NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

JOE H. ENGLE
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is May 27, 2004. This oral history interview with Joe Engle is being conducted in Houston, Texas, for the NASA Johnson Space Center Oral History Project. The interviewer is Rebecca Wright, assisted by Sandra Johnson and Jennifer Ross-Nazzal.

This session is a continuation of the May 5th oral history session, where we closed talking about your transition from the United States Air Force to NASA. You had joined the space agency as one of the original nineteen, in the class that was selected April 4, 1966. But this wasn't the first time you had thought about applying. One time before, while at the Air Force's Research Pilot School, you had prepared an application for NASA, but you told us that [Major] General [Irving L. "Twig"] Branch had called you in and suggested that you pull that application. Well, here was the second time. What type of support or encouragement did the Air Force give you at this time to join NASA, and how did that transition work where you able to stay with the Air Force and be a part of NASA?

ENGLE: It was a very smooth transition. I was at a point in my assignment at Edwards [Air Force Base, California] where I probably would be reassigned in any case, from the X-15 program to another base, so reassignment was not imminent, but it was right over the horizon. So the application at that time, I felt, probably would be my last chance to apply for NASA, to come to the Apollo Program. I had gotten to fly the [North American] X-15, which I dearly

loved, and did, in fact, not relish at all the thought of leaving the program, leaving that kind of flying that I was doing at Edwards.

But there was no discouragement or opposition to my application or to anyone's application, actually, at that time. As far as encouragement, I think there was the kind of encouragement that this would be an opportunity to represent the Air Force in a very visible program, and so that part certainly was there as a positive thing. I think the Air Force also probably hated to see—not hated, but wasn't fond to see too many people who they had shown confidence in and invested a good bit of training money in and all, to see them leave the Air Force and go, because at that time people had not started to return to their parent services, Air Force, Navy, Marines, Army. When they were selected by NASA, they stayed at NASA until the end of their career, and indeed, many of them still do. But there was no program, no precedent of people returning to the Air Force to take that experience and knowledge back into the Air Force.

The transition itself was as seamless as any assignment, any, I would say, exchange duty assignment, like an Air Force pilot going for a tour with a Navy squadron to learn and cross-train with the Navy and then bring that experience back into the Air Force, and vice versa, Navy pilots exchanged to us. So the assignment to NASA was treated as and kind of considered as an extended assignment of that sort, and exchange tour, if you will.

WRIGHT: How did your family feel about you joining the astronaut corps?

ENGLE: Mary (my wife) was pretty conditioned to moving around whenever orders came. Both children were too young, really, to know or have an input. They had made friends there at

Edwards, of course. My daughter had; my son was too young yet. But they had no objection at all to doing it.

WRIGHT: And your parents?

ENGLE: Oh, my parents were supportive of whatever I wanted to do. I think I was in a discipline of flying and flight testing and I was in an area that neither of them really understood in depth at all, but they were wanting to learn more and they were just soaking it up like a wet sponge, and gave me all the support that you could expect. More than you could expect, really.

WRIGHT: We talked a little in the earlier sessions that after you moved to Houston and you went through training, you had some assignments while you were waiting for a crew assignment, and some of the tasks that we talked about was the 2TV-1 [thermal vacuum] test in [19]'68. But we also talked a little about when you were working with the rover development down at [NASA] Marshall Space Flight Center [Huntsville, Alabama]. What phase was the rover in when you became part of the development testing?

ENGLE: The very initial conceptual phase, to the point of, I think when I got down there, they had decided that a four-wheeled vehicle was better than a three-wheel, or a two-wheel, and that in the suit there would be very real restrictions on mobility and getting in and getting out, and what kinds of controls would be feasible for a person in a lunar surface suit to easily operate.

So at that time, the concepts and the development of the single hand controller for forward and brake and reverse and left and right turns in the center so that either crewman could

operate, it was evolving. It was a concept at that time. I was working with engineers who developed what the shape of the controller should be and how responsive it should be in the various axes.

And other things on the rover, like the antenna that transmitted data and images and voice back to the Earth, from lunar surface back to the Earth, that antenna was dish antenna, not a lot unlike the TV antennas, the small dish antennas that we have now, except that it was collapsible so that it would fold up and go inside the lunar module. Then when you got the rover on the surface, you'd open it up. It had a very simple, like a tripod, pointing a camera on a tripod; you point it up and down and left and right. It had a very simple aiming device, where you looked through a mirror sighting device and when you saw the Earth there, you locked it in, and that meant you were pointing to Earth and you would transmit back to Earth. It could be done easily with one hand in the pressurized suit and done quickly, too, because as you go from one site on the lunar surface to another, the rover—you didn't move so much that you went around the curvature of the Moon, but it could be tilted in a crater or the side of a hill and oriented differently than the last position, so you had to readjust and re-point and re-aim very quickly.

So those kinds of things were being conceptually designed and then prototypes made, and we would try them out in the workshop. It was fun. It was a very interesting thing to do.

WRIGHT: At one point a test vehicle was flown on the [Boeing] KC-135 [Reduced Gravity Research Program] to allow the astronauts in spacesuits to investigate the entry and the exit. Were you part of that test?

ENGLE: Yes, I was, and I don't remember a lot of details on that, to be honest, other than the biggest hassle was getting into the suit, the lunar surface suit, because it took a while to get into the suit and get hooked up and get pressurized. Of course, you had to do that before they could start the series of parabolas. Then in the suit, during the pullout part of the parabola, I remember it was very uncomfortable in the suit, because you could end up in any of a number of positions pushing against hardware on the inside of the suit as you pulled out. So that was not a big deal, but that's one thing I remember about that.

But the purposes for the KC-135 were primarily to learn to ingress and egress in a one-sixth gravity. Rather than the zero gravity it was capable of, they would fly one-sixth gravity parabola and we could develop the techniques, and the changes to the rover in some cases that had to be made in order to ingress and egress, and to get to the scientific equipment packages that were carried on the rover as well.

WRIGHT: Do you remember one of the areas that you consider the most challenging aspect of working on that lunar rover that took the developers maybe, with your help, to find the answer so that it would work the way it needed to when it reached the Moon?

