about now on Station, we tried them first on Skylab. That was all brand new. We had thirty-two, thirty-three corollary experiments and then there were another nine, I think, on Earth resources, first time we ever looked at the Sun through a telescope that you could look at the Sun and see it totally out of the atmosphere. It was fascinating. The deep space stuff was really neat. That was the good part.

When we got to Space Station, it was Skylab but bigger and better. It was this time we are going to build it bigger, we are going to have a lot more room. Initially it was an all U.S. vehicle and we were going to do all these neat things and we might invite people, we might not. Then the cost came in and we became an International Space Station. It was the politics of it. By then we had a shuttle. We knew the cargo capability of the shuttle, we knew the dimensions of the cargo bay. We knew the emergency landing

constraints on that. The center of mass could not come forward except to a certain point and could not come forward any more than that. That defined the modules.

In between that, we were doing Spacelab, so we had already learned a lot from Spacelab, a lab that went up inside and stayed inside the shuttle and it came home. Its mission was a week or two weeks like the shuttle stay was. We already knew what living in a can was going to be like. Station was just bigger and better. All the posturing and the gyrations were what made it interesting, if you want to use that term. It is interesting. Someone should really write a book on that. They could capture everybody's position, that would really be a story, volumes. It was a way of watching NASA turn into a bureaucracy, dissolve into a bureaucracy, which is where it is now. It is a full-blown bureaucracy. We lost that craziness, excitement, that was out there during the Apollo Applications Program, AAP, which evolved into Skylab.

It was still fun to come to work. I always enjoyed the development. We were involved in working with the Italians very closely and that got us back to what the team feel was that we had when we first started out on Skylab. That was the next time I had that feeling, [when we were] working with our friends over in Italy. They were brand new at it, it was totally new to them. They were looking at it through the rose colored glasses that we did when we started. They did not have all that water under the bridge yet. It

was really fun to work with them. We goofed off with them too. That was fun. I think the International Space Station is an absolutely wonderful vehicle, the capability is incredible. What we have not done yet is use it. We have spent all of our time putting it together. We are still looking for the mission use and we need to get people creatively thinking about how they can use it. You have a lot up there. You can go so far talking to the kids in the school classes, doing the spherical liquids and things that we have been doing since Skylab, or even Apollo, for that matter. I think the contrast is technological and political challenges.