NASA ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT 1

DAVID J. HOMAN
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is June 14th, 2023. This interview with David Homan is being conducted for the NASA Oral History Project. The interviewer is Jennifer Ross-Nazzal. Thanks again for coming in. Nice to meet a fellow Wildcat. I wondered if you would talk about your interest in science and engineering as a child.

HOMAN: Let's see. Obviously I was around when the Russians launched Sputnik. That's about when everybody started talking about that kind of stuff. I guess I was in fifth grade when they started launching Mercury. I liked it, got involved in it then, or was interested in it then. I always liked math and science. Didn't care much for anything else.

When I graduated from high school, I went to—like I said before—the University of Arizona [Tucson]. One, they had an aeronautical engineering program, and two, they weren't in Iowa. I'd never been away from home before. [It was the] end of the summer, [1968, when] I got on an airplane for the first time. It was a DC-9, so I got on through the aft stairwell. It was before D.B. Cooper [who hijacked a plane in 1971. I] headed out to Arizona.

It was interesting. I [lived] in Cochise Hall, which was right under the flight path to Davis-Monthan [Air Force Base, Tucson]. We didn't have air-conditioning, so the windows were open all the time. As I sat at my desk, I'd see every plane on final approach. There was a building that sat right across the street which blocked the view of the airplanes till they got past that site, so [I]'d hear them long before [I]'d see them.

It got to the point where sitting there I'd recognize the sound of all the engines. I could tell what different planes were coming. I usually didn't look up unless I heard something that I hadn't heard before. Davis-Monthan had a reconnaissance wing at it. Every once in a while, a U-2 would come in which was interesting to watch.

One time I was sitting there. I heard this engine that I'd never heard before. When it came into view it was a big black airplane with delta wings. It flew by. That night my roommate and I went out to the bookstore downtown and got a copy of *Jane's* book of military aircraft and found it in there. It turned out it was an SR-71 Blackbird. I thought that was really cool. I wondered what it would be like to get up close to something like that. That was the only one I saw that year.

[I] finished the school year, and then I transferred to Iowa State [University, Ames], which was a whole lot closer to home. I had a car, and I roomed with my best friend I'd known since kindergarten. Everything was going good, and I figured I wouldn't be leaving there any time soon.

Then partway through the first quarter I found a letter on the bulletin board outside of class where NASA was looking for co-ops, cooperative education students. I went to the aero department there and back then being a co-op wasn't as, I don't know, exciting or popular as it is now. When I went in and asked about it, it was interesting the amount of time that it took them to track down the form. A few people stuck their heads out of the office when they heard somebody wanted to be a co-op. But they finally found that [form], and I filled [it] out and started co-oping with the NASA Flight Research Center out at Edwards [Air Force Base, California]. I started there in December of 1969. That was the same month that the Air Force delivered to NASA two YF-12s, the predecessor to the SR-71, which was really cool.

The first year I was there I worked in the High Temperature Loads Lab where they researched aerodynamic heating and aerodynamic loads. I worked on lifting body loads and proof-loading of supercritical wing. It was really neat to watch the stuff that they flew out there.

While I was out there the bottom fell out of the aerospace industry. That was when Boeing was going into the toilet, basically. There were signs around Seattle that said, "Will the last person to leave Seattle please turn out the lights." It was right after they canceled the supersonic transport, which Boeing was building.

I figured that [it] might be a good time to change my major to something a little more generic. I changed to mechanical engineering. When I got back to school, I went to the mechanical engineering department. They had a co-op program, but it wasn't with NASA. The co-op adviser I got really could [not] have cared less about me being a co-op for NASA. The aeronautical department was upset because I refused to relinquish my position to an aero student. They didn't want to have anything to do with me [either]. From then on it was me making out my schedule, not only my work schedule, but my class schedule. It was what I decided. Nobody helped me. I'd fill it out and do that.

When I went back to NASA at Edwards the next time, they moved me to another section in that facility. They were working on the YF-12. They were doing aerodynamic heating studies. It could cruise at 2,000 miles an hour and 80,000 feet. At that speed temperatures ranged anywhere up to 1,000 degrees on the skin. They were trying to separate out the aerodynamic loads from the aerothermal loads or the heating loads that it experienced. What we were going to do was build basically a full-scale heater to put the thing in.

ROSS-NAZZAL: When I read that, that sounded interesting to me.

HOMAN: Oh yes. They instrumented the airplane with strain gauges to measure the loads as it flew, along with thermocouples to measure the temperatures that it saw during different flight regimes. Then we built a heater, to basically heat it up to those conditions, and measure the heat loads that it was seeing, and subtract that from the total loads that the strain gauges saw, which then would give you the aerodynamic loading it saw. It separated those two [components] out.

What I did was basically design [the reflector panels]—I think [it] had 460 some stainless steel panels and all the locations for the quartz lamps on those panels to fit around the airplane, which involved designing each one of those [panels] and making the assembly drawings. That [covered] that time out there.

When I got back to school, I took classes and looked forward to going back out to Edwards to resume that [work]. When I got out there the next time the heater had been built and Lockheed had just delivered it. I spent a few weeks out there with a wrench crawling around on this thing adjusting everything that had slipped during transit.

[We] started getting ready for the heating tests and started working night shifts then. We went through the heating tests. I went back to school. The next time I came out there, we were done with those tests, and they were moving on to other things.

I worked on various things over the course of [those] six months. Towards the end, I guess maybe the last three months, one of the engineers in the office with me—there were two; they were heating experts, and they'd been around for a long time—he decided he wanted to move over to the Propulsion Section and work on inlet performance on their SR-71. I thought that sounded good. As a co-op you can move around. I went over there with him and did some things there till the end of that session.

