

## ORAL HISTORY TRANSCRIPT

DOROTHY B. LEE  
INTERVIEWED BY REBECCA WRIGHT  
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WRIGHT: Today is November 10, 1999. This oral history session is being conducted with Dorothy B. Lee, who is known as Dottie to her friends and her colleagues, for the Johnson Space Center Oral History Project at the offices of Signal Corporation in Houston, Texas. Interviewer is Rebecca Wright, assisted by Sandra Johnson and Carol Butler.

Thank you again for taking the time to visit with us today. You have contributed to the design and development of spacecraft for all of America's manned space programs. Were your childhood dreams in any way related to what you were able to accomplish as an adult?

LEE: Not as a child, although I was interested in astrophysics. That word didn't exist when I was a child. But I read...[George Gamow and other] astrophysicists, and I knew that we were going to go to the moon [when] I was ten years old. That was in 1937. No one outside of "Buck Rogers" or what have you had stories of those tales in those days.

I was recruited, while in college, to go to work for NACA [National Advisory Committee for Aeronautics], and then it became a reality by virtue of just being at the right place at the right time, which is the story of my life. My entire life has been lucky, and I've always been at the right place at the right time.

WRIGHT: Were you very unique as a child to have those dreams about going to the moon?

LEE: I wasn't aware of it. I had playmates, but I did a lot of reading because I was an only child. So I just read a great deal. I wasn't aware that I was unique, but I haven't met anyone else who read [Gamow] and the rest of them when they were a child. Mother wondered why

I liked classical music. I think it worried her. I was so glad that ultimately she loved opera, because I didn't want her to think something was wrong with me.

But, no, math was very easy for me, just happened to be the easiest subject, and that's the reason I majored in math. Then when we were recruited—I say "we." There were several girls—I was from Randolph-Macon [Woman's College, Lynchburg, Virginia]—who went to work for NACA at Langley [Research Center, Hampton, Virginia], and again I was put in the best division there. It was called PARD, Pilotless Aircraft Research Division. We had the exciting opportunities to launch vehicles, to test different configurations, and how those configurations would [ultimately design] spacecraft by virtue of the shape of the nose. We went from cones to blunt bodies. You see today your different vehicles are all blunt bodies. So I was right there and enjoyed it. It was fun.

WRIGHT: Was the fact that you had gone to a Virginia college—

LEE: I imagine that gave me the opportunity, because I don't know where they recruited. Of course, today, NASA recruits all over the country, but back in 1948, which is when I graduated from college, and there were not many gals, we were hired as "computers." Computers didn't exist, you understand. We had calculators. They gave us civil service exams, and I was fortunate enough to pass the exam at a couple of grades higher than I was hired in, so I got raises.

But the thing that I would like to tell has something to do with Dr. [Maxime A.] Faget. Working as a computer, [later] we were classified as mathematicians. One day my project was to solve a triple integral for an engineer, so it didn't require using my calculator. I could just do it at my desk. Max's secretary was going to get married, and so I was asked to be his secretary for two weeks while she was on her honeymoon. Well, we shared the same office, and all I did was—I don't know how to type, still. Made my girls take typing before

they went off to college. I would answer the phone, distribute the mail, and work my triple integral. I did this for two weeks.

We all were friends. [There were] 100 people in this particular division, but we would party and get together frequently, so we knew each other well. This Friday, the end of my two weeks, Max said, "Dottie, how would you like to work for me all the time?"

I thought he was being funny, because I don't type, and I knew that this was the last day and Shirley was returning Monday. I said, "Sure," in a very flip way.

He gets up, goes downstairs to talk to the division chief, and he returns and he says, "Dottie, you start working for me Monday."

Well, I looked at him like, "All right," you know. So they found me a desk, and I was put with some engineers who were beautiful and taught me how to be an engineer. I learned on the job.

Brilliant men have touched my life throughout my career, and I couldn't help but win and do well because these people did guide me and continued to guide me even when I got here in Texas. But that was when I went to work for Max Faget. It was just a marvelous experience. That also led the path of my becoming a project engineer, which is something rare today, male or female, anywhere. Projects are so large, you can't have just one project manager.

But our launching of spacecraft from Wallops Island, which is off the coast of Virginia [in the] Atlantic Ocean, I had to do everything in the design and the trajectory and the stability analysis of the spacecraft, plan the instrumentation, and then when the data returned, analyze those data and document them. If you've seen my bibliography, you see these reports. As our Mach numbers increased, our knowledge increased...and that is how we started the development of today we can go to the moon and go to Mars or wherever. It was just by virtue of that experience at PARD, Langley.

WRIGHT: Did you have other levels of increased responsibility from the time you worked for Dr. Faget till the time you were project engineer?

LEE: I guess by having a project, and the projects become more complex. I started out with what we call a single-stage vehicle, and before I left Langley and came to Texas, I had a five-stage vehicle in which the payload, if you would, or the configuration, the nose, was going to be the shape of the blunt body of the Mercury. So I did progress in complexity of the firings or the different flights that we had.

WRIGHT: Speaking of Wallops Island, was there one case in particular that you were working with out there that has a special memory to you?

LEE: Yes, it was another five-stage vehicle. We were waiting for another rocket to be launched before we could go. Well, we waited all day long. The wind picks up, and you wanted to make sure that your vehicle[’s trajectory] would not be [jeopardized] by the wind. You wanted to orient it properly...

We'd sent up balloons to see which way the wind [was] blowing, get...atmospheric data, and finally [by] dark [we were] able to launch. It was exciting, a night launch, because you'd see, as each stage separated, of course, after a while they're too far from you, but you could see the fire, if you will, from their rockets. But the fifth stage we never saw ignite. [We would have to] wait to get the data telemetered back to us [to] see what we could do.

Out from Wallops Island you took a ferry to the mainland, where a car was parked, then drive home. It's midnight. We were on this ferry. We're going through these charts, trying to determine [why] that fifth stage did not ignite. Now, this is what we would call a failure. Turned out that it did give us data, indeed, but the rush and the thrill of trying to solve a problem was the fun part of our job. I don't think it [will] go down in history as

anything except you learn with each experience, of course, and that's what I did every day of my life.

In the old days, in the beginning—I did start a talk one time, I was invited to speak to some seniors, high school seniors at the University of Texas in Arlington, and I think it was to lure them to go to that school, and I began my talk with, "In the beginning." So I frequently say that and I laugh each time. But I've already forgotten what I wanted to tell you.

WRIGHT: You were talking about in the early days.

LEE: We didn't work past our eight hours. No one did. You might stay a few minutes, but no one worked until eight and nine o'clock at night as they do now, nor on the weekends. But I was so excited, because when it was my project and had the responsibility of the entire vehicle, I couldn't wait until Monday morning to get back to work. Can you imagine? It was that exciting.

I was married and ultimately had two daughters, fortunate enough to have full-time help, because that was how I could work...to make sure I had someone at my house at all times. But still, I just loved my work, just really, and still do, and I'm happy to say I'm still working.

WRIGHT: Good. Good.

LEE: That's exciting. I'll let you ask another question. I hope you can edit out all these little side things.

WRIGHT: We want to hear them all. When you graduated with your mathematics degree, before NACA talked to you, did you have any idea what you wanted to do with that degree?

LEE: Yes, I was going to teach, and I was going to teach high school geometry, because that's what I did my practice teaching in. But by not having any idea, when NACA recruited us and we got to Langley Field, I had never heard the word "Mach number" or "Reynolds number" or any of the terms. I knew nothing about it. And so my job was to do mathematical support for the engineers. Then as time went on, there's an old expression now, "I used to not be able to spell engineer and now I are one." [Laughter]

WRIGHT: You graduated in 1948 and went to work with NACA. Ten years later, the United States formed NASA, and you just automatically fell into that.

LEE: Automatically became part of NASA, yes.

WRIGHT: Was there a transition for you, or did it just fall right into place?

LEE: Well, I remember Max coming to me, because Max was one of the men who helped NACA become NASA, he and Bob [Dr. Robert R.] Gilruth. I presumed that he mentioned Gilruth in his talk. Gilruth had been my division chief at one time.

I'd like to tell a story about Bob Gilruth, if I may, this beautiful, brilliant man who now has Alzheimer's. Walked upstairs, and I worked in an office with perhaps seven men, and I'm in my little corner. He stops at the door, and I can see him. The men are discussing something, trying to solve a problem, and he listens. Then he asks a question which turned their thinking around and headed them down the right path. And he turned around, with a smile on his face, and walked out. I thought, there goes a big man. He didn't tell them how

to do it; he just asked a question. Well, that became my modus operandi when I became a manager over men. I knew never tell anyone how to do his job, but I would ask questions.

