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

Harry Craft
Interviewed by Steve Johnson
Huntsville, Alabama – Unknown, Circa 2012

Steve Johnson: I am talking to Harry Craft, who worked at Marshall Space Flight Center from 1960 to 1998. Harry, talk about your education, what prepared you to be in the space program?

Harry Craft: I was torn. I wanted to be an engineer, but to get to be an engineer, I had to co-op, that was the only way I could get myself through school. Co-oping offered the opportunity every three months to work with some of the senior engineers and the [Wernher] von Braun team. They would teach me. As I went to school, I would be able to apply some of the things I learned at Auburn [University] some of the next three months at work. It took me six years to get through and I guess the biggest part of my education was that. It was not the on-hand engineering that I learned at Auburn out of the books.

Johnson: What kind of engineer were you?

Craft: An electrical engineer.

Johnson: An electrical engineer, and you co-oped. You actually started out working for the Army as a co-op student.

Craft: Yes, sir. I started working with the Army. NASA [National Aeronautics and Space Administration] did not exist in the late 1950s. I started with the Army and was given the opportunity at the beginning when NASA was formed to elect to go to NASA and that is what I did.

Johnson: When you first got to NASA, you ended up going to Vietnam for a few years.

Craft: I had to. Co-oping, the draft board would not stay away from me, so I had to do the ROTC [Reserve Officer Training Corps] bit. I ended up in Vietnam as an avionics officer, which was directly related to what I had done here at NASA.

Johnson: During the Saturn Program, talk about what you did.

Craft: During the Saturn Program, my initial jobs were in measurements. Measurements is trying to get a look at vehicle parameters while it is sitting on the pad

getting ready to launch. We also tried to provide data to the crew during the flight so they would understand how the vehicle was performing. We had a lot of measurements, instrumentation, telemetry items that we had to go address. That was the biggest part of what I did in the beginning. It was hands-on engineering, which is different today, there is not that much of that. It was hands-on engineering and I could probably attribute my success to that, not being afraid of the hardware, understanding what the hardware will do, being able to touch it and feel it, and being able to make a mistake every now and then. The German team was very tolerant of us going out on our own and trying to solve the problem and not beat us over the head severely if we did not solve it the first time.

Johnson: Did you have to do testing in what you did?

Craft: We did a lot of testing.

Johnson: Talk about the kind of testing you did.

Craft: Most of the testing we did was either thermal vac [vacuum] or it was vibration.

Johnson: When you say thermal vac, what is that?

Craft: Thermal vacuum is seeing that the hardware will operate in the harshness of space where the temperatures are real cold and there is no air or atmosphere.

Johnson: You would do vacuum chambers with freezers and heaters in them, that kind of thing?

Craft: You would get a vacuum chamber that you could put a vacuum on and at the same time heat something up to high temperatures or take it down to real cold temperatures, which is typically what you see in space.

Johnson: What kind of hardware are we talking about?

Craft: To people who are not in the space program every day, the hardware looked like a little grep box with a lot of printed circuit boards in it. It might look like a motherboard on a computer with a lot of little chips plugged in it today. That is what it looked like. We put that in a chamber and did the environmental testing, would take it out on a shaker and subject it to launch conditions from a vibration standpoint.

Johnson: What would you say were the biggest challenges in doing the kind of work you were doing to make sure the hardware would withstand the rigors of launch and getting into a microgravity, no oxygen environment?

Craft: I think most of the time our biggest challenge was to isolate the testing such that we thought testing was going to put the hardware into the environment it was going to see. Doing that sounds like it ought to be easy. We just said thermal vac chambers and vibration tables. There were also other things, simulate a sand storm if you had that at the Cape [Canaveral, Florida], if you had that while your box was sitting on the pad, or a big rain storm, things like that. We had to go through and do a lot of that type of thing. It was making sure we understood the environment our hardware was going to be subjected to, test to that environment, and then a lot of us older guys used to say we test, test, and fly and the hardware would never know it. That is basically what we did.

Johnson: Was your hardware ever tested with a test firing at Marshall, for instance, on some of the test stands?

Craft: We sure did. We had a number of times, this is back in the day when we used to do more of that here, but we used to do booster testing here, the IBs and some of the big

engines. We would take our measurement packages over, put them on here, run the static tests, and be able to then go analyze how well we did.