Then I went back to school. I was going to graduate in February the next year. The way the mechanical engineering department did it, as a senior they had a series of courses that you had to take. They were all related, one after another. They had to be taken in order. The last one was a four-hour design lab where they gave the class a problem and you had to come up with a solution and build it. The problem I had with that was the only time it was presented or available was spring quarter. By that time I would have had way more hours than I needed to graduate, and I really couldn't see sticking around for that one course.

About the same time, I guess end of the summer, *Aviation Week* did an article on the YF-12 heater that we built.

ROSS-NAZZAL: Not bad experience, right?

HOMAN: Yes. They put a picture of it on the cover of the magazine. One day I went over to the library and stole a copy of that [magazine] and went into the office of the professor that taught that class. I introduced myself, and we talked. That's when I told him I didn't think I needed to take his course.

ROSS-NAZZAL: I'm sure that went over well.

HOMAN: Yes. He said, "Oh yes? Why is that?" I laid the copy of *Aviation Week* down in front of him and said, "I designed that." He sort of sarcastically said, "Oh, sure you did." We talked a bit more, and I think he figured he'd have some fun and call my bluff. He said, "Okay. I'll get with your adviser, and we'll figure out what you're to do."

I got back with them. First, they wanted some documentation that I'd actually done that. It took me a few weeks, but I got back with my section head out at Edwards. [He] wrote up a letter on NASA letterhead that described all this stuff. I showed that to [them]. That put [them] off a little. They decided well, what I needed to do was make a presentation, so I agreed to do that. It was towards the end of the fall quarter. I went in, and there were three people there: the professor of the class, my adviser, and the head of the mechanical engineering department.

I gave my pitch, and they said thank you. As I was leaving, I asked when I would know whether or not I passed the course. The head of the department said, "You passed. You did a good job." But then he followed up with, "But there's one caveat." I asked him what that was, and he said, "You can't mention this to anybody until after the next quarter starts." Basically that was for them to come up with a new policy to avoid that from ever happening again.

ROSS-NAZZAL: Even though you had the on-the-job training [OJT]?

HOMAN: They figured every co-op in the place would now want out of that class.

ROSS-NAZZAL: Of course.

HOMAN: Essentially I was the first person and the last person ever to test out of a mechanical engineering course at Iowa State.

ROSS-NAZZAL: Tell me about that heat structure. How did you approach that? Like you said, you were still an engineering student. How did you start and figure out what you needed to encapsulate an entire aircraft?

HOMAN: Like I said, it was a project that this group was working on. That was just my piece of it. There was another old guy who built the bridge structure that held everything up. I had engineering drawings of the YF-12 and went through those and basically designed the curvature on the panels to match the curvature of the airplane at all these various sections. Then I made engineering drawings and assembly drawings to show where they went and basically it was just geometry or drafting. It was interesting.

ROSS-NAZZAL: Tell me about the test when you came back and were part of that. What did that involve? What was your involvement?

HOMAN: Part of it was I was the smallest guy out there and the youngest, I guess. I remember one night we were testing it, we had to work at night because of the power it drew. One night they fired the thing up, and we were running through this whole scenario. Basically a 30- or 45-minute flight time history that they followed.

One of the guys noticed that something looked funny on one of the channels. The way this thing worked was when they turned it on it had zones, small zones all over the aircraft that had a thermocouple in the middle and a strain gauge. I'm not sure how many. I think there [were 235] zones. Each zone controlled a set of lamps on the heater. We had a computer program that read the time history of what the heat was. The thermocouple would measure what

heat was being put out by the lamps as they were being commanded. As it went through the trajectory, as the temperature in the profile increased, they increased the power on the lamps and followed that time history.

But there was a flaw in there. I don't remember exactly how it worked or why it was there that way. They had it set up so that if a thermocouple failed, it failed to a certain temperature. The way the program worked, as it cycled through once, if that zone wasn't getting the temperature that it required, then it went through and doubled the power to that zone to raise the temperature.

It kept doing that, and they had no real check on that. It dawned on them that this thermocouple that had failed to a temperature that was sort of within the range of what that temperature should have been, but it wasn't ever increasing, never quite getting up to where it should be, and all of a sudden they had this thing on full power. It went up 64 times. It just doubled each time. It dawned on them that all of a sudden this one zone in the heater was at full power and nothing was happening.

They shut the thing down. They were a little concerned. Since I was the smallest and youngest, I had to snake my way into the engine nacelle. They'd taken the engines out but the engine nacelle on one side where the zone was. [I] go in there and see if I could see any discoloration in the metal. It was like crawling around in an attic over the ceiling joist where one false move and you step through the sheetrock.

It was interesting from that standpoint. Like I said, I left just before they finished up. But when they finished up, they wrote reports and that's basically what they did out there.

ROSS-NAZZAL: You were working also on a supercritical wing.

HOMAN: Yes. That was a design from Langley [Research Center, Hampton, Virginia]. It was a design of a wing that basically delayed the transition period from subsonic to supersonic. In that transition phase drag is really high. It delayed that. I guess most airplanes now have that type of wing so they can fly faster more efficiently.

ROSS-NAZZAL: I was curious about that.

HOMAN: They built the wing, and then they mounted it on an F-8 that they had. They took the wing off that and modified the airplane. Back then the way they proof-loaded something like that, they put different loads on it that they thought the wing would see. They did it with 50-pound shot bags or 25-pound shot bags, hundreds of them. I had to lay out how many shot bags to pile up in what particular area on the wing. It was interesting.

ROSS-NAZZAL: Did you have to figure out which ones and where they would go? Or you were just told, "Hey, put these out"?

HOMAN: No. I had to figure out how many to put where, based on how the wing was loaded [in flight]. I figured out how to stack them that high without having them fall over. That was long before any of the fancy computers and things we have now.

In fact we had a slide rule in the office, a 20-inch slide rule. What you usually see were 10-inch ones. It was 20-inch because it gave more accuracy.

We also started having calculators.

