NASA Headquarters NACA Oral History Project
Edited Oral History Transcript

Dr. Eldon E. Kordes
Interviewed by Rebecca Wright
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WRIGHT: Today is February 19, 2015. This oral history session is being conducted with Don Kordes at his home in Tehachapi, California, as part of the NACA [National Advisory Committee for Aeronautics] Oral History Project, sponsored by the NASA Headquarters History Office. Interviewers are Rebecca Wright and Sandra Johnson. We'd like to thank you again for letting us in your home today to talk with us about this project. We'd like for you to start, if you would, by sharing with us how you first became part of the NACA.

KORDES: Well, that's a long story. I was at graduate school at Purdue [University, West Lafayette, Indiana], and I was working on my master's degree, and I was also working on some research projects to pay my way. We did use the NACA technical reports in some of the classes I was in. Also, I was a lab instructor for the structures testing lab. I was also designing a little race airplane for a local flight instructor, and I used the NACA report on airfoils as a base for the design. And so I was familiar with some of the work that was going on at NACA, particularly Langley [Research Center, Hampton, Virginia].

Then my last year of Purdue I had a chance to talk with one of the people from Langley. Dr. [Eugene] Lundquist happened to be a personal friend of Professor [Elmer F.] Bruhn, who was head of the aero department at Purdue [School of Aeronautics and Astronautics], and Dr. Lundquist came to Purdue and gave a talk to the engineering group about the work going on at Langley, particularly in the area of structures. That was kind of my major. After the discussion session, I talked to him a while, and he said there were openings at Langley for new hires. Would I be interested? So I filled out an application and sent it in, and I got hired to go to Langley to work in the Structures Lab.

Of course my first experience was a little bit negative because I found out when I got there that there was a budget crunch, and we had to buy our own paper and pencils. They didn't have any supplies.

WRIGHT: What year was that?

KORDES: That was in 1949. I went to work there in August of 1949. I was assigned to work with John [C.] Houbolt, and he was working at that time on advancing the concept of the loads response to clear air turbulence. Up to that time, all the airplanes had been designed as rigid bodies entering a so-called sharp-edged gust. John thought that the airplane flexibility of the wings and bending and torsion would have an impact on the loads and that it'd be more realistic than the rigid airplane response, especially when the airplanes were starting to become larger.

John and I worked on theoretical analysis of several different types of transport aircraft to different kinds of gust inputs, sharp-edged gusts, sine wave gusts, and so on. We published several joint papers on the subject. Then John got promoted to Assistant Division Chief of the Loads Division, so I got reassigned to work on other programs.

Most of the work that I did for the next few years was working on aircraft structural vibrations, both theoretical and experimental, on different structural types, straight wings, delta wings, swept wings. We did both the analytical and the lab tests on structures. We published several papers on the subject of that, different kinds of wing vibrations, and how well you could do the analysis to predict. And that was prior to NACA becoming NASA.

WRIGHT: Were you doing a lot of that testing in the wind tunnels?

KORDES: Most of the work we ever did was in the Structures Lab. We were doing load tests and influence coefficient tests and vibration tests of large-scale structures. About that same time, we started to become aware at Langley in the Structures Lab that the [North American] X-15 [Hypersonic Research] Program was going. We got a little bit involved with instead of working with aluminum structures, looking at structures that would withstand higher temperatures, above Mach 3. I got involved with a phenomenon called panel flutter.

Airplanes were experiencing severe noise levels in the cockpit and in the airplane with certain speed ranges, primarily transonic, and they discovered that what was happening was that the skin panels were vibrating, and acting like loudspeakers. I got involved in doing some of that, and we did both wind tunnel tests and theoretical analysis on trying to predict that phenomenon. About that time some of the concepts for high temperature structures were with corrugated skin backing and stuff for stiffening, and I got working on the test program in connection with Boeing, ran the tests in a Four-Foot Supersonic [Wind] Tunnel at Langley. These were steel panels.

We found out that the design concept wasn't quite right. Then we discovered that they were using the same kind of design on the fairing panels on the X-15. The X-15 was starting to push the Mach number up to around 3, and they were having problems with that, so they asked me to come down to Edwards [NASA Dryden Flight Research Center located adjacent to Edwards Air Force Base, California]—this was about 1960—for the X-15 Program.

They were having panel flutter problems on the vertical tail and the side panels. We came up with fixes on that, and then we had structural problems with windshield cracking because of the thermal stresses in the window frames.

