NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

TOMMY W. HOLLOWAY
INTERVIEWED BY REBECCA WRIGHT
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[The questions in this transcript were asked during two separate oral history sessions with Tommy W. Holloway. The first was conducted on July 25, 2002, and the second was conducted on August 26, 2015. Mr. Holloway chose to combine the two transcripts into a single transcript. This final document reflects his revisions and edits]

WRIGHT: We had a chance to visit with you in July of 2002, right before you retired from NASA, and we would like to pick up from that conversation. I want to let you take it from here, and you can share with me what other thoughts, experiences, and comments you would like to share with us today.

HOLLOWAY: Going over the list of questions that we had, some are answered in the previous interview. Others are either new, or an expansion of what we talked about, and I'll try to fill in some blanks.

WRIGHT: Thank you. I'll let you take the lead. What would you like to talk about first?

HOLLOWAY: We'll just start at the top of your list. The first one was, "What inspired your interest in engineering and space exploration?"

I'd like to back up. I was raised in central Arkansas and attended Griffithville School for 12 years. This was a B-school, so the options for courses were limited. We all took the same classes. I had one year of algebra, no trigonometry, no physics, no chemistry, and certainly not any calculus. I was way behind compared to many students who went to college.

There weren't many people from Griffithville who went to college. Over twenty or thirty years that I'm familiar with, only four or five Griffithville students graduated from college. Two of those were my brothers. Going to college was a big deal. Most kids didn't go. Fortunately, in Arkansas at that time, there was a state law that if you graduated from an Arkansas high school, you were eligible to attend any Arkansas state college. Otherwise, I would not have been able to attend college because of the limited courses I had taken in high school. My life would have been very different.

I attended Arkansas Polytechnic College at Russellville, Arkansas, for two years, catching up. However, I didn't quite catch up. When I transferred to the University of Arkansas [Fayetteville], I was surprised. At Russellville I had taken one of two five-hour courses in calculus. When I got to the University of Arkansas, I found it had three, three-hour courses in calculus. I could take the second course the first semester and the third course the next semester, or I could just take the third course.

When I registered for math classes, the head of the math department, Dr. Richardson, helped me. I explained my situation to him, and he suggested that I take both of the last two three-hour courses. I reluctantly signed up to avoid the possibility that I would need to attend college for an additional semester. In the beginning, it didn't go well, but Dr. Richardson had a tutoring opportunity. He was an older gentleman, head of the math department and nearing

retirement. He came to class and tutored kids every week. I signed up and attended his regular tutoring class every week. I made an A in one class and a B in the other. I was proud of myself.

Now, for the rest of the story. In 1995 the University of Arkansas conferred on me the College of Engineering Hall of Fame Award and the University Alumni conferred on me the Distinguished Alumnus Award. I also gave the commencement address for the Engineering Department. During that time, I talked a lot about Dr. Richardson. His grandkids heard this story about how Dr. Richardson helped me, and they came and visited me in my office at JSC when I was the Space Shuttle Program Manager. We had a great visit. They talked about their grandfather, and how he was approaching retirement, and they were really proud of the fact that he took the time to mentor students. It was a memorable and heartwarming experience.

Since I had to catch up and Arkansas required 144 credit hours for an engineering degree, I was a four and a half year student. As a result I finished college with 162 hours of credit. I even took one course my last semester that was not required. I routinely took 18 hours a semester and needed another course.

Why engineering? My mother was adamant that I go to college. I thought about the options which included agriculture, teaching, and engineering. I talked to the Griffithville assistant school superintendent and the agriculture teacher, and I decided engineering sounded right. It wasn't a big calling, and my skills did not point me to engineering. Besides, teachers didn't make very much money in Arkansas. They still don't make enough. I decided to study engineering, and I settled on mechanical engineering, because I didn't think I wanted to do civil engineering, which was the other option. Chemical and electrical sounded like they were too tough for me.

WRIGHT: You did get several job offers.

HOLLOWAY: In the fall of 1962, after having spent two years at Russellville, Arkansas, and then two and a half years at the University of Arkansas, I was on the job market. The Mechanical Engineering Department Head suggested I go to graduate school, but with four and half years in college and little money, I was ready to go to work. I had borrowed $1000 from a federal education program and didn't want to borrow any more. I was tired of being broke.

I interviewed on campus with a general recruiter for the Manned Spacecraft Center [MSC, now Johnson Space Center], Marshall Space Flight Center [MSFC, Huntsville, Alabama], and Kennedy Space Center [KSC, Florida]. Later, Lee [R.] Nichols, who was the executive assistant to Warren [J.] North, got in touch with me, and we exchanged information. Mr. North was the division chief of the Flight Crew Operations Division, which later became the Flight Crew Support Division. Jack [R.] Lister, Director of MSC Human Resources, eventually sent me a telegram with an official job offer. Thanks to my wife, we still have the telegram in a scrapbook.

I had five or six job offers, mostly from aerospace companies, but one which I found most interesting, and I almost went to work for, was the Chicago Iron & Bridge [Company]. They had an appealing offer with a program that brought young engineers onboard, provided mentoring, and on-the-job training while letting you grow up in the company. Moving to the projects was part of the job. However, after thinking about it, I decided to go to work for NASA and come to the Johnson Space Center which was just then beginning to form up in Houston. At that time the job sounded interesting, but I still did not understand the scope of what I was signing up for.

My brother, who was four years younger than me, started college at the University of Arkansas my last semester. During that semester our parents gave us permission to take their '55 Plymouth to school probably so we could come home more often. I had been hitch hiking home and back to school for the first four years and never had a problem. Once a man picked me up and asked me to drive his new ford from Fayetteville to Conway, Arkansas. It was the first new car I had driven. I worried about getting stranded on the road from Conway to Beebe but the slowest was from Morning Sun to home on Highway 11. Going back to school, my dad always took me to Beebe and gave me 10 dollars to "catch the bus." I never rode the bus but the 10 dollars came in handy.

I graduated in January of '63 and since I could not afford a car, I drove the '55 Plymouth to Houston. Unfortunately, I do not remember the conversation with my parents about taking the car. A few months later, although he never asked or expected it, I sent my Dad my monthly check for the car.

WRIGHT: At least you drove when it wasn't summer, so that was good. What were your first duties and responsibilities here?

Holloway: I came to work in a group who developed flight plans and crew procedures. Since the procedures were short and simple, they were included in the flight plan. The flight plan is a schedule of crew activities which includes the crew's work/rest cycle and the work they were to perform. Starting in Apollo, the more complicated procedures were in checklists. The Mercury Program was preparing for the last Mercury flight when I came to Houston.

I spent the first five months, between February 3rd and the first of July, following the people around that were working on the last Mercury flight, [L.] Gordon Cooper [Jr.'s] flight, and then immediately started working in the Gemini Program. In the Gemini Project, our primary job was to produce the flight plan, which included the crew timelines and crew procedures. I did a short study on how many astronauts NASA needed to fly the Apollo Program.

WRIGHT: Do you recall if you worked all of the Gemini missions, or which ones were more memorable to you?

HOLLOWAY: Gemini was an exciting program. It was the beginning of learning how to do flight operations, from how to rendezvous, dock, and to conduct spacewalks or extravehicular activities (EVAs), systems management, and how to prepare for flights. All were started in the Gemini Program. EVAs were really difficult including those on Gemini IV, IX, XI, and early Shuttle missions. They did not go very well.

We flew 10 crewed flights: Gemini III through XII. The first two flights were unmanned. The first one was a launch vehicle demonstration. The second one launched an unmanned Gemini vehicle sub-orbital from Florida to off the coast of Africa. The rest were crewed flights. I was the flight planner on Gemini III, IV, VI, VIII, X, and XII, and Ted [A.] Guillory, was the flight planner on V, VII, IX and XI. We worked together during all crewed Gemini flights. During the flights, we both were Flight Activities Officers [FAOs] in the Mission Control Center [MCC].

It was a very fast-paced program. We launched every two months, so things went very quickly. All the flights have unique memories. Gemini III, just flying the first flight and getting started was exciting, with Gus [Virgil I.] Grissom and John [W.] Young. The flight went smoothly. I supported a flight team led by Glynn [S.] Lunney that checked out the new Mission Control Center in Houston. The flight was controlled from the old MCC [Mercury Control Center] at the Cape.

EVAs started with Gemini IV. There were a total of six EVAs in the Gemini Program, and two did not go well. The Gemini IV EVA was okay, but part of the plan did not work. That EVA was generated in an attempt to keep up with the Russians. The Russians had just accomplished the first EVA and NASA, not wanting to be behind, decided that they wanted to do an EVA on Gemini IV. They initiated a crash program to get ready for this spacewalk, which included developing the hardware and procedures and training the crew. NASA decided to do the EVA but wanted to keep it quiet in case they changed their mind.

Although I was the flight planner, I only found out about it three or four days prior to launch. The remote site flight controllers even went to their sites with an EVA package to be opened after they arrived. The plan originally was to fly formation with the upper stage of the Titan and, during the EVA, go out and touch the booster or at least get in the vicinity of it. It would be something more than what the Russians had done. Well, in the process of getting ready, they didn't involve the people that understood formation flying. If you're behind a spacecraft, you don't speed up to try to catch up. You actually slow down. It's opposite from intuition. To make a long story short, the formation flying failed. [James A.] McDivitt wasn't trained adequately. After expending a large amount of propellant, the formation flying was called off and [Edward H. White II] did the EVA.

Gemini V had a heater failure in the supply tank that supplied oxygen to the crew atmosphere and the fuel cells that were flying for the first time. Heaters were needed to keep the operating pressure up in the oxygen tanks. I remember listening to Dr. [Christopher C.] Kraft, the flight director, work with the systems operator, with input from the contractor, to determine how to proceed. Kraft personally talked to the crew and described powering down the spacecraft to a very low level and waiting for the quantities to go down before powering back up. After the O^2 quantities are low the tank heat leak would keep the pressure up in the tank. He also described the plan to abort if it did not work. It was my first experience watching a flight director work a major problem. The flight flew the full duration, but flight planning did not have a lot to do until the tank pressures recovered.

