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ORAL HISTORY TRANSCRIPT

HENRY W. "HANK" HARTSFIELD, JR.
INTERVIEWED BY CAROL BUTLER
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BUTLER: Today is June 12th, 2001. This oral history with Henry Hartsfield is being conducted for the Johnson Space Center Oral History Project. Carol Butler is the interviewer and is assisted by Summer Bergen and Kirk Freeman.

Thank you very much for joining us today.

HARTSFIELD: Happy to be here.

BUTLER: To begin with, maybe you could tell us a little bit about how you got interested in physics, aviation, and how that led to your career first in the Air Force and then NASA?

HARTSFIELD: When I went to Auburn University [Auburn, Alabama], I majored in chemical engineering. Another reason I did that is I had a cousin who went to Georgia Tech [Georgia Institute of Technology, Atlanta, Georgia] who was a chemical engineer, and I couldn't think of what I wanted to do. Then I found out I was a natural disaster in a chemistry lab. I was always blowing up things and catching things afire, so I decided I'd better change fields. I switched to physics, and I thoroughly enjoyed physics. That's a crazy story, but that's how I really got there.

BUTLER: It's not crazy if that's the way it happened. While you were in school, were you participating in any type of ROTC [Reserve Officer Training Corps] programs or did you go in the military?

HARTSFIELD: Yes, I was in Army ROTC, Corps of Engineers. When I was in my senior year, the Air Force was looking for pilots and agreed to give a commission to graduates of other branches of ROTC if they wanted to fly. So I took a series of tests at Maxwell Air Force Base and another base in Georgia and passed it all. They offered me the commission and I accepted it. So I graduated from Auburn, I went into the Air Force instead of the Army. I had previously applied for graduate school, was accepted at Duke University [Durham, North Carolina] in physics.

I was going into theoretical physics when I started there, but then the Air Force sent me a letter not too long after I got there, says, "It's time to report to active duty." I said, "Whoa, wait a minute." Too soon. So I switched over to experimental physics, experimental nuclear physics. They had an accelerator, a van de Graaff accelerator. I started doing a project to get my master's, and the Air Force delayed me until June of the following year, but not any more past that. The head of the physics department wrote a real strong letter asking for three more months, but the Air Force wouldn't give it to me, so I went on active duty and begun to fly, and discovered I really loved flying. So I stayed in the Air Force.

BUTLER: Had you had dreams of being a pilot when you were younger?

HARTSFIELD: When I was a kid, that's all I thought about, was flying. The guy my dad worked for smoked Wings cigarettes. That's an old brand that had a little picture of an airplane on every pack. He used to bring them home to me, the pictures of airplanes. I collected those cards. They're probably worth something today, but I don't know, I think I threw them away.

BUTLER: I think we've all done that. Those childhood mementos.

HARTSFIELD: Well, I mean I had a fortune in Big Little books, if you know what those are. I had two big cardboard boxes full of them. My mother gave those away.

BUTLER: Oh, all the things that might have been. When you did enter into active duty then, if you could tell us a little bit about some of your early experiences with the Air Force and with flying, leading up to when you went to the Aerospace Research Pilot School.

HARTSFIELD: I entered the Air Force in 1955, after leaving Duke, and went to primary at Bainbridge, Georgia, and basic training at Webb Air Force Base out in Texas here, Big Spring. Then I went to gunnery training at Williams Air Force Base [Mesa, Arizona] and flew F-86Fs there.

My first duty station was at Seymour Johnson Air Force Base in North Carolina, Goldsboro. There I flew F-86Hs, which was, I think, one of the finest airplanes I've flown. It was more of a pilot's airplane. It didn't have any unusual characteristics and was a good performing airplane. It was a bigger F-86 than the normal variety, had a bigger engine in it, a little heavier, but it was a heck of a performing airplane.

We transitioned out of that airplane to the F-100C, which was one of the early F-100s. The "A" model was the first one. They didn't build "B." They had the "C." The "C" didn't have wing flaps, so it had a very high landing speed. We used to call it the world's fastest tricycle because of the high landing speed. Flew that for about a year or so.

Then we transitioned to F-105s, the "B" model, which was one of the early 105 models that didn't have any rigged flaps, for example. The 105 had leading edge and training edge flaps, and it had a separate lever for each. The later version's got them all on one handle so that when you pick the different positions, they gave the right configuration for the speed range you were going to be flying in.

From there, I was a fighter pilot, so I flew all those years around different bases, mainly at Seymour Johnson, but we did some extended TDYs [temporary duty] down to Eglin [AFB, Florida], put on a lot of firepower demonstrations for the Army, dropping live ordnance, which was fun.

They'd been there about four years. This was in late [19]'59, early '60, I decided that I wanted to get some education that would lead me into the space program. I was kind of getting interested in it. Big rockets were flying then. I'd elected to get a master's in astronautics, as the Air Force called it, and I was selected to attend the Air Force Institute of Technology, which was at Wright-Patterson Air Force Base [Dayton, Ohio]. So I went up there in 1960.

In the spring of '61, as a matter of fact, I was getting a haircut, and on the radio they had the flight of Alan [B.] Shepard [Jr.]. I said, "That's what I want to do." So I started researching what it took to get into the space program. All the people that had been selected at that point had been test pilots. So I said, "Well, I've got to go to test pilot school." Then I find out I didn't have enough flying time. So I applied for an overseas assignment.

Actually, I quit the school for two reasons. One, my family was very unhappy there. I was unhappy because the class that was graduating that summer got their assignments and not a one of them had a flying assignment. They were all going to silos to baby-sit missiles, and that wasn't what I wanted to do. So I quit. I was fortunate in that SIE, self-initiated elimination, was a bad, bad thing in the military, but I had done my homework. I had researched and found that the flying skill I had, specialty code for [F-]105, was a critical skill. They were staffing overseas. In fact, they were building up two bases over there with 105s, Bittburg [AFB] and Spangdahlem [AFB] in Germany.

Secondly, I'd never been overseas, so I was ripe for an overseas assignment. That kind of airplane, 105, later modified to 105D, was the kind of experience I needed to go to test pilot school. Having done all the homework and finding an ally, the military assistant to the dean in

the outfit was on my side. He felt that if you volunteered for a program and it really isn't leading you where you want to go, you ought to be able to resign without prejudice, and he supported me with—a [Tape interruption]

BUTLER: Okay.

HARTSFIELD: So the military assistant to the dean supported me, and I was allowed to resign without prejudice. It was about a month later I got the assignment to fly 105s in Germany. All the people in my class said, "Oh, you pulled strings. Who do you know?"

I said, "I didn't pull any strings. I just researched." I had not been to an overseas assignment. I had a critical AFSC, a critical skill, and the odds were I was going to get what I wanted, and it worked out.

So I spent three years in Germany. It was a good assignment. I enjoyed that, flying fighters. We always did our gunnery training down at Tripoli [Libya], because the weather was great down in North Africa. So I got to visit that base, the big base that now belongs to [Moammar] Gadhafi [Libyan Head of State]. The Libyan Air Force wasn't very big in those days. I remember one day we laughed about they had two-thirds of the Air Force airborne at one time. They only had three airplanes, and two of them could fly. [Laughter]

BUTLER: [Laughter] Well, I guess everybody's got to start somewhere.

HARTSFIELD: But it was a good assignment, and it helped me build my skills. When I got past the magic mark of 1,500 hours in high-performance planes, I applied for the test pilot school and was selected right off the bat. It was first try, so I was fortunate.

I made my way to Edwards [Air Force Base, California], and that was a good experience as well, the test pilot school. I enjoyed that. Had a good class. We had a lot of fun together.

We had a lot of competition in the class, friendly competition. We had four of us that were within a few points of each other, total score, when we got to the end of the thing to graduate. They had a trophy they gave to the top graduate, you know, and it ended up I was fourth. But the four of us were within one point.

The guy that got the trophy, I'll tell you about him. He was a really sharp guy, but out of my class at the test pilot school, four of us got in the space program, but the top graduate wasn't one of them. It was kind of interesting. The others were Al [Alfred M.] Worden, Charlie [Charles M.] Duke [Jr.] and Stu [Stuart A.] Roosa. You may have talked to some of those. Well, not Stu. Stu died here a couple of years ago. Stu was my next-door neighbor at Edwards. We had a lot of fun together. His widow and us are still very close. We've known them for years.