WRIGHT: When you came out to Edwards, was that a temporary assignment, or did you take it as a transfer?

KORDES: It was a temporary transfer. When the X-15 Program got pretty well along, we had some other programs coming along at Edwards. We decided just not to go back. Part of it was a family choice, and we were starting to get involved with some of the aspects of the space program, primarily the Gemini. We did some work on the Parawing [also known as Rogallo Wing] for recovery instead of the parachutes. We built a Parawing [Paresev (Paraglider Research Vehicle)], and our test pilots flew it.

WRIGHT: I want to go back to that, but I want to ask you about the transition. When you were still at Langley, when you were still with the NACA, you were there during the time period where Sputnik [Russian satellite] was launched, and the move of the United States to a space age. Did you have an opportunity to move into some of that work at the beginning?

KORDES: I gave some thought to that from the list I got of potential things. The transition that I saw, because I was a working engineer, I wasn't worried about budgets, so I don't know what the administrative things were. But, the changes I saw was a change from working on aircraft problems to starting to work on the space program. In the Structures Lab at that time we were starting to look at things, real high temperature materials, ablation materials for heat shields, these high temperature panel studies.

I did do a little work initially on the Mercury Program capsule. But when they decided to move to Houston [Texas, Manned Spacecraft Center, now Johnson Space Center], I decided not to go to Houston. I'd been there. But the main thing I noticed, I think, was the transition from—NACA was more of a technical supporting organization to the industry and DoD [Department of Defense]. When it became NASA, it started to become an agency that was working on their own projects, like Mercury, Gemini, and so on. That was the main thing that I noticed in the transition. As far as the technology was concerned, it was just shifting from aircraft type problems to what you might run into in launch and reentry, different loads caused by rocket separations and so on, rather than landing loads and gust loads.

But when I got out to Edwards, one of the things that didn't come around till later, and that was when they started going to the [Space] Shuttle. The flight test group out here had done a lot of work with pilot control, control systems, system augmentation. We had started doing a program with digital flight controls rather than mechanical. They had a flying airplane that was all digital flight control. So there was quite a bit of effort at that point in supporting the Shuttle Program with looking at different control laws.

Also we developed the Lunar Lander Trainer [Lunar Landing Research Vehicle (LLRV)], it was developed out at Edwards, that finally it was used by Neil [A.] Armstrong and the rest of them for [training for] lunar landing. That was the main thing that I noticed, the transition was more from looking at things concerned with aeronautics and flight and atmosphere to the space program and supporting that kind of thing.

WRIGHT: What about differences of working at Langley, compared to working out here at the Flight Station?

KORDES: The big difference is almost everything done at Langley is either through the wind tunnel labs or structures labs or various things. Of course out here it was all aircraft. Your philosophy was use the airplane. It was an in-flight lab tool rather than there being laboratory type tests.

Of course you had all the additional problems associated with it, because it had to be done safely, it had to go through all kinds of inspections to be sure it was flightworthy and that the flight program was safe. In the lab you could pretty much design a specimen and test it pretty much any way you wanted.

WRIGHT: You found the actual flight test program to be more of your liking?

KORDES: Yes, I think one of the reasons I stayed at Edwards was because I liked to be associated more with aircraft than satellites and capsules.

WRIGHT: You mentioned when you were at Purdue you were actually building a plane for someone. Did you also fly? Were you a pilot?

KORDES: I'm a private pilot. I got my pilot's license in 1945. Now the design I did for the flight instructor, he actually built the airplane and did high speed taxi tests and liftoffs. Unfortunately, he flew a charter, and I think they ran into some kind of storm and crashed, so the airplane was never flown. But as I say, he did build it and taxi it and took off a short distance. Yes, I was always hoping he would—at that time in Cleveland they had the Goodyear Trophy Race, the air races. They had a light plane category, and he wanted to fly on that. That's what I designed, an airplane to fly in that light plane category, limited to 65 horsepower, gross weight couldn't be more than 600 pounds, restrictions like that.

WRIGHT: That's quite a project for a grad student.

KORDES: Yes, well, I was an instructor at the time. I was teaching structural analysis and aircraft vibrations at Purdue. It was in line with what I was doing. At that time I taught an elective class on wood construction, structural design of wood aircraft. Wood aircraft was the original composites.

WRIGHT: That's true. Are you from that part of the country, from the Indiana area?