Gemini VI was planned to rendezvous with an Agena vehicle. The Agena was lost due to an Atlas failure, so Gemini VI, with the main objectives being to rendezvous and dock, did not have a rendezvous target. Someone came up with the idea to rendezvous Gemini VI with Gemini VII, a 14-day mission.

The most interesting thing about Gemini 7/6 was the Gemini VI launch countdown six days after the launch of Gemini VII. At Gemini VI ignition, a control plug came out of the bottom of the booster and shut the booster down and prevented launch. The commander, Wally [Walter M.] Schirra, could have legitimately ejected, because the booster had ignited. If he was still alive, he'd probably tell you that he knew the vehicle wasn't going anywhere, and it wasn't falling over, so he just hung tight. The two-man crew stayed in the vehicle. The vehicle was recycled, and the problem that caused the control plugs to come out was corrected. Launch occurred two days after the pad abort. Things like that wouldn't happen today.

We had a close call on Gemini VIII. It was the first flight for Dave [David R.] Scott and Neil [A.] Armstrong. It was also the first docking flight. The target vehicle was a previously launched unmanned rocket, an Agena. Shortly after docking, one of the Gemini thrusters in the orbital module stuck on and established a rotation on the docked vehicles, the Gemini spacecraft and Agena. Thinking the problem was the Agena, the crew undocked. After undocking, due to less mass, the rotation increased even faster. As we learned later, the spacecraft was eventually rotating at about 270 degrees a second. Dave Scott later told me that he didn't know what he would have done if he had been the commander. Neil Armstrong activated the forward RCS, the Reaction Control System, that was in the nose of the Gemini spacecraft and managed to damp the rates while using about two-thirds of the reentry fuel. The reentry RCS had two independent propellant systems but both were activated and used.

I will always remember AOS [Acquisition of Signal] at Hawaii. (We used ground stations for communications, so the entire sequence occurred out of contact with the MCC.) At HAW AOS the crew briefed the MCC on what had happened. It was a close call but fortunately Neil had the skills and the capability to get out of the situation. He was prepared to stand in the gap. Due to the low entry fuel quantity and the possibility of another failure, the flight was terminated at a contingency landing site off the coast of Japan.

I was the lead flight planner, so I was disappointed that we were not able to complete the plan while thankful that the crew was able to deal with the situation. Prior to launch, during a briefing of the crew, Neil had told my Division Chief, Mr. North, that I had done an excellent job preparing the plan. Too bad we didn't get to execute it!

On Gemini IX Gene [Eugene A.] Cernan did an EVA, planning to fly a Manned Maneuvering Unit [MMU] that was in the back end of the Service Module. Gene had started the

EVA out of contact with the MCC. At Hawaii AOS Commander Tom [Thomas P.] Stafford recommended the EVA be called off. Gene had worn himself out trying to don the MMU. On Gemini X, while flying in formation with the Gemini VIII Agena, Mike [Michael] Collins performed an EVA and retrieved an experimental package from the Agena.

Gemini XI astronauts conducted a tethered operations between the Gemini and an Agena rocket and conducted two EVAs one of which did not go well. Dick [Richard F.] Gordon did an EVA to attach a tether to the Agena. His work position was on the nose of the Gemini. After a while, it sounded to me as if he was overworked. I used the term he sounded like "a dying calf in a hail storm." He was breathing very hard. Buzz [Edwin E.] Aldrin flew on Gemini XII and did a terrific job of doing a spacewalk.

EVA problems continued in the Shuttle Program. The first attempt to do a spacewalk was on [STS, Space Transportation System,]-5. I was the lead flight director on that flight. I cancelled the EVA on STS-5 because of a spacesuit pressure gauge problem in one of the EMUs [Extravehicular Mobility Units]. On a later Shuttle flight, we had similar problems that occurred in Gemini.

I led a review team that recommended some basic requirements to successfully implement EVAs. First, restraints are mandatory to keep the crewperson stable. Second, a disciplined approach to training in the water tank. The primary training environment of EVAs is a large water tank where the crewperson is ballasted to "float." During training you need to refrain from swimming in the water because swimming is cheating; you've got to learn how to use the restraints, use your hands, and not over-work yourself. Third, the EVA plan should be reviewed by a peer group which includes a crew person who has performed an EVA. Fourth, the EVA organization needs to step up and be responsible instead of just "supporting the crew."

I couldn't praise the EVA community enough. They have done an absolutely magnificent job in the last thirty years, particularly on the International Space Station. By 2016 there have been 193 spacewalks on ISS [International Space Station], 165 were ISS based (conducted from the ISS airlock) and 28 were Shuttle based. They have all gone exceptionally well except for the guy [Luca Parmitano] who almost drowned [July 2013] when water got in the helmet. Otherwise, the spacewalks themselves have gone very well.

WRIGHT: Before we move on, you were talking about flight planning.

HOLLOWAY: You asked, "What were the steps for developing a flight plan?" First, you need to develop a basic understanding of the vehicle's capabilities and constraints and the operational environment. Operational environment includes orbital mechanics, vacuum, and communications capability with the MCC, etc. Of course the crew's capabilities and constraints are important. Second, you need to understand the mission requirements for tests and science from a technical view and translate them into operational actions. The requirements usually came from the program office. Third, you integrated the actions into the crew time available.

Occasionally what people wanted to do was not compatible with what you could do, so you had to negotiate. I remember once in the Gemini Program a scientist was studying the wake behind an orbiting vehicle. What he wanted to do was to get behind the Agena and measure the wake field. There were sensors on the Gemini to collect the data. He wanted to maneuver the spacecraft up and down and laterally, relative to the Agena, but didn't want to fire any thrusters. Now, I don't know how he thought you could move the vehicle back and forth without firing any thrusters, but here's a guy with a Ph.D. who was serious. You have to explain the options to him

and tell him what you can do. The job was understanding the requirements, and how they could be implemented, and how much time it will take. Concurrently, on Gemini, you developed the procedures. I thought it was the best job in the world.

WRIGHT: It seems like taking the opportunity to learn, and then applying that knowledge, knowing that that knowledge could change any minute, and you still have to make it right. What a challenge that you had.

HOLLOWAY: We implemented the mission requirements considering the vehicle capabilities and constraints, the environment, the crew capabilities, and constraints to develop the flight plan.

You asked, "How did we develop contingency plans?" We analyzed the plan to determine what could cause you to want to do something different. In Shuttle, we developed the concept of a minimum duration flight during Return to Flight [STS-26] after *Challenger* [STS-51L accident]. Situations that resulted in minimum duration missions were defined in flight rules. Failures that resulted in the Shuttle being at higher risk than was acceptable for a full duration flight would be shortened to four days. That was pretty straightforward. For other situations you would determine what might go wrong that would result in a different plan and warranted a significant effort to build a contingency plan.

That was the process that was used. For some flights we had four different sub-plans. It was an interesting period, a learning period, a very good time for a young engineer to be working for NASA. Of course, all times have been good.

WRIGHT: Part of the time that you were Flight Activities Officer, you were in a Staff Support Room [SSR], and then at some point, the Flight Activities Officer was moved to the Mission Operations Control Room [MOCR]. Could you tell us the differences in your experiences of being right in the middle of everything, and was there a difference of being in the two different areas for your job?

HOLLOWAY: That was an interesting transition. Glynn Lunney, who was a young flight director at that time, was responsible for getting the FAO moved from the SSR to the MOCR reporting directly to the flight director. Previously, the CapCom [Capsule Communicator], an astronaut, was the interface with the flight director for flight plan and crew procedures. I thought that was a problem because the CapCom had not participated in the process of generating the plans and procedures and did not understand the requirements and the constraints. He tended to be overly protective of the crew and would be a bottleneck in getting things done.

The Flight Planning Group provided propellant usage data that allowed Lunney to make an important decision on Gemini IX which, I think, convinced Glynn the FAO should report to the flight director. Glynn discussed the situation with me and then got the change made. I was the first Flight Activities Officer in the MOCR on Gemini X. The change motivated flight planning and made our work more rewarding. We were able to give our inputs directly to the person who was in charge, so it made a great deal of difference in our ability to get the job done.

WRIGHT: At what point did you begin developing plans for the individual Apollo missions?

HOLLOWAY: The Gemini Program was over in November 1966. I had worked Gemini XII, so I'd been busy up until the end of Gemini XII. Assignments were already made for the first Apollo flight. Tom Stafford was scheduled to fly, at that time, the second Apollo flight, and I remember Tom explicitly asked my management to assign me to his flight. He was eager to get the timelines built. I suppose he thought I could get the job done. Immediately after the Gemini XII flight, I started working the second Apollo flight and had worked for a short period when the Apollo 1 CSM [Command and Service Module] fire occurred [January 27, 1967] during a test on the launch pad in Florida. As a result the program was delayed and redefined.

Somewhere in this time frame, I became a first-line supervisor. In those days we called them section heads. Today they are called group leads. At that time flight planners worked for me.

WRIGHT: After you learned of the fire and had time to think about that situation, did you ever think that NASA wouldn't recover from that loss, and maybe the plans that you had started to make would not reach fruition? Or did you believe that the Agency would recover and move toward its goals?

HOLLOWAY: At that time, I had a great deal of faith that we were going to go forward. It may have been I didn't understand enough to be worried about it. I'm not sure. As I reflect on those times, I always had confidence in the management team and the actions that were being taken. George [M.] Low was named the new Program Manager, and he had a very positive influence on the overall program in terms of the stability and the leadership and our ability to move forward.

So, in retrospect, I was impressed. You'd have to be impressed in terms of how quickly the Agency and the program responded to the accident, made corrections, and continued to fly. [Apollo 7 launched on October 11, 1968.] I think it reflected on the resiliency and the management skills and the leadership. They also had an adequate budget and commitment of the President and Congress.