The three services handled the applications for the space program differently. It was kind of strange that NASA had requirements and the military had requirements at the same time, and the military was asking for flight crews for their Manned Orbiting Laboratory [MOL], and NASA wanted flight crews. The way the Air Force did it, you could apply for either program or both. If you applied for both, the Air Force would decide which program they would nominate you for. They wouldn't send you to both programs, your application. The other services did it the other way.

I remember Charlie and Stu said, "Hank, better apply to NASA only. If you apply to both, they're going to send you to the Air Force," and they did.

I applied for both and was sent to the MOL Program. But we had a lot of fun with that program. It was a challenging program, but it was a little bit depressing to see the funding issues that we had. It was almost a constant story. Every year we had a big funding profile where we had to get 600 million dollars in one year, which wasn't a lot of money, but that was big then. The program planned on that, and then would come the budget was actually passed, "You're only going to get 400, but plan on 600 next year." So the program had to go through all

this rephasing everything. It takes a while. We'd spend about ninety days just rephasing the program, turning subcontractors off for a while, and that's expensive. Finally you get the program on track and the next year went through the same cycle again. Well, we thought we were going to be, but, "No, you still aren't going to get the 600." Four hundred again plan.

Of course, as the program stretches, the cost goes up because you've got a marching army. So the cost of the program had almost doubled in three years. In fact, we always had a projected launch date. It was kind of funny, Bo [Karol J.] Bobko was in that program with us, and he had made a graph of where the launch date versus the real time, you know, to see where it projected we would launch. He said, "Gee whiz, we launched in 1929. I didn't know that." [Laughter] We were losing ground from the launch date.

I think at the time the program was canceled in June [19]'69, on Black Tuesday, we had a projected launch date, as I recall, of April '72, so it was slipping away from us. But we were at the point where we flight crews were getting ready to move to Vandenberg [AFB, California]. We'd already been up looking at base housing. The crew quarters were built, the training building was built, it wasn't completely outfitted. The pad was 90 percent complete that it was going to be launched from. We were going to be launched on a Titan 3M, which was a modified Titan 3 with seven segments, solids [solid rocket boosters], instead of five.

It was an interesting program, and the Air Force kept it highly classified, and they still haven't unclassified what it was all about, but a lot of people speculated. But it kind of broke our hearts when it got canceled. I won't forget the day. I was on my way to Huntington Beach [California].

The Air Force had a strange contractor arrangement. They had co-contractors, which was kind of unusual, like having two prime contractors. One was Douglas [Aircraft Company, Inc.] and one was General Electric, General Electric out of Pennsylvania. I spent a lot of time in Valley Forge [Pennsylvania] area up there, and Douglas down in Huntington Beach.

I was on the way to a meeting at Huntington Beach at 7:30 in the morning, listening to the news as I always was. They used to call me "Ned News," because that's all I did. L.A. [Los Angeles, California] had two news stations, 24-hour news stations, and I'd flip back and forth between them. They came on this newscast and said, "This morning, Deputy Secretary of Defense [David] Packard announced the cancellation of the Manned Orbiting Laboratory program." What? Well, I didn't like that news channel, so I switched to the other one, and I got the same report. So I thought, "Holy cow, what do I do? I'm on my way, I'm halfway there, I might as well go on."

When I got to Douglas and walked in, it was like walking into a morgue. I mean, it was just sudden they canceled the program. The general that ran the thing at L.A. was a little bit miffed. "A little bit" is putting it mildly, because he argued with the people that made the decision during the night, said they were going to announce it at 10:30 in the morning Eastern time, which was 7:30 in L.A. He says, "Let me tell my people first."

They said, "Well, Secretary Packard's got a busy day, and that's the only time he can do it." So they went ahead. So no one on the West Coast knew it. It caught them completely by surprise. They heard it on the radio like I did, or they came to work and found out they didn't have a job. It was massive layoffs. I mean, people were getting pink slips almost immediately, you know, on the contractor force. So it was a very unhappy day.

Well, then they said, "Well, what do you want to do?"

I said, "I don't know. Go to Vietnam." I mean, we're all fighter pilots.

They said, "Well, you can go, but you can't fly because you've got a two-year duty and travel restriction." Because of the classified things we'd been exposed to, we couldn't be put in an environment where we could get captured. They said, "You can go to Saigon, work in a command post."

I said, "Baloney. I'm a pilot. I'm not going to sit in a darn command post and ride a chair," you know. None of us wanted to do that. So everyone took different assignments.

There were three of us decided we wanted to go to school, might as well get a master's in the interim. Then I'd be eligible, two years would be up, and I could go do what I'd been trained to do all those years.

So somewhere in there, I think it was early July, Dr. George [E.] Mueller, he was the person that swung it all, recommended to the folks up there, "Hey, you know the Air Force has got fourteen people there that have already been through all the wickets. They're partially trained. Why don't we take them down to NASA." Well, I found out later, a lot of the NASA folks didn't want us, you know.

But in any event, all fourteen of us came down to Houston, and we toured the facilities and talked with the people about the prospects. I think Tom [Thomas P.] Stafford was running the astronaut office then, because Al Shepard was getting ready to fly Apollo 14. So he toured us around and told us, "Well, you know, if you do get here," he told us the situation, Apollo 20 had already been canceled, but we had 18 and 19, and probably going to fly the second Skylab vehicle and maybe a third one. So there were opportunities to fly pretty soon.

But nothing came of it. So I moved out of my house, went out to operations at LAX [Los Angeles International airport] to pick up my flying gear, and I'd just picked it up and I was walking back to the car. I had the family in the car, we were all packed, the moving van already picked up all our household goods. I was going back to the University of Tennessee Space Institute in Tullahoma, Tennessee, to get my master's. A guy came running out of ops [operations] and yelled at me. He says, "Captain Hartsfield, you got an important phone call. Come back."

So I went back and talked to him. It was Bob [Robert F.] Overmeyer. He said they'd just gotten word from NASA that they wanted seven of us to come to Houston, and three of us, as I say, had school assignments, Don [Donald H.] Peterson, Bo Bobko, and myself. So I went back in there and called Tom and asked him, "What do you want us to do? Cancel and come on to Houston?"

He said, "No, it's going to be a while before you fly. Go ahead and get the master's degree, and then you'll be in better shape to work for us." Of course, some of us wanted to really go down there, and he insisted my idea wasn't a good idea to make your potential boss mad, so we said, "Yes, then we'll go to school." So that's what we did. Went back to the office one day, we stayed in the motel, and then headed out to Tennessee, and stayed in touch, in fact, even made some visits to Houston and to the Cape [Canaveral, Florida] to start getting indoctrinated when I had breaks in school.

BUTLER: Before we go any further, if I could ask you a couple follow-up questions on the MOL Program. I know some of it is probably that you can't go into much detail on. As you said, some of it is still classified to some degree. But if you could, describe a little bit about what the program consisted of with the Gemini capsule, the laboratory, and some of your training. I don't know if you can go into any of that.

HARTSFIELD: Well, the idea of the lab, as I recall, was about forty feet long, to fly on top of a Gemini and on the top of a Titan booster. On top of the lab or at the end of the lab was the Gemini vehicle. They had designed it with a transfer tunnel between the Gemini and the lab internal, pressurized tunnel, and this tunnel was accessed through a hatch. In Gemini, you sat at a slight angle, and right between the two crew members was this hatch that went through the heat shield. So you would reach, undo that, and pull it into the Gemini where then you could crawl down the tunnel into the lab.

Now, the concept was that once in orbit, it was a thirty-day mission, you crossed through the tunnel, and you stay there thirty days doing the experiments, and at the end of the thirty days, you brought the data capsule back with you, the data, and stowed it in Gemini. There wasn't much room, but they had it planned so you could get most of the data back. And you closed that hatch and came home.

Well, they had a concern. Okay, now you cut a hole in the heat shield. Is that going to work? So they actually built one that way and tested it on a flight out of the Cape. They launched the Gemini, unmanned, of course, on a Titan, and then the Titan had a trans stage, which was like a little third stage. They drove that Gemini. It went up, and then drove that Gemini at the proper entry speed back into the atmosphere, then the trans stage went on out to change the attitude and burn back into orbit, and it came through with flying colors. The cut to the heat shield didn't hurt anything. There was no heating problem or any burn-through or anything like that, so it proved the concept.

The program, the support for the lab, had quite an extensive software development program, which was going fairly well. We had solved some major problems with that. Avionics. I was following the communications system. Each crew member had some area they followed. Communications was coming along well.