KORDES: I was born and raised in Missouri, just outside of Kansas City. When I got in the Navy they sent me to [University of] Notre Dame [South Bend, Indiana] for training, and so when the war was over I went to Purdue for graduate work.

WRIGHT: It's a pretty good combination.

KORDES: Yes, there weren't any jobs for graduate engineers in 1946, because the companies were changing over from trying to retool and redesign for commercial rather than military. In the transition period there was a few of the people that I graduated with that did get jobs in aircraft. But that was the semester before I got out. When I got out, I didn't even get a reply back. I think I sent out 10 or 12 resumes and applications, and didn't even get a postcard back that they received them.

WRIGHT: You feel like the NACA at that time when you went down to Langley that you felt it was a good learning experience? Did you learn a lot from the people that were there?

KORDES: I did. I think I was very fortunate to be able to work with people like John Houbolt and a few of the other people there, John [M.] Hedgepeth and Bernie [Bernard] Budiansky and [John] Lyell Sanders and Manny [Manuel] Stein. I worked with them for quite a bit, I guess about five years.

WRIGHT: Sounds like it was a nice exchange of ideas and hands-on learning.

KORDES: We had both. We did theoretical analysis and then we also designed specimens and put them in the laboratory and tested them. We had to learn to design stuff and learn to set up test programs, get the equipment to do the programs. It was a real good background experience.

WRIGHT: Even in budgetary lessons, right? You didn't have anything when you walked in the door, and learned to do with nothing.

KORDES: We didn't get much in the way of budgetary lessons, we finally got paper and pencil. But one of the interesting things, when John Houbolt and I were working on the flexible airplane program, Langley had just gotten one of the first digital computers. It was put out by Bell Laboratories, and it was banks of relays. In the digital system, the relay was either open or closed, a one or a zero. They had banks of these, so John and I looked into the possibility of using that for engineering calculations. We did do some calculations on that machine. I got a little pocket calculator I've had for 30 years that'll do more in 5 minutes than that machine did in 3 hours. The whole building would shake when it was running.

But then when they first got the first IBM computers, they were primarily for finance. By that time John had gone over to the Loads Division, and he found out that the IBM 650 could be used for some calculations. I think that was the machine he did for some of his early calculations on the minimum energy path to the Moon which he came up with.

But they wouldn't let engineers program. You couldn't touch those machines. That was the main thing I found when I came out to Edwards, the computer system was off limits to everybody except the computer operators. They didn't want anybody doing their own programming. It was primarily for data reduction. But later on I got a couple of engineers who ended up with Ph.Ds. in computer science at UCLA [University of California Los Angeles], and they could make those machines talk.

WRIGHT: Yes, that's what I understand. If you know how to make them work, it'll do wonders for what you're working on.

KORDES: Yes, the head of the computer department came over one day and wanted to know if he could use him for two or three days. They had a problem with a computer. They couldn't get the data. So I called him and asked him. He said, "I'll check into it." He said, "Let me get back to you in an hour or so."

About an hour later, he comes back and he says, "You can forget about it."

I said, "What?"

He said, "Oh, I took care of it." They'd been working on it for three days. He did it in his lunch hour.

WRIGHT: He became the wonder boy, didn't he?

KORDES: Yes. He was a genius on that. I had a couple of guys that were. They could get in the machine, get their data off the airplane flight, and have it worked up before the technical people, the computer data people, had gotten their setup to run them.

WRIGHT: Well, if you can maybe share with us when you were first here and how the technology changed. You mentioned the computers.

KORDES: The X-15 Program, all the data was recorded on a galvanometer film recorder drum. They did telemeter some data, which had primarily to do with the flight controls, like airspeed, altitude. Then those films had to be hand-read, and they had a machine that you run the film through, and cursors that you could take the measurements with off of the little traces. Of course later on it all went digital, and you could run it through the computer, and the computer would print out the final results with all the calibrations and everything else already in it, instead of having to read the film and put it into the process and convert it to engineering units and supply the calibrations and everything separate.

Then of course the flight data packages became manageable, like on the X-15, they had an instrument bay that was so big by so big by so big and full of vacuum tube type stuff that was not that reliable.

WRIGHT: I have to assume it added weight to the plane as well.