We formed a team—and I'm getting way ahead of myself—this is how when I become a project subsystem manager for aerothermodynamics on the Shuttle. At the contractor there were fifty-six men who had to respond to me because I [was responsible for the] heating to the vehicle both during ascent and during entry. It would require that number of people. Well, we have remained friends even to this day, quite a few of the men. We still correspond or they'll come in town, give me a call, because we worked as a team and I, in my endeavor to do my job, would have each man come to me, inform me how he was progressing, and I would just ask questions, knowing sometimes the answers. And I think it's because of Bob Gilruth, this brilliant, beautiful man. And I thought, why can't everyone be like this man?

WRIGHT: He sounds like quite an inspiring figure.

LEE: Oh, yes, absolutely. Absolutely. He was not dynamic at all. His wife was a cute little gal. She died very suddenly. They had been friends of a couple in New York, where the man was extremely dynamic, one of the most dynamic men I've ever met. He was vice president of Grumman [Aircraft Engineering Corporation] at the time. He dropped dead suddenly. And his wife, who is a charming, lovely, quiet gal, the two quiet people married each other, having lost their spouses.

WRIGHT: Did you see a lot of Bob Gilruth during those early days?

LEE: Oh, yes. When he progressed from division chief up to the directorate—and I don't know if you're familiar with the organization of NASA. In your headquarters of the local

centers, you have directors of different groups of people. As Max was director of engineering and development, so was Gilruth at Langley director of engineering. You have operations directors and what have you. As I said, we were all friends...

And here I had a breakfast, a brunch one Sunday. I was with Gilruth in L.A., waiting for an airplane, and I said, "You know, I want to tell Max how much I appreciate him, how much I love this man."

And Bob said, "Well, you should."

And I said, "I want to have a party." So I had a Sunday brunch, and Gilruth and his second wife, and the Fagets and two other couples. Did you interview any people other than JSC [Johnson Space Center] people?

WRIGHT: Here and there.

LEE: And so I had a chance to entertain both the Gilruths and the Fagets. Of course, Nancy and I were very close friends. We were neighbors for a while up in Virginia [and] we were neighbors [here] and friends, so I've seen them for—fifty years? Yes. Great day! I wish I hadn't said that. [Laughter]

WRIGHT: Well, it's been a busy and full fifty years.

LEE: It has. It has. Each day, even while I'm not working at the moment because of—I'll tell you that later—I stay busy. I have a desk. I have a ten-by-twelve room that I call my desk room. I can't call it my office, although it is filled with the thirty-nine years of NASA projects and Christmas presents I buy along the way. They're on the floor. This ten-by-twelve room has three file cabinets, eight bookcases, and it's crowded. [Laughter] And I'll go in there and sit down as if I'm at work. I'll go through things.

WRIGHT: Before NASA became NASA, there was an event that occurred that took most Americans by surprise, and that was the launch of Sputnik. Of course, you were there.

LEE: I was thrilled to death, frankly. It meant we would get money. We would get funding to do those ideas that people like Max and Gilruth had. Because we were an advisory committee for industry or what have you before NASA was formed. Indeed, we would advise companies in how to design or help them in their airplane design. P-51s, for instance, and, I think, P-47... Those were helped by NACA engineers.

WRIGHT: Were you surprised? Was the group at Langley surprised to hear this, or did they know?

LEE: I wish I could remember that. When it was launched, my husband and I and children were driving to Florida to his twin brother's graduation, getting a master's in something. Well, we were excited about that, because we knew how it would help us, but whether we knew it or not, I don't remember. That's a question you'd have to ask Max. [Laughter] Those people. I don't remember.

WRIGHT: But you saw a change afterwards?

LEE: Oh, yes, immediately. Immediately. In fact, I feel like the director of Langley—and I remember him saying—he was Thompson, Floyd [L. "Tommy"] Thompson—getting up on the stage and saying, "We have a tiger by the tail and we've got to swing it so it won't bite us." We had to really get in there and work...

Of course, there is Max. And I'll have another story to tell you. When Max designed Mercury, he would make paper models of the capsule as you now see it, and he would put little tabs out, we called trim tabs, to make [the models] stable. I remember him getting up on his desk and he would drop them to see if they were stable. That was in 1958...

Well, when Shuttle began, Bob Gilruth had asked Max to design a vehicle, and Max did this in his garage, unknown to anyone. There was a house that separated our houses. Well, the day that a group of us were called in and we were called in secretly, we couldn't tell anybody where we were or anything, Max has a garment bag, and he takes out a model. The first model of the Shuttle was a straight wing. Again he gets up on the desk and he declares it [is] stable in two attitudes, zero degrees angle of attack, so he flies it across the room and someone retrieves it. And [at] 60 degrees angle of attack, and he angles it up by eye and throws it again. And I thought, what goes around comes around. I can remember him standing up with that Mercury, and now here we are again on the Shuttle. [Laughter]

But these men who had ideas just were able to bring them to fruition because of this Sputnik, and now we were challenged and we would get funding to do these different ideas. I remember asking Max—every Saturday night for years several couples got together and took dancing lessons. This is in Virginia. We would return to either our house or the Johnsons'. I don't know if you've interviewed Caldwell [C.] Johnson or not, but he and Kitty were one of the couples. We had a breezeway where we danced, and Max had sat down on the sofa and I sat on the arm, and I said, "Max, now that we're flying Mercury, what are we going to do [next]?" And he looked up at me and he said, "Dottie, I'm always thinking." [Laughter] And indeed he's thinking even today.

WRIGHT: During that time, you were the only female engineer in that group.

LEE: In that group, yes. We did get another gal from our section to go out [of the computer group.] I can't remember when her classification became engineer. I don't remember seeing her until we moved here. There was one, to my memory, one college graduate engineer female in another division, whereas I gained my classification on the job.

WRIGHT: Then about three years later, you moved to Houston. What expectations did you have of this new venture?

LEE: Well, I must say it was mixed. I had grown up in New Orleans, where it is hot. I wasn't looking forward to moving to Houston, where it's hot, even though knowing that it's going to be a new adventure, which I enjoy, so I did have mixed emotions about it.

But again another story. They flew a group of us down to find a place to live, and my husband and I are in the motel and I'm thinking, I wonder if there's a way I can talk John into not [moving]—because he had already joined the Space Task Group. I was queen bee at Langley. I had my projects and was happy as a lark. There's a knock on the door, and it's Max. He says, "I have found where we've going to live. Come on."

So the three of us get in the car and drive to a community south of here called Dickinson. Indeed, he had found two lots on the bayou. He said, "Now, Johnny, I have to go back to Virginia tomorrow. I want you to negotiate for my lot, and if you can't get it, then you negotiate for me for this lot. Otherwise, that'll be yours." [Laughter] So Max gets on the plane and goes back.

Johnny and I go back to Dickinson the next day, and I wish I—I need to ask him, "What did you do to get Max's lot?" Because we did. He successfully got the lot for Max. And our lot...had a sign, so we pull up the sign and go to the agent, who also had [a] savings and loan. As we walked in—and this man's office is glassed in, so he can see [us], and he

has someone in there whom he dismisses very quickly, because...he says, "I've had a lot of people ask me about property, but I've never had them bring me the sign before." [Laughter]

The three of us went to lunch, and we became very good friends with this man and bought that lot. From then on, it was fun. I designed our house. In fact, yes, I returned to Virginia, and every day at noon, on a piece of graph paper I would do the floor plan. Ultimately that graph paper was given to our architect, who built the house from that, because they put it on blueprints and did it professionally... I don't know if I still have that piece of paper.

WRIGHT: That's great. And you didn't get the lots mixed up?

LEE: Max's was larger. His was on the corner.

WRIGHT: You co-authored numerous papers with him, as well as with other—

LEE: Yes. Ted Rumsey, or Charles B. Rumsey, who took me under his wing. It was he who really showed me how to do very basics, and I credit him for that. And we still correspond. Sometimes his wife writes the Christmas note. Max and I only co-authored one paper together, and Aleck [C.] Bond.

In fact, I remember that paper. The vehicle had gone to angle of attack and had rolled, which we didn't want, and when you have instrumentation which consisted of thermocouples...thermocouples will measure the temperature of the outer skin, and from that temperature we translate that into heating rates, and that's how you design spacecraft, [in] very [simple terms]... Well, with the instrumentation on a certain line and the vehicle is rolled at angle of attack, it kind of challenges the interpretation of those data. That was a

very difficult paper, I remember. It took quite a while to [analyze the data]. But again, it was a challenge and fun.

WRIGHT: And you found somebody else to type it, I'm sure.