We were really disappointed when the thing was canceled, because at the time it was canceled, we could touch flight hardware. They had flight hardware being built and tested. In fact, one of the modules which Douglas built had already been shipped to GE where they were going to install the guts of the lab. So that was coming along real well.

As I say, the pad was 90 percent complete. A lot of the construction at Vandenburg had been completed. The buildings were being outfitted, and we were becoming convinced that the program was real, it was finally getting off the ground. We would be able to do something, even though it was still a couple of years away.

The training was on the operations, and I can't say too much about that. We'd started that. A lot of our early training was in a development sense. We were participating in the development schemes for running the experiments. So that was the early part of training. We also got some of the routine survival training. We'd had water survival. We'd gone down to Panama for jungle survival. We were getting that kind of training to get ready to go, because we were going to fly out of Vandenberg into high-inclination orbit, which meant you covered a

pretty good piece of the world. If you had to abort, you could almost go anywhere, jungle or polar regions.

But it was a fun program, as I say, and we had good people working on it. It was just a sad thing that they never got enough money to make it go.

BUTLER: During some of my research, I was coming across some articles that talked about some of the interaction between the Air Force and NASA during this planning. Along with the budget problems, there had been some critics saying that the programs were duplicating, and that actually NASA and the Air Force were trying to work together to make sure that they weren't duplicating and exchanging information back and forth. Did you personally have much interaction with any NASA personnel at that time?

HARTSFIELD: Not at my level. I had made one trip down to Houston. We talked to some people. Mike [Michael] Collins, and some others down here, we had some conversations with, regarding different aspects of space flight, just trying to get smart, things to plan for, things not to plan for. There wasn't that kind of contact, and from what I know, we really didn't have a conflict. There wasn't duplication, is what I'm trying to say, because things that we were trying to do in space were totally different from what NASA was trying to do. We weren't duplicating anything. Even though it was called a laboratory, it was different kinds of experiments. So it wasn't duplication.

BUTLER: Actually, a little bit later, after you had moved into NASA and the astronaut program, the Russians put up their Salyut, which may have had some similarities, and I realize you may not be able to compare some of those. But were you aware of the Salyut when it went up?

HARTSFIELD: Yes. We read *Aviation Week*, so we knew what was going on. *Aviation Week* had pretty good sources. They dug out some information. Of course, at that time, we didn't have a lot of contact with the Russians and there was speculation on what they were doing. And the Salyut history, now, we go back and we know that some of those had military purposes almost totally, even up until just recently. In fact, even Mir early had military experiments going on. Whether that duplicated what we did or not, I can't say. But there was definitely an interest on the Russian part, military, but that whole program was military. If you recall, it was run by the rocket forces. It is today. I think they reorganized here under the rocket forces, but the military did all the launches even until about a year ago. I think they still do them now, but the organization is different and their reporting is slightly different. It was always a military program. There was always a Russian general had the final say on whether the crews launched or not. There was a gentleman by the name of Ivanov [phonetic]. I don't know, I think he's been replaced by another general. He retired, I think.

BUTLER: Was there, in light of the Russian activities, did you hear any stir about trying to reactive something such as the MOL, or had things pretty well by that time moved into more unmanned type of operations for the military?

HARTSFIELD: I think that it'd gone to the unmanned. MOL, when it was canceled, there wasn't much of a chance of reviving that. It was a disappointment to us, and I think it would have been a successful program, but it just didn't go.

BUTLER: The Air Force did have a variety of programs that it was trying to get into the manned space aspect of things between MOL, Dyna-soar, and some others. What was some of the driving considerations of having manned military programs, but then actually they did shift to unmanned military operations, which did provide quite a bit of information and were quite

successful? Can you compare some of those or look at what some of the early motivation would have been for manned?

HARTSFIELD: I think the primary driver was a person, a human being, is probably the only computer around that can reprogram in a hurry. When you operate any kind of an automated vehicle, you can only operate under terms that you program into it, and it can't react real time. The early attempts, I think, by the military were to investigate what a person in orbit could do, what they could see and what they could do, and what kind of things they might control from space. It was those kinds of things, you know, what can the military person do. It was unknown, an unknown quantity at that time.

So the focus was on that, and the Air Force, for DoD [Department of Defense], was trying to get a vehicle up there. They started with Dyna-soar. In fact, Al [Albert H.] Crews, who was on the MOL Program, was supposed to be a Dyna-soar pilot. After that program was canceled, he had the opportunity to come down to NASA, but not as an astronaut. He was too old. In fact, there were fourteen of us on the program, and what they decided was to take the seven youngest. They drew the line at age thirty-five. They said, "If you're over thirty-five, unfortunately, we can't take you."

There were seven of us that were under thirty-five. I was thirty-two at the time, but I remember Abe, [James A.] Jim Abrahamson, Abe was on the program. Abe was two months past thirty-five. He argued with them, but he didn't win. But Abe went on to become Code M [NASA Headquarters Head of Manned Space Flight] and run the program for a while. He was a young-looking fellow.

I remember Jim—what was Jim's name? He was the space reporter for the *Houston Chronicle*. Jim, a little short guy, I can't remember his name to save my life. [Jim Mahoney of the *Houston Post*.]

BUTLER: I know who you're talking about, but I'm drawing a blank.

HARTSFIELD: I remember it was [Donald K.] Deke Slayton's retirement party at [the] Gilruth [Center], and Abe was flying down from Washington with a special award for Deke, and they had weather problems. He got there a little late. I wish I could remember that guy's name. Anyhow, he was standing by the hors d'oeuvre table, and I was standing next to him. Abe came in and walked around, walking really fast up the far side of the Gilruth Auditorium there. He turned to me and he said, "Is that Abrahamson?"

I said, "Yes."

He said, "He looks so young."

I said, "Well, believe it or not, he's older than I am."

Whatever was his name, he turned to me, and he says, "How can that be?"

I said, "Well, he was born before I was." [Laughter] And I thought he was going to hit me. I inherited my daddy's tendency to white hair. My hair was turning gray, I had little gray streaks, when I was in my late twenties. By the time I was in the middle thirties, it was really starting to gray up, so I grayed at a young age. But I guess Jim was looking at that.

BUTLER: That's pretty good. That's a good story.

When you did come over to NASA, what were some of the—you said you were in school, obviously, finishing your master's first. But once you began training with NASA, what were some of the differences or similarities between either your training or even some of the equipment between MOL and NASA at that point, or were there many by then?

HARTSFIELD: Of course, the basic physics involved in flying in space doesn't change. I mean, you've got orbital mechanics and those kind of things to worry about. And systems, you know, having worked on the MOL Program, a lot of us had some understanding of different space

systems and the kind of compensation you have to do to systems to make them operate in a vacuum and micro-G [microgravity] environment and sometimes severe thermal environments. You have to deal with all that.

So from that standpoint, I think we were well prepared when we came down here. All seven of us went to work and we were given assignments. I don't even remember now some of the things that we did. First, it was little jobs, you know, and most of us were given support assignments of one kind of another. Early on, I was assigned to the support crew for Apollo 16 and wound up being a Capcom [capsule communicator]. I got an awful lot of time in the simulator.

Since [Thomas K. "Ken"] Mattingly [II] had trained for Apollo 13 and had been exposed to the measles, he was taken off that flight and put on Apollo 16. Then he had gone through a lot of that training before for the command module part of the mission, and he asked me to verify his flight plan. So I flew many, many hours in a command module simulator. I flew all his entire flight plan, virtually, to make sure it all played and the timing was right. So I learned quite a bit about Apollo at the time and then wound up supporting the mission as Capcom.

It was kind of exciting when we had the abort here. If you remember, they didn't land on the first opportunity. The plan was for the command module to take the LM [Lunar Module] down to an elliptical orbit with a low point, I think, of ten miles. They were nominally up at fifty or something like that. I don't remember the exact miles. They made the burn with the command module, and in that elliptical orbit from the low altitude, that was to save fuel for the lunar module, so they would have more fuel for the descent, and they dropped the LM off, and then these circular burns had to be done on the far side of the Moon.

So on the back side of the Moon, Ken was supposed to burn the command module and service module engine again to raise the orbit back up to circular. It seems like that was sixty miles, but I'm not sure. In any event, I knew things weren't going well because we didn't get the

acquisition of signal like we should have. First thing he said was, "No circ burn." Well, that just shocked us all.

I said, "No circ burn?"