KORDES: Oh yes, the stuff was heavy, a lot heavier than the solid-state stuff. I think the space program is the one that made that big conversion from the old style electronics to the solid-state transistors and so on. Later programs, we were even flying airplanes—the early parts of this drone thing, the pilot had a ground cockpit. He was flying the instruments, and the instruments telemetered information from the airplane. Then the computer transmitted back to tell the airplane what to do. Earlier than that, you couldn't do it.

The simulator on the X-15 was semi-mechanical. It had all the control surfaces and stuff that moved. All the actuators were the same as in the airplane. Now a lot of the simulators are all electronic. The X-15 simulator didn't move, just the control surfaces moved.

WRIGHT: Were you watching the X-15 when it would land or during the flight test, were you out on the flight line doing that? Or, were you monitoring the flight?

KORDES: All of the above. Certain flights I was monitoring the flights. One of the things I got involved with was the dynamics of the landing with the skid landing gear. We did some analysis of the loads in the landing, so yes, a lot of the flights, I was out on the flight line watching the actual touchdown.

WRIGHT: Were you able to learn a lot from observation? Or was most of it learned from your instruments and other ways of monitoring?

KORDES: You're so far away from the landing itself that you really couldn't tell a whole lot about it, except to see how the airplane actually transitioned. We got more from the analysis and then going out after the flight and tracking the skid marks from the landing gear and seeing how that agreed with what we predicted could happen. We came up with some solutions. A little problem getting the pilots to think about it, because a conventional airplane, the landing gear is near the center of gravity. On the X-15, it was clear at the back. The control surfaces were right over the landing gear, where on a fighter, or something like that, the tail was farther back from the landing gear. The pilots, I had a time convincing them that they couldn't hold the nose off.

All it did when they pulled back on the stick was load the landing gear at the time when it was taking that load from landing. We ended up with things like a switch in the landing gear when it touched down, the controls would go neutral. We took a lot of the loads off of the landing gear. We also found out that you could slightly steer the airplane—they thought they could steer it with rudder, but again, the rudder was right over the landing gear. We found out little things like if you wanted to turn left, you put in left aileron. What it would do is load one skid, and unload the other one, so they'd get more drag on one side. You could turn the airplane somewhat. But had trouble telling them. Pilots instinctively—in fact, they practiced all their landings in an F-104, because they had the same glide characteristics, with the full flaps. So, their tendency was to try instinctively to land it like a fighter plane. It didn't work that way.

WRIGHT: During that time period, was the process such that you were able to tell the pilots directly your results of your analysis? Or did you have to pass that up through specific people?

KORDES: No, on that program, for every flight, there'd be a flight planning session. Everybody would talk about each maneuver for the whole flight program, and then things like this landing loads, they sat down with the pilots in between time and talked to them about it, got their reaction to trying stuff like putting in ailerons at landing, and see what it would do. Yes, it wasn't a lot of formality and filing a lot of paperwork. But you did have to go through the flight qualification steps. If you wanted to put any kind of instrumentation on the airplane, it had to go through a review and be approved.

The flights themselves was pretty much people involved in that particular flight sat down around the conference table with the pilot and crew chief and whoever else was involved, and discussed it step by step. After launch you do this, and the duration of the rocket burn, and what maneuvers would be done during that time period to check out the control systems and handling qualities. Everybody had to agree that that was a good sequence. Then they'd practice it on the simulator to be sure. It was a very inefficient glider, once the power was off, energy management to get it back to the base was a major consideration. The pilots and the flight planners worked long and hard on each flight, just to be sure that each maneuver would fit into the program.

WRIGHT: Did you stay with the program until its end?

KORDES: Yes. Then we transitioned to the Lifting Body Program, which was an early look at space return ships. Langley had their ideas, and Ames [Research Center, Moffett Field, California] had their concept of what the return should be, and Houston had their ideas, and the Air Force had their ideas.

WRIGHT: All were good ideas, right?

KORDES: We were pushing for the Lifting Body concept, and Houston decided to go with the Shuttle concept. The Shuttle proved very successful. I don't know whether the other concepts would have worked any better. But there were a lot of arguments going on technically about advantages and disadvantages of different shapes. We flew three different shapes out at Edwards. We flew the shape that was being pushed by Langley, and we flew the shape that was being pushed by Ames, and the shape that the Air Force wanted to work with. It was rocket-powered and dropped off the [Boeing] B-52 [Stratofortress], and the pilots flew them.

WRIGHT: Quite a sight to see I guess.

KORDES: Yes, it was an interesting program.

WRIGHT: What were some of the challenges that you worked through as part of what you were doing at that time with the Lifting Body?