LEE: Oh, yes. [Laughter] Interestingly enough, I would have to make the figures. That means taking these data points and fairing a curve, and then putting them on charts. Sometimes the charts had the values of the parameters that you were plotting. I would type the numbers, spaced an inch apart, and sometimes it worked. I don't know how. You did everything. In fact, that's the beauty of how we all started out. We had hands-on engineering. Every engineer faired data and they could feel it and understand it and [understand] the meaning. Today, projects are large, you have contractors who do all the work, and so the engineers are just monitoring the contract.

Now, I say that and it sounds derogatory, the way I said that, but it doesn't give them the opportunity to really get the feel of it. But a project that—and I'm really skipping ahead—just before I retired, I was the local manager for a project called AFE, Aerobrake Flight Experiment. We initiated it with the idea it would give the engineers hands-on opportunity, hands-on engineering opportunity. We had twenty-six people here at JSC to design the brake part, if you will, the blunt entry face. It was a four-center project, again with the idea that it would be hands-on engineering. The propulsion system which was behind this brake was to be done by Marshall [Space Flight Center] in Huntsville, Alabama, and then we had primary investigators from Ames [Research Center, Mountain View, California] and Langley.

Well, in the course of this hands-on engineering, we here at JSC designed and manufactured that brake. I'm proud to say that. [Unfortunately,] the paperwork associated

with this project, which another center imposed on us, became so costly that it cost more than the hardware, and the project was canceled.

This project, to me, was going to help justify the Space Station, which meant you could have a vehicle at the Space Station. Now, this is my idea. This wasn't part of Space Station or the AFE's definition. But if a satellite up in geosynchronous orbit went out, we could launch the vehicle from the Space Station, retrieve that satellite. And I must explain. The Space Station is orbiting at 26,000 feet a second. Those in geosynchronous orbit are going 36,000 feet a second. So you have to slow down to rendezvous with this Space Station. All this is in my head. And I could just see, we could get a satellite, brake in the atmosphere, return to the Space Station, and repair the satellite. [AFE] didn't happen, and I'm so disappointed.

When I retired—oh, maybe now is the time to tell you this story. Us gals. The night of the party for me here at JSC, one of the [speakers] said, "Dottie's retirement is a line item in our budget." Well, I did not know what he meant or why he said that till I found out later I was replaced by ten men.

WRIGHT: Wow!

LEE: Three NASA guys and seven contractors. And I can say that to us because I'm so proud of that... I just love it. Well, one of the three NASA men took over my task as the program manager of the AFE here, and he did an outstanding job and progressed it to [completion]—it's sitting over in a building now... And he's equally as disappointed as I am that it didn't continue on. At least we have the brake ready if we ever revive this.

WRIGHT: And many years before that, you had a team that was responsible for a heat monitor that ended up becoming the standard equipment for all the Mercury capsules, as well as a model for similar equipment.

LEE: Oh, you're talking about a calorimeter. I remember this. It has another story that is a parallel that has nothing to do with it. We were in apartments. When we moved here, our offices were at Gulfgate, in apartments. I'd been given the project to design a calorimeter to put in the last Mercury that was going to be launched, to make measurements in this ablative body. [Brief interruption]

...calorimeter. And I wonder if that's a story I want to tell. I think it is. And it was on the last Mercury to be launched. We wanted some measurements, because this was an ablative heat shield, and you [could not] get good measurements in ablative [material]. So this calorimeter was to recede, if you will, [with] the ablator. Well, we were in apartments, as I said, and I think my office was in the living room. [Laughter] And a man came in with telephone equipment, and he started doing something with my phone, but I'm working, I'm doing my thing, and finally he said, "Now, you will be able to answer so many phones." And I look[ed] at him like, "You have lost your mind." "No, I'm not anticipating having to do that." He thought I was the secretary. He quickly found out that [I was not]. I was too busy to be diplomatic. I said, "No, you're not going to do that," and up I get and go [to] find the secretary, and she gets things straight. Well, he still wondered what happened. [Laughter] It was ugly...

LEE: This instrument, whatever we did with Mercury, we then attempted to do it on Apollo, and it was a disaster. The Apollo design had what we call wafers, graphite wafers. Of course, Apollo was going to be much higher temperature in [more] recession because it would be simulating coming—in fact, we did put sensors in a flight vehicle to get

measurements at this high velocity, because coming back from the moon, you enter at 36,000 feet a second. We'd get temperatures, but the moment that it would be getting interesting for our analysis, the wafer would be gone. So we didn't get any meaningful data [from] the one on Apollo, I'm sorry to say. All we could do is gauge how the material charred, and with our theoretical predictions try to rationalize our predictions with the char depth and slope of the curve, that type of thing.

But...instrumentation...[has] just not [been] able to achieve the degree of technology advancement that the spacecraft have. We need sensors that are capable of handling higher temperatures than they are presently designed for. It hasn't kept up with us, if you will, and it's been a challenge, one that we haven't quite achieved. Thinking of the lee side of the vehicle away from the blunt face on the Shuttle, the pressure measurements just were so low that we couldn't get them to the [level of accuracy] that we wanted. Hopefully some day it'll all come together and we'll have the instruments. The materials now are advancing rapidly, that they can withstand high heating, and we'll get [the instrumentation], or they'll get it. I won't be—I hope I'm not designing any sensors anytime soon.

WRIGHT: You've watched quite a progression from those days, from Wallops all the way through here, haven't you.

LEE: Yes.

WRIGHT: How were you able to put in your designs, or how were you able to—all the testing that you did and the writing and compiling of information, how were you able to work all of that and present that to where these other engineers could accept—

LEE: It's called enthusiasm. One year at Langley, true, they were simple vehicles, one-stage, maybe two-stage vehicles, and in my eight hours, I did ten hours of work in eight hours. I actually launched three vehicles, analyzed the data, and wrote them up in one year. That's moving out. That's really going fast, and doing it with a calculator. Now, this calculator, Friedan, very noisy contraption the size of a small television...[is used to calculate] the trajectory, oh, goodness! You can't begin to appreciate what it takes to calculate the trajectory of a vehicle, and you do it [for] every second...[of time in flight]. Whereas today you just punch a number in and there's the answer. No, you punched lots of numbers. To do that and three of them in one year was quite an achievement.

I'm so glad I can talk with just us gals, because in this man's world, I knew that I had to take ten giant steps. This is going to go into the answer of your question of how did the men accept it. The men respected me. They loved me. But I think that those my age had great difficulty letting me be an equal, particularly since I was a math major and not an engineer. Today that isn't true. The young people...give women a little more credit, not that our men didn't. "Our men," men my age. Women still were the wives and the homemakers.

The thing that I [find] today—this is a criticism—I went to JSC to a meeting and there was a gal chairing the meeting. When I left, and I was with one of the men—I worked for a contractor at this point—I said, "You know, that gal was tough." And what she had left at home was charm. Both men and women, to deal with other people, you still have to have charm. Now, that might sound old-fashioned to these young gals, but it'll work every time. My family said, "Dottie, sugar will get you farther than vinegar any day." [Laughter] And that stuck.

The first interview I had at Langley, hadn't been there long, a woman—and why I was selected, I do not know to this day—came, and as she walked in, she said, "Do you believe," and I wish I had reread this, "that women working with men have to think like a man, work like a dog, and act like a lady?" And there was a fourth thing I don't remember. And I said,

"Yes, I agree with that." Well, the article came out in the Sunday paper, and in quotes, "Dottie Lee says," and she repeats that. I thought, "I didn't say that. She said that." [Laughter] But that is true. That is true, but yet as the tortoise and the hare eventually. And I did some work that was recognized. I've received many awards.

One of the greatest compliments I received, which would answer—you have a question down there, what was my biggest contribution to the heat shield. I have a contribution to the heat shield, but it was my work. Just before we launched Shuttle for the first time, a group of us went to Ames to present to a committee called ASAP Committee. That's the Aeronautical Space Advisory Panel, composed of directors of centers or leaders of industry, a very august group of men. And each of us was to present the status of our discipline in regard to preparation of the launch of Shuttle.

I was to be last on the program, and I was the only woman. I had forty-five minutes. I was given that allotted time. Well, I started putting charts together to tell this group of people, who did not necessarily know all the nuances of heat transfer, and I ended up with forty-five charts. Well, you don't give a chart a minute, but I had to tell this story. I looked at my watch and I started talking and turning my viewgraphs and talked. They all listened attentively. And when I finished that last chart, I looked at my watch and I had done it in forty-five minutes. I said, "Fantastic."

Well, I'm putting them together and people are milling around because they're going to have to catch planes and what have you, and after a while one of the men from the panel came over, the committee, and said, "Based on what you have told us today, we're going to recommend to the President that we launch the Shuttle." I hope I gave an appropriate response, because I still get chills thinking of that. I really—I was quite proud of that.