He said, "Roger." What had happened, when he did the gimbal checks on the service module, the secondary gimbals oscillated, they weren't stable, and that was a no-go. Well, if they didn't do the circ burn, that meant we had to pick the LM up and call it quits, I mean, you know, we couldn't do it.

What was amazing was how quickly NASA responded. Lunar orbit is about two hours. So from the time that happened, in four hours they did a test down at Downey on the iron bird. You know, they had a model of all that gimbal system out there with real hardware. I think Stu Roosa did that test and determined that—they duplicated the problem, whatever it was that made it oscillate. But they determined it was a stable oscillation. It didn't diverge. And if you had to, you could use it.

So the flight rule was that you had to have a backup or you come home, because if you didn't have a backup, you're one string, and that engine is the only thing that's going to get you home. So the next burn is come home, kind of thing. So once they knew they had the backup, two revs later, Ken did the circ burn. They fortunately never had to use the backup gimbals, even on the burn to come home. But it was a good example of how quickly NASA responds.

That part made the mission exciting. It made it exciting, too, from the standpoint that the carefully constructed flight plan now went in the toilet, because they were four hours late and had to replan everything. Also, they had the crew missing a switch when they left the LM, you may recall. The flight plan was all marked up. I wrote up change after change after change for them to modify their checklists. In the interest of getting the crew some rest, they had broken the deactivation of the LM up, as I recall, into pieces instead of a continuous thing. I mean, they broke it up so that part of it would be finished the next day.

Then doing all this markup with a checklist, somewhere along the line, and no one knows why, you never know, a switch was missed, and when they separated from the LM, the ground didn't have control of it anymore. They were going to fly it from radio control from the Earth, and their plan was, as they do in all those, they crash the LM into the Moon and they had seismometers on the Moon to study the geology or how the Moon was put together, the structure, and they could get the impact transmitted around to the seismometers they put out. They didn't have control of the LM. It eventually crashed into the Moon, but it was disappointing that this didn't happen [as planned]. But that's what happens when you mess up a flight plan.

But it was a lot of fun. I enjoyed working that mission. That was a good crew.

BUTLER: Were there good interactions between the support crews, the backup crews, the prime crews?

HARTSFIELD: Oh, yes, yes. We spent a lot of time at the Cape with them, supporting them. Charlie Duke and John [W.] Young and Ken were all great people to work with. Ken's a little bit of a workaholic, but everybody knows that. So when I got my first Shuttle flight, he was my commander. We spent many, many hours getting ready for that, but it was a lot of fun.

BUTLER: It certainly sounds like an interesting opportunity for you there.

HARTSFIELD: It was. And I worked for a short time right after I got there—I'm trying to think whether it was before or after that. It was after that mission, I think, I worked for a very short time with the Space Station Program. In those days, NASA had decided what the next step was. There was proponents to building a big space stations. Others said, "Let's build a Space Shuttle,

a transportation system." In fact, in the early day it was called STS—in fact, it still is, Space Transportation System.

The grand concept then, as I recall, were a whole bunch of components, which included the Shuttle. It did include a station, eventually, as part of this thing, a permanent station. It was like a docking place. A tug that would go—what am I trying to say? The satellites, the fuel stations in orbit would go back and forth. You had a lot of components, but we wound up only building the Shuttle, of course.

In fact, I remember going out to Seal Beach [California]. They had a mockup of the Station out there that was based on an S-II stage, Saturn second stage, which was huge. That stage is thirty-three feet in diameter and 130 or 40 feet long or something, so to allow that big a diameter and four decks, it was a fantastic Station. They opted to go the other way.

In fact, John Young was on the Moon when NASA made the announcement that they were going ahead with the Shuttle Program. It was an interesting time. I remember one night I was Capcom and I'd been talking to the crew on the Moon. I walked out, and it was an absolute clear night. It was absolutely beautiful in Houston. It was nighttime and there was the Moon up there. All of a sudden, it hit me, I was just talking to some people who were up there. It's just mind-boggling, you know, that you could get that great experience. I don't know why it hit me then, but it did.

I get frustrated now with these idiots who say we really didn't go, it was done with smoke and mirrors. I mean, I know the people, I know what was there, I have seen the parts that come back, I talked to them, I watched them leave, you know, I watched the tracking radar. I mean, there's no doubt. I don't know how anybody can be so stupid to think this was not real.

BUTLER: I wonder if they even took a little effort to think and had question, supposedly, if they took a little bit of effort, they could talk to people like yourself.

HARTSFIELD: You'd think, though, really, in this day and age, that if it had been faked that somebody wouldn't have talked? You couldn't keep a secret in this country if you wanted to.

BUTLER: No, certainly not.

HARTSFIELD: I mean, maybe there's some zealots who would take something to the grave with them. There are people that are willing to die for what they believe in and will keep their mouth shut if it's a conspiracy kind of thing, but to pull off something of that magnitude, there are too many people involved to make it work. There's no way you're going to keep that secret, no way. Are you familiar with the [web]site NASA Watch?

BUTLER: Yes.

HARTSFIELD: [Daniel S.] Goldin would have a meeting behind his doors up there, and it would be on NASA Watch before the night was over. I mean, who's leaking it? But I mean some reason, somehow, they knew what was going on, what was being said in there. It's crazy.

BUTLER: Yes, the word certainly spreads very quickly, very quickly. Part of, I guess, being in an open society. There's not much that is hidden, and certainly not anything of that magnitude could be.

HARTSFIELD: No, and people see things they don't understand and they try to ascribe other reasons to it.

BUTLER: Yes, without looking into the scientific facts and the flag-waving and all those things, there's very simple basic explanations.

But it is interesting that you mentioned your moment of realizing all that was going on. At that point, what were your thoughts about being involved in the space program? At that point, did you realize that the later Apollo missions had been canceled?

HARTSFIELD: Yes, by the time we got to Houston, they'd canceled 18 and 19. They were, of course, no longer talking about building a third Skylab, and somewhere along in there they decided that they weren't going to fly the second vehicle, which is now in the Smithsonian. So all the seats went away. So the only thing left was [the] Apollo-Soyuz [Test Project, ASTP]. Of course, that was for the Apollo crews to fly, the ones that still hadn't flown, along with Stafford. It was good to see Deke get his flight.

BUTLER: I bet.

HARTSFIELD: Flew a long way. But during that period, I worked on the Shuttle Program. I was given the responsibility of working with the engineers to develop the flight control system, the entry flight control system. I had a lot of fun doing that. I spent many hours in simulators at Downey [California, at the Rockwell International Corporation facility] and here. We were primitive at first, just looking what kind of control laws we want, all the way to very sophisticated ones, trying to figure out what the aerodynamics is like.

I don't know what the final count was, but, as I recall, the Shuttle Program had over 22,000 hours of wind tunnel time to try to figure out what it flies like. Because the decision had been made, there are no test flights. We were going to fly it manned the first flight, and an orbital flight at that, which demanded that, the best you can, understand this. Well, hypersonic aerodynamics is difficult to understand, and it requires—well, let me put it this way. The uncertainty on the aerodynamic parameters that you get out of the [wind] tunnel are big. The things that we were looking at in the simulations were if these uncertainties in the different

aerodynamic parameters stack in a certain way, the vehicle could be unstable. What we were looking for, for those combinations, statistically were possible, but hopefully not very probable they'd happen, but if they did, that was the kind of things we had to plan for.

We had developed an idea of what we called downmoding. There were flight control laws, modification of flight control laws. We had a switch in the cockpit on the *Columbia* that we could throw. Fortunately, we never had to use it, but it was a backup thing, and there was a lot of controversy over it. I remember there was some strong feelings from Chris [Christopher C.] Kraft [Jr.] about not liking that technology, that capability. I felt strongly that we ought to have it. It was my feeling that John Young wanted to have it, although we were fortunate in that the aerodynamic parameters weren't too far afield. Although we had some aerodynamic parameters, they were outside the predicted bounds of uncertainty, but, fortunately, they weren't combined with any others that would get us in trouble.

It's just an uncertain world. You can't predict, because in the wind tunnel, you have to put in scaling factors. If you're doing wind tunnel things off a small model, it doesn't really scale to the big model perfectly, and you have to make assumptions when you do that. The scaling ratios have a big factor, a big effect on what the real numbers are. So if you could fly a full-scale orbiter in the wind tunnel, it would go mach 15 or something, it would be great, but you can't do that. You have a little-bitty model, and it's a shock tunnel or something. You'd get a few seconds of runtime at the right mach numbers, and then try to capture the data off of that.