Johnson: How often would you test? It almost sounds like you would be doing daily tests, but I imagine it was not quite that frequent.

Craft: If you go back and look at it, it is probably fifty-fifty in terms of testing versus engineering on the board or on the table putting it together. It takes a lot of time to do a test. The test is not just the time you are on the shaker or the time you are in the chamber. You have to go get everything ready. You have to make sure you know the levels you are going to go to. You have to make sure you know the cables and you can access the data during the test. There is a lot of prep time. We did spend a lot of time testing.

Johnson: Did you have to develop any new tools or come up with any new materials because of the testing, because of the work, to make things be able to withstand the environment?

Craft: We did. We used industry for a lot of that. Yes, the environments we had were obviously harsh. Every now and then we were given a requirement to operate in an

environment, we would go out to the vendors, and, of course, they would not have it. They would say, "We will work on this with you, but we do not know if our hardware will withstand that kind of environment." A lot of times, we had to push the envelope. When you do that, going back to my later days before I left, you get some of that kind of technology that was directly implanted into American industry. The automobile industry was able to use a lot of the kind of testing and environmental work we did here. Yes, we pushed a lot of hardware to the extremes.

Johnson: Can you talk about any particular material that you made work in the program?

Craft: It was not so much the material. I do not remember a given material creating that much of a problem. It was an aggregate of materials that we did not know how they would work together that normally caused the problem, an aluminum against a steel or a plastic against some other kind of material that it was not used to being against. Compatibility of materials, I would say, was the biggest problem we had.

Johnson: I have to believe with all that testing, from time to time, things you thought might work did not work.

Craft: That happens all the time. We bought hardware, we tested it, it would fail. We would say to ourselves, we still have to do the job. The crew still needs us, we have this measurement and we have to figure out a way to do it. We would go up against one dead end and tackle it another way, kind of start all over. We did that a number of times, but you learn a lot when you do that. Start over does not mean day one. Start over means I have a good bit of experience and I am going to go and take that experience and not make the same mistakes but do it a different way.

Johnson: Were there ever any dead ends where you thought to yourself, "I am not sure we are going to be able to figure this one out?"

Craft: I never gave up on anything and maybe that is why I had a pretty decent career. I did not give up on stuff. I always decided this was my hobby, the space business, I am still in it today. My hobby is to make sure that I can try to do something nobody ever did before. I do not throw up my hands many times.

Johnson: Were there surprises, things you may have discovered during your testing that had a later application that surprised you that it worked? Were there surprises in what you were doing?

Craft: We had the action of making the weight of the box as light as possible. In doing that, we, NASA, kept pushing the industry, no more tubes, little transistors then smaller transistors, then chips. If I had a surprise, it was understanding what we pushed because we had to lower the weight of the boxes, what industry and American ingenuity was able to do with that because of the computers we have today, the cell phones, it is amazing how far that industry has come.

Johnson: The Saturn Program lasted about a decade, maybe some Saturn work was done under the Army. Talk about the pace of work. You are doing this testing, you are working on the hardware. How fast did you have to get things accomplished during the Saturn years?

Craft: That is a long time ago. I do not remember feeling the pressures. I am sure they were there. Looking back, we had schedules to meet. In everybody's mind in that timeframe was what President [John Fitzgerald] Kennedy had said, we are going to get up to the Moon in this decade. We had an end date and everybody recognized that and we recognized there were test flights before that and we recognized there was hardware and tests we had to do before that. That was probably always in the back of our mind and we always wanted to preserve the option to make sure we could meet that. We would try to work to gain margin back in schedules when we could.

Johnson: Did that end date actually help? It sounds like you are saying it did, knowing you had to be done at a certain time.

Craft: I think it helps in any job. Personally, I think it helps to always know what you are trying to accomplish and when you are trying to accomplish it by. If you just say you are going to go out and put in a garden and you do not know what you are going to do and you do not have a timeframe to do it, I do not think you end up appreciating it as much. Yes, it helped a lot.

Johnson: How about the work hours and shifts you had to work in the Saturn days? Do you remember having to work hugely long weeks?