The other contribution—you know, I've really gone far astray from your question.

WRIGHT: You're doing fine.

LEE: You said how did I get it out there. Well, bit by bit, report by report, and time. I didn't advance as quickly, but, again, I wasn't a graduate engineer. But ultimately here [in Texas] every one of my co-workers in my section was either getting his Ph.D. or his master's. There were days I was the only person in the office. But even with all those Ph.D.s, I had the same grade they had. So they finally gave me the same recognition that they gave those Ph.D.s.

WRIGHT: Did you know at the time, especially during the fifties, and before you moved to Houston, did you feel like other women maybe in the private sector had the same advantages or opportunities that you did?

LEE: In the private sector? That I don't know. Even today they're still not paid equal pay... Statistics say that they're getting 80 percent or some percent of what men are getting. But then we have a lot of lawyers, women lawyers, women doctors, and they are getting equal pay.

But in the private, you mean private industry as far as engineering is concerned, when I was first given a group of men to support me, and I think this was on Apollo Program, there were men working for me, contractors, that made more money than I did. I've seen very few women. I've really not had many women I've had to interface with in the private sector.

Another story. When I retired, about a month after I retired, I got a call because I was going to travel for a year with my mother, and I got a call from a man at JSC saying, "Dottie, there's a company up in Detroit that would like some aeroheating support. Could you do that?" And I said, "Yes, I'd be glad to do it." I had to make my reservations and get my car and everything. I'd been spoiled, because at JSC there were gals that did that for me, and I really appreciated it.

Well, as soon as I got back, the president of Eagle Engineering—and I don't know, surely you've met Owen [G.] Morris and company—called me. Bass Redd is the one who called me. He said, "Dottie, I thought you were going to play for a year. I hear you worked. Come talk to me." Well, after having made my own reservations on my own, I said, "I'll be right there." [Laughter] And so [I] went to work for Eagle. I would say three months later, Eagle got a contract with a company in Italy and sent nine of us to Italy to help them design an entry spacecraft. They had put up satellites, but they had never retrieved [one], so they didn't know how to do entry heating per se.

I had a reason for telling this. Oh. In this company, and it was called Air Italia—I get that [and the] airline confused. It's now changed its name. It was sponsored by the Italian government, even though it was a private industry. But in this company there was only one woman engineer. She was charming. They could all speak English except one young man. Of the nine of us, we each had a separate discipline, mine, of course, being heating. We had a thermal protection man and a retrieval man and an aeronautics, various disciplines. One of the young men in my group couldn't speak English, but he sat and he watched me the whole time. We were there for nine days. [Laughter] I thought, I wonder if he's trying to learn English, and with this Southern accent? I thought no telling what—but that was fascinating. There was only one woman in that company.

WRIGHT: At least you were easy to spot in a crowd.

LEE: I have a green ultrasuede coat, and it can be washed, so I use it for a raincoat or to keep me warm. Well, I wore that to Italy. Now, we went in November, but with sweaters and what have you, it did keep me warm. As we got off the plane, several wives went with us. I said, "I guess they can tell we're Americans." She said, "Dottie, with that green coat, they know you're an American." [Laughter] Everybody else was in black or brown. There wasn't

a color anywhere but my green coat. It was a little bit—well, almost the color of your jumper. And it was things like that, that made my entire life fun.

WRIGHT: You've mentioned your mom off and on. What did she think about her daughter going off to school and then ending up—

LEE: She really cried when I—because we were living in New Orleans, and a number of my family had no children. I was the only child, as a matter of fact, in the entire family. They sent me to Randolph-Macon, giving me an opportunity that was fabulous. We would travel by train from New Orleans to Lynchburg, Virginia...[on] the Southerner. We picked up girls along the route all the way up to Lynchburg, Virginia. As the train pulled out, I looked out and Mother is just heart-broken, tears. Oh, she was heart-broken. Her only child. But prior to that time, they had sent me to camp in North Carolina for eight weeks each year, to get me out of the heat of New Orleans, at Lake Lure Camp for Girls, which was a personality development camp and a marvelous opportunity for me. I think it had a large influence on my personality.

Before I went to Lake Lure, I can remember being so bashful that if you asked me a question, I would answer it, but that was the extent of my conversation in the classroom. When I came back, I was nominated and selected to be a class officer and various things. So that was a tremendous opportunity for me.

[After I graduated from college] when I returned to New Orleans and a month later took the job at Langley, Mother was not going to have her daughter again, and I think I may have caught the same train. I don't remember how I got to Newport News. Doesn't matter. Really, Hampton, Virginia. I left Mother.

Then I married, and when the first child was coming, Mother told my stepfather, "We are moving to Virginia." And then when I moved down here, again, in fact, it was tragic, my

stepfather died very suddenly before I moved. Johnny had already moved down, and [the girls and I] were going to follow suit. Well, when Mother retired—Mother, by the way, was a budget analyst for the IRS, so she moved down here, and her last twenty years were spent here. Yes, twenty years. So we did get together, and her last three and a half years, she lived with me. We were close friends.

WRIGHT: Do you think during your early adulthood she had difficulty explaining to her friends what her daughter did for a living?

LEE: I don't know. Of course, everybody knew how proud she was of Dottie. Oh, my. And Mother was a person that everyone loved. She was a beautiful woman. I must say I look like my father. I want to preface all that. Mother was actually a beauty. So they would tolerate hearing about the daughter who was doing all this fabulous work. I don't know what she said, to be frank.

I don't even know if my girls understood what I did, and it's from their friends that I found out indeed they would talk about me. I did not know, which is interesting. I remember my younger daughter went out to the center to see a gal she knew, and when she came back, she said, "Mom, they say that you're a role model." Well, that's a tremendous compliment to [me]. My entire life has been a reward, particularly my work. I feel blessed.

WRIGHT: When you worked at NACA, you mentioned everybody worked eight hours.

LEE: Then you went home.

WRIGHT: And went home. And no weekends. Then when NASA was formed, especially after you moved here, did the hours change?

LEE: Yes, and, of course, we did work, even at Langley. As I said, I came home at midnight on the boat. You didn't mind working, but it wasn't the routine. Things here, particularly when we were put on the schedule for the Apollo, when [John F.] Kennedy said, "Before this decade is out," and we were in a race with Russia, but again you worked because you wanted to.

John and I drove in separate cars, fortunately, so he could stay late or I could stay late, and, as I said, I had full-time help until [our] girls were through high school. We did, we worked and volunteered many hours, but then I did that when I worked for Eagle. We were writing a proposal. Of course, you use your own money when a company's writing a proposal. And they asked that we would limit our hours to eight hours a day. Well, of course, you want the company to succeed and you want to get that proposal, so you volunteer. I think when you like your work, it's not work; you just do it. I never saw anyone gripe or complain. You just knew it had to be done.

I'm suddenly remembering the first flight of the Shuttle and when they opened up the payload bay doors and you see the tiles [off of] the OMS [Orbital Maneuvering System] pod. I actually cried. I'm sitting in a room with eight or ten men, and there's silence and you're sick at your stomach. Immediately the question is, can they come back? Well, I get on the phone with my counterparts at the contractor, but I have to determine the heating here as they're doing the same in California, and their bosses are here with us.

At about eleven o'clock at night that first day...[after only drinking water all day and working steadily], we got on the telecon with the [contractor] bosses sitting with me...and we declared that indeed [the orbiter] can [enter], "You will not burn up the spacecraft." We here had been told, "Be prepared to return to the office at 4:30 tomorrow morning..." because at 5:00 we were going to tell headquarters in Washington the findings. Well, fortunately I lived right across the street.

I remember getting in the car at midnight, walking into my house, and I had not eaten any food. I opened the refrigerator door, and, like a child, stood there, like, "What can I eat?" and there was a patty sausage. I fixed me a Tangaray on the rocks, I ate that sausage, drank my drink, went to my bedroom, took a shower, got in bed, and three hours later got up, got dressed, and was back out here, or at JSC, at the appointed time, to say, "Yes, they can come back." You were tired, but you had to do that. And nobody complained, nobody griped. It was something you had to do.

WRIGHT: While we're on that subject, would you share with us the background of why you were in that responsible position?

LEE: Well, at the group for whom I worked, we were Structures and Mechanics Division in the Aerothermodynamic Section. The head of that section was Bob Ried, that I mentioned earlier, felt that I could be...the person to work with the contractor, to see that whatever our requirements were, the contractor met. The contractor was responsible for the design. In my particular area I had to see that they did it correctly, if you will. I guess Bob felt that I was capable, and it was he who appointed me to be the subsystem manager.