So it was an exciting time for me when we flew that first flight, because watching that and seeing whether we was going to get it back or not. Of course, we didn't have com all the way, and so once they went LOS [loss of signal] in entry was a real nervous time to see if somebody was going to talk to you on the other side. So it was really great when John greeted us over the radio when they came out of the blackout. So it was flying okay.

BUTLER: It did perform very well.

HARTSFIELD: Yes, excellent.

BUTLER: Then you had been involved to some extent on some of the approach and landing tests with the Shuttle Training Aircraft [STA], is that correct?

HARTSFIELD: Yes. As part of the flight crew's training development, I flew the Shuttle training airplane. I flew the TIFS airplane, total in-flight simulator, which was something Calspan [Corporation] had. That was a modified Convair with an extra cockpit out on the nose, and you crawl through in there. But in the back were computers, and the airplane was modified with direct lift flaps and controls that let the cockpit give you the feeling, the motions, that you have in the real vehicle that you were simulating. It was used by Calspan mostly in support of airplane development, Air Force development programs, all military, to model different airplanes, and then the flight crew could fly them and give their opinion of how many characteristics and qualities and make them push the redesign and modification of flight control.

We used that quite a bit in developing the Shuttle. Then we developed a Shuttle training airplane based on G-2 [Grumman Gulfstream II]. That was a great accomplishment, I think. How we had predicted the Shuttle would fly subsonic was pretty doggone close. When John's comment after, you know, was when we made that first approach with the Shuttle was the Shuttle training airplane paved the way. I mean it was just like we had predicted. But that part of the flight regime was easy to predict, because it's low speed. The part that we were really concerned about were the hypersonic regions and also the transonic, because the basic Shuttle is unstable in both the yaw and pitch in different phases of the flight program and flight regime envelope, and it relies on the electronic control system to keep it stable.

So we were concerned about transonic, because at it goes transonic, say from mach 5 down to mach 1, the stability margins are at the most reduced region. There's pretty good

margins on stability and being able to control with the computer. But in this especially mach 3 to mach 1 area there, the characteristics are changing like it's going from unstable in yaw to stable in yaw and then going unstable in pitch. So it's when those kind of regions are overlapping, you're kind of wondering how it's all going to come out.

BUTLER: Very dynamic.

You mentioned earlier that the decision had been made to have the first flight manned. Was that in relation to some of these situations where having someone in there would help control the spacecraft better throughout the whole?

HARTSFIELD: No, I think it was the expense and the difficulty in flying it unmanned, you know, because we never planned it from the start. The Russians flew their orbiter unmanned, automated, and it did a great job, but they had planned it from the start. If we had, it would have been major modifications to the current orbiter design, so that it could be flown unmanned, because you had to think about the software conversions and all the things you've got to do. We had separate software modules that we had to load once on orbit into the entry and all that. All that had to be loaded off of storage devices or carried in core, because, remember, the Shuttle computer was only a 65K machine. If you know much about storage, it's small, 65K. You take a memory chip in your normal computer, just in real-time storage is 512K, but this is 65. Even our newer computers, we're now running 125K software.

But when you think about complexity of the vehicle that we're flying a complex machine with full computers voting in tight sync and fly orbital dynamic flight phase and give the crew displays, and we're doing that with 65K of memory, it's mind-boggling. I mean, you take the little computer you carry in your purse or something, and it's got more memory than that.

But the memory has to be radiation-hardened, too. I mean you have to have memory that radiation is not going to flip a bit and destroy the whole thing, you know. It could correct for that. Of course, the Apollo guys will tell you how small their computers were, too.

BUTLER: Yes, the space program certainly has made the best out of what they've had with the computer technology and really pushed it to its edges.

You've talked about being involved in the flight control systems, in the STA, and in all these development phases of the Shuttle. How much input did the entire astronaut corps have into the actual design development throughout the whole buildup of the Shuttle Program?

HARTSFIELD: Quite a bit, especially where it came to crew interface with the vehicle. As far as flight control goes, it was the flight crews would evaluate the flight control system and give it a write-in. There's a scale called the Cooper-Harper ratings. There were two flight engineers, and I think both of them were pilots, too, that worked for Calspan and developed this rating system. It's a very good system, and it's been used by test pilots for years. You fly a vehicle and depending on what you're looking at, what flight phase, whatever, you're asked to give a Cooper-Harper rating. It varies from 1 to 10. You give it a 1 rating, very few airplanes, any airplane, will get a 1. A 1 is it flies perfectly, it does everything it's supposed to do, it has no bad characteristics.

It starts very simple. Is it controllable? If it's not, it's a 10. Obviously, you aren't flying when you do that one. You do that one in a simulator. I can't fly it. It's totally uncontrollable. Then the next broad category, like 7, 8, 9, I don't remember the exact adjectives, but it's like is it controllable with extreme concentration, barely so, and you cannot achieve the mission. Then the next three ratings, you know, depends on either the top or the bottom of that, but it's controllable but I have great difficulty doing the mission, you know, doing what it's supposed to do. I mean, I'm spending all my time just keeping the airplane flying. Then the 1, 2, 3 ratings

are I can do the mission, it's controllable, and I can do the mission, and it's either excellent or it's down to it's minimal acceptable.

BUTLER: Looks like a pretty good system there.

HARTSFIELD: But when you get into that, you start answering those questions, you know, starting with the very simple one, can you control it all the way up, and then you refine it. You arrive real quickly at a number rating, which is a quantitative rating, which is very good, a good tool.

BUTLER: Did the Shuttle system work its way through some of that rating or did it start out pretty—

HARTSFIELD: Yes, I think, depending on the flight phases, I think I would rate the Shuttle as in the three-to-four range. It's an unusual airplane in that especially for landing it—it flies fairly nice, except for landing. The problem there is that the pilot sits at or slightly forward of the apparent center of rotation, if that means anything to you. If you're flying an airplane and you pull back on the controls to raise the nose, the first thing that happens in a conventional airplane is the elevators go up in the back. In doing so, they dump lift, but they also rotate the airplane. They're putting a torque to rotate the airplane.

So the first thing that happens as soon as you pull back on the yoke or stick or whatever you have, is dumping the lift, the airplane begins to settle. The CG [center of gravity] actually starts going down, but the nose is coming up. Then the increased angle of attack on the airplane gives it more lift, so now it starts to climb, which is what you wanted to happen, or you wanted to decrease the rate of descent.

If you take those two motions, the CG is going down, the front is going up, somewhere is the part that never goes down or up initially. It's the apparent center of rotation, and the airplane appears to rotate about that point. Most airplanes, the pilot is well forward of the apparent center of rotation, so even a light plane, you're flying, your Cessna, you pull back on the yoke, the nose goes up, you feel it, because the CG is behind you, you feel the airplane rotate, you see it rotate, and you've got positive feedback immediately that something happened when I moved the controls.

Even an airplane like the 747, the pilot's way up in front of the CG, or apparent center of rotation, and when he pulls on the yoke, the nose goes up. The CG of the airplane does a real big sink before it recovers, almost three-quarters of a second before it starts to respond to climb. But the pilot sees it right away because the nose moved and his out the window checks.

The trouble with the orbiter is it doesn't have a nose. You look out the window of the orbiter and the nose slopes off and there's nothing to see out. You don't see the nose. Secondly, you're at the center of rotation or slightly aft of it, and so you don't see anything. You're not aware of that slightly aft thing, but I mean when you move to put in the stick control to make it pitch, you don't see the pitch and you don't feel it, because there's nothing to feel.

The result is that you learn to fly it in a little bit of a bang-bang motion. You put in small inputs until you see what happens. But you learn it very quickly. Pilots that come to us from the military pick up real quickly on how to fly it. Early on, we had a tendency for pilot-induced oscillations in the control systems, PIOs we called them, where you don't see what you want to happen, and so you make another input. The first thing you know, you do see it, but now you've got big inputs in, so it kind of goes further than you want, so you back it the other way. The first thing you know, you're doing this [Hartsfield gestures in an oscillating motion].

Some airplanes, you get behind them like that, and it's called a pilot induced oscillation, they can become very violent, leading to loss of control. This is not a feature you want in the Space Shuttle.