ENGLE: I don't recall any particular problems or challenges that stood out. I guess one of the more interesting things to solve on it were the wheels or the tires themselves, and I personally had really nothing to do with it. I stood and watched while that development took place. But as you know, we ended up with a wire mesh wheel, and that was the type of a tire surface, I guess, to interact with the lunar regolith, the thin lunar regolith, whereby you could still get traction on

the Moon. You didn't have to worry about puncturing a pneumatic tire with a sharp rock you might run over.

Although some of the regolith would get up in the mesh, as the tire came over onto the surface, when that part came up, the regolith, which is kind of dust, really, would clean itself out right away. Then, of course, there had to be fenders to keep that regolith and that dust from kicking up and coming back onto the crew as they maneuvered around on the surface.

WRIGHT: Any encounters you want to tell us about as you were taking it out of the testing area at Marshall? Were you able to go over some of the terrain there and use it to test drive?

ENGLE: Yes, we did. There were some areas set up as representative of the type of terrain that it would need to be able to traverse. Again, I don't recall any real problems or difficulties. Very early in the design it had already been decided that the vehicle would have a double Ackerman steering mechanism, which means like on your car, the front wheels steer. On the rover, the rear wheels steer as well, and a very clever redundant system was made whereby if either the front or the rear failed, you were able to line them up and pin them or lock them, and disengage that drive and then use the other, either the front or the back alone. You didn't have as tight a turning radius, but you could still maneuver and still use the vehicle.

The rover is a very ingenious vehicle, really, in that respect of redundancy, because it not only had two separate and independent steering mechanisms where, as I mentioned, using them together, you had much more maneuverability, but you could still get around on the surface of the Moon with either the fore or the aft mechanism.

Then the drive mechanism for the wheels were four independent electric batteries, so you could lose, in fact, up to three of them and you could limp back to the lunar vehicle with one wheel going on the rover.

WRIGHT: Amazing. It must have been quite something to watch it come together a piece at a time.

ENGLE: It was. It was very interesting to see it develop. The interesting thing is that once the initial concept design was laid out and a mockup was made out of plywood, it didn't really change very much from that initial concept. It was kept very simple, kind of like the jeep during World War II. Its initial concept was very similar to what we ended up at the end of the war with.

WRIGHT: Very durable.

ENGLE: Yes, very durable, very maneuverable, very flexible, very usable.

WRIGHT: You've told us about working with the rocket flyer. Were there any other concepts that you were involved with regarding suggestions for using—

ENGLE: No. Those were the only two that seemed to still have survived by the time that I was assigned to help with that development. I know I remember hearing of a two-wheeled vehicle,

kind of like a motorcycle, but I think that was dropped very early, realizing that in the suit, in the inflated suit, that type of vehicle really wasn't the most desirable to use.

As a matter of fact, the rocket belt was dropped fairly early because of the concern of kicking up dust and losing your landing site and disturbing the geology and where you were going to go check out an area, by the exhaust of that rocket site. Not only displacing material that you might want to take off the very top surface, the dust-type thing, but also the remnants of the rocket fuel itself becoming interspersed with the dust and you wouldn't know what was there before and what you brought with you. Contaminating is what I'm trying to say. Contaminating the surface, the soil where you were landing.

WRIGHT: [Donald K.] Deke Slayton assigned you to be part of the support crew for Apollo 10, which was going to be the dress rehearsal of sorts for the lunar landing. Can you share your experiences and the training involved that was necessary for this position and some of the duties that you did?

ENGLE: The duties of the support crew at that time were primarily to go to the manufacturers, to Rockwell International in Los Angeles [California] and to Grumman [Aerospace Corporation] on Long Island [New York], where the lunar module was made—the command module was made at [North American] Rockwell [Corporation]—and to follow through and take part and participate in the systems testing and all the checkout testing of those vehicles as they were built. And those were the specific vehicles for that mission at that time, too.

While we were at the plant, of course, if there were some tests going on on either a subsequent or previous flight vehicle that we were there and it meant somebody else couldn't or

didn't need to fly up to take part in those tests, and it was a simple test, we would, but we primarily were responsible to follow that vehicle, that command module and that lunar module, through its manufacture and test and checkout at the manufacturer's origin and follow it down to the Cape [Canaveral, Florida] and then follow it through its testing down at the Cape.

We did get to be part of some of the simulations, but only when the prime crew or as part of the backup crew simulations, when one or more of the backup crew couldn't be available. We would sit in those sessions and train and learn about the mission then. Then, of course, we also participated in the integrated simulations in Mission Control [Center] as CapComs [Capsule Communicators].

WRIGHT: You also served as CapCom on that mission, is that correct?

ENGLE: On Apollo 10. Yes.

WRIGHT: Can you share with us how the training and simulations served you while you were in that seat during the mission?

ENGLE: The experience that we gained and that everyone gains from support crew in the assignments that they have as support crew is extremely valuable. It's hands-on training and for the most part, it's real-world, one-on-one simulation training that the crew is getting, so that you really are aware of what the crew is being faced with, the other things that are going on, the priorities of sending up information and receiving information from the crew, and gaining a respect for that so that later, when you are assigned to a crew, you not only have that experience,

but you've got a backup crew that's training and learning that same thing so that you work together as a team much better that way.

WRIGHT: During that mission, when the *Charlie Brown* [Command and Service Module] experienced some gimbal lock, Gene [Eugene A.] Cernan expressed his feelings at what was going on at the moment, and some possible off-color comments were made. Did you happen to be in Mission Control during that time?

ENGLE: I did. I happened to be there and, of course, anytime that you're not there and you have no direct insight as to what's going on and somebody pushes a mic [microphone] key and says, "Holy smokes! What in the world was that?"—or words to that effect—that really gets your attention. You have no idea what's going on. You have no idea what the problem is until the data stream comes down and can be sorted out by the folks on the console to learn what happened.

And, of course, the poor crew, when something like that happens, I don't think anybody has the composure to very calmly and coolly tell you what accelerations are happening in all three axes and why and all. So it was an exciting few moments until we learned that General [Thomas P.] Stafford had safed the vehicle and stopped the rotation, and I think it was some time before all the pieces were put together to determine what caused that maneuver and how to avoid it happening again.

WRIGHT: Was the astronaut corps instructed in better use of language for future missions or did Cernan's remarks in that time frame seem to just go by? Were there any implications for later of what not to do or to do when you were on the mission with an open mic?