WRIGHT: And those same leaders made the decision not too long after that to send Apollo 8 to the Moon. Could you share with us your reaction to hearing that news and your involvement in those plans?

HOLLOWAY: Ted Guillory was the lead flight planner for the Apollo 8 flight. I was working on Apollo 9. To some extent I worked on all the flights since I was the section head and worked as FAO in the MCC. When I first heard about the Apollo 8 plan, I was amazed that NASA would take that giant step. The Command and Service Module had flown one mission, and the Saturn V booster had flown twice. During the second flight of the Saturn V, two second stage engines shut down prematurely due to pogo [oscillation]. After a few days, as the team matured and got involved and started working on Apollo 8, it came together amazingly well. Challenge is what NASA responds to best. The challenge of big problems is what makes human spaceflight great. My fondest memory was when the Apollo 8 crew read the Genesis Creation story while orbiting the Moon. I can still see the stark lunar landscape on the TV downlink.

Apollo 8 wouldn't happen today. NASA leadership would never do anything as bold as launching Apollo 8. Risk avoidance, in my opinion, has gone to the extreme resulting in

excessive costs and schedule. Of course, flying five very successful Apollo flights in nine months to land on the Moon in July 1969 involved a lot of risk and perhaps a bit of luck.

WRIGHT: Apollo 9 had a new challenge because they were moved out of their rotation but still had the same objectives. Are there any comments you'd like to make about their mission and the work that they had done?

HOLLOWAY: The Apollo 9 mission—Jim McDivitt was the commander—was the precursor to the lunar landing mission, only it was staged in Earth orbit. The crewed Lunar Module [LM] separated several miles from the Command and Service Module, fired the LM descent stage, staged the ascent stage from the descent stage, and rendezvoused and docked with the CSM. Later Rusty [Russell L.] Schweickart performed a spacewalk to demonstrate the spacesuit. In terms of the system requirements, it was a full rehearsal for the lunar flight, except for the landing. All the propulsion systems were exercised, the lunar flight was exercised, and it went quite well, with one exception. Rusty did not do the full spacewalk that was planned due to space adaptation syndrome, space sickness, but he did a shorter version. In the end, it all worked out great, and the flight went very well.

WRIGHT: I'm sure it must have been a rewarding feeling to know that your flight activities plan actually went to plan. Do you recall many occasions where things did not go to plan during those early Apollo flights?

HOLLOWAY: There have been many times when the flights did not go smoothly. We have already discussed "formation flying" on Gemini VI, high spin rates on Gemini VIII, EVAs on Gemini IX and XI, and the Apollo 1 fire.

On Gemini IX, the planned docking with augmented docking target could not be accomplished due to the "Angry Alligator." Since the Agena was not available, the plan was to dock with an augmented docking target, but when they got there, the shroud over the docking target had not separated properly. The shroud was partially open but had not separated resulting in the name "Angry Alligator."

During Apollo 7, the crew continuously objected to changes and direction from the MCC. In my view, their complaints were petty. On Apollo 10, when we were getting ready to separate the Lunar Module from the Command and Service Module, we had a problem with removing the docking mechanism from the tunnel between the LM and CSM.

Lightning struck the launch system twice during Apollo 12's ascent and resulted in the Command and Service Module main power being disconnected. Fortunately, the Saturn launch vehicle was not affected, and it flew to orbit. After achieving orbit, power to the CSM was restored, the systems were operating properly, so the mission was continued. An oxygen tank explosion on Apollo 13 resulted in a massive effort to recover the crew. The team's response to the Apollo 13 accident was one of NASA's finest hours. However, I must say that it could and should have been prevented with attention to detail. A Guidance and Control Failure resulted in a six hour delay in landing on Apollo 16. The flight plan for the period after lunar ascent was completely redone. Things were not always as smooth as some like to remember.

We have not talked about the evolution of the flight data file [FDF], the material, mostly books, onboard the spacecraft. In the Mercury and Gemini programs, the procedures were

relatively simple and were an integral part of flight plan. Most of the procedures were included in the flight plan and were developed as part of the flight planning process. In Apollo and all subsequent programs, the flight plan was a timeline that referred the crew to a procedure in a checklist. The Apollo flight data file for lunar flights was a very large set of books containing checklists, cue cards, vehicle schematics, maps, and clips to help manage the books. There were 65 pounds of FDF in the CM [Command Module] and 35 pounds in the LM. The books contained various materials from timelines to detailed crew procedures, to malfunction procedures, to systems description information. So we had a large amount of procedures and timelines. A lot of it was backup information and contingency procedures.

At that time, I was managing the overall group that developed the timelines, the crew procedures, and delivered the finished FDF for launch. The checklists were managed by one individual for each spacecraft. At the beginning of Apollo there were no configuration control procedures. In the process of getting ready for Apollo 11, a large number of last minute changes occurred most of which came from the Flight Control Division [FCD]. After discussion with [Eugene F.] Kranz's organization—Kranz was managing the Flight Control Division—a configuration control system for the flight data file was implemented. As a result, I was assigned manager of the flight data file.

We developed and implemented a crew procedures change process, which included a form to propose changes that is used today. We also worked with the FCD managers to get different individuals assigned for each checklist. We were initially required to have individual drawings for the FDF books, but we got it changed to a generic drawing for each size book. The FDF manager was the ad hoc manager for the FDF including schedules, development and assembly and delivered of the FDF to KSC for flight. A control board was established originally

chaired by Deke [Donald K.] Slayton, who was Director of FCOD [Flight Crew Operations Directorate]. Later it was chaired by the Crew Procedures Division Chief.

I traveled to Florida to make the last minute changes to the flight data file and get it ready to stow on the spacecraft for Apollo 12, 14, and 16. By then I had a growing family, a wife, two boys, and a girl. We would go to Florida and typically spend two weeks to implement changes and turn the FDF in for stowage on the spacecraft. The family enjoyed the beach while I was working. They also enjoyed watching three Saturn V launches. My kids, who were very young, still talk about the launches.

WRIGHT: Where were you, and what were your first thoughts when you heard that Apollo 13 was not going to follow the plan that you had set out?

HOLLOWAY: I'd been to Cleveland, Texas, to participate as the leader in a lay witness mission, which is a religious activity where you spend the weekend with a church congregation and share your religious experiences. Those were great times, but I won't dwell on that.

I was driving home on Sunday evening after this great weekend and heard on the radio about the Apollo 13 explosion. Of course, you don't learn much on the first report from the news media. So my first reaction was one of a great deal of concern, and the second reaction was one of wanting to do what I could to help. We came home, and I immediately went to the Control Center and spent the next 72 hours working. I believe I slept about six hours during the 72 hours from the explosion until landing.

It was really a focused period where a large number of people across NASA and the contractors came together to do a huge job of getting a lot of procedures, timelines, system

management plans, and trajectory considerations worked out to use the LM for life support and the LM propulsion system to get back to Earth with the proper interface with the Earth's atmosphere. Also, procedures to charge the CM entry batteries, to power the Command Module up, to jettison the LM, and to get it ready to do the entry had to be developed. It was really a very intense period. In my opinion, the readiness and preparation of the team and outstanding leadership was what made Apollo 13 a success.

WRIGHT: Did your role during that time period change from your normal activities? Did you have more tasks that you needed to do? Could you share with us exactly what you were able to do?

HOLLOWAY: Kranz and Glynn Lunney provided the leadership. John [W.] Aaron, electrical and environmental flight controller, played a tremendous role in terms of putting it all together.

My primary role was one of providing a management function and making sure the simulators were ready and flight planning and procedures were supporting all the activities that were going on. I worked in an organization that provided the crew training, the flight plan, and the crew procedures. I made sure that people who developed flight plans and crew procedures were in all the groups that were working the various aspects of the problem. So I spent most of my time coordinating, making sure people were working together.

WRIGHT: Another time in the Apollo Program where there was a change in flight plans occurred on Apollo 11, when, once safely on the Moon, Armstrong and Aldrin, with consent from Mission Control, decided to break from your flight plan and bypass their four-hour sleep period to

proceed with the EVA. Could you share that moment with us of what it was like to be there and to witness what was going on?

HOLLOWAY: I think people already had an indication that Neil would like to reverse the sleep period and the EVA. Can you imagine the idea of being the first person in history to land on the Moon, and then after you've been there for a few hours be told to go to sleep? This probably wasn't a very good idea. So I think most people expected Neil to skip the short sleep period and get on with the EVA

Prior to the EVA, I'd been working in the Control Center on a previous shift and finally decided to go home. So I went home and watched the first Moon EVA in my living room. At that moment, the impact of the fact that we had landed on the Moon really didn't strike me. A few days later, as I was observing the Moon, it finally struck me that people had walked on the Moon, some 240,000 miles away. The enormity of what had just happened finally struck me. As I reflect back on the Apollo 11 landing, the work that the Agency did to land a man on the Moon in this decade across the Agency is amazing. I played a small part.

When I first came to Houston, I reported to work at the Human Resource Office at a bank building off the Gulf Freeway, and later went to work in the Franklin Complex, which was in apartment buildings right off the Gulf Freeway about halfway from Clear Lake to downtown Houston. Those buildings are still there, and they are real apartments today.

In February 1963, I drove down past what was to become the Johnson Space Center. NASA Road One was a two-lane highway, and I looked out across what looked like a cow pasture or an empty field. A lot of the tunnels and the foundations had already been poured but you couldn't see them from the road.

In March of 1964, I moved into Building 4, where I spent the first 20 years of my career in various offices. The office buildings, labs, and test facilities appeared in 13 months. At the Kennedy Space Center the launch pads and the VAB [Vehicle Assembly Building] were built. At the John C. Stennis Space Center, [Mississippi], the test stands to test the Saturn systems and the canals to get to the test stands were built. It all came together in the early sixties. The incredible Saturn series of boosters were developed and built. The CSM and LM were built. The quality of the flight hardware, a quantum leap from Gemini, was impressive. Landing a man on the Moon by the end of this decade was one of the most, if not the most, amazing accomplishments of the 20th century. Assembling the ISS is just as impressive.