KORDES: The main problem that I got involved with was primarily the problem that they had with structural interaction with the flight control systems. One of the problems we had was they had mounted the battery system on one of the doors in the equipment bay. They started getting some feedback into the control system and getting some oscillations. It turned out what was happening was that the door acted as a spring, the battery acted as a mass, and it was vibrating. It happened to be in the frequency range of the flight control instrumentation, so there was feedback into the gyros and the accelerometers in the flight control system. It wasn't a major problem but it was a concern. We did things like change the characteristics of the mounting system, and the problems go away.

Back on the X-15 Program we had some things like on one of the flights they came back and they landed, luckily with no problem, but the nose wheel tires were blown. We got in there after the flight and found out there was all kinds of melted tubing in the nose gear compartment. We did some tests in the lab then on the door and found out that the heating had warped the door in such a way that there was an opening and the hot gases were impinging into the compartment. It overheated everything and melted some of the aluminum tubing and blew the tires. Some problems like that.

But, a lot of little things happened on the program. The X-15 was the first airplane that actually flew to Mach 6, and we had a number of different problems with heating, because the nose gear door thing was one thing, another one we had was that the windshield glass was cracked. Luckily it didn't come out, it just became opaque, one side only. It turned out that was because of the design of the glass and the glass frame, and uneven heating was causing stress to be put on the glass and caused it to fracture. We got to talk to the contractor and Rockwell changed the shape of the thing and changed the way the glass was mounted. Never had any more problems with it. We had things like that.

We initially had the panel flutter problems primarily on the vertical tails. Again, with the side panels we already knew there was going to be problems with that from the panel flutter standpoint, so that got taken care of. Then things like the wing leading edge was a heat sink, and they had slots for expansion slots, but they didn't have enough of them. When they started going to the higher Mach numbers, come back and there'd be wrinkles in the wing skin. We had a few sessions on what to do about that.

WRIGHT: Were you the one that discovered the wrinkles?

KORDES: I didn't discover the wrinkles, but I helped find the solution.

WRIGHT: How much time does that involve? Looking back on it now, the problem was discovered, and then the problem was resolved. But was it months, weeks? How soon were you able to resolve these issues?

KORDES: I think the issue of what was causing it and what the fix would be didn't take all that long. But to actually do it on the airplane, make the corrections on the airplane, the first thing you had to do was put in more expansion slots. That's difficult to do. Inconel X [alloy] is very difficult to work with to start with. Then without tearing the whole wing apart, how to get in there and increase the expansion. Then of course the buckles in the skin or wrinkles in the skin had to be straightened out. That had to be done. So the actual physical work to do it took weeks. But to discover what caused it and how to fix it was relatively simple.

WRIGHT: If I understand correctly, there were three X-15 vehicles. So each time you made a modification, was it made on each one?

KORDES: Yes.

WRIGHT: You worked closely with the aircraft manufacturer. Were you working close with their people?

KORDES: Oh yes. They had people on site all the time, and they had a shuttle airplane that went every day back and forth to Inglewood [California]. We made a lot of trips down there, and people came up. It was a good working relationship between the company, and then of course the Air Force was supporting it, and they had people in there, and they had their own pilots involved in the program. It was a pretty well-run joint program.

WRIGHT: It's a good thing there was a lot of communication and teamwork with that many people involved.

KORDES: Yes. That many agencies. The people were no problem. The people who were working on that program, everybody was working for the same goal. It worked. In all phases of the program there was joint effort between the company and the Air Force and NASA. Well, the Navy was involved also. In fact one of the first pilots of it was Navy—the first three pilots, one was Navy, one was Air Force, one was NASA.

WRIGHT: During the program, a couple of the planes were lost in crashes. What were some of the lessons or some of the information you were able to obtain from those incidents?

KORDES: The first accident they had was a contractor's accident, when they blew up the engine. It turned out to be Number 3 ship, and that was the one that was scheduled to have the first of the designed engines. The original flights were done with four of the old X-1 engines, and so the throttling effect on the first airplanes was either they fired one rocket, two rockets, three rockets, or four rockets. But they didn't have enough thrust to get to the design point, so they developed the Thiokol [Chemical Corporation, Reaction Motors Division] engine that was basically throttleable. That accident happened on the test stand.