Craft: Yes, a standard work week for a long time was what we called six days a week, eight hours a day. That means we worked Saturdays and took Sundays off. Every now and then we would have a test that would require you to work the seven days because a test could not be interrupted. We had a lot of long days. Maybe those long days helped us maintain schedule. I cannot go back and tell you that for sure. I do not remember for sure. We did what we had to. There were some long days, yes.

Johnson: How about the work environment? You have a bunch of men and women who are working long days. Was there any grumbling about that? Was everybody motivated and excited about what you were doing?

Craft: I think everybody was. I do not remember much mumbling and grumbling about that. Most of us knew we had a mission to accomplish. We knew when we had to get it done by. You had setbacks along the way like you always do in anything. Part of the challenge was figuring out how to work around the setback. No, I do not remember much of that. I think we were all proud of what we were doing and we were constantly motived to figure out a way to do it. Do not accept "I cannot get that in here tomorrow" or "it will take until next week before we get the part." If we needed it, we would figure out a way to get it and meet the date.

Johnson: Did you worry much about controlling costs, about how much money you spent?

Craft: That is a question that keeps coming up today. Were we able to accomplish what we did because we had an unlimited budget? I do not remember the budget ever being unlimited because there was always somebody telling me they did not have the money or could not afford it right then. We did not have an unlimited budget. Comparatively,

the dollar today versus a dollar then, maybe we had a few more, maybe we had a little more flexibility. I know we had more flexibility in how we worked, how we procured, the kind of things like that. Believe it or not, we used to be able to go down and buy stuff at Radio Shack to run a test if we needed it. Today, you can do that, but it is a little bit more difficult. In those days, we would go down there, do it, and get reimbursed.

Johnson: What you are saying is during the Saturn days, developing the most powerful rocket that has ever flown, you guys would buy commercial, off the shelf parts sometimes if you needed them?

Craft: To support a test, not the flight vehicle. To support a test because it was going to stay on the ground. If it is going to stay on the ground, you really want it to function and be able to support the test. Yes, we were able to do that.

Johnson: That sort of makes it sound like whatever you guys had to do within reason, you did it.

Craft: That is right.

Johnson: Talk about the involvement of Dr. von Braun in this process you were involved in. Was he involved? Did you see him? Did he come down and watch the tests? Did he talk to you guys?

Craft: That was one of his major attributes. We were talking earlier about what makes a good manager. A good manager to me, you know he cares about you and you know he cares about what you are doing. I remember one of the first times I met him, I was in the laboratory working on some measurements for Saturn. He walked down the hall, walked in our room, pulled up a stool, and said, "Mr. Craft, what do you do?" I, of course, explained to him what I was doing. He said, "Is that working the way we want it to work?" I said, "Yes, sir, we have it working the way you want it to work." We had a very good conversation, no pressure, no audience, no room full of people you had to perform in front of. It was just two engineers talking. I always remember that about him because he was that way. He was easy to communicate with. He was a neat guy. He had a vision for the future.

Johnson: I understand he liked to test. Did he make that apparent that he wanted you guys to test?

Craft: Test, test, and fly. You would keep testing the hardware. You would test, then put it on a vehicle and fly it, and the hardware would never know the difference. That was basically our philosophy.

Johnson: Did it make your job easier knowing the people you worked for wanted you to do what you were doing and they were vitally interested in the outcome?

Craft: It always helps if you know the guy or gal you are working for, the individual you are working for, is aware of what you are doing, is aware of the challenges you have, that type of thing. I think that helps a lot.

Johnson: How about the integration of all the different parts, projects, designs, all the different things you guys tested, other people tested? How did all that fit together?

Craft: Sometimes not easily. We still call them today the interface control. You make an agreement between yourselves as how you are going to build something, you make an agreement on how you are going to go together. Are we going to use quarter inch bolts or are we going to use half inch bolts? You make those agreements ahead of time and everybody is supposed to live up to them. Do we always meet the interfaces exactly

right? No, but that is why we test at the Cape and that is why we integrate and do testing offline at KSC [Kennedy Space Center].

Johnson: How did you feel when the Saturn V finally flew and all that testing you had done, the ground testing, the vacuum chamber testing, all that testing actually did the job?