The NASA team built the infrastructure, built all the hardware, put the flight operations together, and got to the Moon in 8 years. When people want to take six or eight years to do what looks like a small project, I remind them this country fought World War II in four years and put a man on the Moon in eight, so we ought to be able to do projects in a lot less time than we take today.

WRIGHT: I agree. The administration had decided to not have as many Apollo missions as originally planned. How did that affect your overall planning activities, and how were you able to take some of the mission objectives that you had planned for some of the later flights and incorporate them into the flights that were actually going to be flown?

HOLLOWAY: We were disappointed that Apollo 17 was the last flight to the Moon. We would like to have flown all three flights that were cancelled. The hardware was well on the way. The hardware is displayed in multiple places around the country.

Overall, we executed the plans that we had. By the time we got to Apollo 15, the activities of the Apollo Program had shifted a great deal. The J-series of hardware were developed which increased the number of experiments to be deployed on the Moon, increased the EVA time on the Moon, and made a major increase in science done from the orbiting CSM. Starting on Apollo 15, the work that was done in orbit and on the lunar surface grew. The Lunar Module got additional capability to carry hardware to the surface of the Moon. We were deploying more instruments on the Moon than we had in the past.

We also carried the Lunar Rover to the surface of the Moon on Apollo 15, 16, and 17. The rover greatly expanded the ability to traverse the lunar surface and gave a much broader range of lunar surface activities. The distance the rover could go from the LM was constrained by how far the crew could walk back if the rover failed. The activities on orbit, both with cameras and with sensors, expanded greatly resulting in a busy orbit flight plan. The program had evolved into a more focused scientific program rather than just an exploration program with some science. It came together very well and was moving along quite well. It added a new dimension to Apollo flight planning.

WRIGHT: And actually moved into a new era for you with Skylab, which brought on the long-duration flight. You were the head of the mission operation section of the Flight Planning Branch at that time. Could you tell us what your role was in planning crew activities?

HOLLOWAY: For me, transitioning from Apollo to Skylab was similar to the Gemini/Apollo Program transition. A lot of work had already been done by John Carter getting ready for the Skylab. When the Apollo program was over, my job evolved into managing the flight planning

activities in the Mission Control Center. All of the Flight Activities Officers worked for me. We had five teams of people, rotating though three shifts, who prepared the timelines and procedures updates that allowed the crew to execute the flights.

One of the first things that I worked on was defining the timeline for developing the plan in real time—we call it "execute package." We had two versions of the execute package, a smaller one that we sent the crew, and one that we distributed to the team on the ground. It was a package of material that included crew timelines, the updates to crew procedures, plus the new procedures that the crew needed to execute the timeline.

The timeline for producing the package was: 1) Develop a preliminary execute package; 2) Go through two shifts in the Control Center where the preliminary one was reviewed by the MCC teams; 3) Update the package, 4) Obtain approval by the flight director, 5) Distribute the final execute package to the team and up-linking it to the crew. So in the preparation phase, my primary contribution was transitioning from the previous program and developing the timeline and the procedures for developing the execute package.

I worked a shift in the SSR in the Control Center on all three of the manned Skylab missions. I never liked the shifting protocol. Five teams cycled thought the swing shift, the midnight shift, and the day shift. So you'd work five days, and then after a day and a half off you'd rotate to another shift. It really got old after 56 or 85 days of rotating though the 3 shifts. I also continued to be the FDF manager.

After the Skylab Program was over, I resolved that in the future we should have a different, more people-friendly way of working people in the Control Center. I did a survey to see what kind of shift protocols others were using and found several options. I didn't anticipate it would be quite so long before we would again be flying long duration missions. That was in

’73, and we just started flying long duration flights a couple of years ago, from 2002. I thought we would be there in 10 or 15 years. The Station Program may not be quite there, but they are implementing innovative work schedules so that most people can have a normal life. Of course, there are some people that like to work the midnight shift, and if you find them, it works out quite well.

WRIGHT: Before the Apollo Program came to an official conclusion we had our first partnership with the Russians and Apollo-Soyuz. Can you share with us what your responsibilities were and what your involvement was with the Apollo-Soyuz Test Project [ASTP]?

HOLLOWAY: I was not directly involved in the Apollo-Soyuz Project, and I personally did not work with the Russians. I did not build timelines or procedures. Elvin [B.] Pippert was our primary flight planner and worked with the Russians on ASTP. My primary role was one of providing the management, and I continued to manage the flight data file. By that time, I was a branch chief, and I provided the management oversight for the crew procedures and the crew timelines and the overall flight data file that the crew used to execute flights.

WRIGHT: During this time, NASA was preparing to make a transition into a new era with a new spacecraft. Can you share with us how you transitioned into the Shuttle era?

HOLLOWAY: That comes in two parts. First, after the Apollo-Soyuz Program was over, we went through a period where we documented lessons learned and spent a great deal of time

documenting what we thought we had learned relative to the flight planning function to provide that input for the future program.

Then in 1977, Gene Kranz asked Neil [B.] Hutchinson, Don [Donald R.] Puddy, and me to work on flight techniques to get ready to go do the flight operations job in the Shuttle Program. Flight techniques got started back in the Apollo days by [Howard W.] Tindall [Jr.], who did a terrific job of bringing the operations community and the technical community together to develop what I call the overall architect for the flight operations implementation. It is a framework for the flight rules and the way the flight operations group were to respond to different scenarios or different failure conditions.

Since it was the first Shuttle flight and systems were much more sophisticated than previous spacecraft, we spent three or three and half years working on flight techniques. I did on-orbit. Neil started off on ascent techniques and then transitioned to STS-1 ascent flight director training and dropped flight techniques after which I continued with orbit and picked up ascent. Don did entry. I was a very busy fellow for those years. Altogether I had something like 130 formal on-orbit meetings and about 30 meetings for the ascent work.

One interesting thing in terms of reflecting on how people work, Don Puddy could survey the situation and write the minutes before he had the meeting, and then he'd have the meeting and maybe adjust a little bit. I would have a meeting, and then try to write some minutes, and then I'd figure out that I probably didn't have the answer quite right. Then I would have to have two more meetings before I was finally satisfied that I had it right.

At the time it seemed to me that the Shuttle was fragile compared to previous spacecraft. For example, the surface of the vehicle is made out of tile that is very easily damaged. The previous spacecraft surfaces were very fracture-resistant material and very hard to damage. The

Shuttle depended totally on an avionics system driven by computers, and the previous vehicles didn't depend on those computers. The big payload bay doors on the Shuttle were going to open, and they had to close correctly. We had very sophisticated software that managed the redundancy in the systems, so we worried about what would happen if that software management system didn't work quite the way we thought it was designed to work.

I worked on the IMU [Inertial Measurement Unit] redundancy management problem to make sure that we were not outsmarting ourselves building all the software to control the IMUs. I also worked power management cases for contingency cases. For ascent I worked on the maximum altitude the ejection seats might be successful and abort options. In retrospect, I may have worked ejection too hard since there were not any options if you needed to eject. I spent a lot of time worrying about making sure that we could get the payload bay doors closed and how many payload bay door latches we really had to have.

We worked dozens of subjects like this to get ready for the first flight. The interesting thing is that for the next 20 years, as I saw things evolving in the Shuttle Program, the subjects are still the same and the answers probably stay in the same ballpark. They just are adjusted a bit.

WRIGHT: Before the first flight, you became a flight director. Tell us how that happened and why you moved into that direction.

HOLLOWAY: I worked in FCOD for the first almost 10 years of my career, and the flight directors were in a different organization until after Apollo was over in '73. In '73, FCOD was combined with the Flight Operations Directorate, and I continued to work in flight planning and

crew procedures. Kenny [Kenneth S.] Kleinknecht was the first Director, followed by George [W. S.] Abbey and Kranz as a Deputy Director

I had never really considered that I might be a flight director. I had been in a different organization, and typically flight operations did not go outside their own organizations to recruit flight directors. I had progressed to the point that I was the Flight Planning Branch Chief. I have never been one to think a lot about my long-term career path. I can truthfully say I've always thought, in all my jobs, that I had the best job in town. They were always very interesting, challenging, I was always very happy with what I was doing, and the promotions probably came faster than they should have, particularly in the early days.

So in '77, the flight techniques job came to pass, and for two years or so I did flight techniques while concurrently managing the branch. Kranz assigned Chuck [Charles R.] Lewis, Don Puddy, and Neil Hutchinson, who were flight directors at the end of the Apollo Program, as flight directors for STS-1. Then Kranz asked me to become a flight director. I suppose I can say I was the fourth guy in the group.

I haven't talked about this with a lot of people, because most people would never understand it, but I didn't know if I wanted to be a flight director. I really struggled with whether I should accept the position, primarily because it was a change. At that point, the extent of my career visions was that I might be the Crew Procedures Division Chief someday. I am a person who struggles with change.

When my wife and I were much younger, we attended a seminar where you take a test on twelve personality characteristics. You come back once a week for 12 weeks and discuss your score on one particular characteristic. One of the characteristics was on change and your responsiveness to change. In other words, were you a person that really liked new events and

new situations and changes in your life? My wife scored 90. She really liked change. I believe I scored zero, which pointed out some of the problems in our lives. Over the last 25 years we both have changed. I suspect if we took the test over again, she'd probably score 60 or so and maybe I would score 40.

The point of all of that is I really was not one who eagerly jumped to new events and new situations. I always start slow which is not all bad. About a year after I moved to the Shuttle Program, a Shuttle colleague shared with me, "You know, I really appreciate you. You didn't come in and turn the world upside down right away. You took time to figure out what was going on," which is I what I like to do.