ROSS-NAZZAL: What kind of calculators? Were you using the Friden computers?

HOMAN: One guy in the office used a Friden. One of those thrashing machines where you type in the equation, it just sits there and goes back and forth and back and forth and back.

I guess it was a big-time deal when they got a programmable Olivetti where you had a magnetic card about a foot long and you could program not very many instructions. They were really impressed when they'd programmed in a sine function. That's all [the program] did. They were just starting to get that type of equipment out there.

I'd been told the whole time that I was there, co-ops would be hired back. When I got back to school, I knew I had a job out there. It was just a matter of graduating and getting back out there. I sent out some applications and resumes to places. I wanted to see if anybody would give me a flight out to interview with them. I wasn't really interested in doing it because I had a job.

Then it turns out in January—I was going to graduate in February—one of the guys I worked with in the office there, the guy that I'd moved over to the other section with, Frank, called me late one night and said that he'd worked a transfer for himself to Langley, a permanent transfer, to move out there and work on something else. We talked about that, and I thought that was great and said, "Why are you calling me at 10:30 at night to tell me that?" He said, "But one thing. They weren't really happy with me doing that. I think they're going to take it out on you."

ROSS-NAZZAL: Oh no.

HOMAN: I didn't understand why. But sure enough, first thing next day I got a call from HR [Human Resources] out at Flight Research Center, said they didn't have a job for me. With no explanation. I asked them if they'd help me get another job, and they said no.

I was sort of—I guess depressed might be [the right word]—but at the time I was sending out resumes and things; I'd filled out an application at JSC [Johnson Space Center, Houston, Texas]. I think within a couple days of them getting rid of me out there I had two phone calls from different people at JSC offering me a job.

I talked to them. One guy was pressuring me quite a bit. The other guy, I told him that. He said, "It doesn't make any difference which job you take, just pick one. When you get down here you can move around."

I took one, and it was with the Structures and Mechanics Division down here. I came down here. When I started in March of that year, I was the only person they hired until June or July of that summer. I went to work at the Arc Jet [Test Facility], and it's way out in the middle of nowhere.

ROSS-NAZZAL: I remember, Building 222.

HOMAN: Yes. I didn't really get a good idea of what was going on in other places. I worked out there. Then in like I said June or July then they hired a bunch of new interns. Since they had so many, they basically set up tours for that group to see what was going on.

That's the first time I'd gotten around the place. I'd gotten over to Aeronautics or the Aero Systems Section in Engineering. I thought that sounded pretty neat so I made an

appointment to interview with Ivy [H.] Fossler. I thought that was a really strange name for a guy.

ROSS-NAZZAL: It is.

HOMAN: But it was Texas so I went over there and that's when I met Ivy.

ROSS-NAZZAL: Were you surprised when you walked in?

HOMAN: Yes, sort of. We talked, and she offered me a job over there so that fall I transferred over there. In that section they did a lot of the separation dynamics work. They were responsible for the SRB [solid rocket booster] separation and ET [external tank] sep when the orbiter comes off the tank. They were also [working] the approach and landing test where they flew the orbiter on the back of a 747. She was responsible for the separation aerodynamics for that. It flew with the tail cone the first few flights.

What they decided early on in the program was they'd fly it up to altitude with the tail cone on and then separate [the vehicles] and then yank the tail cone off with parachutes. The first thing I was assigned was to work that part of it, getting the tail cone off after [they] separated, which involved wind tunnel testing. The first thing I did was work up a test matrix to test in the wind tunnels the separation of that tail cone, but before we started testing they decided to fly the first flights with the tail cone on and not take it off.

From then on, I worked orbiter/747 separation. Did wind tunnel testing for all that. We were responsible for the proximity data and the mated vehicle data. The simulators used that data to develop their simulations. I spent a lot of time in wind tunnels.

ROSS-NAZZAL: Which wind tunnels were you using?

HOMAN: Let's see. We used Boeing at Boeing Field; I think a big transonic tunnel. Let's see. Ames [Research Center, Moffett Field, California]. Spent a lot of time at Ames. Langley. LTV [Ling-Temco-Vought] up in Arlington, Texas. They had a rig that they could fly where it would actually move the orbiter away from the 747. They had two separate rigs so they could look at the data during separation.

Langley, we were looking at the wake vortex that the 747 created. I went there to run some tests to define that envelope so that we could define the separation [maneuver]. What the 747 did after it released the orbiter—to get out of the way so that when the orbiter came back down it didn't come back down through the wake vortex.

That was interesting. That night I went to Langley, and the next day I was waiting for the data to come back. One of my friends from Edwards was on a tour of duty out there for a year. I looked him up, and we had lunch and he showed me what he was doing. We got back to his office, and he introduced me to his boss, Dr. Richard [T.] Whitcomb. If you know anything about aeronautical engineering, he was the god of that. He invented various things, [such as] area rule [and the supercritical wing that I had worked on as a co-op]. One thing that people are probably familiar with—he invented the winglets on the tips of airplanes.

ROSS-NAZZAL: I didn't know that.

HOMAN: If you're an aeronautical student you saw his books and you learned a lot about everything [he did]. He was talking to me and asking me what I was doing, and I explained to him that I was there for and told him I was working the approach and landing tests.

He looked at me, and he started laughing and he said, "That's the craziest thing I've ever heard. It'll never work." After that when anybody would disagree with me or say anything derogatory about something I said, I'd say, "Hey, I've been laughed at by smarter people than you."

ROSS-NAZZAL: Did you tell him about the tests that had been done here with the model airplanes?

HOMAN: Yes.

ROSS-NAZZAL: What was your role in terms of the wind tunnel tests that you were doing all across the country? Obviously you weren't setting up the wind tunnels and operating them.

HOMAN: That's basically it. Set up the test matrix so that they got all the test points to cover all the various flight conditions.

Then we'd go to the wind tunnel and be there and collect the data and basically run the test.