Craft: Probably scared to death. I do not really remember for sure what I felt like when it actually happened. I watched it like everybody else did and was able to attend some of the launces. I had hardware flying on it, and your first thought is I just want to make sure my hardware did what it was supposed to do. I can remember many times, as soon as the flight was over, getting a chance to go talk to somebody about what we call the quick look data, that small amount of data you get immediately. You are able to do something with it and see how your instruments performed. That is what most of us were into, let the thing clear the pad, get up there, and then take a look at the data and make sure our box did what it was supposed to do.

Johnson: Did it always do what it was supposed to do?

Craft: Not always, but we designed enough redundancies and other paths to make things work most of the time, the vehicle did not know the difference.

Johnson: Did you know you were part of making history during those days?

Craft: I had no idea. No, I really did not. I knew we were doing something that had never been done before. I knew some of us as Americans were probably embarrassed with the first Russian satellite, when Sputnik went up. I think I felt a pride and an honor of trying to recapture that momentum for the United States. I do not know that I felt like I was part of history though.

Johnson: Looking back on it now and knowing that you were a part of history, how does that feel?

Craft: It makes you very proud. I am very proud of my career. I am proud of what I was able to accomplish. I am proud of the missions we flew that were successful and how well the hardware performed, for the good of the country, not so much for us engineers. It is something I think America can be proud of, our children and our grandchildren.

Johnson: You worked on other programs. You worked on Skylab, which was a continuation, so to speak, of the Saturn Program, and you worked on the shuttle and Spacelab. Did you do the same sort of work on those projects?

Craft: I had been working the propulsion side of the vehicle, the Saturn itself. Skylab came along and the people at Johnson Space Center that were in charge of the astronauts, they wanted to do a number of medical experiments aboard Skylab. They were running short on enough manpower to be able to do that, so they came to Dr. von Braun and wanted to know if Marshall could step in and help do some of the engineering on these experiments. I got a chance to be on the ground floor in designing and working on some of these life sciences experiments.

These are going to sound very crude, but an astronaut breathing in and out, we wanted to understand how his oxygen intake returns CO_2 [Carbon Dioxide]. We went to the hospitals and doctors and asked how they did this. The way they do it on the ground would not work in space. You would breathe in a chamber on the ground and that would not work in space because there is no gravity. We started pushing medical technology. Everywhere we went, they said, if you get that to working, call us, we want one in these hospitals. I got to start on the science side of the house. From that day on, most of my career was on the science side. Spacelab was a science laboratory. Skylab

was, it had a lot of experiments in it. Spacelab came along in the shuttle bay, and I was in charge of that program and the first flight for years. That was always about doing science and trying to help push the way we live on Earth to something a little bit better, if we could.

Johnson: Did that also call for a lot of testing, getting those programs up to speed?

Craft: Some of us old guys that were brought up that way, we did not give up on it. That is what we did. We tested and tested and tested. Unfortunately, a lot of the scientists had a university kind of background. They operate in a research environment and they do not have to perform to a set of standards. When we would introduce them to the fact that we wanted them to test and test and test, they got a little irritated with us sometimes. I think in the end, they understood and appreciated why we were asking them to do that. They never had to it in their labs at their university.

Johnson: Did your experience working on the Saturn propulsion help you even moving into life sciences work? Did it help you with that?

Craft: Absolutely. We used the same specs, standards, and approaches that we would have whether it was an engine, a measurement, or a life science experiment. We used

the same approaches. In fact, still today at Marshall, you will find we still use a lot of the specs and standards that were dated back in that timeframe. Have they been updated, sure, because technologies have changed, materials have changed.

Johnson: Talking about surprises and setbacks, things like that, developing the life sciences experiments and later working on Spacelab ,which was carried aboard a shuttle, you were breaking new ground figuring out experiments that could be done, I am assuming, to show how human beings can work and live in space.

Craft: Our setbacks became fewer, and this is a tribute to the Shuttle Program and the engineers who designed shuttle. The environment that we encountered onboard Spacelab in the cargo bay of the shuttle and with the ride the shuttle gave us from an environmental standpoint, sometimes our jobs got a little bit easier. The shuttle, we were able to carry inertia atmosphere with us, so we did not have to do things with materials. If they were safe to use in this room here, they were safe to use on Spacelab, by and large. The technology and NASA's understanding of how to build propulsion systems got to where the environment we provided to people like me who were working the science was a little bit better.