Meanwhile, there was another man. I don't know if you have met with Milt [Milton A.] Silveira. He was the deputy to Aaron Cohen, who was in charge of the Orbiter part of the Shuttle system. Milt had been assigned to be over the subsystem managers, and he approved that appointment and felt that I was capable of being the contract monitor, if you will, for the aeroheating. I just was there, again, at the right place at the right time. The men responded to me well.

Previous to that, I had a small group of contractors support me on the Apollo Project, so that gave me [managerial] experience. I did something that I recommended to my daughters, because they both work with men, one with chemists and the other with lawyers.

I said, "Write down everything you want done, just one-liners, so that there's no misunderstanding in your communication when you ask someone or tell someone what you want done." Because I've left meetings with ten people and they heard ten different things come out of the mouth of the man asking for the support. I said, "Write [it] down, and you'll have a copy, the contractor will have a copy," and...I just knew [what] to do... There was no textbook that told me how to. But having had that small group, I guess Bob felt I could handle the Shuttle contract.

WRIGHT: Big difference between the Shuttle and your previous spacecraft, that the testing would be done with the spacecraft manned, whereas tests that you had been able to do before was unmanned. Would you share with us if that caused you a larger challenge or was it just different?

LEE: Well, it was different. Frankly, when we finished Apollo, which was a marvelous experience, we had several facets to the heating world, such as radiative heating. [When] you have a [strong] shock in front of the vehicle, coming back at 36,000 feet a second, you didn't know...[all of the] contributors to the heating. You have convective and you have radiative heating. Behind that shock you have a high spike of radiative heating, and then it will reach equilibrium and get less intense as [the flow] approaches...the spacecraft.

Well, that was quite a challenge, trying to determine how high that heating would be. When we started Shuttle, many of us were asked to determine how complex is the Shuttle going to be relative to Apollo. Well, to the aeroheating person, as well as the aerodynamicist, I put a factor of 10 more complex, because you have the Orbiter, which is the airplane-like structure, external tank that houses the liquid hydrogen and oxygen, the [two] solid rocket boosters, plus we had nozzles at the back end of the Orbiter. Those are the four elements...of the Shuttle system.

Well, the [air] flow around [and between] each of those elements...[is complex]. As a designer of a spacecraft, you want your flow to remain laminar as long as possible, because once you get turbulent flow, that increases the heating significantly. ...To describe that environment analytically or theoretically is very complex. So the Shuttle was much more significant in its challenge than the Apollo...

And what was your question? How did it get different? What did you ask me?  
[Laughter]

WRIGHT: Before when you had designed for spacecraft, you were able to test with unmanned spacecraft.

LEE: The challenge...[With a manned vehicle,] we had to make sure that [the sensors] would not interfere with the safety of the vehicle, and putting in pressure sensors and thermocouples [in tiles was relatively easy]. We had tiles, if you'll remember...on the Orbiter. Trying to instrument the SRB [Solid Rocket Boosters] and the ET [External Tank] was a challenge [because] you [couldn't] penetrate the skin. So that you would not jeopardize the safety.

And the fact that the man was in there...did interfere once with [a couple] of the flights... The aerodynamicists wanted to get various effects of angle of attack on the aerodynamics of the vehicle, and so came up with the idea [of] what we call pushover-pullup. Well, I didn't like that, because that was going to disturb this nice flow that we had so carefully [maintained with] smooth [tiles] so it would not prematurely trip the boundary layer from laminar to turbulent.

Well, [Joe H.] Engle, who was one of the astronauts, had me go over to the trainer and get into the simulator with him, and believe it or not, he said, "Now, Dottie, we're going to go five seconds down," and he did, "1001, 1002, 1003," and then four, five, and then up. I said, "Well, that's all very good, but you could still trip the boundary layer." He wanted to

show that he wasn't going to do anything to my vehicle. Well, I was outnumbered. And indeed, it must have been...STS-4...when they did [the pushover-pullup and] it tripped the boundary layer. Fortunately, [the flow] re-laminarized, [i.e.] went back to laminar, but...we had that trouble for those few seconds. It wasn't enough to cause so much heating that we exceeded the capability of the thermal protection system, but we did upset the [flow] and...I knew we were going to do that. But the man was safe. The only time we worried was that first vehicle, when we lost the OMS pod covering, I mean the tiles on the front.

WRIGHT: Have you been able to see a landing in person?

LEE: I almost did. Again, being so busy, I had a meeting in California the day after one of the Shuttles was to land, but they wanted me to go out to Florida to look at a retrieved SRB, solid rocket, because we had a lot of TPS, thermal protection system, on the SRB. Well, I knew that if it didn't launch, I would be [in Florida]—if I'd gone to watch the launch [and] I would then not be able to get to California for my meeting...which was with another [project]. So I waited until it flew and returned, and then I quickly got on a plane, looked at the SRB, got back on the plane, changed clothes, and caught the plane to California. So I never got to see a Shuttle launch. Of course, I've seen a lot of them on the TV. I did get to see the last Apollo.

WRIGHT: That's great.

LEE: And that was exciting. It was a night flight, and we were back three miles from the launch pad. But when it ignited, the vibration you could feel in your chest, and I'm watching with field glasses. I wanted to watch it all the way. One of the people with me was hitting my shoulder, and I didn't want to look away. I didn't want to lose it. He was trying to tell me

that there's a couple here that we know, and I didn't want to let go of watching that. But, no, I haven't seen a Shuttle launch.

WRIGHT: Well, maybe that could be a new accomplishment for you.

LEE: I could go to Florida sometime. I lived at Florida for a while. It seemed like I lived there. Everything seems to be in nines. I was there for nine days before we ever lifted off. Our task was to see that those tiles were put on to the nth degree. It's a terrible burden we put on the people, but we did not want to have a rough surface, because that can cause tripping of the boundary layer. Oh, I memorized practically all 35,000 tiles, and would crawl up on scaffolding and look at things once they were up and in the VAB [Vehicle Assembly Building]. I don't know if you've seen all this. Which was fun. And some of the scaffolding would move. Fortunately, I'm not afraid of heights.

We went to [Louisiana] once to see an external tank, and it was up[right]. External tank is a little over 300 feet high. I had a group of men from the contractor with me. We had what is known as panel meetings frequently, in which you would call upon experts from other centers to help you solve a problem. So I'd have a panel meeting maybe every two or three months. Well, one meeting was in [Louisiana], at Michoud [Assembly Facility, New Orleans, Louisiana]... And one of my men couldn't go up to the top [of the ET], but the man leading us, who was stationed there, and I'm behind him...says, "I had a man come up with me, but he was digging his fingernails into the steel arm railings. I had to carry him down on my back." It's interesting. I'm claustrophobic, so I understand these phobias. That was interesting to get up, and you could see for miles...

I deviated, and I don't even know if I'm on the subject that you asked or not.

WRIGHT: All of them are. We were talking about the Shuttle. We understand that there's a definite contribution you made to the design of the Shuttle.

LEE: Oh, the nose.

WRIGHT: The nose. Give us the background of that.

LEE: I have two stories to tell you about that. As you know, in the heating world we want everything to be smooth. Every month I made a trip to L.A. once a month to meet with the people that worked to support me and to see the progress and whatever. But as the design was developing, I went to the drawing board to see how they were progressing, and [the] designer that day had put a sharp corner [on the OV]. Well, we couldn't take that. Now, the aerodynamicists might want it for better lift, but aeroheating people didn't want that. So I got with my counterpart and I said, "They're going to have to change this design." Fortunately, the man in charge [of the design] recognized that if I said so, [his response was,] "Yes, ma'am." We called a meeting, and in forty-five minutes that design was changed so that it would be a smooth configuration.

Soon after that, I was here at JSC and I think Hans [M.] Mark, who was the director of Ames at the time—and, by the way, he's [one] I'm sure you've talked with—and Glen Goodwin, and they had with [them] Dr. Teller, Edward Teller. I think he was a nuclear physicist. I speak in the past, because I think he recently died. Brilliant man. Why he was there, I don't know. Well, I'm trying to describe this gradual radius of curvature change as you look at the side of the nose [so] that it maintains its smoothness. And Dr. Teller said, "You mean like a French curve." And I said, "Yes! Like a French curve! I could kiss you for saying that." [Laughter] I didn't. And I completed my presentation. As I started out, Dr. Teller rose from his chair and bowed. ...I thought, how charming. Again, charm still exists

in this world. But that's how it became "Dottie's Nose," because I stopped the design...on the drawing board to one that's smooth and will maintain its laminar flow.

WRIGHT: And apparently it's worked out well.

LEE: Yes, it did. It did. I should wait for you to ask a question. I'm anticipating.