ENGLE: No. No, I think everyone is quite aware that when you have a hot microphone and you are transmitting, the whole world is listening, and you do tend to tailor your words a little more carefully, just like I'm doing with you right now. But, on the other hand, when something that is a total surprise and a potentially life-threatening thing happens and the vehicle goes out of control and you're 240,000 miles from home and close to the lunar surface, you kind of forget that the whole world is watching and listening. You're more interested in what's going on right inside the cabin at the time.

No, there wasn't any reprimand at all, I think. After the fact, Geno [Cernan] realized what he had said, what had happened; so did Tom. I'm sure they talked among themselves in the cockpit there and said, "Man, we've got to watch this." [Laughs] But that's happened before, and it'll happen more, too.

WRIGHT: A few months after the first lunar landing, you were named to the crew with Gene Cernan and [Ronald E.] Ron Evans to serve as backup for Apollo 14. What was your crew doing during the time of Apollo 11? Were you part of any of the support for the first lunar landing, and if not, where were you when we first landed on the Moon?

ENGLE: When Apollo 11 flew, we were the—gosh, we weren't support for 10, but I think we were assigned as backup for Apollo 14, I believe. We were not supporting Apollo 11, mainly

because we were focused on the backup duties for Apollo 14. Other astronauts within the corps were assigned as support and Mission Control and duties like that for Apollo 11. We followed it, of course, very closely.

WRIGHT: Were you in Mission Control?

ENGLE: As a matter of fact, I think I was, on landing, but I think I was in the viewing room instead of down on the console. I can't remember for sure, but I think so.

WRIGHT: Tell us about the duties of a backup crew and working with Alan [B.] Shepard [Jr.] as the commander of Apollo 14 and the expectations of you and your crew.

ENGLE: The backup crews during the Apollo Program, and is the case, I'm sure, still now, the backup crew was charged with getting themselves fully trained and fully ready to go and being ready to go in case anything happened to the prime crew. Although it was never really laid out, I think it was a flexible thing that allowed a real-time call as to whether if one person became unable to fly a mission, whether that single seat would be swapped out or whether the entire crew would be swapped out. They tried to maintain crew integrity, but many times it made more sense to swap out one person, one crew, as on Apollo 13. It happened on Apollo 13.

But crew integrity was one of the things that really developed during that time period. You trained together, you started assigning different duties and tasks and finding what strengths each individual had, and assigning those duties where he could contribute the most, be most value added during the mission. So you worked together as an integrated team.

There was a lot of good-natured rivalry, I think, on all the Apollo missions, but I think we tended to foster that more on Apollo 14 than certainly I observed on other missions. We had a good time with the prime crew, with Al Shepard, [Stuart A.] Stu Roosa, and [Edgar D.] Ed Mitchell. We just had a fun time with them. We always would take every opportunity possible to remind them that we were trained, we were ready to go. All it would take is one of them to hiccup or stumble or get a blister on their foot or something, we'd jump right in and take over. In fact, we tried to encourage them. We didn't ever buy them, but we were going to buy them tickets to—gosh, I forget what it was, go skiing or go skydiving or go something, some rather risky thing that we weren't allowed to do anyway, just to let them know that we were ready to go.

WRIGHT: Your crew had such a bond that you had your own mission patch. Can you explain that to us, about the patch and what its reasons?

ENGLE: We did. We sure did. It really was almost a direct development of the prime crew patch, the Apollo 14 crew patch. We had, as I mentioned, told them we were right behind them and we were going to beat them to the launch pad if they didn't keep a quick pace up. I don't remember where it started, but we acquired the nickname "the roadrunner," so our crew patch, that I think Gene was most instrumental in designing, in place of the astronaut symbol, leaving the Earth and on its way to lunar trajectory, we replaced that with Wiley Coyote with a long beard, because we were merciless in kidding Al about how old he was and how he was really too old to go anyway. Then on the lunar surface, which was on the prime crew patch, the roadrunner

was sitting there waiting for Al Shepard to get there with his crew, with a "Beep Beep" on the patch.

WRIGHT: Our research shows that at one point you and Gene Cernan bet Alan Shepard and Ed Mitchell a case of scotch if they couldn't make it to the top of the Cone Crater if they dragged the MET [Mobile Equipment Transporter] up there with them. Can you tell us how that bet came about and why you posed that?

ENGLE: Oh, they made it. They did it okay, and we knew they would, but that was a good-natured bet to—I mean, we wanted to do that anyway. [Laughs]

WRIGHT: Did you send up some of your patches to find during the mission?

ENGLE: We were able to stow a number of patches, as a matter of fact, in the packet, in with their clothes and food so that as they opened up different things during the mission, why, every once in a while they would be treated to one of our crew patches. And we would hear about it in very carefully worded transmissions from Al and Ed.

WRIGHT: You must have made friends along the way of all the people that helped get these mission patches up on the equipment.

ENGLE: It was fun. A lot of people really enjoyed it. It was a great motivation and incentive. Everybody was very professional, but we had fun on that mission. We sure did. And the nice

thing was that Al and Ed and Stu brought all the patches back. I think they kept some for themselves, but they gave the patches back to us after the mission.

WRIGHT: In Cernan's book, he mentions that just a month before the launch of Apollo 14, there were some discussions about possibly moving you to be the LM [Lunar Module] pilot for Apollo 14. Were you aware at the time that they may be moving you into that slot?

ENGLE: I was. As soon as the decision was made from a budgetary standpoint to cancel Apollo 18, 19, and 20, soon after that—I won't say as soon as, but soon after that, then the discussion surfaced that the scientific community was very avid and pushing very hard to get [Harrison H.] Jack Schmitt on the surface of the Moon, because Jack had a doctorate degree in field geology and, of course, that's what the lunar missions were all about. So it was a perfectly legitimate rationale to consider and to see if it were able to get Jack ready to go on the last mission, Apollo 17, rather than on Apollo 18, which he would have been scheduled for. Jack was backup for Apollo 15.

So, yes, there was no secret about it. It was being discussed openly. I think that both Gene and Deke, their first choice would have been to leave the crew intact, but I think that there was a great deal of pressure on them, and understandably so. So I was told that the decision had been made and that Jack was going to replace me on Apollo 17.

WRIGHT: Was that information given to you by Deke Slayton?

ENGLE: Actually, I think it was Al Shepard that called me into the office. Al was the head of the Astronaut Office at the time. I think it was Al, after he had returned, told me that that was what would happen.