Johnson: Let us drop back a second to Skylab. Did Skylab, the work to develop those experiments, help with what you did on Spacelab?

Craft: Sure, that is why I got picked to help work on Spacelab. The science we did there, although it was done to a different set of standards, the way we interfaced with the science community, how we worked with them, how we asked them questions, some of us guys had to develop a softer personality in dealing with them. The hardware side, everything we learned on Skylab helped on Spacelab.

Johnson: Skylab was essentially the first space station. Spacelab, how do we describe that, a traveling space station? How would you describe Spacelab?

Craft: In the beginning, we called them sortie flights. It is sort of like in the military where you have a flight you go up and fly from the United States to Germany, turn around and come back, you are in the air a given length of time. We were going to be in the air a given length of time and it was going to be somewhere between eight and ten days. We had a certain amount of power we could use. The biggest thing there was managing our utilities. It was a take it up and bring it home. That is something that was absolutely unique to Spacelab, and that was we got our hardware back every time. If we

had a hiccup, if we had a problem, we could go learn directly from the hardware. We did not have to have to guess what may have happened.

Johnson: Doing testing on Earth, even with the best vacuum chambers, did you find it to be different from when it actually got into space and got tested in real-time? Did it turn out to be a little different?

Craft: Every time it turned out to be different. You can do the best testing you can on the ground, but when you get in that environment up there, it is going to be a little bit different. "I did not realize it was going to be real close to another box and the Sun was going to bang off that box at a certain angle and we were going to get a hot spot." There were a lot of things like that that you could not predict. Tools today, the young engineers today have tools we did not have and they can go in and do a lot of that. They can go in and make, I call them secondary reactions. Their jobs, in some ways, are a little bit easier, but we are never going to be able to do it. You have to go up there to experience it.

Johnson: Sounds to me like there are a lot of surprises when you fly things.

Craft: Always, there is always a surprise when you fly something.

Johnson: Do you feel like when things did not act like you thought they would because of Earth-bound testing that that is when you really learn things?

Craft: Every time you do a test, you learn something, every time. The flight always induces something that you did not anticipate before. I can remember on Spacelab 1, we put the Spacelab in the bay, did some testing on it at the Cape. When we actually got into orbit, one day we woke up the commander with a big pop. It was a piece of metal relieving itself because the environment it saw in space, a combination of no gravity, the heat, and the way it was designed. That is what it did. We did not have a way to do that on the ground. It would have taken us a humongous amount of testing to find that. We probably never would have found it.

Johnson: We have the International Space Station for the foreseeable future. Are the things you learned first on Skylab and then with Spacelab still being applied? [Are they] maybe even responsible for the success the Station is having?

Craft: I can tell you if you go out to the control center for the Space Station here and the guys that run that. It is almost identical to the way we ran things on Spacelab, the operations, what you have to prepare. You have to prepare the hardware now and take it up in a smaller package or aboard another flight, sort of like packing a suitcase, all the

technology from Spacelab, I would say, was directly applicable to Space Station. You have to carry it in through a small opening, you have to assemble it in a low gravity kind of thing, have to work, sleep, eat in that kind of environment. I think that is probably one of the best learning tools we have and that is probably one of the reasons we have been able to maintain the science operations here at the center. We have been doing it now for almost thirty years.

Johnson: Say we go to Mars at some point, do you in your mind think there are things we did in the mid 1970s on Skylab that will make that trip to Mars possible?

Craft: I have not worked on anything yet that is supposedly Mars bound or would have to go there. They are working on the launch system now, the SLS [Space Launch System]. I know in theory one day we will have the capability to launch payloads toward Mars. I have not really thought about that. The biggest thing I can say we probably have learned from all of those problems starting back with Skylab is that with Skylab, Spacelab, and now Station, we are learning how man can live in space for a long period of time. We are also learning what it does to him, what it does to his body, and making sure that on a long trip to Mars and back that our crew can perform the way they want to and that the hardware will perform the way we want it to. I think we can

test the hardware to make sure it will last that long, but when you integrate the hardware with the crew and the environment, there will be a challenge there.