ROSS-NAZZAL: Oh, you were. I figured there'd be technicians.

HOMAN: We didn't run the wind tunnel.

ROSS-NAZZAL: Did you bring your own models, or did they have models?

HOMAN: Rockwell and Boeing provided the models.

ROSS-NAZZAL: How large were the models?

HOMAN: It depended on--

ROSS-NAZZAL: Depends on the test.

HOMAN: Yes. Some of them were fairly big. Like the orbiter was 2 or 3 feet long. I forget what the scale was. It was 1 and a half percent or 3 percent. There were the other ones that were smaller. They varied in size depending on the size of the wind tunnel also.

The whole tail cone [thing] was kind of interesting, too, in that before we flew—I don't know if you [know about] Jack [John W.] Kiker in the Spacecraft Design [Division]. He was into radio-controlled airplanes. He built a model of the 747 and a model of the orbiter, and they were pretty good size models. I think his orbiter was around 2 feet long.

He went out to fly this thing and go through this maneuver; it didn't prove anything, but it was interesting. The first time he did it; they flew it up there. The orbiter separated and all it

did was pitch over and head for the ground nose first. There was nothing they could do to right it. The elevons did not have the control authority to do anything.

This is late in the day. They informed us. There was a whole potload of people in the division office that night, and we were trying to figure out where we'd screwed up. How could we have missed it by so much? Nothing we could think of.

The next morning Paul [O.] Romere and I went over to Spacecraft Design. I think it was in [Building] 29 at that time. We'd go see what we could determine or figure out. The minute we walked in the door they had their orbiter sitting on the table with their tail cone on. Since I'd done all this work with the tail cone—in fact I think I was the only person on-site that had any drawings of the tail cone itself—I walked in the door, and it was obvious that the tail cone that they'd built, they built upside down. If you're familiar with the tail cone, it comes to a point behind the orbiter. If you look at it, that point is like 11 or 12 inches above the centerline of the orbiter. You looked at their model, it was that much below the centerline of the orbiter. They'd basically created this huge body flap that did nothing but pitch the thing over and the elevons did not have the control authority to overcome that.

I pointed that out to them and told them I'd give them the drawings of the tail cone that I had. They fixed that, and then the thing flew fine. But it was interesting, that meeting, how concerned we were. What did we miss?

ROSS-NAZZAL: I bet. Had the 747 already been purchased by this point?

HOMAN: Oh yes.

ROSS-NAZZAL: I imagine that was a tense meeting.

HOMAN: Basically had nothing to do with the 747. It had everything to do with the orbiter.

ROSS-NAZZAL: Did you receive an award for that?

HOMAN: No. In fact that was a time in my life—well, no. Then we started the flight testing out at Edwards. Deke [Donald K.] Slayton was the program manager for ALT [approach and landing tests]. I got to work with him. That started the point in my career where [it seemed] like I ended up getting blamed for a lot of things. If you're [not] familiar with Edwards, it's out in the middle of nowhere. Everybody who works there, they carpool, and they get there at 7:30, and at 4:30 everybody clears out. Nobody hangs around to do anything.

When we were out there testing, or getting ready to fly, I went back to the place that I'd co-oped at in the Heat Facility and commandeered a desk and was doing my thing out there. I knew how the place ran.

On the 747 struts we'd put load cells and then mounted the orbiter to those, so that would measure the forces that it saw, and we'd compare that to the wind tunnel data. Basically we had a full-scale wind tunnel test out there like that. When they put the two together the first time, the load cells weren't saying what we predicted they'd say.

We were a little concerned about that. I was out there, and everybody cleared out. I went back to my desk at this place, and it was real quiet. There was a note on my desk to call Deke, who had his office at the north end of the base. It was just me. I called him.

Unbeknownst to me, I called in to a conference room filled with people. He'd heard about this problem, and it was me who he was asking to explain to him what it was. I did. I basically said, "If we can't figure it out, we may have to demate everything and start over," which wasn't a popular idea. I explained that to him. We talked for a while. He said fine.

It turns out what it was, somebody had called their congressman and told them about this problem. They were getting calls from Congress about this. For some reason they assumed that it was me that had done that. I didn't know anything about it. Turns out it was one of the contractors that had done that. At one of the flight parties—and this is where I found out that I'd called in to a conference room—one of the Rockwell program managers came up to me and told me that he was in that meeting. He told me that he thought I did a really good job of explaining that.

Let's see. We went through the ALT Test Program. [I] was out there for all the flights. When that program finished up everybody in the office had their own task or job they worked on, like I said SRB sep and orbiter/ET sep and various things. I basically got back there with nothing to do. I guess I could have glommed on to one of those projects, but I decided that I'd go look for something else.

I moved over to FOD, Flight Ops Directorate, and into [the Flight Dynamics Section]. Let's see. They created a new [position] called Aero for some reason, but it was in there with the flight dynamics officers and the guidance officers and that group. Jay [H.] Greene was the section head. I worked there for a while and we were getting ready for the first Shuttle flight, but this was back in 1978, and it slipped and it slipped and it slipped. I figured I didn't want to be doing that for all the time.

One of the guys that I'd worked with in the approach and landing test was from MPAD [Mission Planning and Analysis Division], Aero Branch. At that time, I guess Engineering had proposed a robotic arm for the Shuttle, and basically the Canadians came in and said they'd provide the robotic arm for free, which kind of upset the Engineering folks. They didn't want to have anything to do with the Canadian robotic arm.

Charlie [Charles J.] Gott from MPAD, [who] I'd worked with, he'd gotten involved with that and was going to be responsible for designing and verifying autotrajectory or autosequence modes. Essentially the way the arm worked, it had various modes. You move it around manually with hand controllers or one joint at a time. Or it had this automatic mode where it had a table that you could put in up to 200 points, positions and attitudes, of a particular point on a payload or the arm then go through the sequence and the arm would automatically drive to those positions.