WRIGHT: What were your options for assignments after this decision? As you mentioned, the final Apollo missions had been cancelled, so what were going to be your options?

ENGLE: Let's see. I think the next program already being talked about was Skylab. I can't remember the sequence or how quickly the missions downstream began to be formulated, but Apollo-Soyuz was also another mission coming up, and the Space Shuttle was in its very early preliminary design phases. It was a program that was going to be not too far down the road, we hoped.

WRIGHT: Were you able to select where you wanted to move into?

ENGLE: I wouldn't say I was able to select, but Deke was very, very good about it and asked me, in a one-to-one conversation, not promising that I would be assigned to a Skylab or not promising I would be assigned to the Apollo-Soyuz mission, but implying that if I were interested in that, he would sure consider that very heavily. Then he also indicated that the Space Shuttle looked like it was going to be funded and looked like it was going to be a real program.

So at the time, I think I responded something to the effect that it had a stick and rudder and wings and was an airplane, and was kind of more the kind of vehicle that I felt I could

contribute more to. And Deke concurred with that. He said, "That was my opinion, but if you want to fly sooner than that, I was ready to help out." I think Deke was happy that I had indicated I would just as soon wait for the Space Shuttle and be part of that program, the early testing on that program.

WRIGHT: Did you have the option of returning back to the Air Force to get another assignment from them?

ENGLE: At that time, I don't know. I probably could have, but I just don't know. I hadn't flown yet. I had left the Air Force to come here to fly and had not flown yet, so I felt that I really would be of more value added to the Air Force if I flew before returning to the Air Force. So I didn't even consider that.

WRIGHT: Could you share with us what the mood was like in the Astronaut Office and on the [Johnson Space] Center after the program started getting cancelled and the people realized that there were going to be no more Apollo flights after 17?

ENGLE: There was disappointment. There's no question that there was a lot of disappointment expressed, because the Apollo missions were just getting to the point where we were able to employ a lot of mobility with the lunar rover and bring back more varied samples of lunar surface, rocks and dust and samples, and to stay longer on the lunar surface as well. We were getting our confidence up in staying on the surface, so the missions were getting much more efficient as far as the scientific return.

It was probably a rather shallow rationale from a crew standpoint, but I know we all said, "Man, this is the wrong time to cancel, because now we're able to really bring back a bunch of stuff." Plus, there was planning to land on the backside of the Moon and there was also a planned polar orbit of the Moon, something that we had not done, not gotten any samples from the backside. So I think from a crew office standpoint, I doubt that there was very much desire to vary the scientific return by going to the backside, but I think everybody wanted to go to the Moon, so that was our selfish reason and rationale for wanting to continue. Of course, we had no vote with the budget issue like it was.

WRIGHT: One other aspect of Apollo that certainly has made history is Apollo 13, of almost losing a crew, but was able to get it back. Were you involved in some of the recovery discoveries on how to bring them back? Were you involved with the rest of the astronaut corps in developing some of the procedures to get them back home?

ENGLE: Yes, very much, very much so, because as a backup crew, we had a good bit of training, a good bit of knowledge in systems, the lunar module and the command module systems, as the backup crew for [Apollo] 14 by that time. And, yes, we were thrown into the hopper along with, I think, almost everybody else on this site at the time. I think everybody, if they didn't work twenty-hour days seven days a week, it sure seemed like it, because everybody was there, wanting to help, standing by, ready to help, and much of the activity that we as a backup crew did was to run sequences in the simulator to see what would work and what wouldn't work.

As MOD [Mission Operations Directorate] and Engineering [and Development Directorate] would come up with concepts of how they could keep the crew alive, how they

could maintain attitude or temperature or whatever, then we would take those ideas and go into the simulator and employ them in as real-world a situation as we could, and that data would come back and either modify the approach or confirm the approach was good.

I remember also very specifically in being in Mission Control and the CO_2 [carbon dioxide], I guess it was, was building up, and it was obvious that the lunar module did not have enough lithium hydroxide canisters to wash out the atmosphere. I was one of the group that Deke called over and said, "We've got a lot of canisters in the command module and we've got fans that will blow the air through these canisters in the lunar module. We've got no power in the command module. The only problem is, one of them is square, one of them is round, so take what's on board, go over to the simulator, take the checklists, take anything that's in there, but you can't take anything new in, and figure out how to make it work."

So it was a very simple adaptor made with the plastic covers from the checklists, cutting them to size, and duct tape, and fitting a square to a circle. One of the things that allowed the continual washing of CO_2 out of the atmosphere.

WRIGHT: It must have been very satisfying, knowing that all that came together so well.

ENGLE: It was, yes.

WRIGHT: Were you in Mission Control when they successfully landed and returned?

ENGLE: Yes, I was. Yes. It was a pretty happy day, happy location, happy site, when that happened.

WRIGHT: Tell us how you began working with the Shuttle development, at what point. We know that you were involved with the approach and landing tests, but did you work with the Shuttle in its development in some of the testing stages before you moved into that phase?

ENGLE: Yes, in fact, I even was working during the selection, the down-select of manufacturers in the conceptual design of the Shuttle. I do remember Rockwell and McDonnell Douglas [Corporation] and Grumman were three of the primary competitors initially and had different design concepts for the Shuttle, all pretty much the same, but they were significantly different in shape and in configuration for launch, using different types of boosters and things.

I was part of that selection process only as an engineer and a pilot, and assessing a very small part of the data that went into the final selection. But it was interesting. It was very, very interesting, and it, fortunately, allowed me to pull on some of the experience that I had gotten at Edwards in flight testing, in trying to assess what might be the most reasonable approach to either flying initial flights, data-gathering, and things of that nature.

WRIGHT: In [19]'72, [NASA] Dryden [Flight Research Center, Edwards, California] started testing and verifying the computer hardware and software, and then following a few years later with the parachute recovery system and the tile testing. Were you involved in any of those aspects during those time periods?

ENGLE: Let's see. The computer testing, well, the flight control system itself was put onto an airplane that—let's see. [Calspan Systems Research Laboratories, Calspan Corporation] It's a

research laboratory up in Buffalo, New York. They had an airplane that you could put different flight control systems that had different responses in, and the anticipated flight control system and responses of the Shuttle were put into that airplane to see if it would be, in fact, flyable by a crew. And, as a matter of fact, we did learn that there were some concepts that were being considered that just wouldn't have worked, wouldn't have cut it. So in that respect, yes, I was involved in those early checkouts and tests.