Johnson: You worked on the Ares I-X, which at one point looked like the direction we were headed with our manned spaceflight program. Talk about the challenges of that. That was certainly different than the shuttle. It was, in many people's minds, going back a bit to the Saturn V.

Craft: It was. I think when they first conceived the whole Ares I, Ares V, and the I-X flight some of us were privileged to work on, there was a great deal of justification in our minds that we were going back and doing it the way we did with Saturn. A lot of people dug out old drawings and old tests saying we can go do this, we can do that. It turns out the tools today, some of the computer-driven analytical tools are good enough that some of that we can probably simulate a whole lot better than we could back then.

How is Ares different? It looks different. The electronics of it are different. The basics of how we put it together, however, do not change. It is a bunch of engineers building boxes and we all have to arrive somewhere at the same time, put them together, and they have to work. Ares would have worked. We maybe made some management mistakes early in the program that allowed the costs to overrun significantly.

Johnson: You worked from the time when basic computations were done with slide rules up until the time when advanced computer programs did the big work. It made it easier, obviously, but it strikes me that we were still able to get it done with what would be considered primitive tools. What made it possible for engineers with what would now be considered no tools at all to send men to the Moon?

Craft: I was down at Auburn a few months back and one of the guys in the bookstore said he found a whole carton of old slide rules that had never been taken out of their cases. He said he put them out there as antiques and he said they were all done in a matter of an hour or two. That slide rule, to us, was what we trusted. It was an analytical tool we had that would allow us to multiply and do whatever. We trusted it just like the young people do today with the calculator in their hand or the computer on their desk. We trusted it, it gave us answers, we double-checked answers, and that is really all they do today. Now you can do it on a keyboard, but we had to slide the slide rule. It is a tool. We used the tool to its maximum capability. Today, fortunately for the young engineers, the computer is a tool with a lot more capability.

Johnson: Is hands-on still as important in your mind as it was back in the day?

Craft: I probably cannot tell you how important I think that is. I do not even know the words I would use to describe it. A lot of the young engineers today are absolutely afraid of the hardware. I know they are going to argue with me and say, "I am not afraid of it." They are afraid of it because they did not touch it. They did not sign their name and say it is ready to go. I do not know how many times I signed my name and said that is as good as I can make it, it is ready to go. The young engineers today withdraw from that a little bit. I will give you my two cents of why. If you go to the aftermath of *Challenger* and *Columbia*, you can understand why if you see people getting beat up on because they thought they were doing their job as well as they could and the system failed them. I can understand why people are withdrawn, but that is really becoming a detriment to what we want to do.

Johnson: When you say the system failed them, what do you mean by that?

Craft: What I mean by that is our society felt like it had to hang somebody. Our society felt like whoever was in charge, we have to find fault with them, they did not do their job right. That is a terrible way to be because that allows people not to want to go out and take a challenge or take a risk. That is my view of it.

Johnson: In the Saturn days when things failed, and there were some failures during the Saturn days, it was not a blame game so much then. It was more what went wrong and how do we keep it from going wrong again. Was that the difference?

Craft: That is the difference. I can remember one time I was designing the power supply. In those days, you designed it and then you would build it as an engineer. I put a component in backwards, it was my fault, no question about it, we plugged the thing in. It was a capacitor, and it exploded, blew paper and stuff all over the room. It did not hurt anybody, did not damage anything. Everybody came running down the hall, they had heard the explosion. "What happened?" "That guy put that in backwards and it blew up." Somebody walked over to me and said, "Do you know which way to put that in from now on? Did you learn a lesson there?" (Laughs) From then on I had learned a lesson. I was going to make sure I put that thing in right. We were able to accept failure without an inquisition to go behind it. Today, unfortunately, the agency has documents now that say this is how you conduct the inquisition if you have a failure.

Johnson: I have been told by more than one NASA veteran that von Braun actually appreciated failures or even mistakes as long as someone would say I made a mistake so they would not have to repeat the test. Is this something you came upon?

Craft: Yes, he and the German team did a fantastic job of bringing some of us along that did not understand the space business. They gave us an opportunity to fail and you learned significantly from failure.