He, like I said, was responsible for designing and verifying that mode and those trajectories. The first few Shuttle flights with the arm had various payloads that had instruments that measured various things around the orbiter and the payload bay. They were looking for the arm to move the payloads to various positions.

In order to do that job, he bought some new computers and wanted to know if I'd come over and help him program them, because one, they needed to program in the RMS [remote manipulator system] code, the software that drove the arm, the algorithms. Two, they needed some graphics program because in order to do this verification you had to make sure that as the arm went through all these trajectories it didn't also go through the orbiter and went the right way without banging into itself or tying itself up.

I went over there. To get over there, I had to tell the control folks, Jay Greene, my section head, that I wanted to transfer over there. It was a Friday. I went and talked to him about that, and he said they had other plans for me. They wanted me to become a flight dynamics officer, but if I wanted to do that he wouldn't stand in my way. But just realize, since it was a lateral transfer, that anybody could stop it any time they want for no reason at all. He said, "But I don't want to be the one to tell you that. Just be aware that that's going to happen."

I finished up with him. He took me to Dave [David C.] Schultz, the branch chief, and we sat and talked. It was basically the same speech. He said, "Since it's a lateral transfer all they have to do is say no and they'll stop it. But I don't want to be the one to stand in your way."

I finished up with him and he took me up to Pete [M.P.] Frank's office, who was the division chief, and we talked, and he said exactly the same thing. "Just be aware that now Gene [Eugene F.] Kranz can say no and it's not going to happen, but I don't want to be the one to stand in your way."

I went home, came back Monday morning. Jay Greene comes into my office and throws the papers at me and says, "Kranz signed it."

ROSS-NAZZAL: Oh jeez.

HOMAN: As near as I could tell, when it got up to Gene, I assume he figured if these guys don't want him why do I want him. That was always a point of contention between us afterwards. Jay and I always joked about that. They screwed up, and I'd gotten out. I moved over to Mission Planning with Charlie Gott to work on the robotic arm.

ROSS-NAZZAL: How much computer programming knowledge did you have at that point? Was that OJT?

HOMAN: Yes. They came with manuals. One thing that was great about working for Ivy was she encouraged you to do stuff; she delegated a lot of things, and she'd back you up. She didn't micromanage you. They bought a Hewlett-Packard whatever it was at that time, and we had it in the office. We played around with it, and I programmed it to do some data reduction. You played games on it. There were no actual programs commercially available, so you did all the programming yourself. It was basically reading the manuals and programming it.

This was the same thing. You got a better version of that computer, and you ordered some graphics machines. They were CRTs [cathode ray tubes] and a box that would allow you to display, I think, 2,000 vectors. There was no software package that came with it. You built your own to draw it. The interesting thing was the computer had 16K of memory. It was early on in those days.

I programmed from what they called the functional subsystem software requirements for the arm, which was basically a manual of all the algorithms and how the arm worked and all the subroutines that they had. Programmed that up, at least the auto function part of it, then developed graphics programs that displayed what the arm was doing, so we could evaluate and verify that the autosequences worked.

As part of that, I got that program up [and running]. In order to do the autosequence mode or have the arm work automatically—everything that it needed to do—if you added the subroutine that added the hand controller inputs with the manual inputs, and a couple others, you could basically develop a complete simulation of the arm.

I did that, and at that point I guess that's when I met Sally [K.] Ride.

ROSS-NAZZAL: I was wondering about that, Sally and John [M.] Fabian. Did you do any work with him?

HOMAN: Yes. Judy [Judith A.] Resnik I met earlier when I was back in the Aero group. When I finished ALT, one thing they were going to do was look at residual fuel slosh in the external tank to see what happened when you stopped the acceleration and tried to separate the two vehicles. You had all this residual fuel sloshing around in the tank.

We put together a program that we were going to fly on the KC-135. In order to fly you had to have a flight physical and go through a couple days of physiological training in the altitude chamber. They were going to give me that class. Just before I started, I got a call from the secretary in the Astronaut Office. Judy was the first of that group to report, and they wanted to know if I would mind if she took that class with me, because you basically had to have a partner in the chamber. She took that class with me, that's where I met her.

Then later on it was Sally Ride, John Fabian, and Judy Resnik and Norm [Norman E.] Thagard that were assigned to the RMS, the robotic arm—the payload [deployment] and retrieval system. I got to working with them.

ROSS-NAZZAL: What was Judy like? I have to ask because we never had a chance to interview her. We would never have that chance.

HOMAN: I can get into that in a minute. It gets interesting.

CAROL HOMAN: You want me not to be in the room?

HOMAN: Let's get to the Sally part first. STS-1, when they opened the payload bay doors, there were tiles missing, and they didn't know if there were any missing on the bottom. They had no way of looking at that.

After that flight, what the community did was look at how do we look at the bottom of the orbiter. We looked at extendable booms with cameras on them like the masts that drove out the solar arrays on the Space Station. Smaller versions of that that you'd pick up with the arm and stick underneath and basically run this camera out there and then survey the bottom, and various other things.

Essentially, they came to a dead end where they couldn't develop something like that before the next flight. One night playing softball I was on one field and Sally was playing on the other field. We were sitting back-to-back in the dugout. Between innings we'd be talking, and she asked me what I thought we could see with just the end effector camera on the end of the arm.

I went back and worked on that. As part of that I'd also written a 3D graphics program that took a while to run, but it would show all the different camera views and out the window views. I went back, and I essentially came up with a set of arm configurations, using the camera on the end of the arm, stuck down below at various positions, [where] you could basically survey up about 90 to 95 percent of the orbiter. You couldn't see on the far side because you couldn't have an arm over there, and this one didn't reach.