WRIGHT: 1977 began the taxi test for the Shuttle, for the Orbiter testing out at Dryden, and more plans were being made to test. Tell us how you became very involved in all of the testing procedures for the Orbiter and how you were part of the approach and landing test.

ENGLE: I had been selected as one of the two crews. [Richard H.] Dick Truly and I were one crew and Fred [W.] Haise [Jr.] and [C.] Gordon Fullerton were the other crew, who would fly the approach and landing tests, which were glide tests from off the top of [Boeing] 747. Initially, the concept was to put air-breathing engines on the Orbiter and to take off and fly it around and check its aerodynamic characteristics and then return to land.

Also at one time, those engines were conceived as being able to be rotated inside the payload bay, or in part of the payload bay, so that after the reentry, they could be deployed and fired up and they could extend your landing area after reentering the atmosphere. That really wasn't a viable concept, it turned out, so the air-breathing engines never became part of the Shuttle, although they were part of the Russian's Buran vehicle, which is a very close copy of our Space Shuttle. They flew it with air-breathing engines, jet engines, initially.

But I think one of the reasons that I was selected to fly the Shuttle, initially, by Deke was because of the experience that I'd had at Edwards with the X-15 and air launching from another vehicle, from a carrier vehicle, then glide testing unpowered glide testing of a low L/D, which means a low lift-to-drag-ratio airplane, not very much wing for a lot of drag, and that's what reentry vehicles, space vehicles, tend to do. They're not optimized aerodynamically, because they have to launch off a rocket and perform as a spacecraft in orbit, and a very small part of their operational mission is in the atmosphere acting like an airplane. So they're not optimized to glide shallow and land at very low speeds.

The initial approach and landing tests on the Orbiter vehicle were, in fact, just that, and that was to place the vehicle in aerodynamic flight by itself and exercise all of the systems that we could, hydraulic systems, electronic systems, the fight control systems, and landing gear, of course, systems and things like that, do it in a real flight environment, and to gather as much as flight test information as far as stability and control parameters and performance parameters, and do it partly in an ideal environment. In other words, not have to worry about coming in to land and the wind having coming up and giving you a big cross wind, or low clouds or things like that.

You could take off and an hour later, drop, and you knew what the weather was going to be. Of course, at Edwards, it was normally pretty good anyway. But you could set yourself up ideally over the lakebed, too, so you didn't have the navigation concerns that you do coming back from orbit.

Plus, the vehicle itself, really, was ready to go before the rocket engines, the propulsion system was ready. So that gave NASA an opportunity to get a look at the Orbiter vehicle, its basic configuration, its flight control system, and make sure that it had an airplane or vehicle that

could fly the pattern, the approach, the flare, and the landing, which was a very, very small part of its mission, but a very, very critical part of its mission, and gain confidence in that prior to committing to launch into orbit.

So the approach and landing test was designed to do just that. It was initially designed for about eleven flights, as I recall, and as we flew more and more flights, there was indeed pressure from the other end to hurry up and finish up so that those engineers could be assigned to the orbital flight test vehicle, and the orbital flight looked like it was going to take resources and shorten up the initial approach and landing tests. The approach and landing tests were going very efficiently, too, so we were getting a lot of data and were able to condense the program from eleven flights down to what ended up to be five.

WRIGHT: Were you involved in all the flights in some way or another? Were you either observing or chase planes?

ENGLE: Yes. Dick and I, when we were not flying, we normally would be in Mission Control here at Houston. The chase planes were flown by a cadre of pilots from the Astronaut Office, who were given the task of chase pilots, and they concentrated and practiced on chase techniques, joining up, flying formation, optimizing their relative position to the Orbiter, particularly being able to adjust and maneuver in case there were certain things that needed to be observed and verified or confirmed to the crew or to ground, whether either a control surface in the right position or that nothing had fallen off the airplane. But then as the flare and the float into landing and a touchdown approached, they would verify that the landing gear in fact was

coming down and was down and locked, then at that time would call out the height of the main gear above the ground as we came in to touch down.

So, developing proficiency in those areas so that they could do that kind of second nature, kind of intuitively or instinctively, and concentrate more on what they were looking at and not flying their chase airplane, keeping it in position, was a real important thing.

At that time, I don't think we had the radar altimeter working initially, in fact. But even when it was hooked up, we really didn't have confidence in it yet. So a visual callout on how many feet off the ground the main gear was, was very important. Because in the Shuttle, you were so high off the ground, with not a lot of visibility out those windows, you had no feel for how far off the ground your wheels were, really; you just didn't know. So it was a big help.

WRIGHT: While you were in the Mission Control with Dick Truly, what were some of the duties that you had? What were you looking for?

ENGLE: Primarily systems failures or anomalies that would come up. With things that would happen, whether or not it was okay to press on with the drop, or to continue the climb out to the drop, or what the options should be when that happened.

Quite frankly, with the tail cone on, the streamlined tail cone on the back end, that was there really to cut down on drag for ferry missions, and it is, in fact, employed on all missions when the bird is ferried either West Coast back to East for launch, or East Coast back to West for the major modifications, or major maintenance and mods. The Orbiter flew pretty benignly with that tail cone on. You had a relatively shallow glide slope. You could get to a higher altitude for

launch, because there was less drag, and the flight duration, as I recall, was well over five minutes. In fact, I think it was maybe up to seven minutes with the tail cone on.

But that was not the configuration that we needed to really have confidence in, in order to commit for an orbital launch, because that reentry and landing would be made with the engines exposed and the blunt tail and required a much steeper glide slope, much more demanding profile, much more condensed time period from flare to touchdown, because the air speed would bleed off much faster with the additional drag.

So although we were able to get a lot of really good systems data and time on the systems, on the hydraulic systems and electrical systems and computers and flight control system, although we were getting more time on those systems with the tail cone on, from a performance standpoint and a piloting task standpoint, we really didn't have what we needed until we flew it tail cone off, and those flights were only about two and a half minutes long.

WRIGHT: Being a former X-15 pilot, you had been used to being dropped, whereas now the Shuttle was actually being launched. Share with us the differences and what that experience was like to be in that type of maneuver.