Johnson: We know that von Braun and the German team that you have talked a lot about got a lot of recognition. Do you feel like the rest of the workforce, at least during the Saturn V days, got the recognition it deserved, yourself included?

Craft: I think we got the recognition in a little bit of a different way. We were not on the media, we were not written up in the newspaper, but we were part of a team that had a tremendous success and I think we felt a lot of pride in that. A lot of people always said the German team did this and the German team did that. If you go back and look and if you were here, the majority of us were United States engineers. There were a very few Germans comparatively in the workforce. When I was coming along at Marshall, maybe a workforce of several thousand or so civil servants, maybe 350 or 400 of them were Germans. The rest were all U.S. [United States] citizens from all over the country. I was able to live with it. I do not remember anybody ever really getting upset about that.

Johnson: Can you talk about the difference over your career between Marshall and the other NASA centers? Were there rivalries?

Craft: Yes. Rivalries are good. I know you are an Auburn guy and I am, but we can talk about how that Auburn and Alabama rivalry is bad the week it is happening, but it is good for the program, it is good for the state. We can push it to extremes. Rivalries between the centers, yes. All of us wanted to make sure we had plenty of work to do and all of us had certain projects we would see coming along in the country we felt like we could do well. Von Braun loved astronomy. When the Hubble Space Telescope was conceived, von Braun was very much in favor of Marshall having something to do with that. For many, many years, we worked on studies and how would you do this, that, and the other. Finally, it was given to us to manage. Yes, there is a lot of rivalry, but NASA also cooperates a lot and that does not get written up.

Johnson: Over your career, did NASA Headquarters help or interfere in the various projects that went on?

Craft: Being an organizational kind of guy, I have to say they helped. It always helps to have somebody at the top who can be the final referee. Obviously, there were technical disputes that would come up and there were management disputes that would come up. Headquarters, yes, they played a role. They play a valid role and one we need in that they interface with the outside. They interface with the Congressional people and know how to do that kind of thing. Some of us would probably flounder real bad if we

had to do that on a daily basis. Once in a while we give a briefing or staff briefing, that is fine, but doing that every day, we need that. They help or hinder, it depends on what it is. In general, I think they played a valid role in the overall organization.

Johnson: How about the contractor experience? You undoubtedly worked with numerous contractors over the years, was it by and large a good experience?

Craft: Absolutely. The contractors in the Huntsville area, and really throughout the area, they all understood what we were trying to do. We had mutual appreciation for everybody's approach. The contractors had their way of doing things. We had our way of doing things. Did they always match? No, they did not always match at all. The contractor community, they have good engineers, they are smart, and in some ways they are a lot more flexible that we are in the government. I think we recognize they have the talent and the flexibility that we did not. They were always, in my opinion, a vital part of the team.

Johnson: When you look back over your NASA career, is there a big lesson you learned? Working with all these people and accomplishing all these things, is there something you can look at and say that is something I learned?

Craft: I think one thing I learned is that the biggest asset we all have is our people and our organizational structure and the way people work together. I learned how to work with people the hard way, by making mistakes and having to go back and correct my mistakes and say I am never going to do that again. I learned about people in a way that is sort of like learning about the hardware. If I walked away with anything, it is an appreciation for people, what motivates people and how you get them to enjoy what they are doing.

Johnson: To be successful in the future, does America's space program need to learn from its earliest days?

Craft: You are asking an older guy who has been around a while and I still think there is a lot to be learned from the way we did things. I am sure the people coming along today, the young engineers out there, whether they are contractor or NASA, saying our way will work also. I think they are right, I think their way will work. Can you learn something from talking to the people who have been there before? I think probably in my lifetime and yours, we have heard history tells us a whole lot, learn from history, learn from your mistakes, learn from your positive side of things as well. I would say that yes, there are still some things they could probably learn, but they are doing it their way.

Johnson: Once again though, hands-on is important.

Craft: I think so. I told you a while ago, I do not know if I can tell you how important I believe that is. Get out and touch the hardware, pat it on the back. I know it is a piece of metal and does not know you are petting it, but pat it on the back and say go do what I ask you to do. It is our team. A coach can do that with his ball team, but we had to do it with pieces of equipment that we built. Sometimes they seem to have taken on personalities and we would treat them pretty much like a person sometimes.