I put that together, and I guess that's when I first met Gene Kranz, too. I hadn't known him before. [The idea] appeared to be a fairly—I wouldn't say controversial—but something that nobody really wanted to talk about. I was scheduled a number of times to present this pitch to the Flight Techniques Panel. I guess Dr. [Christopher C.] Kraft and upper management did not want to use the term tile survey at that time, just from a PR [public relations] standpoint. It's not something they wanted to advertise that they'd have to go look [under the vehicle to ensure the safety of the crew and vehicle].

I'd be set up for the Flight Techniques Panel on the agenda, and then they'd cancel it. Finally they came up with something, a generic term that they could use that really didn't highlight the "Jeez, we're thinking we're missing tiles."

At that time I had to go up and make that presentation to Gene and explain what I'd done and went over that with him. It was him and me, and that was the first time I'd met him. [That procedure] flew on every flight in the RMS package [whenever] they flew an arm. Up until *Columbia* [STS-107] where obviously they revamped the whole thing.

ROSS-NAZZAL: Did they talk to you about that after *Columbia* and the ideas that you had had?

HOMAN: By then it'd been so long that I didn't get any credit for that either. Years later, between those two [events], somebody from the RMS world put an intern on [the task of] looking through checklists, and she was concerned that one of the configurations wasn't looking at the orbiter at all. She wanted to come over and talk about it.

I went through my notes and the presentation, and we compared them. Somewhere along the line they'd dropped a minus sign on one of the joints. Once we fixed that everything was back to normal.

ROSS-NAZZAL: Did you ever try and encourage them to always fly an arm based on what had happened on STS-1?

HOMAN: No, that was a function of what payloads they had and what they were doing at the time. Let's see. Also part of those first flights, they worked arm contingencies. What if the arm didn't do this?

One of the modes of the arm was a single joint mode which was basically a hardwired switch to each of the joints so you could drive them individually. If the arm failed, you could work it back in and put it away. One thing we wanted to look at was if that happens and you deployed a payload or have a payload on the end of the arm, how do you get that back into the orbiter payload bay.

The way the arm [is] configured, it was very configuration-dependent depending on where the payload was in the payload bay and which joints did what at what particular time. That's [what] Judy and I spent a whole lot of time in simulators working out for each flight: "Okay, if this happens how do I get the payload back latched down in single joint mode." We spent a lot of time doing that. During that time I created basically a single joint simulation on the desktop computer, and we used that to work this out.

On STS-8 Dale [A.] Gardner was the arm operator. He and I had been working [together]. I'd showed him this capability that [I] had. Turns out that while they were in

quarantine and sleep shifting, they were awake all night. He got bored and came over to my office and played with the single joint simulator. When I got into the office the next day some of the things were moved around and I could tell something had happened, but I didn't know what. That turns out to be what it was. After a while, I talked to him. He told me that he'd come over. After the flight in the lessons learned, he wrote a memo that they needed to put that in their training schedule, which nobody knew existed.

I guess on STS-4, if we go back, that was the first Department of Defense mission. I got involved in some of that in the beginning and knew that I didn't want to do that. It was a real pain to work with those [black ops] people. I put a simulation in their secret room. They had an Air Force person that operated and did all the planning that we'd done before.

On STS-3 one of the things they were going to pick up with the arm was the Induced Environment Contamination Monitor, which was a box. It had a bunch of sensors on it that looked at contamination around the payload bay when they fired various jets. We'd created the autosequence that would put it in various places, and they'd fire the jets and take measurements. I guess the end effector camera failed on STS-3, so they didn't think that they could pick up the payload. They didn't have enough visibility into where the grapple fixture was. They moved that to STS-4 as part of that [mission]. So I basically duplicated the data and handed it in and forgot about that.

They were flying, and it was late one night. The phone rang, and it was one of the flight controllers. It became obvious that they had a problem on the flight. They wanted to do something with the arm. But based on what he was saying, they didn't know what they were doing. I figured a few hours later I'd be getting another phone call. [I] lay in bed for a while,

and the phone rang about midnight, and it [was] somebody else. "Could you come in and help us with this?"

When I got there, they took me into this room with a bunch of guys in uniform and some in civilian clothes. A cover on one of their instruments on the secret payload wouldn't open, and they wanted to tap it with the arm. Could I come up with an arm configuration that would allow them to do that? They explained to me or told me what they thought I needed to know about dimensions. I went back to the office and created a configuration and took it back.

No, that's not what they wanted. Obviously I didn't understand. We got into it, and they explained some more to me. Went back to the office and came back and that wasn't quite what they wanted [either].

The third time they started explaining it again, and it was obvious that either they weren't explaining it or I wasn't getting it. Finally, one of the guys without a uniform, one of the civilian guys who obviously was the highest-ranking guy in the room, stood up and said, "Just show him the damn photos." This guy with a uniform reached under the desk, pulled out his briefcase, and pulled out a folder of the closeout photos of their secret payload and showed me what they were trying to do.

I went back to the office and created [another] arm configuration. But the end effector on the arm is basically a hollow can, and in order to tap what they wanted it had to be in a very specific configuration. The displays for the arm read to a tenth of a degree for each joint angle which with a 50-foot arm and six joint angles you really don't know where the end effector is actually going to be. I could give them an exact configuration, but there's nothing to guarantee that they could hit that. Plus, you had all the thermal and mechanical effects of being on orbit and the orbiter bending and moving. Really the only way they could assure that they had the arm

in the right configuration would be a view from the end effector camera of what the target looked like exactly so they could line it up that way.

But there was no way [that could be done] at that time. They didn't have any way of sending [up] pictures or anything like that. They could downlink things. They'd put a teletype machine on the orbiter. It was their first way [of uploading written instructions]. Instead of just reading up changes, they could actually send up paper and words.

I basically made a view from the end effector camera. Created a picture of what they'd actually see if it was in the right configuration to hit the point that they wanted to hit.