WRIGHT: Please, go ahead.

LEE: When you said about contribution to the heat shield. The heating people tell the thermal protection people how hot something's going to get or whatever, the pressure loads or whatever, and they design it. Well, again, I'm at the contractors, and someone had—are you familiar that the nose and the wing leading edges are made of carbon-carbon that can take the high heating? Well, they had carbon-carbon from the nose to aft of the nose landing gear door.

That's very expensive and very heavy, and to make this carbon-carbon leading edge, it's laid up in layers, literally. In fact, I met a man in Dallas who was in one section of the wing, a little old man. Oh, he was so proud of what he was doing. He laid up a layer and he had to get inside. He explained exactly what he did. Can you imagine having the entire bottom of that vehicle past the nose landing gear door out of carbon-carbon?

Well, I knew, based on wind tunnel data, that the heating drops off rapidly from the nose as you progress aft, and negotiated with my counterparts at the contractor to [move] that carbon-carbon [forward]. That took all day, because you don't [just tell them to change a design.] They're the designers. They just have to meet our specification. So you have to be diplomatic and you have to negotiate. Indeed, I convinced them that, "Here's what the theory

says," ...And they agreed, at the end of the day, to take that carbon-carbon off and move it forward as it stands today.

Of course, it turned out to be a headache. The tiles immediately behind that carbon-carbon nose, in trying to apply them on this curvature and not have any steps required a lot of retiling. They would have to take it off and put it on, take it off, and so I bet they hated me for doing that. [Laughter] And that saved us, in those days, 7.3 million dollars, so that was a savings. That was money in those days.

WRIGHT: Still is. You happened to work during the time period where NASA encountered its two misfortunes in the space industry. Of course, the most recent one being the 1986—

LEE: *Challenger*.

WRIGHT: —*Challenger*.

LEE: I was in Virginia, having a panel meeting, and on my panel I had two men from Marshall who were experts in plume heating from the exhaust of the SRBs and the main engines. I must have had fourteen, fifteen people. One of the men went out to get coffee, and when he came back in, he said, "Dottie, the Shuttle has exploded." And I looked at him like—and we fortunately had a TV in our meeting room for in-house review, and turned it on. Well, you sit there in horror, in horror, as you watch this. And we played it over and over again. Meanwhile, my two men from Marshall knew they had to get back. You don't know what has caused this explosion, where, why, or what. Of course, they leave immediately.

It was quite a traumatic experience. When I [returned to JSC], they [called] all of the people [together]...managers of each discipline—because we were going to have to

investigate each of our [inputs to this flight]. It meant traveling to different contractors all over the country. I had a Rockwell [International Corporation] man with me here, he still works here, and thank goodness for Frank. We'd be changing planes, and you worked constantly, [even waiting for the next plane]. I'd forget...what city I was in, to change the plane, we traveled so much.

It turns out that our world was not the culprit, but the thing that was so amazing about it, the segments of the SRB have seals between them—you probably know all this, and you probably talked to twenty people who told you this story—[and] this gas that escaped from that seal...[where] the plume impinged on the attachment between the SRB and the ET, melting it, causing the nose to go into the liquid oxygen tank, and that caused the fireball—had that opening been at any other segment or any other degree at that segment, we would not have had that explosion.

We used to play "what ifs." Suppose such and such happened. What if this? What if that? We would have never come up with that scenario. Never. I sat on a plane next to [Michael J.] Smith's widow, and I was on my way to an AIAA [American Institute of Aeronautics and Astronautics] presentation. We had never met. I knew who she was. She, of course, didn't know who I was. But I told her that story, because I believe what's to be will be. I don't know whether it was any comfort to her at all, but I said, "It happened for a reason, because this is the worst on worst on worst case. You would never have come up with that ever happening," because we've had other leaks and we didn't lose the vehicle.

That was a terrible, terrible time, and a lot of people did a lot of work. You had to work from the bottom up and the top down, trying to determine what did happen...

LEE: ...In fact, my first rocket I launched was a Thiokol rocket called the *Cajun*. [Laughter]

WRIGHT: That sounds like a story.

LEE: Yes, it is, as a matter of fact. It was a single-stage and it had never been flight-tested, this *Cajun*. They usually do what they call static firings. They're tied down and they just fire them to see how long they'll burn and what have you. So I was given the project and it meant designing the fins so it would be stable, and the nose so it would survive. I guess we thought it would go to some Mach number, maybe 3. Well, I did my thing.

Oh, there are several stories in this. To get to Wallops Island, I was the last passenger ever flown on the *Goose*, which was a Langley amphibious plane. That's written up in history, I want you to know. [Laughter] And I have the shroud with the fins on the floor beside me and the nose cap in my lap, and we get to Wallops Island and I stay as they screw on the fins and the nose, put it up on the launcher, but the weather was coming in. They said, "Dottie, we've got to fly back. You've got to leave."

I didn't get to see my flight, but we have photographers. They were very talented. They could follow a lift-off, and you have multi photographers, fortunately, because this took off faster than they expected. It went out of sight with one photographer. We actually got a Mach number higher than Thiokol had advertised. I wrote up the data, and it was fun.

Well, when you do analyze the data and you document it, everything then was confidential in those old days. We called them RMLs with assigned numbers, research memoranda, "L" for Langley...and then the numbers. Well, because they wanted to know the results as fast as possible, instead of having a review committee, which is standard procedure when a paper is being put out, you'll have five or six people from around the center, review it for its technical acceptance as well as its English and everything else.

I had one reviewer. I know you've talked to Guy [Joseph G.] Thibodaux. He was my reviewer, and so appropriate because he's from Louisiana. The name of it was *Cajun*, and I think that was the first time anybody had ever written a report that had a single reviewer so we could get it out. [Laughter] But that was a fun thing.

WRIGHT: We want to hear some more. We're going to take a break for just a minute and change the tapes out.

LEE: All righty.

I enjoy stories that are funny. I just saw a movie that I thought was horrible. People either loved it or hated it, and it's because I wasn't entertained by it, and yet, I mean, everybody—I went with this gal and she said she loved it. I thought it was awful. American Beauty or something. I wasn't entertained. I'm sure you didn't need all this in this interview, but I try to think of things that I think are funny, so I don't want to be flip about any of this, but because I enjoyed every facet of this experience, it's fun to me. Those are the things I remember.

I gave a talk at an AIAA meeting, the last AIAA presentation [I've made], and it was on the Shuttle. I remembered saying how challenged we were and how much we enjoyed it, and I said even the bad days were good days, because the challenge is there. I never want to stop learning. I don't care how insignificant a fact is. If it's something I didn't know, I'm thrilled to death. The day was not a failure; I learned something, regardless of what it is.

WRIGHT: I have to imagine that those early days, as you refer to them, when you started out as a mathematician and then gradually moved into the engineering status, there was never a day that you didn't learn more and more information. Then, of course, the programs were changing.

LEE: Oh, yes. Everyone was learning as we progressed. I just remembered something. Again, I was talking with Max Faget in his office here, and he said, "Dottie, how do you know such and such?" It had to do with boundary layer transition. And I said, "Well, Max,

it's a judgment call." And he said, "Yes, that's a good word." Judgment, which has to come from experience. There are no theories that can predict boundary layer transition. It's been a nemesis to all aerothermodynamicists. I used those words when I was a chair at a session at Langley.

So just by experience and looking at data, you have to use judgment sometimes. Today, not everyone has the opportunity to look at data, because there are other people doing it for them. I don't mean to talk against contractors. I'm now a contractor. And you need the help. The engineer at NASA, regardless of the center, needs support, because projects are so large, and you have to have computer and whatever support.

Speaking of computers, I told you about the Friedan calculator, the noisy—well, when computers came into being at Langley, to first use a computer in those days, you had cards that you fed into the system. And to get those cards to feed into the system, you had to punch the data. We had a floor between the second and third floor that looked like you were out in the beams of the building, and that's where the keypunch was. Again, I didn't know how to type, but I could do two fingers and a thumb, which I did. I hated that aspect of my job, punching those cards. Then you take this bundle of cards and you go and submit it to a machine.

Because of that experience, only recently have I accepted computers. Meanwhile, having had the opportunity to have people work for me, I let everybody else do the computer. I did not want to do the computer. Of course my [daughters] have them. And I'm going to have to break down and get a computer. I'm the only one I know that doesn't have a computer. [Laughter]

When the current job—we sold Eagle [Engineering] and then about two years ago I received a phone call saying, "We need an aerothermodynamicist. Would you come talk to us?" Well, I thought, yes, because I want to keep busy. I don't ever want to—I'm going to walk to my grave. I'm just not going to stop. Well, at this company I was hired, and it's part

time. I can work eight hours, two hours, whatever. It's a nice way to be retired and work. In order to sign out each day, you have to put it on a computer. I was forced to learn this computer.