We had a case of PIO on the fifth preflight. It wasn't totally Fred [W.] Haise's fault, but if you remember, he got into a — hit and then he got into PIO on landing and wound up with a very firm landing. What happened in his case was a fault in the flight control design such that if you saturated the roll channel, it would lock out the pitch channel, and vice versa. It's just the way the control law was put together. No one, the engineers didn't see that, and I or no one else that flew it had ever seen it, but, unfortunately, Fred encountered it on his landing, in that the airplane has slight wheel down, one wheel was lower than the other, one wing was lower than the other when he touched down. Just as he made a pitch input, I'm trying to remember how all this happened, and when the wheel touched, the other wheel came down, and it put in a roll.

The control center automatically compensates. If you aren't commanding something, it tries to keep that rate zero. Well, touching the ground put a rate in, and the flight control system put in automatically a command to take the rate out, at the same time he had made a pitch input, it saturated the roll channel, and his pitch input didn't get in. He made another one, then the roll channel unsaturated, and gave him the pitch command more than he wanted. So it really wasn't his fault, and it led to an oscillation error.

We learned a lot about flight control system there. We went in and fixed that, but it was embarrassing to Rockwell that this design problem had been there all along but no one had ever encountered it in any simulations. So we fixed it so you couldn't lock a channel out.

Then in the Shuttle Training Airplane, we had some flight crews still get into a PIO. There was a tendency to do that, and it wasn't a lockout, just the control system was sensitive. So we put in a filter in the flight control that would limit the pilot input. It was called a PIO filter. It worked great since the software could compute faster than you could move. If you tried to command too big of a command, it would compensate and not let it get in. That worked very well, and it's still there today, as far as I know.

BUTLER: Certainly good that the opportunity was there to test these and work them out before the very first flight when so many things had to be tested and tried.

HARTSFIELD: Yes, you know, this is the way you normally do it. See, the other problem of the orbiter or the Shuttle versus normal test routine, when you fly a new fighter or any kind of a new airplane, it's gone through hundreds of hours of flight tests before it gets out in the field and many, many flights. We didn't have that luxury with the orbiter. I mean we flew it one time.

Even today we've had a little over 100 flights, which is not even a normal test program in most airplanes. So we had to accept what we could get. From that standpoint, I think it's done remarkably well. It's a great airplane. Don't get me wrong. It takes a lot of tender care and a lot of expensive care to make it work. But you know, for being the first of a kind, it's still a wonderful vehicle. It's the only one in the world that can do what it does. A lot of the things they could have made it cheaper to operate were taken out of the program early on for cost savings because they were complicated, SEP [separation] monitoring systems and things like that that just weren't feasible to put in at the time.

BUTLER: It certainly has been a high-performing vehicle. It's lasted quite a few years and will be around for quite a few more.

HARTSFIELD: I hope so. It's good to see, until we find something better.

BUTLER: Well, moving then, into more on the Shuttle, at what point did you learn about your assignment to STS-4? Was it during this early phase?

HARTSFIELD: No. I was trying to remember. I don't remember the exact year. It was somewhere around '78, '79, somewhere in there. Well, first off, we picked the crews for ALT

[Approach and Landing Tests]. I was extremely disappointed that I wasn't one of those, to be honest with you, and still don't know why. I mean, I thought that having developed the flight control system, I'd be in a good position. So did a lot of other people, didn't understand either, but we learned along the way you don't—crew assignments are strange things. You don't need to second-guess them. You just smile and press ahead.

Then they announced the crews for the OFT, Orbital Flight Test Program. They were A through F, but we didn't know how they were going to fly. Ken [Mattingly] and I were in E crew. The Orbiter Flight Test Program originally was going to be six flights. Later, it was changed to four. So no one knew exactly how this was going to work. All we knew was that [John W.] Young and [Robert L.] Crippen were A, and [Joe H.] Engle and [Richard H.] Truly were B. We knew John was first, and they were being backed up by Engle and Truly. But after that, we weren't quite sure what was happening. It all began to sort out, and it was kind of a funny picture.

Ken and I wondered, "What are we going to fly?" Well, I remember it was kind of a strange thing. [Jack R.] Lousma and [C. Gordon] Fullerton were training. Eventully we figured out they were going to be three. It kind of got down to where they were starting to train. They'd been told they were flying the third flight. They started training for it. Well, then we got this call the ninth floor over there [from the administrative offices in Building 1] that we should go to St. Louis [Missouri] or wherever they were, I can't remember now, training, that Ken and I should go up there and start getting this training.

Well, it was kind of funny, because it scared them. Lousma made a panic call back to Houston, said, "What's going on? Are we being replaced?" It just raised—because nobody bothered to tell anybody what was going on. But what eventually turned out is that we were going to back them up. It turned out that the original plan was Jack's crew was going to back up Engle, but it didn't. We wound up backing up Engle and Truly. We backed up 2. Well, then,

since we were backup on 2, I think it made 3 nervous, Lousma and them, they thought we were going to replace them. That wasn't true. What really happened was we backed them up as well.

Then we flew 4. It was kind of a funny way the crews were labeled there, you know. But as E crew, we were backing up the third flight, but we weren't flying. So we wound up flying. I think the D crew flew 5, and we flew 4, but so it was the last of the two-person flights. It was a little bit confusing as to the way the crews were announced, because no one really knew. It was kind of a standard, I won't say a joke, but it started around the office trying to figure out this crew structure and how it was going to work.

But it all sorted out, and I think sorted out fairly. Everybody got to fly, and nobody got kicked off a flight, you know. For some of us who had waited so many years, when the seven of us that came from the MOL Program, and some of them had been in the MOL Program longer than I, like Truly was in the first group and I was in the second group that were picked, so from the time we were picked for the space program till the time we flew was around sixteen years with the Air Force and a long time at Houston, so it was a long wait. At that point, you didn't want to see anything get in your way. When the crew confusion started going on, "Well, I hope I'm not losing my place, I've waited too long." But everybody got to fly, so it was a good deal.

BUTLER: What did your training entail for, first, for backing up those two crews and then for your own? Were they pretty similar since they were the orbital flight tests?

HARTSFIELD: Yes, each of the flights had something different to do. But the basic flying the orbiter was about the same, and that was what we were training. We spent a lot of time in the simulator, doing ascent training, entry training, and orbit training. Orbit flights for each of those were different. All of them had the Canadian arm [RMS, Remote Manipulator System], which I was the arm operator on the STS-4. So I started training on the arm to back up 2 and 3, and got

a lot of use of it on 4. Spent a lot of hours operating that arm. We had tests we did with it as well as long experiments. We had an experiment package, contamination monitor, a big package that I maneuvered all around different parts of the orbiter over the payload bay, over the thrusters.

This thing was to see what kind of things it was picking up, whether it was getting propellant vapor or water that was in the atmosphere, because they were trying to get that because the science community was concerned about if they put a payload in the orbiter bay, what kind of environment was it really going to be in. Were there outgassing things going on that were going to affect the experiment? So we did this contamination monitor experiment.

BUTLER: Working with Ken Mattingly, you'd worked with him as support crew on Apollo 16 and had built already some connection with him there and then moving on to STS-4, so was your interaction pretty comfortable between the both of you?

HARTSFIELD: Oh, yes, Ken and I got along well. We both went to Auburn. I think it's the only time the entire crew went to the same university in the space flight business. We used to take a lot of ribbing from the University of Alabama folks, saying the only reason they put two Auburn guys on one flight, that way we'd only mess up one. [Laughter] So we had to take a lot of ribbing, but it was a lot of fun.

You know, in between those two, I worked as support crew and Capcom for all the Skylab missions, too. So that was an interim assignment that I enjoyed. It was in '73.

BUTLER: I'm glad you mentioned that. I was going to go back to that at some point. Since we're on it now, what did those duties entail for supporting and Capcom for Skylab since it was so different from Apollo and very different from what Shuttle was being of long duration? Can you tell us what some of that, what all of that was like?

HARTSFIELD: I was, they called it the BCMP, backup command module pilot, which really you weren't the backup pilot. You were the support crew. Some people got the idea it was, but the job at the Cape was to tuck the crew in along with the regular support crew that did that. So during the Cape activities, when the vehicle is in the final launch phases, then the BCMP, I would go in the module, I forget whether it was eight or ten hours prior to flight, whatever it was, and set the switches, go through a checklist and put all the switches in the right place as they begin to activate the flight computers and all that sort of stuff, so that when the crew got in, everything was all set up.

When the crew got in, I would be in the lower equipment bay, which is at their feet at the back end of the command module, and then help them get their feet in their launch restraints and all that sort of stuff. Then when they were all strapped in, then I would crawl under the seat and out between the center seat and the hatch area and climb out. Then they'd start sealing the hatch up and doing all that. But that all worked fine. That was the way we trained.