Then the first flight accident we had was the landing at Mud Lake [Nevada], where the rocket failed to ignite, and then the pilot didn't have enough time to dump enough fuel, so he came in pretty heavy. That's when we discovered that the pilot technique of trying to hold the nose off by pulling back on the stick actually overloaded the struts, and one of the struts collapsed, one of the skids. We went in to look and find out why it collapsed, and that's when we discovered not only did they have landing heavy, but he landed fast, and the extra airloads. That's when we started looking at the phenomenon of the skid type landing gear.

Then of course the last accident they had was a reentry accident. I'm not sure what the final result was. In general he had the airplane not configured right because it was all in the reaction control. You had to set the airplane up at a certain attitude to do the reentry. Apparently something happened that he didn't do that. Of course the airplane overloaded and came apart. But those are the only incidents they had. We had some others, some close calls that didn't amount to anything.

WRIGHT: You learned a lot from those too I guess. Where did you move on to then after the X-15? What were some of the projects that you were directly involved with?

KORDES: I was involved somewhat with the Lifting Body Program. Then I got involved with the [North American] B-70 [Valkyrie] program and I worked up a program with the contractor to put little canards on the front of the airplane that we could change the frequency of, and do in-flight vibration testing, because Rockwell had the capabilities of doing structural analysis to predict the vibration characteristics. Then of course one of the things we were interested in was did the aerodynamics affect the aircraft structural vibrations, because all the vibration tests and stuff that they do on an airplane is done on the ground. That was part of the thing with the program. I worked primarily on the airplane part of it and the flight testing, and John [H.] Wykes at [North American] Rockwell did the analysis based on the design. Then he and I presented a paper at AGARD [Advisory Group for Aerospace Research and Development] in France on the results of that.

WRIGHT: Well, if you have to present somewhere, that's a good place to present, in France.

KORDES: Yes, it was a good little program. As a result of what we did there, the [Rockwell] B-1 [Lancer (Bomber)] came out with those little canards on the front. That was for load alleviation in the turbulence on low [altitude] flight.

WRIGHT: That's quite an accomplishment.

KORDES: It gave the pilots a better ride, if nothing else.

WRIGHT: I'm sure they appreciated that. Then you also had mentioned something during the Gemini Program. Were you involved with some of the checking out the parachutes?

KORDES: The Gemini Program is when they were first thinking about altering things to water landing. We built a little test airplane, a glider with a Parawing, which the hang gliders have been using ever since. But then some group at Johnson Space Center wanted to take that a little further, so they got Rockwell to build a similar device. We used metal struts for the structure. They don't fold too good, so the concept they had Rockwell working on, I think maybe they worked with Goodyear, to have inflatable booms.

They built at least one model. It was a full-size, we had a weight on it. It was a Gemini capsule thing. They did drop that, made some tests, then it went away. I'm not sure what the real reason for dropping it. But we proved that you could fly it like a glider, and flare and land with it.

For some reason the concept went away, and of course it wasn't even considered for Apollo. I think packaging may have been the main reason, bulk and packaging to get the inflatable struts and then the gas source to pressurize it. Because they did the tests at Edwards, we were in on that to a certain extent but we never followed up on it.

WRIGHT: You also mentioned the Lunar Landing Research Vehicle. Did you have some involvement in that project as well?

KORDES: More as consulting and some of the structural design, but in the concept and the actual test program I was not involved with it.

WRIGHT: Did you watch it fly?

KORDES: Oh, yes.

WRIGHT: Your thoughts about how that worked?

KORDES: At that time NASA was pretty fairly small at Edwards, pretty small, and kind of a big family. Any time a project like that did anything, everybody had to go out and watch it.

WRIGHT: Structurally what were you thinking when you watched that apparatus get off the ground?

KORDES: We were concerned at the time not with the lunar lander but with the concept. Could it be used as a trainer? We weren't concerned so much with things like weight that you'd have to do to package the whole thing and get it to the Moon. But the whole idea was could you simulate with the engine thrust the difference in gravity so that the pilot would only be working with the lesser gravity. We weren't so much concerned with the design but as a test bed. It wasn't really anything more than just mostly common sense. Don't make it any heavier than you have to kind of thing.

WRIGHT: How long were you with NASA here at Edwards?

KORDES: I was out here about 21 years.

WRIGHT: And you retired in what year?

KORDES: In 1980.

WRIGHT: Right at the beginning of the Shuttle Program. Were you here for the Approach and Landing Tests [Program (ALT)]?

KORDES: Oh yes.

WRIGHT: Were you working with that program as well?