Now, the first time I looked at that mouse, I wanted to make sure I did it, and they said, "No, Dottie, one hand, not two hands. One hand." And it took about a week for me to learn all the steps of just checking out. I worked eight hours on this project or whatever, and I got pretty good at it. I [can] do it in five minutes. Took a half hour the first time. [Laughter] But I got that down. So I'm still learning, and I'm gradually going to accept computers. They're marvelous contraptions. We could not have gone to the moon if we hadn't have had the computer. Just to calculate the trajectory could not have been done on that Friedman calculator. Too long. Couldn't have done it.

WRIGHT: Tell us about some of those days of preparations for going to the moon and how your—

LEE: In fact, I'll tell you about Mercury. Is Bob [Robert O.] Piland one of the men you've talked with?

WRIGHT: Yes.

LEE: When Mercury was being designed, we were doing a lot of the work in house, and I think this is before we had McDAC [McDonnell Aircraft Corporation] on board. I have an interesting story to tell you about that. McDonnell-Douglas, I've always called it [McDAC]. I'm sorry. Max Faget and Bob Piland are behind me as I'm calculating the trajectory for the Mercury as to how many Gs the pilot will experience. The reason they're standing there is because up in Pennsylvania is a man sitting in a centrifuge, waiting to find out how many Gs,

because they're going to test him up to that capability. And that was exciting. And you don't make a mistake, because there's a human. That was fun. That really was fun, that being Mercury.

When we got the contractor, McDonnell-Douglas, and a man from McDonnell-Douglas gave me this information, he said, "Dottie, did you know that the first Mercury was designed by twenty-six men at McDonnell-Douglas?" ...In thirteen months, for thirteen million dollars. Now, that's fascinating to me. Today, what's thirteen million dollars?

The secret, I think, is that you didn't have so many people involved, because you had brains, you know, like Max and Bob Piland doing a lot of the technical work, but you also had good engineers there. Systems were simple. You did have a life support system...that really makes a design complex, and you want to have redundancy...[to assure safety]. So putting the man in the vehicle makes it much more complex. But today when everybody and his uncle designs one little part—and I don't know how Caldwell feels about that; he could design the whole thing himself—I'm sure, you get too many people, and communication can really get lost...

WRIGHT: How did your duties start to change from Mercury to the Apollo concepts?

LEE: Well, by that time I'm here in Houston, because we were still flying Mercury when I came down here. It was a natural transition. The aerothermodynamic—[one of the first people] on the design is your aerothermodynamicist, and you have to work hand in hand with the [aerodynamicist], and it has to be an iterative process, because you might want it one way, but you'd interfere with the accomplishment of another discipline, so you pass it around the room, which is what we did with Shuttle, by the way. You asked a question, but remind me about around the room.

WRIGHT: Okay.

LEE: ...The Apollo, we were going to the moon. The President said so. But you knew that the only material that could let us go to the moon was using an ablater, which we had tested at Langley, various types of ablative material, Teflon and what have you. This material—and again you should be talking to a materials man—was a honeycomb structure which little old ladies literally gunned the material into the honeycomb, the ablative material.

Each project has just been a natural transition, depending upon what's thought up or whatever the goals are of the nation or what have you. For instance, the Shuttle—can I go to the Shuttle now?

WRIGHT: Yes.

LEE: ...I had some contractors supporting me on Apollo analyses [and my Division Chief called me to his office on]... a Friday morning, and said, "Monday you're to report to Building 32. You don't tell anybody where you're going or what you're going to do. Read this document," which had other thoughts and concepts about a vehicle that could go up to orbit and return to land.

So I had to call my contractors and say, "I'm going to be out of pocket for a little while. I cannot say anything of where I am." And it turned out that when I would need [their support] to make calculations, I couldn't identify [the project]. [It] was just like "job number ten," and I would get in a taxi and go elsewhere, maybe to my [old] building, so they wouldn't know where I was.

But in this room we had a representative of each of the disciplines—a trajectory man, a heating gal, a structures man, a TPS man, different people. Max, meanwhile, is designing—or he now has three men on a drawing board doing changes that we would come

up with. A design would pass around the room in a matter of hours. Sometimes the design would change three times in a day because I might bump you and then you, in turn, as we go around. That was exciting.

We had a man in charge, called Jim [James A.] Chamberlin. He's now deceased. He and a group of AVRO [A.V. Roe Aircraft, Ltd.] men from Canada had come to us at Langley, brilliant. He never finished a sentence. But we ate lunch together every day, he and another man and I. I got so I knew what he was saying or going to say or didn't say. Frightening. It really was. He was an amazing man... But we were locked up, literally. There was a guard outside the door.

One rainy morning—and this building has no windows. It's...a [highbay] next to an office building. In the one-story office building is Caldwell Johnson. He's division chief at that time, at that office. [As] I'm walking from my car to my building, [with an]...umbrella, and lightning...is very close,...the next thing I knew, I switched hands [holding my umbrella] and I'm shaking my [other] hand, and I must have screamed. I told Caldwell this story, and he said, "Dottie, I almost turned around and looked outside because it was such a tremendous bolt of thunder." [This] has nothing to do with space, but I just happened to think of that story, so I'm telling it. [Laughter]

So I get inside and I say, "I was almost struck by—" and Johnny happened to call me, I guess to see if I'd gotten to work or whatever. I told him. He said, "You go find out if you—" You know, your heart can go into fibrillation. I thought, "I don't want to get—" "Get a taxi come to the door." I thought, "I could get killed just to go find out if I survived." [Laughter] But that's just a little side story of things in the daily routine of whatever you do.

But that's how you design a vehicle. A small group of people and pass it around the room. And we did it. Of course, ultimately we had to go from the straight wing. I'm sure Max told you all that aspect of it and why, to the swept wing that we now have.

We landed on the moon for the first time when we were locked up in that room [designing] Shuttle. I can remember saying, before I knew I was going to be in the Shuttle [project], that I was going to really celebrate our landing on the moon. Well, we landed. No, it's when we were coming back. That's when we were going to celebrate, after the return. That day I'm working. I worked past hours, got in my car to drive home. I was living in Dickinson. I don't know where John is, because he's driving [his car]. As I drive down NASA Road 1, cars are parked everywhere. They're in different bars and places. And I wasn't celebrating. I was just going to go home. I had to relieve the babysitter. [Laughter] And I didn't get to celebrate...

But we are the beginning of a project, and so we'd finished our [input] with Apollo. We were starting the next [project]. I've always looked at our work as we are creating tomorrow today. That's what makes it fun.

WRIGHT: You were always a step ahead.

LEE: Yes.

WRIGHT: But using that past experience.

LEE: Oh, yes. Each door or each step took us up higher on the ladder, technically.

WRIGHT: That night on your way home, did you think about the time that Max Faget had told you that we were going to go to the moon?

LEE: No. And interestingly enough, I didn't think about the time when I was ten and sitting out in New Orleans looking at the stars, and knowing we were going to the moon. That

didn't enter my head then. I think I was tired, I felt sorry for myself that everybody else was partying and I wasn't. [Laughter] I did not think—I'm sorry to say I did not think about those fabulous things. I do now.

WRIGHT: And even the time when you heard—or heard about—Kennedy making the challenge to America that we should do that, what were your first thoughts on that?

LEE: I knew we'd do it. Of course, with the Apollo fire, which was an awful experience, but one that was necessary, apparently, Johnny and I and another couple were driving to New Orleans to go to a Mardi Gras ball. When we got to the motel, the radio, for some reason, was on in our room, and they were talking about the fire on the Apollo. I said, "It's not due to lift off now..."

Well...we go to dinner, and Johnny has to catch a plane to come back to help on the investigation of [the fire], so I stay with this couple, because we're in our car. We go to the ball... But [the fire] was an awful experience, and it's a shame that some lessons have to be learned through tragedy...

WRIGHT: Did you ever have any doubt that America would pick up its program and begin again?

LEE: No doubt. No. Everyone was motivated to succeed, to do right. From the beginning, when we worked at Langley, you did the best you could do and you had pride in your work. Again I think it's the hands-on experience that gave you that self-pride.

About six or seven years ago, they had something called TQM, [total] quality management, and they had courses in this. Well, again, I was working for Eagle, and the contractor we were supporting at the time had us take this course. Well, it was a day devoted

to quality management, and in [the course] the words were that you should do good work. I thought, "I don't need a course [to do] this. You automatically are going to do the best you can. You're going to do it right the first time. If you make a mistake, that's because you're human, but you learn. But you do the best you can." And I couldn't believe there were courses.