ENGLE: Oh, it wasn't a lot different, really. It's a matter of going from a mated or a purely dependent situation on the carrier pilot to either throwing a switch or, in the case of the Shuttle, pushing a button and blowing bolts and being free on your own. The X-15, your immediate concerns were, first of all, to keep it under control as you came off the hooks, but then to get the rocket engine lit right away so that you could get off on your mission, but you were dropping away underneath and there was no real concern with recontacting the carrier airplane.

With the Space Shuttle, that was our main concern, was to develop a separation maneuver with [Fitzhugh L.] Fitz Fulton [Jr.], the carrier pilot, to optimize the separation between the two vehicles, both vertically and laterally. So Fitz would put the combination vehicles in a slight dive to get the right air speed—you wanted to be able to get 240 knots, I believe it was—in level flight, with the tail cone off.

So he would dive the airplane and when he got on speed, he would call, "On speed." We would separate and call the separation, the "three, two, one, sep." And at that time, the Orbiter was sitting with a 15-degree angle of incidence. In other words, it had 15 degrees angle of attack and was trying to fly off the 747 at that time. Fitz would, in addition, put the spoilers out to dump lift on the 747, throttle back to idle so that as we came off, we didn't slide back and take his tail off. Then the two of us would turn in different directions as well, so that as soon as we lost energy and started to come back down, we didn't come back down on top of him.

In looking at the videos, there was lots of room, lots of separation, but initially we weren't sure, so we optimized everything we could. We didn't compromise anything by doing that, but we did have plenty of room for separation, and it was a coordinated maneuver. Fitz would dive away to the side; we would pull off to the right; he'd dive off to the left, then we'd go wings level and go right into the data-gathering maneuvers, because we had very little time to get data. We had about a minute and a half to get data and then, well, the rest of the time was flare and land, to get the gear down and touch down.

WRIGHT: Did you land on both the dry lakebed as well as on the concrete?

ENGLE: I landed only on the lakebed. The last flight, the second flight, tail cone off, Fred Haise and Gordo [Gordon Fullterton], the flight was set up to land on the runway, and I think one of the reasons was we had been able to gather enough, certainly the majority of the flight test data parameters that we needed for confidence that the wind-tunnel data was good and the analysis was good on the airplane, so we were able to get a lot of data on Free Flight 4.

Free Flight 5 was dedicated and designed as a demonstration maneuver that we can land the Orbiter on a runway, and that was really the only purpose for Free Flight 5. So Fred and Gordo were set up to land on the runway.

WRIGHT: How much did you and Dick Truly and Haise and Fullerton exchange information? How were you able to share the lessons learned from each of the crews with the other crew?

ENGLE: We would debrief, get together for sessions in the office and, if necessary, go to the simulator to show or demonstrate things that had happened or we thought had happened on the flight so there were no surprises for the next crew. There weren't a lot of flights, really, to pass that information on. A lot of times, the first time you see something in a flight, you're not sure what it was you saw or just how to describe it. We didn't have the luxury of that, really, because Fred and Gordo had a flight, tail cone on; Dick and I got the next one, and then Fred and Gordo flew the third one.

The third flight, really, was to engage the autopilot and to give the autopilot as much time to control and watch its reaction and correction to offsets on the final glide slope, and that really had no application to what Dick and I were going to do on the subsequent flight, the tail-cone-off flight, where we came down very, very steep and got the data with the tail cone off.

So, basic characteristics as far as handling, response of the vehicle, we were getting a pretty good feel for that through the simulators, both the ground-based simulators and the in-flight simulator, the Gulfstream G-2. So we did exchange what information was important. But each mission was a little unique during ALT [Approach and Landing Test].

WRIGHT: How were you able to help enhance the Gulfstream G-2 training? You flew that before you flew the [Space Shuttle] *Enterprise* [OV-101] and then you flew it after, so what types of lessons were you able to share with those that improved that training vehicle?

ENGLE: The Gulfstream was extremely valuable. It was a very, very good simulation, a very accurate simulation of what the Orbiter would do, and I think one of the things that I think as a crew, not just us, Dick and I, or Fred and Gordo, but subsequent crews, when they flew the Orbiter vehicle into space and back, were able to streamline and optimize the Gulfstream a little bit. Because the pilot sat so high above the roll axis, the axis where the Orbiter really rolls, you're sitting way above it, so when you roll sharply right or left, you get not so much of a roll sensation, but more of a lateral acceleration right and left, and that's very disturbing to get those sharp slaps on the side when you're trying to control delicately with a little hand controller that is pivoted down below you, and you get inadvertent inputs in so that you get walking when you do roll maneuvers.

But we learned, really, that when flying the Orbiter, you don't fly it like you do a fighter and like we tended to fly the simulators, where there were no motion cues, or no accurate motion cues. So the inputs that you made when you wanted to roll, even if you needed to be aggressive,

you tended to ramp in the rate of roll slowly so that you got over there rather than slap it over and pull.

The Gulfstream was designed to give the right response in the cockpit when you did one of those hard maneuvers. It had a pair of large vanes stuck down underneath that would move and actually move the whole Gulfstream airplane sideways to give you that lateral acceleration. It made it very uncomfortable to fly, but more importantly, it was kind of dangerous, because those big vanes underneath had structural support that had to go up into the airplane and it went into where the fuel area was. First of all, you couldn't land if, for example, a gear didn't come down; you had these big vanes underneath.

It presented a hazard, and we uniformly decided in the crew office that it really wasn't necessary, because we didn't use a piloting technique that really required where you got the true value of that hard-slap impact. So we did remove those from the Gulfstream. It made the operation a lot safer and a lot less maintenance on the Gulfstream as well.

But the basic Gulfstream airplane in response and pitch and roll was very, very close. The response was tuned as data would come back from the Orbiter flights, but it was a very, very good training airplane and still considered by pilots as the very best single training tool that they have to land the Shuttle.

WRIGHT: What were your colleagues thinking about the Shuttle at this time? Were you getting a lot of questions from the other astronaut corps members of how it flew, what it felt like, after the ALTs?

ENGLE: I'm sure there were. They don't stand out in my mind now as anything particular, other than the four of us that flew the approach and landing tests, all of us, together and individually, telling everyone how good the simulators were, how close the simulators were to the way it felt and the way if flew.