Then what I did was took a blank [form], the form that they filled out for the teleprinter, to type in the information. I forget what it was. [I think] it was 80 characters and 50 lines, maybe not even 80 characters, per page. I took the picture that I'd made, overlaid the form, and then filled in various characters. I don't know if you've ever seen pictures that they created like that with different characters on a machine of people's faces.

ROSS-NAZZAL: Oh yes. I see what you're saying. Yes.

HOMAN: That type of stuff. If you stand far enough back it looks [like an image].

ROSS-NAZZAL: It looks like it.

HOMAN: It looks like it.

ROSS-NAZZAL: But if you look closely, you see something else.

HOMAN: Yes. Basically I created one of those of the picture of what they could expect to see. They uplinked that to the crew. From that standpoint I guess that was the first time pictures had ever been uplinked.

ROSS-NAZZAL: So I have to ask. Was it successful? Do you know?

HOMAN: I didn't find out till years later.

ROSS-NAZZAL: What'd you find out years later? Can you share?

HOMAN: [From] what I read, it didn't work.

ROSS-NAZZAL: That's too bad. Sounds like a lot of work for a possibility.

HOMAN: It was interesting how their secret payload became unsecret. In fact one of the funny things about the STS-4 mission. Ken [Thomas K.] Mattingly and Hank [Henry W.] Hartsfield were flying that. When they first started training for that flight, they weren't cleared to see the payload so they had to have stand-ins for training.

ROSS-NAZZAL: Wow. That kind of defeats the whole purpose of training.

HOMAN: Yes. Then what it all boiled down to at the end is just showing the pictures.

ROSS-NAZZAL: Your single joint simulator. Did that ever get imported into the Single Systems Trainer? Or was this always just maintained as a single system design? I'd never heard of it before.

HOMAN: That was the thing too, there was never any requirement for a bunch of these things that I did. There were a lot of things that went into the checklist that I thought needed to be there, but nobody gave me credit for that.

They'd come over to my facility during quarantine. It got to that point at least where they would come over, usually when they were in quarantine or sleep shifting. When they'd get bored at night, they'd save that part of the training to do then.

ROSS-NAZZAL: Save it to the end.

HOMAN: But that was the only place it existed.

ROSS-NAZZAL: Did you ever tell Spar about the trainer? Were they aware of it and other folks at JSC?

HOMAN: I don't know if they were or not. Like I said we put together that part, and I basically created the first part-task trainer for the RMS on a desktop. The RMS folks and FOD [Flight Operations Directorate] re-created that and used that for whatever they did. The crew, I think they had a copy of it, or they used that where they could come in and basically sit down at a

desktop computer and not fire up an entire sim to do what they wanted to do, and they could do it on their own.

ROSS-NAZZAL: Can you walk me through how it would work? How did they use the RMS? Was there a joystick?

HOMAN: We did have joysticks. We had some, but it also worked off of keyboard input. We created in graphics, or at that time graphics machines, different-colored letters and displays. We created a display like the displays they had on the vehicle to give them the same information. Then we had hand controllers and like I said you could use keyboard as input. They could operate in all the different modes. It was functionally the same.

The graphics were fairly crude. [We] had a box that would create up to 2,000 vectors. I wrote some software that would display the 3D graphics. For each of the flights we also produced [pictures] using the other 3D graphics program that I wrote. We would make pictures at each arm configuration what it would look like from each of the cameras in the payload bay and out the window views. We produced a document for each flight that was basically that [series of illustrations], all the arm configurations and all the different views. They started putting those in the checklist for each arm operation. We had that capability, and they used that in the checklist. Didn't get any credit for that either.

ROSS-NAZZAL: How did you come up with these 3D designs? You weren't in space. It's not like you could sketch it out. So how did you come up with this?

HOMAN: [I] basically wrote the code that created 3D pictures. There weren't any graphics programs or graphics cards. [You] had to draw it all yourself and figure out all the components. In fact I had to also build a program, like a CAD [computer-aided design] program, that would build the models of each payload and the orbiter. So I just created this model building program and a display program at that time.

ROSS-NAZZAL: You used the materials that were given by the manufacturer to create these things?

HOMAN: Yes. It was just writing a bunch of equations and getting them to draw out what you wanted to draw.

On STS-7 they flew a payload called SPAS, Shuttle Pallet Satellite. That was when Sally flew. That was a payload that they were going to deploy and retrieve with the arm. They'd never used the arm for that. That was the first time they were doing that. As part of [those] payload [operations] they'd deploy it and then they'd use it to do proximity ops with the orbiter, rendezvous, or approach it from different places, grab it, stick it back in the payload bay, and then take it out and deploy it again. The SPAS pallet had a number of still cameras. It also had video cameras that they could downlink to the orbiter so they could see themselves doing stuff.

One afternoon Sally came over to my office and said, "Crip was wondering if you could come up with an arm configuration to make a number seven as viewed from the SPAS." So I played around with that and gave her some pictures. Gave her the [arm] configuration and gave her some pictures as viewed from the SPAS, what it would look like, at various distances, etc. They took that, and in their simulation times when they [would] take a break they'd work on how

to make that configuration. [Only] the crew, [I], and their RMS trainer knew what they were doing.

As part of the software there's a 3-foot imaginary envelope around the axis of rotation of the shoulder yaw joint. Basically if the wrist yaw joint intersects that axis, they lose a degree of freedom in the arm. Nothing blows up. They put this imaginary envelope around it that would set off the master alarm when they got close to that region. It would turn off when they got out of it, but it would set off the master alarm. The last step in their procedure that they'd come up with was to back the arm using the shoulder pitch joint until they set off that alarm and then move it out. That's how they knew that they had the arm in the right configuration.

On the flights at that time there was very little downlink coverage. The only time they were in contact with the ground was when they were over a particular ground station, and there were very few of those. Sometimes there was 10 minutes of com in an orbit.