The point is, I really struggled with whether I should become a flight director. In terms of career opportunities, being a flight director during those formative years was a marvelous opportunity. Being a flight director involves some of the best training one can get in terms of developing skills on decision making and understanding what is important and working with people in time critical situations. After struggling with the decision for several weeks, I agreed to be a flight director. I was a flight director for 13 or 14 years, counting Chief of the Flight Director Office. The STS flight directors were moved to a Flight Director Office about a year before the first Shuttle flight.

WRIGHT: Do you recall your first mission as flight director?

HOLLOWAY: The first mission was STS-2 with Dick [Richard H.] Truly and [Joe H.] Engle. Then I'll talk about STS-3, because it was my first time to be ascent flight director and was a more interesting situation.

Before we go on, I would like to add a note on STS-1. The AA [Associate Administrator] asked Dr. Kraft, who was now the Center Director, if he would be the backup ascent flight director if Neil [Hutchinson] was not available. (Dr. Kraft had been a flight director in Mercury and Gemini). Dr. Kraft said, "no way" and passed the question down. The Chief of the Flight Director Office asked me if I would do it. I asked him how much simulation time I would have to prepare for the flight. After conferring with the simulation team and Neil, he told me, "No simulation time." Neil needed, wanted, all of the available time. I told him no. The Chief of the Flight Director Office was the backup flight director for STS-1. He had been a flight director at the end of the Apollo Program but trained for STS-1 ascent by observing during Neil's simulations.

STS-2 originally had been planned for four days. A fuel cell failed soon after launch and resulted in terminating the flight after one day. I was the planning shift flight director on the second shift, so as it turned out, my one shift role during that flight was short since there was not any difficult or serious issues to work. Of course, the decision to abort the flight, after the fuel cell failure, was the predominant issue in the flight, but my role in it was secondary.

On STS-3, I was the ascent flight director and also worked the planning shift. It was a longer duration flight. Two interesting things happened on the flight. As we were approaching launch, we lost the backup computers in the Mission Control Center. We could have delayed the launch, but I made a decision to go ahead and launch. Technically, the flight rules were to delay the launch. However, based on the reliability of the MCC computers, the rule was over conservative considering the backup was mandatory for only the eight and a half minutes for launch.

Also during ascent, the cooling on one of the auxiliary propulsion systems [APU], the system that drives the pumps for a hydraulic system, was overheating. The cooling system for the APU was not working. The flight rule was to shut the APU down after the temperature reached a certain level. We first detected the problem at about three minutes into the launch. What I remember is how long it seemed to be from liftoff to MECO [Main Engine Cutoff]. It is actually 8 minutes and 30 seconds, but it seemed like the longest 8 minutes and 30 seconds I had spent in my entire life. Waiting to get a recommendation from Steve McClendon to shut the APU down just seemed like forever. Everything else was going fine, fortunately, so that was the only thing we had to deal with. I should add that it was not uncommon to have a couple dozen failures in a simulation of the eight and a half minute launch, but the real flight is a lot different from simulations.

The reason this was important is shutting an APU down would put one of the main engines into hydraulic lockup, which resulted in loss of control of the mixture ratio for the applicable main engine. The test data that supported the rule was small but overheating the APU was not good either. So at about a minute from MECO based on Steve's recommendation, I directed the CapCom to tell the crew to shut the APU off. I was later told that Dr. Kraft, who was sitting on the back row, came up out of his chair halfway over the console and then just sat back down. He was not so sure that the young man had made the right decision. Although the response to the failure was in the flight rules, I fully expected my career as a flight director would have been over if it had turned out badly. So that was one of the interesting days that I had in the early days of the program.

I was the ascent flight director on STS-4 while getting ready for STS-5. STS-5 was a very challenging mission for me. Don Puddy and Neil Hutchinson had moved to other jobs and

the new flight directors were not ready for an assignment. I ended up being the lead flight director, ascent flight director, entry flight director, and planning shift flight director on STS-5. One flight controller told me I had lost my mind, but it worked out okay. I do remember being concerned and demanding additional ascent simulations. I was also the lead flight director on STS-7, the first flight for Sally [K.] Ride.

Some others were associated with the DoD [Department of Defense] flights. I worked one DoD flight as a flight director and other missions as the mission director. On the first highly classified DoD flight [STS-51C], I was the lead flight director and had just become the Chief of the Flight Director Office. Nothing dramatic happened on those flights. All the DoD flights all went very well. Just being associated with those programs and knowing what the payload does was quite rewarding. Since the mission was classified, a small team planned and executed the missions. The small team actually made it easier to get things done.

The CIA [Central Intelligence Agency] awarded me a National Intelligence Medal of Achievement for my work on one of the later DoD flights for getting the launch off on time. The flights were so classified that it was a secret I received the medal. The way it worked was the CIA Director pinned the medal on and ten steps later an Air Force Major took the medal off and put it in a safe. The reason I can talk about it is that several years later, they sent me the medal in the mail, so I assume they declassified the fact that I got the medal. When I came home one day my wife confronted me wanting to know what this medal was all about. She did not know why I traveled that day, or that I had received the medal. So it's an interesting story.

WRIGHT: Yes. While you were chief flight director, you had the misfortune of the second time in your career to be a part of a loss not just to the NASA community, but to the nation, when we

lost the *Challenger* crew. Could you briefly describe for us the situation as you experienced it when you heard of what had happened to the *Challenger*?

HOLLOWAY: On the last *Challenger* flight, I was Chief of the Flight Director Office, and at the same time I was the mission director. We were launching an IUS [Inertial Upper Stage] flight to put a TDRS [Tracking and Data Relay Satellite], a NASA communication satellite, into geosynchronous orbit using an Interim Upper Stage [IUS]. The IUS was built by Boeing for the Air Force, and NASA procured the upper stage from the Air Force.

The mission director worked the integrated operation, including getting the IUS to geosync [geosynchronous orbit]. The mission director represented NASA when major decisions had to be made. The IUS Control Center was an Air Force Facility in Sunnyvale, California, and the TDRS Control Center was in New Mexico, [White Sands Test Facility, Las Cruces], and the Shuttle Control Center was here at the Johnson Space Center. During the dock phase, the Johnson Shuttle Control Center was the lead and the other two responded to Johnson. Once the IUS/TDRS was deployed from the Shuttle payload bay, the Control Center in Sunnyvale, run by the Air Force, was the lead until they got the system to geosync, and the IUS separated from the TDRS.

John [T.] Cox—he was scheduled to be a future mission director—and I were in Sunnyvale, California, in the management room when the *Challenger* launched. I had worked ascent flight techniques and been an ascent flight director for four flights, so when I saw the view that we all have burned in our brain, of the Shuttle breakup and of the two SRBs [Solid Rocket Boosters] going their separate ways, I knew instantly that the crew had been lost. There was no hope. I took my headset off and threw it on the floor, and then I just sat down because I knew

there was nothing anyone could do. The MCC ascent team went through the motions, but I knew there was no hope for the crew. I called back to Houston, and my secretary was weeping. She got our travel arranged to come home. John and I managed to get back to Houston that evening. Everyone was in shock but wanted to help determine what caused the accident.

It was quite a traumatic event. I believe that most of us did not believe, or at least accept, it would ever happen. Unfortunately, it did, and it can happen again. It's something that is part of our heritage, and something we should remember as long as we fly people in space. Avoiding accidents requires the proper preparation, diligence, attention to detail, and willingness to make tough decisions.

WRIGHT: September 29th, 1988, was a joyous time for the NASA community, because we returned to flight with STS-26. Share your thoughts and your experiences when you were able to be a part of that great occasion.

HOLLOWAY: There have been three or four particularly rewarding periods in my career, and the Return-to-Flight work that we did getting ready for STS-26 was one of those. Of course, the flight techniques work that I talked about earlier was one of the four special times. During the time preceding STS-26, I was Chief of the Flight Director Office. Mr. Kranz had delegated the technical Shuttle operations job to me which included the Mission Operations Director. STS-26 was the first time I had that job, and it continued until I moved to the Shuttle Program.

During this period we made changes that strengthened the operations for the long haul. We reviewed and updated the flight techniques work we had done in the late seventies and early eighties that I talked about earlier. We updated the flight rules to reflect new safety concerns.

We added a rationale for all of the flight rules to provide an historical record of why we do what we do. Flight rules rationale allows correct interpretation of the rules and improves rules implementation. We updated the strategy for ascent aborts.

We also developed and implemented a formal control process for controlling flight rules. I remember Gene and I had a difference of an opinion on the need to control flight rules. Historically, since each flight was different and each one was unique, the individual teams developed and approved flight rules. Gene thought that worked fine. I came to the conclusion that Shuttle flights had a lot of commonality, and we ought to have a rigorous process for controlling and managing the common rules. So we reviewed and updated the rules, developed rationale for the rules, developed an all-flights set of rules, instigated flight specific rules for individual flights, instituted a change control process for the all-flights rules, and implemented a process to baseline and approve the flight specific rules. I think these actions strengthened the overall flight operations and process and provided a firmer foundation for the future.

On STS-26 launch day the management seemed very worried. We had lost a crew on the last flight. Dr. [Aaron] Cohen, who was Center Director at the time, was in the Control Center with Gene and me. We were sitting on the back row in the MCC where the Mission Operations Director sat. Dr. Cohen was really concerned about the launch.

During Return to Flight, I had participated in Arnie [Arnold D.] Aldrich's team. Arnie was the Shuttle Program Director through all of the Return-to-Flight activity. He instituted a program management review where all of the primary participants in the program met and reviewed issues on a regular basis. I had watched them work together over those years, so I had a great deal of confidence that the Shuttle and the team were ready to fly. Dr. Cohen relaxed after SRB staging. It was a smooth flight. We were glad to be back in business.