KORDES: I was on the team to design primarily the pilot escape system out of the [modified Boeing] 747 [Shuttle Carrier Aircraft]. We were involved of course. But the primary modifications of the 747 was all done at Boeing. Because our pilots were going to be the ones to fly the 747, we got involved in coming up with an escape system, in case they had problems with the 747. It isn't designed to get out of very easy.

WRIGHT: I believe one of the pilots was explaining it, but I'm curious from your point of view, when you were working on it, how the system evolved. Could you share with us how you and your team came up with that escape system?

KORDES: It was basically a chute coming from the cockpit out to the bottom of the airplane that the pilot could drop into and come out the bottom, instead of being in danger of being hit by any of the other structure. An ejection seat would have been out of the question because it puts you right into the Shuttle, if it was still attached. So they had to come up with an alternate system. The general thinking I think at the time was that any emergency wouldn't be a sudden emergency, it would be something that would mean that the airplane was not returnable, and the pilots would have time to make a quick exit. It was working with the chute. It wasn't supposed to be a straight drop, and you couldn't just put it right at the bottom, it was working around the landing gear and various other parts of the structure. That was primarily our involvement at Edwards with the program.

Our pilots were very much involved with the program, because they were worried about the change in the handling qualities and the stability of the airplane. Some of our people that worked with the pilots on handling qualities were involved. As far as the aerodynamics and the structures and that part of it, that was all Boeing.

WRIGHT: Were you pretty comfortable with the design of the mate? Although like you mentioned it was Boeing. But as a structures person, did you feel like the combination was going to work as well as it did?

KORDES: The escape system as far as I know was never used. So that means it was a good system. We were just on the fringes of the actual structural modification. That was pretty much handled by Johnson. We were involved of course with the initial flights when they launched it off the back, mainly because our pilots were flying the airplane, and we were responsible for the landing.

We didn't get involved directly with the Shuttle Program that much. We had the High Temperature Structures Lab out at Edwards. We did do some testing. I wasn't involved in that, but they did do some testing with some different components. At that time I think Edwards was the only one, I think it still is the only one that has High Temperature Structures Lab capabilities.

WRIGHT: As you were there you moved up the management levels, is that correct?

KORDES: Yes. When I retired, I was Engineering Division Chief.

WRIGHT: That's a lot of responsibility, with all those engineers.

KORDES: We had primarily airplane dynamics, flight control, and handling qualities in our division. We worked with that aspect of the thing. A couple of people that worked in my division worked with the early flights of the Shuttle. It indicated some pilot-induced oscillation problems with the control system, so Edwards was running some tests with our digital flight control airplane, and a couple of our pilots and a couple of my engineers worked on that program. They were able to help the Shuttle group come up with flight control system changes. But other than that, we weren't all that much involved with the Shuttle Program.

WRIGHT: What other airplanes were you working on close to the end of your career there?

KORDES: We did some work on the structural dynamics and vibration of the [Lockheed] SR-71 [Blackbird]. We did a series of lab tests, vibration tests. I was involved in that. Lockheed, one of their engineers there did the structural analysis for the vibration stuff, and he and I presented a paper on that at one of the conferences.

WRIGHT: Did you like the SR-71? Did you find that plane to be an interesting plane to work on?

KORDES: It was an interesting plane all around. To work on it wasn't all that much fun because it leaked fuel everywhere. You had to be very careful. When we were doing the vibration tests in the lab, you had to be very careful where you were during the test because of the dripping fuel. But yes, it's an interesting airplane.

WRIGHT: Was that the last plane that you worked on, the SR-71? Or were there others?

KORDES: By that time I was pretty much into administrative work, because we had to work with budgets and we had to work with assignments, and we had project support. We had several projects going, and I'd be sure it had proper people assigned to the projects, the different phases of the program. That was pretty much the way things were going. The last program I had anything to do with was the high speed drone program [Rockwell RPRV-870 HiMAT (Highly Maneuverable Aircraft Technology)]. Not so much directly, but my people were working on the program. It was an interesting concept; it's different from the drones they do now because it was designed to fly from the ground cockpit, like the pilot was in the airplane. I left about the time they started flying that, so I'm not sure exactly what all went.

WRIGHT: If it's okay, I'm going to ask Sandra if she's got any other questions that she wanted to ask you before we close today.

JOHNSON: I was just thinking about the different airplanes you worked on, and being a pilot, would you have ever wanted to do some of that test-flying like the pilots that you worked with?