Unfortunately, for the first Skylab mission, you remember the meteorite shield ripped off on launch and the crew was supposed to fly the next day, after the Skylab was in orbit, but after that happened, they canceled that, and it was about two weeks', I recall, delay, before they launched the crew.

Well, in the meantime, they developed this parasol and the big umbrella they put out to protect the vehicle from heat, and all these tools, because they weren't quite sure what they were going to get into. They knew they had one solar array that was pinned, and the other one had ripped off. So it was a bad situation. To get power, they would have to first protect the lab from heat, and then they'd have to unpin the solar array. It turned out it was a piece of metal holding it. So they had these giant cutters and things and saws and all sorts of tools. They stowed all that under the seats. We had to pack all that in there. In fact, it was Ray Dell'Osso, I think. The night before launch, they reversed. They tanked first and then finished the stowage because we

didn't have it all at the Cape, which is kind of a—normally, once they tank, nobody goes out there but the crew and the closeout crew. But we went out and did all this stowage and came back and set switches.

But anyhow, when I got to the crew, Joe [Joseph P.] Kerwin was in the center seat, there was no place to get out. Under the seats were all full. So I had to crawl over him, and I slipped going out and my knee hit him right in the stomach, so I got this "Oooh!" "Sorry, Joe." He wasn't hurt, but it was kind of embarrassing. But I managed to get out over him and get out the hatch, but they wouldn't let me stow away. I was wanting to go with them.

BUTLER: Certainly tight confines in there, especially when you add even more equipment.

HARTSFIELD: Yes. They did a great job of reconfiguring and saving the mission. Those three Skylab missions I thought went very well. I wound up, I think, getting more graveyard Capcom shifts than anybody. It was just the luck of the draw. In fact, I don't know, still maybe somebody has caught me by now, but I think I held the record for Capcom time for a long time because I did all three of the Skylabs and Apollo 16, so it was a lot of hours sitting in the mission control. A dubious record, not one I'm real proud of. But I had a lot of fun doing that. We had good teams and worked well together.

BUTLER: Did you, when you weren't working your Capcom shifts, were you working some of your other—were you starting to get into Shuttle at that point?

HARTSFIELD: No, because the way the Capcom things did, I forget the work schedule. It was like three, maybe it was five days. I don't know. Five on and three off, or something. Your off times varied, then you shifted schedule. You'd be like five. I forget. I think it was five, five days on the graveyard, and then you would shift and go to the next shift. So you got a planning

shift and whatever they called them, and an ops shift. So you weren't always stuck on it, but you moved around from shift to shift. They gave you a few days to adjust your sleep cycle and to go back to the office and do whatever you got to do to get caught up. But really there wasn't an opportunity to do much else.

BUTLER: Certainly a challenge getting your schedule shifted around like that, getting your body adjusted, and so forth. But Skylab certainly has returned a lot of good information.

HARTSFIELD: Oh, it was great. We had a lot of fun doing that. It was unfortunate that it got ripped apart on ascent, but we're fortunate that we didn't lose it.

BUTLER: Absolutely. Were there any incidents or occurrences during Skylab, either from a technical standpoint or from a more humorous standpoint that stand out for you that you'd like to mention during all those shifts on duty and such?

HARTSFIELD: Oh, you had fun. I don't remember anything specifically. I liked to have fun. Once in a while we'd send the crew up some humorous messages, you know, trying to keep them happy. But they had a pretty good work schedule, too. They were working pretty hard, and some of the guys were doing extra time to go look at the sun through the Apollo Telescope Mount, gathering data.

It was, I think, a learning process for all of us. We learned that for a long-term mission, crews cannot work as hard as they can on short-term. If you're going to have a Shuttle up seven or eight days, you can have a pretty tight flight plan and just drive the crew. There was a tendency to want to do that with Skylab. You finally had to realize, hey, the guys are going to be up here twenty-eight days, fifty-six, whatever the longest was, eighty-four. Give them some

time off. There's no need to drive them like that. Besides, you run into problems and you've got a tight schedule, there's no way to catch up.

They learned a lot about planning flights. Bob [Robert A. R.] Parker, who was made the science czar early on, he did a remarkable job of coordinating all the science, because every one of the PIs [principal investigators] wants the full crew devotion to his experiment. We just couldn't do that. Bob did a sterling job of working together and getting all those people coordinated and agreeing on a science plan. See, they would start planning, I think, the day's activity about, as I recall, about forty-eight hours in advance, and then finalize it during the next day.

Then the night before was when all the detailed plans and messages would be sent up, the data the crew needed to operate. They would review on the evening before the day that was being planned, the final plans were made, they would send up a draft flight plan to the crew, and they'd review it and give their comments. "I think it'd work better if you moved this experiment over here," you know, something like that. The plan was finalized that evening, and during the night they would build all the messages that had to go up, the supporting data for the science day and the flight plan, one flight plan for each crew member, because each one of them had different things to do. We would uplink that over the night, so when the crew got up in the morning, they had their whole package there and they'd distribute it. Cut it up in appropriate pieces, you know. "Here's yours, here's yours, this is what you need for that," and press on for the day's activities.

Bob was coordinating the science, getting all the PIs to agree on which was the highest priority and how much time they were going to need, crew time they were going to need. So we learned a lot from that, and I think Station is going to benefit from that experience. I hope they will. NASA didn't do a very good job of that. After Skylab, there was a book about that thick [Hartsfield gestures] that was lessons learned. I think all it did was collect dust.

BUTLER: Unfortunately, there is a lot of years in between.

HARTSFIELD: You have to learn it all over again, but they will.

BUTLER: Well, hopefully, there's enough people still around that were involved with [Skylab] that can throw out a few pieces of advice here and there, too.

HARTSFIELD: Oh, they are, and they have been contributing to it.

BUTLER: During Skylab, was NASA able to work with DoD at all to incorporate some of the things that had been anticipated for the MOL Program then?

HARTSFIELD: Not to my knowledge, I don't think that ever happened, because MOL never really flew so there wasn't a lot to pass on.

BUTLER: I know they had managed to do some DoD events for the Gemini Program, and I wasn't sure if maybe they had been able to tie in some.

HARTSFIELD: Yes, we did DoD work on the Shuttle, you know, the DoD flew on the Shuttle. In fact, on STS-4, we had a military experiment that we flew.

It was a funny thing happened on that flight. Because it was highly classified, the work we were doing, on this one experiment they had a classified checklist. Because we didn't have secure com, we had the checklist divided up in sections that we just had letter names like Bravo Charlie, Tab Charlie, Tab Bravo that they could call out. When we talked to Sunnyvale [California] to Blue Cube out there, military control, they said, "Do Tab Charlie," or something. That way it was just unclassified.

We had one drawer, one locker that was where we kept all the classified material, and it was padlocked. So once we got on orbit, there was nobody going to steal it because we didn't have to worry about it. We unlocked it and did what we had to.

When we finished the last part of that thing, and I remember I finally got it all stowed, I told Ken, I said, "I got all the classified stuff put away. It's all locked up."

He said, "Great." It wasn't thirty minutes, and they said that the military folks needed to talk to us. So the Capcom came on, the military guy, and says he wanted me to do Tab November. Ken said, "What's Tab November?"

I said, "I ain't got the foggiest idea. I'm going to have to get the checklist out to see." So I got the padlock off and got the drawer and dug down and got the checklist out and went to Tab November, and it says, "Put everything away and secure it." [Laughter] Ken and I really laughed about it.

BUTLER: Of course, they couldn't tell you anything on the com as to what that was. Well, at least it wasn't too complicated of a process.

HARTSFIELD: No, it was just aggravating to have to undo all that, because that locker, the stuff we had just barely fit in there, so it was a really stowage issue here. If there's one thing you learn in zero G, things are always neatly packed. They pack it in FEPC [Flight Equipment Processing Contract] and you get it up there, and once you pull it out, it doesn't always go back in, because it expands or does something in zero G and it doesn't fit very well.

BUTLER: I think I've had that problem down here trying to get something back in.

HARTSFIELD: Well, you pack a suitcase to go somewhere. Once you open it up, you can't get it all back in there.

BUTLER: Yes. It's amazing how that works.

With the Department of Defense and NASA did have a lot of interaction on Shuttle, they had some plans early on with that, being with your background, did you have much involvement in those plans throughout the development of Shuttle and up?