WRIGHT: As a person who didn't particularly like change, once again you were moving into a new position when you got promoted to Assistant Director for the Space Shuttle Program. Tell us about those responsibilities as well as becoming the Deputy Manager for Program Integration.

HOLLOWAY: Well, I like to tell that story about change, because in the Shuttle Program and in the ISS Program, I've often been characterized as an agent of change. That's quite a dichotomy. It's not in my normal character, as I discussed earlier. Of course, most of us don't really like change. But change, in the end, can be very good for us and for the work we do.

In the phases that I talked about earlier, when I was still working in the Mission Operations Directorate [MOD] as Chief of the Flight Director Office and then as the Mission Operations Director over in the Control Center, Kranz had basically delegated the technical management of the Shuttle operations to me while he ran the administrative part of MOD. All of the division chiefs worked for him, and he managed the MOD operation contract, but eventually I got involved.

After STS-26, Kranz reorganized. He decided to focus primarily on Station. Of course, he was assuming at that time the Station would be deployed earlier than it eventually was. Eventually, he made me the Assistant Director for Shuttle Operations and put five divisions working directly for me as part of the organizations. He had another organization that was getting ready to do the Station work, and he spent most of his time working on the Station Program.

Then in 1991, Leonard [S.] Nicholson and I were driving from the [George] Bush Intercontinental Airport [Houston, Texas] after a trip when he asked me if I'd come to work for

him and be his deputy. Of course, I didn't respond immediately. After a while, I thought about it and told Lenny that I really didn't think I wanted to be a deputy. I probably didn't say it that way. I didn't think being a deputy was a good plan, and I didn't want to make the transition.

A short time later Bill [William A.] Lenoir [Associate Administrator for Spaceflight], developed a plan to transition the Shuttle Program management, Shuttle Integration, hardware projects and subsystem management to Florida [KSC]. So Leonard called me again and said, "Well, we're going to Florida. How would you like to be the Deputy Program Manager and stay in Houston and manage the flight operations aspects of the program?" That would involve requirements definition, and the overall integration of the program, working with MOD and the crew office, and chair the Mission Management Team [MMT] in the Control Center. Leonard did not discuss the plan with Brewster [H.] Shaw who was the MMT chair for all phases of the flights. I worked that out with Brewster and was the chair for all the missions during that assignment. After I became Director of the Shuttle-Mir Program and Brewster became Manager of the Shuttle Program, he actually invited me to be the MMT chair on Shuttle-Mir missions until docking occurred.

I thought about that for a while and I said, "Well, that's different. The boss will be in Florida, and the job fits well with what I had been doing." Besides John [W.] O'Neill was next in line for MOD Director, and Kranz might never retire. So I said, "Okay," and I moved over to the Shuttle Program. [Daniel S.] Goldin became the [NASA] Administrator. Shortly after that, Bill Lenoir moved on, and Goldin changed the plan. He left the program in Houston, which probably was the right decision. So that's how I ended up in the Shuttle Program in '91. Since then, it's really been fast paced.

An interesting side note, Frank [T.] Buzzard worked in Shuttle Integration. When the transition of the Shuttle Program to Florida was cancelled, he had already bought a home in Florida and effectively had transitioned to Florida. So he had to turn around, sell his place in Florida, and come back and buy a home in Houston. Sometime later, I signed the paperwork to restore Frank the money he lost in that transition.

WRIGHT: Wasn't too long after that you learned that you were making another change, because they moved you to head up another program called the Shuttle-Mir Program. How did you find out you were going to be working with this new partnership with the Russians?

HOLLOWAY: I first had a hint that some kind of relationship with the Russians was evolving, in '91. I was in Florida and got a call from Leonard. He asked me, "When could we launch a Russian on a Shuttle and do a joint Russian-U.S. spacewalk?" My initial reaction was, "Why would we want to do a crazy thing like that?" Flying a Russian cosmonaut seemed okay, but I wasn't too keen on doing an EVA with an astronaut and a cosmonaut. Reluctantly, I started looking at the opportunities to do one. That idea went away, and then Leonard said, "Well, the people want to look at a mission to fly to Mir [the Russian Space Station], and I think you ought to lead the activity from the Shuttle Program perspective." This was sometime in the first half of '92.

We went to Moscow [Russia] on our first trip in July of '92, with the task of working with the Russians to decide how we could do a joint mission. [Bryan D.] O'Connor was the leader of the NASA team. He was working in Washington, DC, at the time. The second task was to make a recommendation on what kind of docking system NASA would use. At that

particular time, we had three choices. We could continue with the development of the U.S. airlock and build our own docking system and put it on top of the airlock. A second choice was to use the Russian airlock/docking system. The Russians had a Buran airlock/docking system that would fit in the payload bay right behind the Shuttle forward bulkhead. We could use their entire system, including their airlock and their docking mechanism. The third option was to put the Russian docking system on the top of our airlock.

One of the things that I did when I was on the airplane to Moscow for the first time, was read the book on the history of ASTP [*The Partnership: A History of the Apollo-Soyuz Test Project*], and how Glynn Lunney, and [Robert R.] Gilruth managed the ASTP and worked with the Russians. They established joint teams that were aligned along "discipline lines;" for example, they had a flight planning team, a GNC [Guidance Navigation Control] team, a docking systems team, etc. Out of that, I came to the conclusion that was a good idea, and we should establish teams.

The team concept was implemented on the first trip to Moscow. Valery Ryumin was the [Russian] Program Manager and my interface through all of Shuttle-Mir and ISS. Valery was a former cosmonaut who was a national hero. He had flown three times, once on a short Soyuz flight and twice on a six month tour on Mir. He got to be famous because he volunteered for the third flight when a crewman was dropped from the flight. It came to pass that we needed a management team. We talked about a name for the management working group, and Valery said, "Well, we should name it Team Zero since management doesn't do anything anyway."

The second trip to Moscow was September '92, and the third one was in November '92. At some point after that, probably before the end of the year, I recommended that we put the Russian docking system on top of the U.S. airlock. That's what we're using today [in 2002] to

dock with the International Space Station. The rationale for the docking system was that it was a proven operational subsystem and avoided an interfacing problem between the Mir and the Shuttle. The problem with the Russian airlock was it weighed about 8,000 pounds, and the NASA airlock was predicted to weigh 3,500 pounds.

When I first started this activity, I thought it was one flight. In the beginning, based on the Station schedule, there were some who wanted to fly 10 flights. The [Shuttle-Mir] Program was the official Phase One of the ISS. Since most of the planning involved the Shuttle and ISS management was busy with ISS, I was the pseudo Program Manager without having the official title. Later I was appointed Director of Shuttle-Mir reporting directly to the Associate Administrator for Space Flight. The interesting thing is I never had a Mir meeting with the AA, so in effect I was my own boss. During my time in the Shuttle-Mir Program, we operated in a matrix fashion with the various NASA organizations and had a very small staff of three to six people in the Program Office. It worked very well, and I became a believer in very small program offices.

WRIGHT: Did you have any idea on that first trip in July of ’92 that 10 years later we would be in full partnership with the Russians on the International Space Station?

HOLLOWAY: No, I did not. I suspect that the management in Washington had some clue that that might be in the cards, but I did not know that at the time. I really thought we were working on one flight to the Mir.

WRIGHT: How did your experiences with Shuttle-Mir help prepare you for your role as the Program Manager of the International Space Station?

HOLLOWAY: Well, I think overall, the Shuttle-Mir Program did three or four things for the Station Program. The first is what the Russians brought to the table. They had in place a crew transportation and rescue vehicle in the Soyuz. It was extremely reliable. The vehicle has been used for many years, worked very well for three people, and didn't require development. It was in place and ready to go. They also had a logistics capability [the Progress vehicle] and a propulsion capability [Mir and Progress] that was quite capable and had been demonstrated on the Shuttle-Mir. So they brought to the table a readymade capability that NASA did not have. They provided an orbit propulsion system to manage the Station orbit and desaturate the NASA control moment gyros. Later, NASA started developing a NASA propulsion system, but it was cancelled. In retrospect, the Russians provided critical functions and backups that allowed the Station to proceed in the face of the *Columbia* accident [STS-107] and the retirement of the Shuttle.

The second thing the Shuttle-Mir Program did was to enable NASA to learn to work with the Russians. That was one of the major objectives of the early program, and I would characterize it in two or three categories. First of all, the culture of the Russians is significantly different than ours. They're very capable in the work that they do. Their thought processes are much like ours, but there is a lot of difference in how the Russians work, what they consider to be important, and how they relate to one another. So, the Shuttle-Mir Program gave us an opportunity to begin to understand these differences and learn to work with them in spite of the

differences. There are things the Russians do that would be insulting to you and me, but it is not in their culture. So, learning about their culture and accepting that it is okay is very important.

The Russians' overall approach to risk management is different than what we do. The Russians are able to take risk in stride better than we are. After *Challenger*, NASA does not like to take any perceived risk. The Russians are better or perhaps willing to judge what the real risks are and, just as important, what are not real risks. So there's a whole litany of different approaches of what is important, and I think Shuttle-Mir gave us an opportunity to learn to understand and work through the differences. I must add that it is still [in 2002] a work in progress.

There are problems when culture clash. The Russians had a way of doing business, and our way was often quite different. They would want to do something one way, and we would want to do it a different way. We both thought we were right, and that had to be resolved. They also felt like they were in charge. They had been flying long duration missions for 20 years, and we're the new guys on the block.

The Shuttle-Mir provided the opportunity to understand the Russians and understand how they think. One of the more important aspects of the Russian environment or culture is personal working relationships. Many Russians working in the space program have been doing the same job for 20 or 30 years, and continuity in relationships is extremely important to them. Shuttle-Mir gave us an opportunity to reestablish some of the relationships from the Apollo-Soyuz Project and to build new relationships that transitioned to the Station Program. I think in the end, the Shuttle-Mir Program provided a firm foundation for which to engage the Russians in the implementation of the ISS Program. However, the learning process continued on ISS. As Gemini paved the way for Apollo, Shuttle-Mir paved the way for ISS.