We were able to modify the [Northrop] T-38s [Talon] a little bit, with a little larger speed brake, so that our T-38s, which were readily available and accessible and efficient to fly, could duplicate the profile, not the handling qualities of the Shuttle, but the profile, so that sight picture of coming down in a steep approach and the timing of the flare and floating up to landing and getting the gear down, those procedures could be developed so that they were almost instinctive, and that left the only new thing, then, the unique handling qualities and the responses of the airplane, that part of the personality of the airplane, to be new when you flew it. I think all those things combined really helped out.

But I don't recall that we sat down with the whole Astronaut Office and went into detail what to watch for and what not to watch for as far as flying the airplane, because it was available to them in the simulators.

WRIGHT: How did you feel about the first orbital test flight of the Shuttle was going to be manned instead of unmanned? NASA had never launched a spacecraft for the first time being manned.

ENGLE: Oh, we were tickled silly, because we didn't want any autopilot landing that vehicle. We were very vain and thought, you know, you've got to have a pilot there to land it. If you've got an airplane, you've got to have a pilot in it.

Fortunately, the certification of the autopilot all the way down to landing would have required a whole lot more cost and development time, delay in launch, and I think the rationale that we put forward to discourage the idea of developing the autoland—and I think correct one, too—was that you can leave it engaged down to a certain altitude, but always you have to be ready to assume that you're going to have an anomaly in the autopilot and the pilot has to take over and land anyway.

So the pilot flying the vehicle all the way down, approach and landing, he's in a much better position to affect the final landing, having become familiar and acclimated to the responses of the vehicle, after being in orbit, and knowing what kinds of displacements give him certain types of responses. And keeping himself lined up in the groove coming down to land is a much better situation than asking him to take over after autopilot has deviated off. Now he's got an error he's got to correct back and line up the vehicle with the runway, hasn't had the luxury of flying and becoming reacclimated to the stick feedback and the vehicle response portion of that.

So it almost, for us, was hard to accept any argument that said let the pilot fly it down. If he's incapacitated, he's incapacitated and so he's not going to be able to land it anyway, so then you can engage autopilot and see how it works. But you run more risk in damaging the airplane doing it the other way.

WRIGHT: After the tests were completed, what were you involved with between that time and the first STS-1?

ENGLE: Right after the approach and landing tests, Dick and I were kept as a crew and assigned as the backup for John [W. Young] and Crip [Robert L. Crippen] on STS-1, backup for STS-1

and prime crew for STS-2. So as soon as approach and landing tests were completed, we began intense training on STS-1, really, the profile. And it wasn't long before we folded in then the payloads and the experiments on STS-2 into that training, so we could have flown either STS-1 or, as it turned out, then just wait and flew STS-2.

WRIGHT: How were you involved during the mission of STS-1?

ENGLE: I think Dick and I both were in Mission Control pretty much during STS-1 and during the landing. As a matter of fact, come to think of it, I think Dick did go out to Edwards for the landing, but I don't remember that for sure. If he did, I don't recall what his specific mission was out there, because we did have, again, chase pilots assigned who had practiced using radar vectors to join up and follow the vehicle back in to confirm and verify and to call out altitudes still, above the surface.

WRIGHT: Are there any other experiences or remembrances that you have of the approach and landing tests, or any of that experience at all you'd like to recount for us? Any special moments that you recall during that time?

ENGLE: Oh yes. [Laughs] Well, I think from a professional standpoint, from a test pilot standpoint, I think the most exciting and the most rewarding time was the development of the profile for STS-4, which was the fourth flight and the first flight without the tail cone on. By that time the program had been shortened up. We knew that there was only going to be five flights and we knew the last flight was going to be focused on landing on concrete and not

diluting the crew task by doing anything other than making sure they were lined up energy-wise and direction-wise on the runway.

So our goal on our flight, the flight that Dick and I flew, tail cone off, was to pack as much meaningful flight-test data as we possibly could in that short period of time. We did work very hard, not only on the simulators, but at Edwards in both T-38s and the Gulfstream aircraft, in going through and tailoring and modifying and readjusting the profile so that we literally wasted no time at all from one data point to the other. We would go from one maneuver and make sure that we were set up for the subsequent maneuver.

It was a very demanding, fun task that Dick and I shared the piloting task on, really, because we did a very unique thing with the Space Shuttle in that we have two hand controllers, one for the commander and one for the pilot. Normally only one controller is powered on so that you don't get inadvertent inputs from both of them, because they'll sum together. But on that particular mission, in order to hold the vehicle at a certain angle of attack while it's accelerating and going downhill and picking up speed, we were able to use one hand controller, Dick's hand controller.

He would hold, for example, hold an angle of attack right at 5 degrees, 7 degrees, whatever the desired angle of attack was, and while passing through a dynamic pressure or air speed window, then I was able to make a pure input, a doublet input, pitch, for example, forward and aft, or roll left and right, or a rudder kick left and right, without worrying about drifting off from the desired basic vehicle attitude. We were able to manually get some very pure, very clean data that later on was programmed into the flight control system, but at that time we didn't have it programmed in. We developed that while we were flying out at Edwards.

In fact, we learned about the possibility of doing that flying [Lockheed Martin] F-16s [Fighting Falcons] out there. General [Thomas P.] Stafford had left the astronaut program and was back as Flight Test Center Commander at Edwards, and he arranged for us to fly the F-16, which was new at the time and had an electronic flight control system. So we incorporated a characteristic that we learned in that airplane, that was not normally used in that airplane either, but it served us well to get flight test data.

WRIGHT: It must have felt pretty good being back at Edwards.

ENGLE: It did. [Laughs] Yes, it did. It really did. I like Edwards very much. I get back there every chance I can.

WRIGHT: I thought I'd take a moment, while we have finished Apollo and as we're moving into the Shuttle phase, to ask Sandra or Jennifer if they have some questions about that time that I might have missed. Do you have anything there to ask?

ROSS-NAZZAL: I've got just one question, maybe some other ones. Rebecca has asked you about socializing with some of your crewmembers, especially on Apollo 14. I was wondering if you could talk to us a little bit about the camaraderie in the Astronaut Office during the Apollo Program.