On this flight they were scheduled to fly over the continental United States while they had the SPAS out. They went over Goldstone in California and Merritt Island in Florida. Those two ground stations had the capability to take video downlink and voice from the crew. They were set up to do a PAO [Public Affairs Office] pass basically. The way it was set up was as they left the Australia ground site, they were putting the arm away and getting ready for this PAO event.

The next ground station was Hawaii, and all it had was data. They could downlink data. They'd do a data dump, and they had no voice or anything. The next one was Goldstone. This thing gets in range of the Hawaii ground station and starts doing this data dump. What's coming down is page after page of master alarms. I was in one of the back rooms and all the flight director said was, "What the hell is going on?" By then they'd flown out of range of Hawaii.

They came up over Goldstone, and they get the video and the arm is in this seven. During that time I think it was probably against protocol to mention anybody'[s name] from space, but John Fabian gave me credit for the arm configuration. So I think it blew [my cover].

ROSS-NAZZAL: I didn't know that. That's such a famous photo from that mission.

HOMAN: What was interesting, when they got back, at that time they'd transcribe all the downlink.

ROSS-NAZZAL: Oh, right, the air-to-ground, yes.

HOMAN: Yes, air-to-ground. You get the transcript, and when you get to that point what it reads is instead of my name it just says garbled communications.

ROSS-NAZZAL: Were you able to alert the flight ops team? Did they at least tell you how they were planning on doing it and that it would create some of these issues, so you could kind of reassure your colleagues that everything was okay?

HOMAN: No. Like I said it was just me and the crew and the one trainer that knew what was going on. I guess they hadn't really thought about this whole downlink.

ROSS-NAZZAL: That's what I was thinking. It would have been nice to give a heads up.

HOMAN: [Robert L.] Crippen got in trouble or took a lot of heat over that. Along those same lines, when he flew next on STS-13 or [STS]-41C, we were talking after one meeting. He took me aside and that's when they changed the numbering scheme.

ROSS-NAZZAL: Oh, right, yes.

HOMAN: The going theory was they didn't want to have another number 13 in the sequence. He got me aside after a meeting. He said, "They say that, but I really think it's just so that we don't make arm numbers again." Of course I went back to the office and started screwing around with the arm configurations, and I put together an orbiter that had two arms on it. One was in the shape of a four and one was in the shape of a one. Then the two EVA [extravehicular activity] crew members out there, [I] had them feet to feet in the shape of a C.

I sent it over to him. Just before they left [he] sent it back to me, they'd all signed it, he sent it back with a note said, "We knew you'd come up with something."

I was sitting there looking at that, and it dawned on me that obviously you can make a four with the arm, and if you make it so it's a four as viewed from one of the aft cameras in the payload bay, if you set it up right, a view from the camera on the starboard side of the forward end of the payload bay looked at it edge on, so when you multiplexed those two views together you had 41.

Also in that configuration the end effector camera was looking at the C in *Challenger*, so you had 41C. But like I said, they'd already gone to the Cape [Canaveral, Florida]. No way I could get them any kind of information like that. I put that away, and then it dawned on me that the next flight was [STS]-41D and the arm operator was Judy. They were flying *Discovery*, so I

called her up one day and said, "How'd you like a nice 41D?" Back to your original question, she said, "Well, I'd be happy with 34Cs." So I took that over to her and again unbeknownst to the rest of the world they came up on a downlink pass and had the arm configured like that.

ROSS-NAZZAL: I'm going to have to see if I'll find that photo.

HOMAN: They didn't take any photos. But it's on video.

ROSS-NAZZAL: It's on video.

HOMAN: The way I found out about it was in the Sunday newspaper. They made some comment about the flight, and how they'd made a 41D with the arm. I went back and looked through the videos and that's what they did.

Along those same lines, I'd quit working the Shuttle Program by then. But Crippen's next flight was [STS]-41G with Sally Ride again. I was over there in Building 4 and stopped by their office. We were talking and Crippen looks at me and says, "Well, what do you have for us?"

David [David C.] Leestma, it was his first flight, chimed in and said, "The RMS systems folks got with me, and they told me that we weren't to do anything out of the ordinary with the arm. If we plan to do anything we need to tell them."

Crip stopped him right there and said, "If it doesn't piss somebody off it's not worth doing." And then turned to me and said, "See what you can come up with." I went back and put

together a bunch of sevens and fours and ones and things for him and gave him a cue card with all this stuff on it.

They do those PFCs, private family conferences. They'll put together a private com line so the spouses can come in and talk to their respective spouse on board. It was private. At that time Sally was flying. Steve [Steven A.] Hawley was her husband, and he flew on 41D. The way we set it up was he'd have his private conference with Sally; she would tell him what they were planning to do and when they were planning to do it, so then he could relay back to me when to watch the videos. But they had problems on that flight with deploying ERBS [Earth Resources Budget Satellite], and they screwed around with that for hours and they pretty much decided that it probably wasn't a good time to mess around with the arm.

ROSS-NAZZAL: That's too bad.

HOMAN: Then let's see, [STS]-51L, Judy was going to be the arm operator on that. I sat down and thought about it and when you look at 51 in Roman numerals [it] is LI, and L is an upside down seven, so basically if you set up that configuration and you go to one of the aft cameras and you pan it 180 degrees and tilt it 180 degrees, it turns the scene upside down.

I thought that was a pretty good deal. It'd be LIL. But in those days they had mechanical stops on the cameras to avoid getting themselves into that type of position inadvertently. I put that away and didn't do anything with that.

ROSS-NAZZAL: That's interesting, I didn't know any of this about all these photos and the RMS. That's cool. Nice bit of Shuttle history. Would this be a good place to stop? We can pick up next time. Would that work for you guys?

HOMAN: Sure.

ROSS-NAZZAL: Okay.

[End of interview]