WRIGHT: Were you surprised when you saw the Buran with all of the appendages, or did you know that it existed?

HOLLOWAY: I knew it existed. I was surprised at how far along they were. They flew the Buran around the Earth unmanned once and never flew it again. They had built or were building three or four Burans, some of which ended up in museums. On my first trip to Baikonur [Kazakhstan], they gave us a tour of the Russian launch complex. They had a huge warehouse where they had stored three or four big Saturn-type boosters they never flew because they ran out of money. It turns out that four of the boosters had failed during launch without success and the Apollo Program was over.

When Shuttle-Mir came along, the Russian space program was in deep trouble. In the big picture, we didn't spend a lot of money, but the money we spent helped them survive during those critical years of the 1990s. We continued that on Station. On ISS, we bought one module from the Russians and paid for them to travel to the U.S. for joint meetings.

I did not have anything to do with setting up housing, communications, and training. It was actually done by Johnson Space Center. George [W. S. Abbey] was quite involved with it. When I first went to Moscow, the simple was not simple; the process of getting a telephone call to the United States was a big deal. It got much better after NASA implemented a central switchboard at MSFC that made calling home easy. It was like dialing long-distance. It was easy to get a phone call back to the United States by the time we really started flying Shuttle-Mir. A direct communications line was set up to a switch board at the Marshall Space Flight Center where you could be directed to any number in the USA.

The Russians' telephone system infrastructure was old. I think they skipped a whole era and went straight to cell phones. Eventually NASA rented a group of apartment units that folks deployed for long periods to Moscow could use.

Earlier, you asked me what my relationship with the Russians' counterpart was and about my relationship with government officials. The government-to-government agreements were a Washington responsibility, and I didn't get involved. Working with Foreign Affairs, they made the top-level government-to-government agreements. On the Station Program, the current JSC Associate Director [Melanie W. Saunders] played a big part in negotiating the partner agreements on ISS. My counterpart was Valery Ryumin, the Russian Project Manager for Shuttle-Mir and the beginning of ISS. As I said earlier, he was a famous former cosmonaut and being kind, he was a crusty guy.

WRIGHT: He was a force within himself, wasn't he?

HOLLOWAY: Yes. Let me paint the background. From the Russians' perspective, they were the experts. They'd been flying space stations for a long time and had been relatively successful. We were the new guys on the block, so you can imagine what their attitude was. They were getting shoved out; they got shoved out because they ran out of money.

Later I learned that Valery had an appreciative side. First of all, if you read the books about relationships with the Russians, you would learn about drinking vodka with them and getting to be buddies. It is about relationships. However that didn't do me any good with Ryumin. I didn't drink vodka with him, since I don't drink. When we invited Ryumin and a team of Russians over to our house, he brought flowers to my wife. Other than that, I never saw

him do anything just to help the NASA side of the program. I'll talk about why I think that is true in a second. We frequently did things to help the Russians such as flying tools, including supplying one to the Mir to release a stuck solar array.

My first negotiation failure with Valery was very early in the Shuttle-Mir Program. The Life Sciences people wanted to fly a "catch bottle" on a Soyuz flight to collect an air sample from the Mir. The "catch bottle" was a bottle with the air removed creating a vacuum, and you could collect an air sample by opening it, closing it, and bringing it back for analysis. Life Sciences wanted to identify what contaminants were in the Mir atmosphere. The bottle weighed three kilograms. I wanted Ryumin to fly the bottle on a Soyuz mission and bring it back and give it to NASA for analysis. I tried to negotiate with him when we were in Russia, but to make a long story short, he refused. I am sure his logic was that the Mir did not have an atmosphere contamination problem, and he was not going to waste energy on the subject.

Ryumin in retrospect, made tough and good technical decisions, and he didn't do anything just to make me happy. It would not have cost him much to launch that little bottle. Ryumin protected the image that he wasn't going to let these Johnny-come-lately guys from NASA tell him what to do. That was the kind of environment that we were in. On occasion, we would have to negotiate and decide issues. One was the requirements for the docking system. NASA procured, through Boeing, the Russian docking system. Our engineers had requirements that were over-burdening the Russians, and in my view, some were not required. I went through a process of deciding which ones we would not do, with Ryumin cheering me on when I deleted requirements.

Here is a story that relates to the process. The way we typically worked with the Russians was to have joint meetings, most of which were in Moscow. The meetings typically

lasted ten days to two weeks. During these meetings, the teams that I talked about would work and write reports; then we would write a report called protocols that said, "This is what we decided." Ryumin and I would sign it. Basically, that is still how they work on ISS today. There is a preliminary version and then, from our perspective, the Russians would have a bunch of nit-picking comments, so we would have to negotiate and make changes to finally end up with something that both of us would sign.

Ryumin and I were sitting in a little room with an interpreter—I never did learn Russian—and talking. The discussion went something like this. Ryumin said, "You know, Tommy, I don't like this program. It's not good for my country. It's not good for my company, and it's not good for me. I just don't like it."

I said, "Well, Valery, that's fine and good, but our governments have decided we are going to do this joint program, so you and I need to figure out how to make it happen, and how to do it right."

He said, "Well, Tommy, let me tell you how it is. When I have people over to my house, I spread out everything that I have and share everything I have. Then other times, when I have people over to the house, I put out just a little bit." I knew which end of that table I was on; I was on the little bit side.

Anyway, time passed. My philosophy in working with the partners was that I tried to do what was best for the program, not what was in the best interest of NASA. In other words, I tried to look out for everybody with equal emphasis. Sometimes, by the way, that was in conflict with what I perceived certain people in Washington would do.

Near the end of my shift in the Shuttle Program, Bill [William F.] Readdy was in Florida for one of the space flyers conventions where space flyers get together to tell stories, drink

vodka, and whatever. Valery and his wife, Yelena Kondakova, who was also a cosmonaut, were having dinner with Readdy. Valery said, "Well, Bill, what are you doing these days?" At that time, Readdy was working for me in the Shuttle Program, leading the effort for the Shuttle upgrades, updates, and a number of activities going on all across the Program—about $100 million a year.

Bill said, "Well, I'm managing the Shuttle upgrades program, working for Tommy Holloway."

Then what Readdy told me floored me; Ryumin said to him, "You're a lucky man to be working for Tommy." If that hadn't happened, I would never have really understood the man. So, you never know. It took the Russians a long time to recognize and honor NASA's integration role. You can imagine what a difficult time the operations guys in the MOD had during that period learning how to work with the Russians.

One of the keys to success is "work at the lowest level that you can," because if you ever get the boss to say something, that's the way it's going to be. It's true to some extent in all cultures, but particularly true in the Russians' culture. Learning to work together was huge, and probably still is. It was still going on when I left ISS in 2002. Since then, [ISS Program Managers] [William H. "Bill"] Gerstenmaier and [Michael T. Suffredini] "Suff" have gone a long way in making it better.

Bill worked for me in about three different situations. I met him when we both worked in MOD and he was a flight controller. Later, he worked Shuttle-Station integration in MOD for me what I was the Assistant for Shuttle Operations. When I was Shuttle Mir Director, I asked Bill to go to Russia when Shannon [W. Lucid] flew, and he was in Russia [as NASA's operations lead] during all of Shannon's time on the Mir. During that time, whatever he did was

right. The Russians love him. He can still go to Russia, and people talk to him. After his tour in Russia, in my opinion, he was languishing over in MOD before Ron [Shuttle Program, Orbiter Project Manager, Ronald D. Dittemore] and I brought him to the Shuttle Program Office. I would have made a flight director out of him a long time ago, and a whole different career path would have evolved. He worked in the Orbiter Project as a Deputy for Dittemore. Then he was ISS Deputy at the end of my tour. Bill and Mike continued to improve the relationships with the Russians after I left.

WRIGHT: As Program Manager of the ISS, you had so many other challenges to overcome and many goals to reach. Are there some that are more significant than others at this point in your time where you're retiring and can reflect back on your days as Program Manager of the ISS?

HOLLOWAY: The challenges in the beginning were twofold. The first challenge was to evolve to an attitude and approach that schedules were going to be met. Overall, what I found was an environment where people expected flights to slip. In effect, every organization had their own schedule. For example, one project manager briefed me that his product, according to the contractor, would be a year late. I simply asked the project manager if he wanted to be responsible for spending $186,000 a month while we waited on his product. It turns out, based on previous schedule delays, the contractor was working to their own schedule. The project manager recovered the schedules without impacting launch dates. I understand that schedule pressure should not result in bad decisions that risk the quality or safety of the program, but schedules should be worked just as hard as the other two dimensions, technical and cost, of program management.

The second part was restructuring the team to enable concurrently flying flights while developing downstream elements and providing sustaining engineering for the ISS. I thought we needed a dedicated operations team, with support from the development/sustaining organization, to focus on flying flights. As expected, some in the development organizations did not like the idea. They wanted to do both jobs. So, getting the operations/development organization wired together so it would work well and focusing on schedules were the two things that I think I contributed the most to in the formative stages of my watch.

Of course, the third thing is yet to be played out [as of 2002], and that's what to do with the cost problem. We found that there simply was not enough money. The program had slipped two years from the beginning, depending on how you measured it, and money had not moved with schedules. Changes had been made to the program that were not funded with additional money. In my view, the program had been underestimated the operations/development phase of the program from the beginning. Functions required in human spaceflight had been omitted and had to be dealt with. So dealing with the cost problem was probably the major thing that I had to contend with. I simply did not believe that we could execute the program for the amount of money that we had. We were at the point where it was time to face reality. When we were not flying flights and delaying schedules, we could get along fine with the money that we had. But if we were going to execute the program and meet the schedule, we had to face up to reality

The new administration, the George W. Bush administration, provided guidelines that the program is still working through. We went through the cost estimation process, deleted hardware and reduced the budget to the minimum required to safely execute the program. I think we have done a very thorough job of defining an austere budget for what it is going to take to do the work that is important for the future. We are also going through a methodical requirements

review of what drives the need to have a Space Station, and what can be eliminated. So it is probably another budget year or so before the results will be determined.