ENGLE: Yes. It was a very close—I thought, anyway—a very close camaraderie, close in the respect that everybody was totally focused on and tried to help each other out. When you were

assigned to a mission, the entire Astronaut Office, it seemed like, was supporting you. And no matter what their other duties were, they would drop whatever they were doing to help focus on and get you ready for that mission. So there was that aspect of everybody gravitating, like to the drain of the sink, and helping out and yet each mission, the sequence of missions, or the timing of the missions during Apollo, were relatively close together, based on—well, I guess they were several months apart, but they were so immense, the preparations for each mission were so immense and it consumed all of the time of the crew, that the crew itself really wasn't able to focus out or spread out into other things. You were really concentrated on your specific mission, on the tasks that were going to be done, the things that were going to be done on your mission. So although a crew became kind of drawn into themselves from a training standpoint, you never got the impression that that crew was isolated. There was always time to help. They were always ready to talk about things and to share things as well.

ROSS-NAZZAL: Were there any special relationships between, say, the people from the Air Force and the Navy and from the other military fields, or the scientists? Were there any sort of—I guess I don't want to say *cliques*.

ENGLE: Not during Apollo. There was the time-honored tradition of razzing between Navy and Air Force pilots, and that, of course, didn't let up. You wouldn't have wanted that; you'd have felt somebody was sick if they ever backed off from that, but it was good-natured. At that time, most of the astronaut corps were military on assignment to NASA, and so other than what was kind of the good-natured kidding about crew makeup and things like that—and as a matter of fact, good natured, I guess, did get into some growling discussions on, "Well, there's more Navy

guys flying than Air Force," or vice versa, "There's more Air Force guys flying than Navy," but it was not a serious thing at all.

I think most of the people had military experience in their training. If they were civilians, they had gone through military flight school, because at that time, everyone was a pilot, during Apollo, until the scientists were selected. And I think, in fact, I'm sure, that Jack Schmitt was the first nonpilot—as a professional career—he was the first nonpilot to fly on either Apollo or Skylab or Gemini or Mercury, Gemini, any of those vehicles.

Initially, I think, when the science community began to have people selected—when people were being selected as mission specialists, for example, on the Space Shuttle, I think there was initially the feeling and the recognition that there's the pilots and there's the scientists. Even then, at first it was kind of diluted to the point that all the scientists were sent to flight school to go through flight training, so that even diluted that down a great deal. I don't know what it's like now. I really don't.

ROSS-NAZZAL: You mentioned the mission specialists coming in, and you had been in the office for quite some time. What was it like being in the Astronaut Office when you had women coming in and you had this whole new group of people that hadn't been in the office before? What was that like?

ENGLE: It really wasn't a real big deal. We thought it was going to be a bigger deal than it was. You mean when women came in and scientists came in?

ROSS-NAZZAL: Yes.

ENGLE: Actually, the group of five scientists was selected just prior to our group of nineteen. There was [Joseph P.] Joe Kerwin. I guess Jack was in that group, I think. But I know Joe Kerwin was in that group. They were selected as scientists, but then they were sent right to flight school right away, so as I said, it wasn't a big deal.

No, I think the fact of women being selected into the astronaut program, initially they were mission specialists. We knew it was going to be different. In fact, one of the biggest problems at that time was for Deke, I know, really toiled hard with where he was going to put the women's locker room over in the gym, because we just had a guys' locker room over there up to then. So Deke had to figure out—and of course, good old Deke, he said, "Well, hell, we'll just put a curtain up and you can all use the same damn room," but he finally conceded that they would have a separate room. [Laughs]

Shannon [W. Lucid], I think, after her flight, I think one of the funniest things, John [M.] Fabian was on the flight with Sultan [Salman Abdulaziz]Al-Saud and Shannon, and after the flight, one of the post-flight appearances, Sultan was setting up a very, very great tour in Saudi Arabia, and the problem was, of course, that women could not go to the country unescorted. So Shannon, of course, had to go escorted, and she really didn't quite understand how that was going to set with her.

I remember they were having a meeting in one of the small conference rooms in Building 4, and John Fabian came back and just could hardly keep from laughing, and our office was next to theirs on the corner, and he said, "Joe Henry, you're not going to believe this. We spent hours trying to figure out the correct way for Shannon to go to Saudi Arabia, and Sultan and the delegation offered to make [Daniel C.] Dan Brandenstein her honorary father so that she could

be escorted by her father. Shannon wasn't going to have any part of that, and she let them know that."

Then the next step was to make him her honorary brother, and they would concede that a brother could escort his sister in. And she was very, very hard over that she was a woman and she was going to go as a woman and as a crewmember.

So the meeting broke and John had come back and told us this and he said, "Now, don't you say a word of this to Shannon, because she's really not thrilled with this whole idea right now."

So I saw Shannon walk back into the office there, and she was not smiling at all, so I got up and I went over to the door, and John was sitting at his desk and I said, "Hey, Shannon, congratulations." And John turned around and gave me the "Don't you dare. Don't you even think about it, Joe Henry."

They had been given a lot of honors after that flight, as every crew did, and so she wasn't sure what I was referring to, and she said, "Well, thanks, Joe Henry."

I said, "Yeah, that's really, really a neat, neat deal, a very unique honor, too. We're going to have to think of something to do for you here."

Oh, the final thing was that the Saudi delegation, I believe they even had some form they were going to make her an honorary male so that she could go to the country. Well, that really torqued her off.

So I was congratulating her and I said, "God, that is really an honor, Shannon," and she began to get quizzical and I said, "Good god, an honorary male. We could even get you honorary privileges to the men's room down here." And with that, she picked up a paperweight, and John, by that time, was just rolling with laughter. But it was all good-natured. [Laughs]

ROSS-NAZZAL: It sounds like you enjoyed yourselves in the Astronaut Office.

ENGLE: Oh yes. Oh yes. You bet.

WRIGHT: Your good friend and new mentor, Deke Slayton, was able to fly on ASTP, and he had been waiting for so long for his first ride. Would you just take a few minutes and share with us what it was like to work under him and what you learned about him and learned from him?

ENGLE: Deke is about as solid salt-of-the-earth person as you could ask for. I knew that from hearing about him out at Edwards, as a test pilot at Edwards. I wasn't there when he was at Edwards, but he left a great reputation at Edwards as a very solid, good test pilot. So I had a lot of respect for Deke when I came down, and I found that he was that way when he was chief of the Astronaut Office and head of Flight Crew Operations [Directorate] as well. He was very fair, very honest, very direct. You could go to him with any problem that you had. You might not always get sympathy in return, but you knew he'd be fair. He was just a great person to work for. You couldn't help but have confidence in him as a boss.

[End of interview]