I don't know if our young people appreciate that. The work ethic today is a little different, and I don't know whether it's TV, the crime you read about in the newspapers, and that's the only news there is. People are not motivated to do the best, as an overall group. Of course, there are still marvelous people out there doing beautiful work, but in a general sense it's just get by with what you can do.

I have a daughter, Laurie, who [loves to] work. If they had twenty-six hours in a day, she'd do it. Dottie works hard, but she also plays. She likes to play, but she'll work until [late]—she worked for a lawyer here in Houston, and many a night she [called to say], "Mom, I'm on my way home," and I would cook the dinner, and it was ten o'clock at night... Maybe each person, given a challenge or given the reward of accomplishment, would put in his 110 percent, but not everyone has that opportunity.

WRIGHT: For almost forty years you had opportunity after opportunity, and then you decided to leave NASA.

LEE: Well, paperwork. This AFE project. I was still doing Shuttle work and doing an aspect of the ascent heating, as well as being the program manager for the AFE, all this simultaneously. That's the reason it took ten people to replace me. I don't know if I want that on—I mean, there are men listening to this some day. [Laughter]

What did you just say?

WRIGHT: Asked you about when you finally made the decision to leave.

LEE: The paperwork involved with the AFE project. I would get documents; I read everything that came across my desk, and a lot of the documents had "to be determined," but you had the format there. I piled them on top of each other as I'd finish, and I thought, "I just read that in another document." This paperwork inundated everybody, and suddenly it wasn't fun anymore.

Now, the Shuttle was going along fine. There's only one aspect that we never resolved, and I wrote a paper about it, and fortunately they know not to put the elevons up during entry, because you don't want to burn a hole through the nozzle. So we're all right there. We never solved the true heating to those nozzles. Couldn't, because we couldn't instrument them [properly].

But with this paperwork, and Mother—and I was sixty. Mother was getting older, and I thought, "Well, it's time to travel and play." So I retired. A month later, I was working. [Laughter] You know, [during] that first month I would get the mail—it would come at 9:30 every morning—and there was a program similar—in fact, it was the same program now, "The Wheel of Fortune." I don't know if it was Vanna White. I don't remember. But it would be on, and I would read my mail and watch that program, and it was a daily routine. It wasn't that much fun. This was April.

Mother and I did take our first car trip. I had never been to Arkansas, and that was the closest state that I hadn't been to, so we went to Arkansas and came back home. Then I started working again. But that's the reason I quit NASA. I thought it was time. But I was wrong. I don't ever want to quit. I don't ever want to retire. I like the way I'm retired, because I can work when I want to.

The Eagle experience was beautiful, with the NASA retirees and the young men fresh out of school, they knew how a computer worked inside out. We didn't. So it was a good blend of talents. That was fun.

WRIGHT: Would it be hard for you to pick one area of your career that you enjoyed or found more challenging than the other?

LEE: Yes, because each was unique, had its own challenge. I can't say that I was happier any time than another. I enjoyed it all, absolutely loved every [day]—I had a boss tell me—and he was assistant division chief—he said, "Dottie, if you were a man, you would have been a boss." I don't remember what I said, but I would not have wanted it. I had the best job at JSC, absolutely. And being that manager toward the end did involve some personnel activity and some necessary paperwork and getting money, but, no, I liked doing what I did.

WRIGHT: When you began your career, it was during a time period in America that women were not easily recognized or even encouraged to go into the fields that you did.

LEE: That's right.

WRIGHT: Do you feel like your gender held you back at all from progressing through your career?

LEE: Well, I did not get, in the beginning, raises as the others because I wasn't a graduate engineer. Ultimately I did. It just took a little longer. And the men, oh, they liked me, they just didn't really want me to be their equal. Chauvinism existed more then than now. They'd want to help me. I don't object to being helped in the car. Fine. I want to be a woman first.

But I don't want to be recognized because I'm a woman; I want to be recognized because I can do the job. That would be the only thing that would make me resent being rewarded [if only] because I'm a woman.

WRIGHT: Being remembered for all that you've done, if you had to pick, is there one area that you would like to be remembered for, for your contributions more than all the rest that you've been able to do?

LEE: Well, the first thing that comes to mind is the story I told you, based on what I told those men about status of aeroheating in Shuttle. They would recommend to the President we'd launch. I guess I would want to be remembered that I did my work professionally, with a professional attitude, but with a sense of humor and graciously. I am appreciative of the men who touched my life, and I'd want to be remembered by those whose [lives] I touched. I'm extremely proud of what I did. And I guess that would be a way to end, wouldn't it. [Laughter] Unless you have more questions.

WRIGHT: I'm going to ask Carol and Sandra if they have some questions for you.

LEE: Oh, yes.

WRIGHT: If that's okay with you.

LEE: Certainly.

WRIGHT: Do you have anything?

JOHNSON: Probably lots, but I don't want to waste all your time. [Laughter]

LEE: This is quite a compliment to me that I am being part of this historical—

JOHNSON: One question, I guess, is that you went to college at a time when it wasn't that usual for women to go right in college after high school. Was that something that you just accepted as you were growing up, that that's the way it was going to be?

LEE: Yes, I knew I was going to college when I was a little child. Again, I was a very fortunate child, being the only one in the family and there were means to let me go. Interestingly enough, in New Orleans the high schools were such that it was all girls or all boys, and in camp in the summer it was all girls. Then I go to college, where it's all girls. I never had a football team. [Laughter] Consequently, when my girls went to a high school here, every Friday night we went to the football games. [Laughter] But I knew. I was just lucky, very, very fortunate child and person.

Part of that fortunate bit, as a child they would put me in a room and bring the clothes. I could say yes or no to whatever they brought in, and I received many clothes from the time I was little. To this day I can't walk into a department store and buy my clothes. I have a friend who owns a shop in Dickinson. She'll buy for me when she goes to market or she has trunk shows, and if I can't make it, she'll say, "Dottie'll want that." ...When she sells the shop, I don't know what I'm going to do. [Laughter] And I, likewise, have spoiled my girls, I'm sorry to say. However, my daughters inherit my clothes.

WRIGHT: Now that you brought it up, I really want to ask, all those times you were at Wallops Island, at a time when women didn't wear pants—

LEE: Oh, let me tell you about that. At Wallops Island in the beginning, before they built a hotel there or some kind of a thing, they—well, I don't know what the men slept in, because I never spent the night. I flew up [and returned the same day]. But in the room where you received the data, the telemeter room where you'd watch the launch or whatever, there was one bathroom, and all these men and me. Well, the time would come—I mean, it's a door right there. And I had to go to the bathroom. I take it back. They did have a barracks. One day I thought, you know, can I walk to that barracks? I was too embarrassed—I was twenty-something—to open that door and go to the bathroom with all those men there. So there were little inconveniences.

But I went to work when I was twenty-one years old, and grew, and with my daughters helping me mature, I didn't mature till I was maybe thirty-five. [Laughter] But there were some inconveniences, although the men were not ugly. I was very fortunate. Never in my entire career was I ever embarrassed by a man.

WRIGHT: Great.

LEE: Never. And today when I read about women that—what is it they call it? Harassment? Not that I want to say that they ask for it, and I'm not a beauty like my mother, but I was never embarrassed. If they embarrassed me, I didn't know it. I was too naive and I brushed it off and dismissed it as if it was a joke for the day. Never would I have any occasion to have to—of course, I worked with professional men and in an environment, a very sheltered world. NASA really provided a very sheltered world. I never had a problem.

WRIGHT: That's great. A lot of your social activities were with folks that you worked with as well?

LEE: Yes. I remember one Christmas Johnny and I had the Christmas party and New Year's Eve party at our house. I had more energy in those days. [Laughter]

WRIGHT: Especially for the clean-up. [Laughter]

LEE: Yes, and making the food.

WRIGHT: We didn't have stores that provided all that.

LEE: That's right.

WRIGHT: Pre-packaged food for you to put out on a table. Everything was done by hand.

LEE: Thank goodness for Sam's. Of course, you see the same food at all the parties. I'm not embarrassed to say I use their meatballs and all. It is easier.

WRIGHT: I've always heard people praise Fred Astaire for all his accomplishments, but I've always heard the other part, that Ginger Rogers did everything backwards and in high heels. So after spending the afternoon with you, that's what it reminds me of. You've had such great accomplishments, yet you were always accomplishing more challenges and looking for more opportunities. So we certainly thank you for your time today.

LEE: Oh, I've enjoyed this. Thank you for letting me do all the talking.

WRIGHT: And you did very well at it.

LEE: Thank you.

WRIGHT: Thank you again.

[End of Interview]