WRIGHT: Mr. Holloway, I would like for you to take a moment and share with us what you believe to be one or even more of the greatest challenges that you had to face during your four decades here with NASA.

HOLLOWAY: Well, it's really difficult to focus on one or two. Now working backwards, in International Space Station certainly coming to grips with this budget issue and going through the processes of the independent review committee, called the IMCE [International Space Station Management and Cost Evaluation] Committee, was a difficult time. Responding to the action items and questions and bringing all that together in a way that reflected what we think the requirements were was particularly difficult. I had been a program manager for 10 years and, although I didn't know it, I was tired.

Making judgments on where cost reductions could be made is not exactly a science. Some of these things are a matter of just having to decide. It is a matter of making decisions in terms of what might or might not be important in the future. So it was a particularly challenging time frame for us.

Forty percent of the total cost reductions that Brewster Shaw and I made when I worked for Brewster, and later when I was the Shuttle Program Manager was very rewarding. In the same time frame, I phased the Shuttle Flight Operations Contractor into the program in a deliberate, safe, and rigorous way. It worked out quite well.

Back to the ISS Program, the integration of the international part of this program is particularly challenging. I often tell people that I was the Manager of the International Space Station, not the Manager of the NASA Space Station. In that realm, NASA is responsible for the integration and overall management of the program. From that point of view, I considered myself to be the manager of an international program that included the interest of the other four partners, the Russians, the ESA [European Space Agency], the Canadians, and the Japanese. The partners' different cultures, approaches to doing business, objectives and political constraints were a very unique situation that made it a challenge.

Back in the mission operations days, getting ready for a Return-to-Flight after *Challenger* was both a challenging and rewarding time. That's something we talked about earlier. The flight techniques development for the first Shuttle flight was particularly rewarding. STS 5 was a very challenging mission for me.

Back on Apollo, Apollo 17 was challenging and rewarding. The individual assigned to do the flight plan for Apollo 17 decided he wanted a career change and changed jobs to enable him to go to law school. Other flight planners were transitioning to the Skylab Program so I ended up doing the Apollo 17 flight plan, even though I was the first-line supervisor and the flight data file manager. I worked a level deeper in the planning for Apollo 17 and found I could really get things done. It was quite rewarding.

I am often asked about some of the defining moments in my career, and I think there have been two or three. During the Mercury Program, I came to work in February. The last Mercury flight was launched in May, Gordon Cooper and MA [Mercury Atlas]-9, and the operations team went to Florida for the final preparations before launch, the flight and preparing the post-flight report. I had only been around a few months, and I didn't really know what was going on but

they graciously let me go with them. I stayed in Florida for a couple of months getting ready for the launch, and working on the post-flight report. In the early days up through Gemini IV, the Mission Control Center was in Florida, and then it transitioned to Houston.

I remember, on Gordon's flight, walking outside the Mercury Control Center to watch the launch. During launch, at about 10,000 feet, I came to the realization that a human being was in the spacecraft. At that moment I realized the awesome responsibility we have for flying people in space.

It was reinforced by an event a couple of weeks earlier when I had walked outside the cafeteria at Cape Canaveral Air Force Station [Florida] and saw a Titan, which the Gemini would eventually be launched on, pitch over at about 40 or 50 thousand feet, and be destroyed by the range safety officer. Those two events came together in my mind to give me a sense of the risks that we take when we fly people in space and the responsibilities that we have in terms of being rigorous and dedicated in what we do.

I talked earlier about working continuously on Apollo 13 to try and help in the recovery of the crew. After the Apollo 13 crew safely boarded the aircraft carrier, I remember walking across the JSC campus between the Mission Control Center and Building 4, the location of my office, and resolved that in the future the flight planning team would be better prepared to avoid difficult situations. However, if difficult situations occurred, we would be better prepared to respond and help solve the problem. I think that attitude stayed with me for the rest of my career.

The *Challenger* accident is part of the heritage of the Shuttle Program. The image of the vapor cloud, the SRBs continuing to fly, and falling pieces of the Orbiter are permanently burned

in my brain. It resulted in a team that had been through the fire and are committed to doing what they have to do to avoid similar things in the future.

I had the privilege of working in the Program Offices. I never dreamed that a few years later, I would be the Shuttle Program Manager, Shuttle-Mir Director, or the International Space Station Manager. I didn't have the slightest clue that Leonard Nicholson would open the door by asking me to work in the Shuttle Program. As I watched the team operate from '91 through '98, and almost four years as ISS Program Manager, the human spaceflight team has demonstrated that they are an extremely dedicated, committed group of people. Also, they developed a way of doing business that is disciplined and stick to the basic principles that I think are unsurpassed in our culture.

I think over the last 40 years we have tended to fly humans in space, for the sake of flying humans in space. The time has come where we must transition to having a purpose that is more related to objectives such as commercial space, scientific studies, and preparing ourselves for future exploration. There is a wide range of possibilities, but we can no longer afford to depend on the glory of flying people in space as being a reason to spend the kind of money it takes to do human spaceflight.

The international aspect of the International Space Station is extremely important. Backing up a step, the ISS has an enormous potential for doing research and technology development compared to what we have done in the past. When we complete building the Station, get all the partners fully vested, and get a six or seven people crew, the Station partnership will be able to work even better as an integrated team and will continue to build strong relationships that will be the bases for future space endeavors.

I believe the human race is destined to leave Earth orbit someday, and it will be a huge effort. Humans will routinely live somewhere else, and thus the International Space Station could be the starter for a future partnership in exploration. When the next step is taken, I believe it will be an international effort, simply because of the overall cost and the desire of other countries to be part of the next great adventure.

Also, the world is getting smaller, and as we work together, it will be much more difficult to be enemies. I believe that working together can help us in terms of coming closer together as a world society rather than a people who spend their time and energy destroying each other. So I think, in the future, we have a great range of potentials.

It is a great time to be part of flight operations. Human spaceflight is doing a really tremendous job today. Flight operations have never been executed better. Many say the human spaceflight operations are too expensive, and I think with the right focus, the sum cost can be reduced. But overall, if you have recently bought a new car, everything is expensive, and flying people in space is expensive and will stay that way for quite some time.

WRIGHT: Are there some lessons that the human race or society can learn from NASA and its pursuit of space exploration? What have we learned as a people based on what NASA has learned as a community?

HOLLOWAY: Well, I think it is interesting to observe how the Russians and the Americans interact with each other, particularly the people that were in the military. They were focused on being prepared to kill each other for as many years now, and they are working together for a common goal and are friends.

One of the things that I think you learn is that people are more alike than they are different. They all have families, and they all are very concerned about their family. They all have similar concerns about life and what is important to them. They may have a different political or economic view of what makes the world go round, but they still have many things in common with the rest of the world. As people work together and learn from each other, they come to the conclusion that we are really not a lot different; they are not really the bad guys.

WRIGHT: You had been quoted earlier as saying that the most important thing you've learned during your 40 years of civil service is that people matter most of all. You certainly have met hundreds of people in your jobs and your positions and all of the responsibilities that you have. If you had a statement that you would like to make that you have learned about what's important about people, could you share that with us now?

HOLLOWAY: I think the bottom line is that everyone is important, and the team is much stronger than the individual. Everyone can make a very positive contribution. I believe that when everyone is making a contribution, the total team is stronger and is able to do more. I'd have to admit that earlier in my career, I thought that the movers and shakers of the world were the ones who made things happen. Of course, you do need a few movers and shakers in every organization. But in the end, everyone is important. All have an important role to play, and working well together, are able to make the entire team much stronger. Over the years, I've become more and more convinced the best organization is one where the entire team and all the people are fully engaged and appreciated, and they are treated well as human beings.

WRIGHT: As you begin your exit from NASA, have you thought about what you'll be missing the most from not coming to work every day at this Center?

HOLLOWAY: My wife says my truck knows the way up to JSC. All you have to do is turn the key, and it will come to JSC. Since I came to the Program Office, I've always worked on the fifth floor, and I resolved to climb the stairs. I do not ride the elevators, either going to the ninth floor from the fifth floor, or going from the first floor to the fifth floor. That is one of the ways I have exercised over the last 10 years, so I will have to substitute other activities for climbing the stairs. So my wife and I are developing an exercise routine that we're going to implement every day. Anyway, the transition is just beginning. It will take a while to establish a routine.

WRIGHT: Before we close today, I wanted to ask you if you had any other thoughts or reflections that you would like to share with us.

HOLLOWAY: Well, perhaps a couple of things. The work associated with flying humans in space has evolved tremendously over the last 40 years. The quality and capabilities of what we do today is significantly higher and has gotten better year after year. We do things much better today than we did a few years ago or 20 years ago or 30 years, and we make fewer mistakes. The human spaceflight team is the most dedicated and capable group of people around.

The second thing is that the heritage of human spaceflight should be nurtured in terms of what it takes to carry on the tradition. The next *Challenger* will, at least temporarily, stop human spaceflight, and it must not happen. So we should remember the *Challenger* and what it takes to keep it from happening.

WRIGHT: There were many lessons that NASA has learned and many accomplishments, and a lot of that has been attributed to your contributions, and I'm sure that if we ask many of your coworkers they would be first to say that they're glad you didn't go to work at the Chicago Iron & Bridge Company but chose this position. I certainly appreciate your time today and wish you well.

HOLLOWAY: All of the people have been so kind and gracious over the last several weeks, far beyond what I deserve.

WRIGHT: Well, I'm sure there'll be a lot of people that argue with that, so just enjoy those days, and we're so glad that you're part of this Center. So thank you again for today.

Holloway: Thank you.

[End of interview]