KORDES: The answer is dual. Yes, but I knew I didn't have the skill level. You watch these pilots. I never flew with them in a test program, but I flew with them in other airplanes. These guys are so precise and reflexes are so good. I never felt like I would like to really fly the test programs.

JOHNSON: What airplanes did you get to fly with the test pilots?

KORDES: We used to fly the Gooney Bird [Douglas C-47 Skytrain], and we had the Aero Commander [680F] most of the time. Sometimes they'd let me fly the Aero Commander. But that was about the size of it. I knew their skill levels and their dedication was 100 percent. I didn't have that much time. I had too many other things to do. I enjoyed working with them, but I never really had the desire, mainly because I knew I couldn't do it.

JOHNSON: Yes, we've had other people who described it as they were natural pilots.

KORDES: Yes. Some of them, they were so far ahead of the airplane, it was unbelievable. I don't know how they could do it. But that's what they did. I think we had some of the best pilots in the world out there at Edwards at different times.

JOHNSON: What was your favorite project that you worked on?

KORDES: I would probably have to say the X-15, because that was a fairly long program, it lasted like nine years. It had a lot of challenges, because nobody had ever been there before. When we started flying the Lifting Bodies, we already knew that the characteristics of the approach and landing was very similar to the X-15. Then the Shuttle came along, it's about the same L/D [lift to drag ratio] as that. Those programs, we already had the background, so it wasn't quite the same as the X-15 Program where everything was new. There were a lot of new issues and new things.

I enjoyed the B-70 program too, because it had some interesting aspects. We had structural problems with the landing gear on that. Then the in-flight vibration program was interesting. But I was getting more and more involved in the supervision and administration and budget cycles by that time, that the technical aspects and the details were lost.

WRIGHT: Is there anything else that you can remember, or anything else that you'd like to share with us, that part of your career?

KORDES: I could mention a few other things. When I first went to work at Langley, I was surprised that personnel called me right after I got there, wanted to know if I would teach some night school classes for the University of Virginia [Charlottesville] graduate extension. I did that for 11 years. I taught advanced math. Then I worked on my Ph.D. at the same time, went to summer school at Virginia Tech [Virginia Polytechnic Institute and State University, Blacksburg] and got my Ph.D. from that program.

JOHNSON: Did some of the Langley employees take those classes from you?

KORDES: A lot of them.

JOHNSON: I was wondering if that's why they wanted you to teach them.

KORDES: I had been teaching at Purdue, so I had the background. The University of Virginia master's program had just started an extension, and one of the things they were requiring in order to get into the program, you had to take one of the advanced math classes. Almost everybody that went through that program or even started the program I had in one of my classes. So I had 15 to 18, 20 every semester. By the time I left after 11 years, I had been acquainted with almost every engineer at Langley.

JOHNSON: Coming from Purdue, a lot of astronauts came from Purdue too, that school is pretty well known for producing a lot of pretty accomplished people.

WRIGHT: All the way through NASA, engineers also.

KORDES: When I was at Purdue I was teaching the vibration class, a required course for seniors. A lot of the engineering graduates at Purdue the last two years I was there all had to go through my class on that. Almost all my students at Purdue were on the GI Bill [Servicemen's Readjustment Act of 1944]. Over half the class was older than I was.

WRIGHT: Did you continue your teaching when you came out to Edwards? Did you teach out here as well?

KORDES: Yes, I did some. I taught a class for UCLA, and I taught undergraduate classes for Chapman College [now Chapman University, Orange, California], and I taught a couple of advanced engineering classes for Fresno State [California State University], all at night school at Edwards. Then after I retired, I taught for a couple of years for West Coast University, mostly math and physics.

WRIGHT: You stayed busy.

KORDES: Yes.

WRIGHT: Well, thanks for sharing that. I was going to ask you what you did your dissertation on.

KORDES: My dissertation was done on the vibration analysis of a toroidal space station [rotating wheel design]. Shell station, you know, a big tire.

WRIGHT: How interesting.

KORDES: But they haven't built those yet. At the time the thinking was that you had to have some gravity, because a long time in weightlessness could be a major physical problem. They were talking about having this doughnut spin, artificial gravity, so the centrifugal force would simulate gravity. I guess they decided they didn't need to go that way.

WRIGHT: Well, thank you for sharing your time today.

KORDES: Okay.

[End of interview]