HARTSFIELD: Not in development. I was involved on some of the classified flights to a limited extent. Those things they kept very tightly controlled, which they had to, you know. There were some things that I was doing later on after I finished flying that required my access to some of the things they were doing and some of the things that were going on. After *Challenger*, they quit flying military payloads.

BUTLER: Right. What was part of the motivation then, because they had originally thought of flying Shuttle flights out of Vandenberg and having—

HARTSFIELD: In fact, the old MOL pad became the Shuttle pad. They modified that.

BUTLER: Did those needs change at some point along the way, and then after *Challenger* they decided to go more with focused just on the unmanned systems? Is that probably what happened?

HARTSFIELD: I don't know what happened in there. I think when the Shuttle went down, the Air Force realized, I'm assuming, the DoD realized that they had to have a backup at the launch. They were starting to go where everything was going to fly on the Shuttle that they could fly, you know, that they'd better not put all their eggs in one basket. So I think they backed away from the Shuttle.

Besides, during the downtime, they changed the law that said we wouldn't fly commercial payloads either, if you remember. We quit launching satellites and those kinds of things. I don't know what the motivation for that was. It could have been that because we were—in my view, it was payola. It was marketing. "You put your payload on our Shuttle and if it's more than 50 percent of the payload bay, you can fly a person of your choice." It was sort of like a payola kind of thing or a marketing gimmick, you know. People were going to get a Shuttle ride just because their company was putting—that's how [Payload Specialist Gregory B.] Jarvis got on.

In fact, they even made the deal that if you can't fly on the flight that that goes, we'll get them a flight on another flight. It was kind of a ticket to fly anytime. I wasn't alone in the astronaut office, a lot of us didn't like that at all. We thought that that was not appropriate to take inexperienced people and put them on there, because there's a lot of resources in getting them ready to fly. You had to determine their personality. It was hard to do in a short period of time. Were they going to be stable? If you had a problem on orbit, am I going to have to babysit this person, or are they going to be able to respond to an emergency situation and take care of themselves like the crew has to? Because it could be detrimental. If you had a big problem, you could wind up having a person that wasn't used to that kind of conditions to endanger the rest of the crew because you have to attend to them.

That was the thing I objected to about [Dennis] Tito flying. I don't think we were ready for that, especially in their situation if they had to do emergency bailout, where they're in a hurry, get suited up, get in. I'll bet you he couldn't do that very fast. Maybe I'm wrong. But you don't know how he's going to react.

Early on when we were flying payload specialists, we had one payload specialist that became obsessed with the hatch. "You mean all I got to do is turn that handle and the hatch opens and all the air goes out?" It was kind of scary. Why did he keep asking about that? It turned out it was innocent, but at the time you don't know. We had some discussions, so we

began to lock the hatch. We carried a lock. Once we got on orbit, we locked it, because you're not going to open on orbit.

Because you're getting a person that you don't have a lot of experience with. Everybody you fly with, from a crew standpoint, you've worked with for several years. Everybody knows their personalities and their quirks. They've had a thorough psychiatric evaluation before they even got selected. We put them in hazardous situations. Those that weren't pilots that fly in the T-38s, you get to watch them. If you fly long enough, you're going to have some contingencies, and you see how they react to that. I mean, you know, you're building the database that this is a good, reliable person and you can count on them, because you've got to count on each other. Everybody's got a job to do, especially in contingency. Everybody's got something that's their responsibility to carry out. And you've got to have that confidence to make the flight successful.

So some of us worried about these short-termers coming along and joyriding, we call it. Then, of course, some of the guys who hadn't flown yet resent these guys coming along and these people flying. "I'm sitting here, I'm trained, I've been picked, and these people are going." So it's a morale issue for them.

BUTLER: Yes. Tough situation there.

Well, if we could take a quick break here.

HARTSFIELD: Are we running out of time? Yes.

BUTLER: We're getting close. [Tape interruption]

BUTLER: Okay. Well, just to follow up on what you were just talking about with the payload specialist and integrated them into the crews and such. On your second mission, you did have

one with you, Charlie [Charles D.] Walker, I believe. How did that work with building into the crew dynamic and the training? Were you able to work that in pretty well?

HARTSFIELD: Yes. In fact, I worked hard to integrate Charlie into the crew because I felt that was essential for our success. He was a good student. He was going into a strange environment and he wanted to learn, and he gave it his full attention. In fact, he got two more flights after he flew with us. He was probably the only one that flew more than once. Maybe there's another one, but he had three Shuttle flights for the electrophoresis work that we were doing. I had trained in St. Louis on that device, and it made its first flight on STS-4. I spent a good bit of time operating that experiment, and it was very promising.

There's a good example there of what happens in the commercial world. If you get an idea, you've got to push it hard and you've got to push it fast, or somebody else will beat you to the street with it. What the deal was, McDonnell Douglas [Corporation] had cut a deal or had an agreement with Ortho Pharmaceutical. We can all talk about this now, but at the time it was being kept somewhat proprietary because everyone knew when we were going to do something in the medical arena, but they didn't know what.

Well, there's a hormone called arethropoetin [phonetic], I don't know if you're familiar with that or not. It's a hormone that stimulates production of red blood cells. It can be separated out with a protein separation device, like electrophoresis, on the ground, but it's very slow and it's very expensive. It would make the drug very expensive for anybody using it.

Why do you want it? Well, since it stimulates the production of red blood cells, if I were going in for elective surgery, not emergency surgery, I've got to have something replaced or maybe you take out a gallbladder or something, or any kind of a bleeding thing, you give a person this hormone before the surgery. Their body begins to overdevelop, so to speak, red blood cells such that they may not need a transfusion or any external blood sources. So it could

be a real boon to surgery, especially in the fear of AIDS and all the other things, you know, back when we weren't sure how good we were doing it, protecting the blood supply.

So it had a market, and there were a lot of other uses for it, too. People whose blood production was slow, you know, or a little bit anemic, you could pump it up with this hormone. So the market capability was there, but the drug cost too much because you just couldn't make enough of it. We found, in this experiment we flew, that with electrophoresis and microgravity and the technique that they had developed, that you could get five times the purity that you could on the Earth because of no gravity. I forget, it was quite a large factor, it seems like it was 100 times the throughput so that it made it profitable to do it in space.

So what Charlie was doing was, on the three flights he had, was further refining the process with this onboard device. They had already under construction a large electrophoresis factory, if you will, that would fly in the payload bay of the orbiter and really produce large quantities. Well, after *Challenger*, you know, and the two-year standdown, they got beat to the marketplace when some outfit in California using genetic engineering on bacteria, you know, got these bugs or whatever it was to produce this stuff on the ground, and they could do it in fairly large quantities and be very competitive. So the whole idea failed.

The concept was great. I thought this would be the first real commercial thing that we were doing in space and it was to help people, and it would be a good flag for NASA and for the space world to say, "Here's something that you can do." I'm still convinced that there are other things out there that you could do like that, that you can't do—gravity messes up a lot of things on Earth. If you can get into a micro-G environment, you can do things you can't do on Earth.

But unfortunately, that one was a victim of timing. But we had a lot of fun doing that. That's what Charlie was doing. He turned out to be a good crew member. He was a little nervous about it at first, but it was fun to watch him develop his space legs, so to speak, on orbit. From then on, he didn't have any more troubles on his other flights.

BUTLER: Was he assigned to the crew from the start, or did he come in at a later date?

HARTSFIELD: No, he came in fairly early, so we had a good bit of time to work with him.

BUTLER: Good. I'm sure that helped.

HARTSFIELD: Yes, he was good. We put his name in our patch circle, if you will notice. After *Challenger*, or even before *Challenger*, there was so much moving around of people, like which flight [Senator Edwin Jacob] Jake Garn is going to be assigned to, it will be on NASA and these payload specialists [PS] and especially the special guests like they were, and the PSs that were really tourists, so to speak, that were assigned because their company bought, like Jarvis, you know. Their flight assignments changed a lot, you know. Some of the flights had as many as three different people assigned at one time or another, and they had to keep changing their patches. So to save money, you probably noticed they put a ribbon at the bottom with the payload specialist on it, so they wouldn't have to change the whole patch. But when Charlie flew, I had sold George [W. S.] Abbey on this. "He's part of the crew, you know. Put his name on the patch with the rest of us." So it worked out well.

BUTLER: It sounds like it. It sounds like it. It certainly seems worth it, all the results.

Well, I want to thank you for joining us today and for taking time out of your schedule. It's certainly been interesting for us.

[End of Interview]